Diagnostic Competency in Standard Chest Radiography: A Multi-Domain Assessment of Technical, Cognitive, and Professional Skills Among Radiography Undergraduates

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ABSTRACT

Background: Standard chest posteroanterior (PA) radiography is one of the most frequently performed diagnostic imaging examinations, requiring adequate technical knowledge, image-quality awareness, and professional competency to ensure accurate diagnosis and patient safety. This study evaluated the knowledge, awareness, and professional competency of radiography students regarding standard chest PA radiography.

Methods: A descriptive cross-sectional survey was conducted among 301 undergraduate, internship, and postgraduate radiography students using a validated, structured questionnaire. The instrument assessed demographic characteristics, technical knowledge, awareness of radiographic errors and image-quality criteria, and professional competency. Data were analyzed using IBM SPSS Statistics version 25. Descriptive statistics, independent samples t-test, one-way ANOVA, and Tukey post-hoc analysis were performed, with statistical significance set at $p < 0.05$.

Results: Overall, participants demonstrated satisfactory knowledge and awareness of standard chest PA radiography with consistently high professional competency. Significant improvements in technical knowledge were observed with increasing academic level, particularly for patient positioning ($p = 0.018$), central ray centering ($p = 0.004$), and recommended kVp selection ($p = 0.025$). Awareness of radiographic error recognition and image-quality assessment also improved significantly among interns and postgraduate students ($p < 0.05$). Professional competency related to patient care, radiation protection (ALARA), communication, ethics, and lifelong learning remained uniformly high across gender and academic levels without significant differences ($p > 0.05$).

Conclusion: Radiography students possess adequate foundational knowledge and strong professional attitudes toward chest PA radiography. Clinical exposure and academic progression significantly enhance technical competence and image-quality awareness, whereas professional values remain consistently positive throughout training. Strengthening competency-based clinical education and structured mentorship may further improve diagnostic accuracy, reduce repeat examinations, and promote patient safety in routine chest radiography.

Keywords: Chest posteroanterior radiography; Radiography education; Knowledge; Awareness; Professional competency; Radiation protection; Image quality; Clinical competency; Radiography students; Patient safety.

INTRODUCTION

Chest posteroanterior (PA) radiography remains a cornerstone in diagnostic imaging, serving as the first-line

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modality for assessment of cardiopulmonary conditions, trauma, and routine health evaluations due to its accessibility and diagnostic value(Dick, 2002). High-quality chest radiographs depend not only on technical expertise but also on the radiographer's knowledge of positioning, exposure parameters, beam centering, and radiation protection principles. Suboptimal technique can result in repeated imaging, increased radiation exposure, poor image quality, and potential misinterpretation, highlighting the need for comprehensive training in both cognitive and professional domains of radiography practice(Bastos & Nogueira, 2025).

Radiography education has evolved in recent years to emphasize quality assurance, patient safety, communication skills, and ethical practice, in addition to core technical competencies. Effective curricula now integrate competency-based learning, reflective practice, and clinical placements that reinforce practical application of classroom knowledge(Arruzza, 2023). Despite these advancements, emerging evidence suggests that gaps persist in students' readiness to consistently apply these competencies in clinical settings. For example, surveys of radiography and related healthcare students indicate varied levels of awareness and attitude regarding radiation safety and professional responsibilities, even when foundational knowledge is present(Hoagland & Kipping, 2024; Riley, 2012).

METHODOLOGY

A descriptive cross-sectional survey study was conducted to assess the knowledge, awareness, Professional Competency.

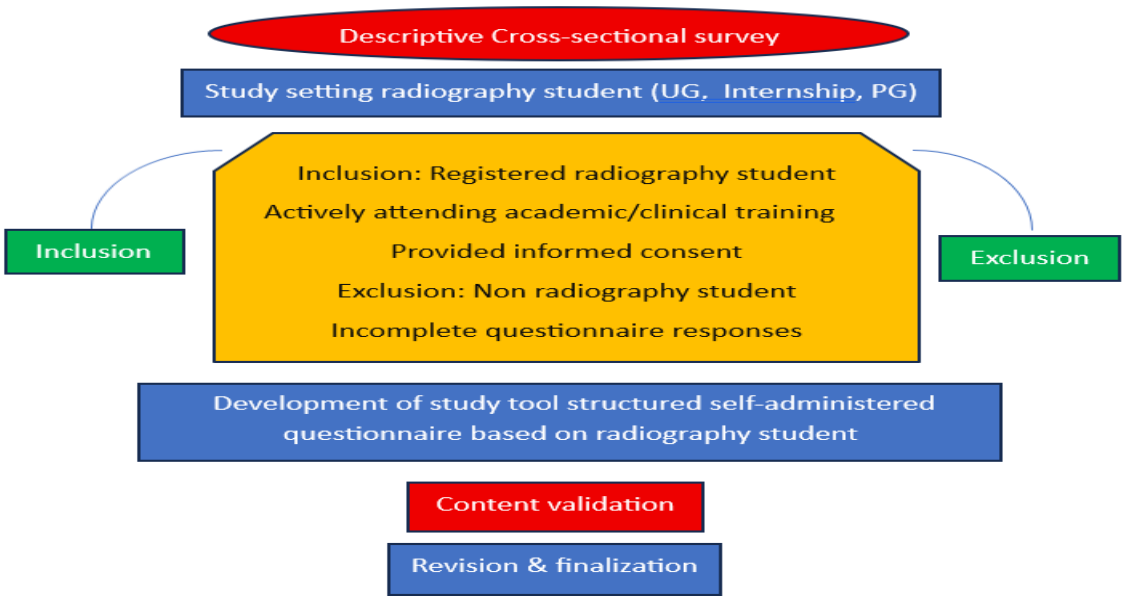

Figure 1 Flow Chart of Methodology of This Study

Study Setting and Participants

The study was carried out among radiography students enrolled in undergraduate, internship, and postgraduate programs at a university-based radiology education setting. Students from second year, third year, internship, and postgraduate levels were included to allow comparison across different stages of academic and clinical exposure. Participants of both genders who were actively attending academic or clinical training during the data collection period were eligible. Students unwilling to provide informed consent or with incomplete responses were excluded from the final analysis.

Study Instrument

Data were collected using a **structured, self-administered questionnaire** developed specifically for this study based on standard radiographic textbooks, clinical guidelines, and learning outcomes related to chest PA radiography. The questionnaire consisted of four sections: Demographic details (age, gender, academic year), figures 2,3,4.

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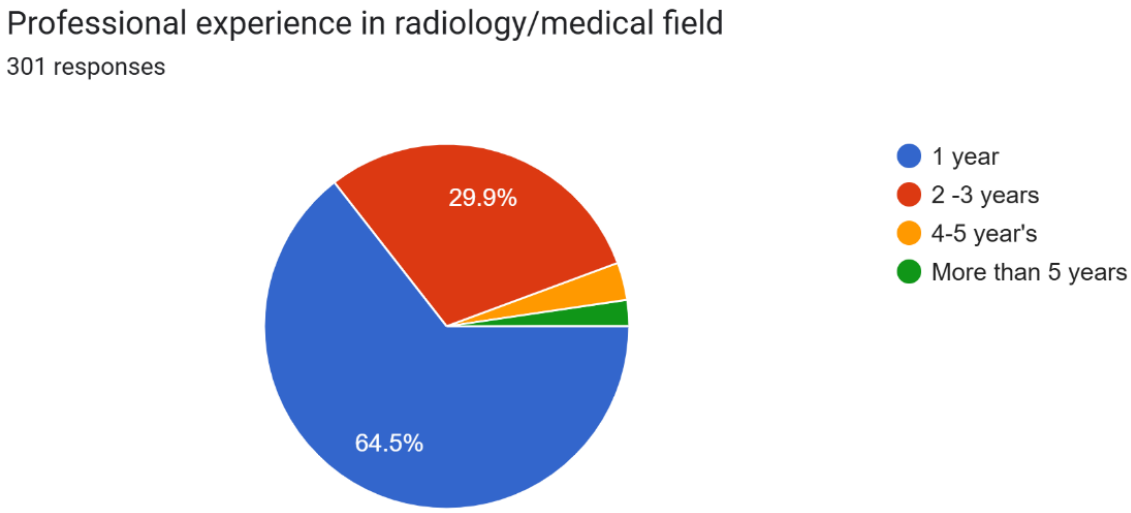

Figure 2 Professional experience of radiology/medical respondents (n = 301).

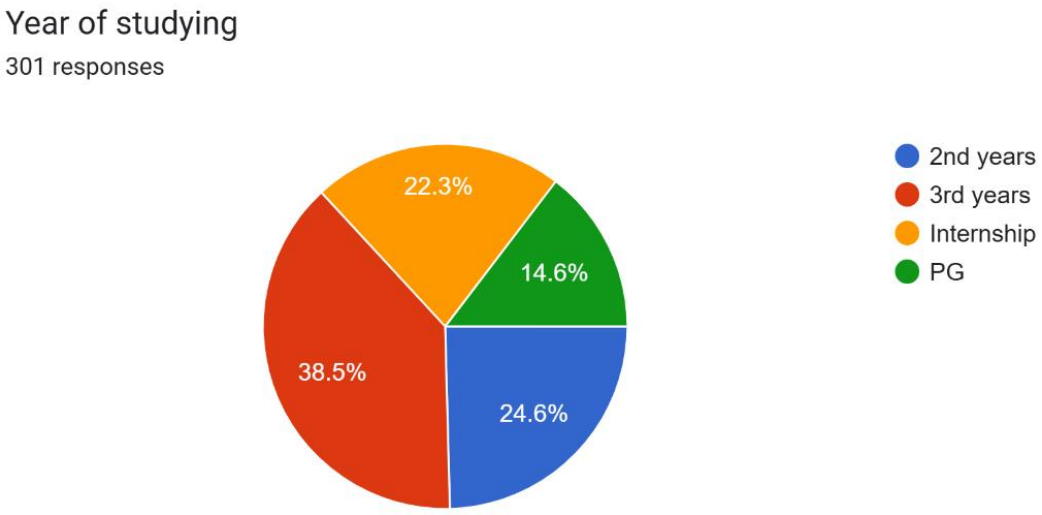

Figure 3 Distribution of respondents by year of study (n = 301).

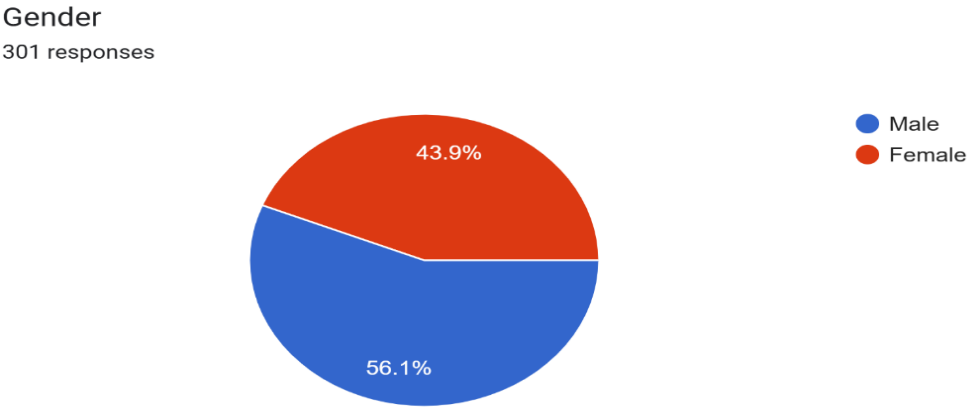

Figure 4 Gender distribution of respondents (n = 301).

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Knowledge domain focusing on patient positioning, beam centering, exposure parameters, and respiratory phase, Awareness domain assessing recognition of common radiographic errors and image-quality indicators, and Professional Competency domain evaluating professional behavior related to patient care, radiation protection, communication, ethics, and self-learning. Knowledge and awareness items were framed as multiple-choice questions, while attitude items were assessed using a five-point Likert scale ranging from strongly disagree to strongly agree.

Validation of the Questionnaire and professional attitude of radiography students regarding the standard chest posteroanterior (PA) radiographic projection. The methodology was designed in alignment in Figure 5 with the stated aim and objectives of the study and followed a systematic and scientific approach to ensure validity, reliability, and reproducibility of findings. The questionnaire was subjected to content validation by three experienced professors in Radiology and Imaging Technology, each having extensive academic and clinical experience. The experts evaluated the questionnaire for relevance, clarity, accuracy, and alignment with the study objectives. Based on their feedback, minor modifications were made to improve wording, eliminate ambiguity, and enhance content coverage. This validation process ensured adequate content showing in figure 6 validity and academic rigor of the survey instrument.

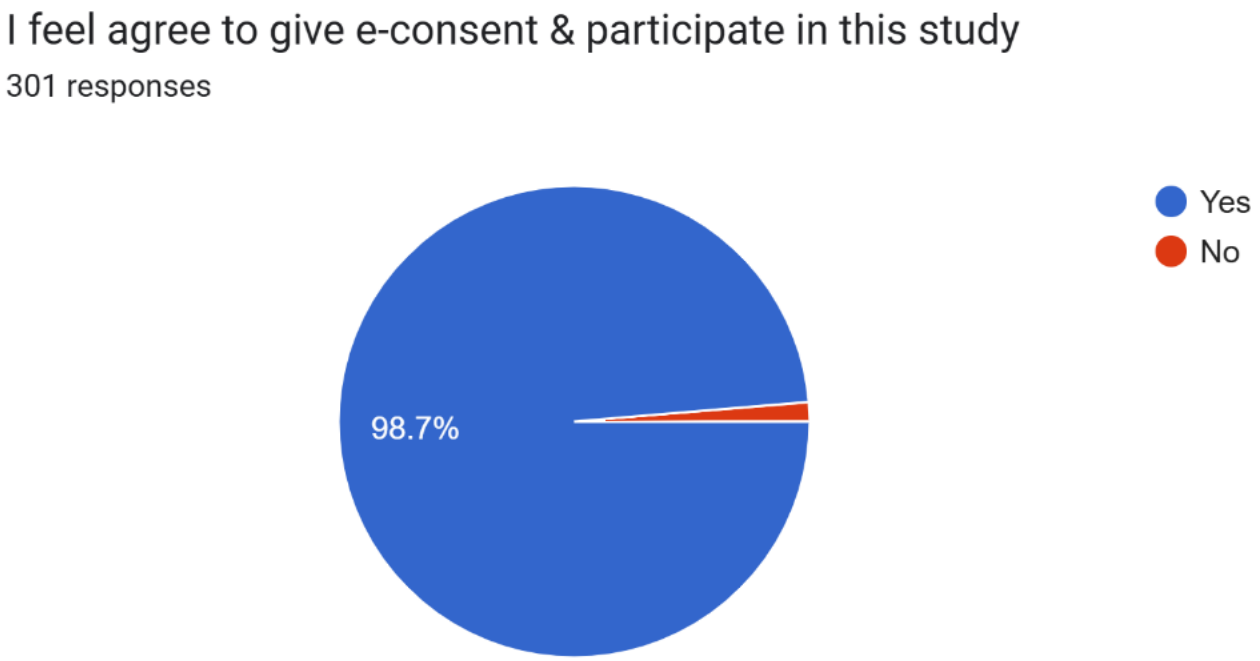

Figure 6 Consent of participants.

Data Collection Procedure

After obtaining institutional permission and informed consent from participants, the questionnaire was distributed either in printed form or electronically. Participants were instructed to respond independently without external assistance to minimize response bias. Confidentiality and anonymity were strictly maintained throughout the study.

Result and Analysis

Collected data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics (Version 25)(Divisi et al., 2017; Rahman & Muktadir, 2021). Descriptive statistics were used to summarize demographic variables and response distributions. Inferential statistics, including independent samples t-test and one-way ANOVA with post-hoc analysis, were applied to examine differences based on gender and academic year. A p-value of <0.05 was considered statistically significant.

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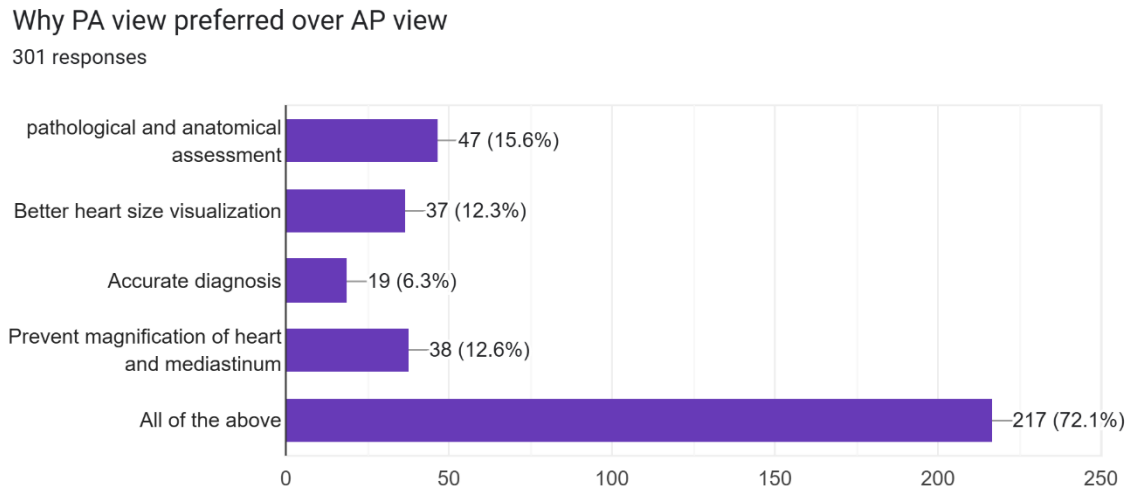

Figure 7 Distribution of responses explaining why the PA chest view is preferred over the AP view among radiography students (n = 301), with the majority selecting "all of the above."

Understanding the interplay between knowledge, awareness, and attitude among radiography students is essential because these domains collectively influence clinical performance, patient interaction, and adherence to safety protocols. Awareness of error recognition and image quality assessment complements theoretical learning, while a positive professional attitude facilitates ethical practice, patient comfort, effective communication, and ongoing self-directed learning—attributes that are critical in modern radiography. Accordingly, this study was designed to systematically evaluate the knowledge base, error awareness, and attitudinal disposition of radiography students toward chest PA radiography to identify educational strengths and areas for curricular enhancement.

The analysis of knowledge related to standard chest PA radiography in figure 2 demonstrates a generally high and consistent level of understanding among students, with only selective areas showing statistically meaningful variation showing in **Table 1**. Descriptive statistics revealed that both male and female students correctly identified the **standing upright position facing the detector** as the standard patient position, with nearly identical mean scores, indicating uniform foundational knowledge irrespective of gender. Inferential testing supported this observation, as no significant gender-based difference was found for patient positioning. However, when knowledge was compared across academic years, ANOVA revealed a significant difference, suggesting a progressive improvement with advancing clinical exposure. Post-hoc analysis confirmed that third-year students and interns demonstrated significantly better understanding than second-year students, highlighting the positive impact of clinical training on conceptual clarity.

With respect to **central ray (CR) centering**, a statistically significant gender-based difference was observed, indicating variation in accuracy between male and female students. Additionally, academic progression played a notable role; postgraduate students showed the strongest knowledge of correct CR placement at the midline level of T7, significantly outperforming second-year students. This finding reflects the cumulative benefit of advanced coursework and repeated clinical practice. In contrast, knowledge regarding the **appropriate respiratory phase** for chest PA radiography (full inspiration) was consistently high across genders and academic years, with no significant differences observed. This uniformity suggests that respiratory instruction is well emphasized early in training and effectively retained.

Regarding **technical exposure parameters**, understanding of the recommended adult chest PA kVp range showed significant variation across academic years, though gender differences were marginal and did not reach statistical significance. Interns demonstrated significantly better knowledge than second-year students, indicating improved comprehension through hands-on exposure and real-world application. Knowledge of the preferred **mA–time combination** (high mA with short exposure time) was found to be uniform across genders and academic levels, with no statistically significant differences, suggesting consistent teaching and reinforcement of motion-reduction principles throughout the curriculum. Overall, the findings indicate that while core radiographic principles are well understood across the cohort, advanced academic level and clinical

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experience significantly enhance precision in technical and positioning-related knowledge, underscoring the importance of structured clinical progression in radiography education.

Table 2 Statistical Analysis of Knowledge Related to Standard Chest PA Radiography

Knowledge Domain	**Descriptive Statistics (Mean ± SD)**	**Gender Difference (t-test)**	**Academic Year Difference (ANOVA)**	**Post-hoc Interpretation**
Patient Position in Chest PA Projection	Male: 1.96 ± 0.39 Female: 1.95 ± 0.23	t = 0.47, p = 0.641 (Not significant)	F = 3.43, p = 0.018 (Significant)	Knowledge significantly improves from 2nd year to 3rd year and internship, indicating progressive learning with clinical exposure
Central Ray (CR) Direction	Male: 1.80 ± 0.52 Female: 1.93 ± 0.47	t = –2.29, p = 0.023 (Significant)	F = 4.56, p = 0.004 (Significant)	PG students demonstrate superior knowledge compared to 2nd-year students, reflecting advanced technical understanding
Respiratory Phase for PA Chest	Male: 1.25 ± 0.63 Female: 1.10 ± 0.37	t = 2.52, p = 0.012 (Significant)	F = 1.07, p = 0.361 (Not significant)	Knowledge regarding full inspiration is uniform across academic years, indicating early and effective concept acquisition
Recommended kVp for Adult Chest PA	Male: 1.89 ± 0.85 Female: 2.31 ± 2.67	t = –1.93, p = 0.055 (Borderline)	F = 3.16, p = 0.025 (Significant)	Interns show significantly better understanding than 2nd-year students, highlighting learning through practical exposure
Preferred mA–Time Combination	Male: 2.12 ± 0.89 Female: 2.00 ± 0.77	t = 1.27, p = 0.205 (Not significant)	F = 0.99, p = 0.395 (Not significant)	Knowledge is consistent across genders and academic levels, suggesting uniform teaching of exposure optimization principles

The awareness analysis related to error recognition and image-quality assessment in chest PA radiography demonstrates an overall sound understanding among students, with selective differences influenced primarily by academic progression rather than gender showing in Table 3. Awareness regarding the non-visualization of lung apices showed no significant gender-based difference, indicating comparable recognition of centering and collimation errors among male and female students. However, a significant difference emerged across academic years, with interns demonstrating superior ability to correctly identify the underlying technical error compared with second- and third-year students. This finding highlights the role of cumulative clinical exposure in strengthening practical awareness of positioning and beam-limitation issues.

In contrast, recognition of motion-related blurring of the heart borders and diaphragm revealed a modest but statistically significant gender-based difference, suggesting variability in perceptual interpretation of motion artifacts. Despite this, awareness of motion blur was consistent across academic years, indicating that this concept is well established early in training and remains stable throughout progression. Evaluation of quality criteria for an optimal PA chest radiograph showed a trend toward higher awareness among female students, though this difference did not reach statistical significance. Academic-year analysis revealed a significant improvement, with postgraduate students demonstrating a more comprehensive understanding of image-quality parameters compared with undergraduate cohorts, reflecting advanced conceptual integration at higher levels of training.

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Similarly, awareness of **blurred lung fields with double-outlined ribs**, a classic indicator of patient motion, showed no significant differences across academic years, suggesting uniform learning outcomes in recognizing motion artifacts. A near-significant gender trend was observed, but overall awareness remained consistent between groups. Collectively, these findings indicate that while foundational awareness of common radiographic errors is well established across students, higher academic level and clinical experience play a critical role in refining diagnostic awareness and interpretative accuracy, particularly for complex positioning and image-quality assessment scenarios.

Table 4 Consolidated Statistical Analysis of Awareness Related to Chest PA Radiograph Errors and Image Quality

Awareness Domain	**Descriptive Statistics (Mean ± SD)**	**Gender Difference (Independent t-test)**	**Academic Year Difference (ANOVA)**	**Post-hoc Interpretation (Tukey HSD)**
Apices of lungs not visible (Error identification)	Male: 1.91 ± 1.02 Female: 1.84 ± 1.01	t = 0.605, p = 0.545 (Not significant)	F = 4.11, p = 0.007 (Significant)	Interns identify improper centering/collimation significantly better than 2nd- and 3rd-year students, reflecting improved awareness with clinical exposure
Heart borders & diaphragm blurred (Motion blur error)	Male: 2.47 ± 1.10 Female: 2.24 ± 0.84	t = 2.041, p = 0.042 (Significant)	F = 0.56, p = 0.641 (Not significant)	Awareness of motion blur is consistent across academic years, though gender-based variation is observed
Criteria for good-quality PA chest radiograph	Male: 3.43 ± 1.06 Female: 3.63 ± 0.93	t = –1.712, p = 0.088 (Trending)	F = 3.41, p = 0.018 (Significant)	PG students demonstrate stronger awareness of comprehensive image-quality criteria compared to 3rd-year students
Lung fields blurred, ribs double outlined (Patient motion)	Male: 2.32 ± 0.84 Female: 2.16 ± 0.59	t = 1.870, p = 0.062 (Near significant)	F = 0.69, p = 0.557 (Not significant)	Recognition of motion-related artifacts is uniform across academic years, indicating consistent teaching outcomes

The analysis of **professional attitude toward chest PA radiography practice** reveals a consistently positive and mature outlook among students, irrespective of gender or academic year showing in **Table 5**. Descriptive findings indicate that both male and female students reported high levels of agreement regarding **ensuring patient comfort and dignity**, reflecting a strong patient-centered approach embedded within radiography training. Statistical testing confirmed that this attitude did not differ significantly between genders or across academic years, suggesting that ethical sensitivity toward patient care is uniformly cultivated from early stages of education.

Similarly, adherence to **radiation protection principles**, including shielding and the ALARA concept, demonstrated uniformly high scores across all groups. Neither gender-based comparison nor academic year analysis showed significant differences, indicating that radiation safety awareness and responsible practice are well established and consistently reinforced throughout the curriculum. This uniformity underscores the effectiveness of structured teaching and practical reinforcement of radiation protection standards in radiography education.

Attitudes related to **clear communication with patients before and during chest PA examinations** were also strongly positive among all students. Although minor numerical differences were observed, statistical analysis

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confirmed no significant variation by gender or academic level. This finding suggests that communication skills, a critical component of professional radiographic practice, are similarly valued and practiced across the cohort. A comparable pattern was observed for **ethical responsibility during radiographic procedures**, where students across all groups demonstrated a shared commitment to professional conduct, confidentiality, and ethical decision-making.

Furthermore, the belief that **continuous self-learning and feedback are essential for improving radiographic practice** was strongly endorsed by all participants. The absence of significant differences across gender and academic years highlights a collective recognition of lifelong learning as a core professional value. Overall, the attitude domain findings indicate a high degree of professional maturity among radiography students, with consistent emphasis on patient care, safety, ethics, communication, and self-improvement. These results suggest that professional attitudes are effectively ingrained early in training and remain stable throughout academic and clinical progression.

Table 6 Consolidated Statistical Analysis of Professional Attitude Toward Chest PA Radiography

Attitude Item	Descriptive Statistics (Mean ± SD)	Gender Difference (Independent t-test)	Academic Year Difference (ANOVA)	Overall Interpretation
Ensuring patient comfort and dignity	Male: 3.66 ± 0.77 Female: 3.60 ± 0.88	t = 0.703, p = 0.482	F = 1.63, p = 0.182	Strong patient-centered attitude observed uniformly across gender and academic levels
Following radiation protection principles (ALARA, shielding)	Male: 4.55 ± 1.01 Female: 4.50 ± 1.13	t = 0.376, p = 0.707	F = 0.38, p = 0.767	High adherence to radiation safety practices, consistent across all groups
Clear communication with patients	Male: 4.54 ± 1.02 Female: 4.40 ± 1.23	t = 1.027, p = 0.305	F = 1.21, p = 0.307	Communication practices are well established and similar among students
Ethical responsibility in radiographic procedures	Male: 4.51 ± 1.02 Female: 4.42 ± 1.18	t = 0.698, p = 0.486	F = 0.43, p = 0.735	Ethical conduct is uniformly valued and practiced
Importance of continuous self-learning and feedback	Male: 4.57 ± 0.95 Female: 4.56 ± 1.06	t = 0.093, p = 0.926	F = 0.28, p = 0.840	Strong and consistent recognition of lifelong learning across all groups

A total of 301 participants completed the survey, providing a robust dataset for analysis. The study population comprised 169 males (56.1%) and 132 females (43.9%), indicating adequate gender representation. The majority of participants were radiology students (98.3%), with most enrolled at the undergraduate level (84.1%), followed by postgraduate students (14.6%) and diploma holders (4.0%). In terms of academic progression, participants were distributed across second year (24.6%), third year (38.5%), internship (22.3%), and postgraduate level (14.6%), allowing meaningful comparison across stages of training. Most students were affiliated with private colleges or hospitals (75.7%), reflecting the prevailing training environment.

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Analysis of knowledge related to standard chest PA radiography showed overall satisfactory understanding with selective statistically significant differences. Independent samples t-test demonstrated no significant gender difference in knowledge of patient positioning ($p = 0.641$). However, a significant gender-based difference was observed for central ray centering ($t = –2.29$, $p = 0.023$) and respiratory phase selection ($t = 2.52$, $p = 0.012$). One-way ANOVA revealed significant differences across academic years for patient positioning ($F = 3.43$, $p = 0.018$), CR centering ($F = 4.56$, $p = 0.004$), and recommended kVp range ($F = 3.16$, $p = 0.025$). Tukey post-hoc analysis showed that third-year students, interns, and postgraduates performed significantly better than second-year students, indicating progressive improvement with clinical exposure. No significant differences were observed for knowledge of the preferred mA–time combination.

Awareness of radiographic error recognition was generally consistent. Gender-based comparison showed a significant difference only for recognition of motion blur affecting heart borders and diaphragm ($t = 2.04$, $p = 0.042$). ANOVA demonstrated significant variation across academic years for identifying causes of non-visualization of lung apices ($F = 4.11$, $p = 0.007$) and overall image-quality criteria ($F = 3.41$, $p = 0.018$), with interns and postgraduate students showing superior awareness. Other awareness parameters did not show significant differences.

Professional competency scores were uniformly high. Neither gender-wise t-tests nor academic-year ANOVA showed statistically significant differences for patient care, radiation protection, communication, ethics, or self-learning ($p > 0.05$), indicating a consistently positive professional attitude across all groups.

DISCUSSION

The present study systematically evaluated the knowledge, awareness, and professional competency (KAP) of radiography students toward standard chest posteroanterior (PA) radiography and provides important insights into how academic progression and clinical exposure influence radiographic competence. The findings are discussed in relation to the study aims and objectives and are compared point-by-point with previously published literature from the last three years.

This study demonstrated that students possessed adequate foundational knowledge of chest PA radiography, particularly regarding patient positioning and respiratory instructions. The absence of a significant gender difference in patient positioning aligns with findings by (Rawle et al., 2023a), who reported that standardized curricula ensure early uniformity in core positioning knowledge among radiography students. However, the observed significant improvement with advancing academic year, especially among interns and postgraduate students, corroborates results reported by(Ashokkumar et al., 2025; Radović et al., 2023), who emphasized the critical role of hands-on clinical exposure in consolidating theoretical knowledge. The significantly better performance of postgraduate students in central ray centering reflects advanced technical refinement, similar to observations by (Hyde & Hardy, 2021), who noted that beam alignment accuracy improves with repeated supervised practice. In contrast, knowledge related to the respiratory phase showed consistency across academic years, suggesting that this concept is effectively taught early and retained, a trend also reported by (Fyles et al., 2023) in a multicenter Indian study on chest radiography competencies.

Variation in knowledge regarding recommended kVp range with academic progression mirrors findings by(Mohammed Ali et al., 2019; Zayet et al., 2014), who highlighted that exposure parameter optimization is better understood during internship when students actively adjust technical factors under clinical supervision. Uniform knowledge of mA–time combinations across all groups supports earlier reports by (Zheng, 2018)that motion-reduction principles are consistently emphasized throughout radiography training.

Awareness findings indicate that students were generally capable of identifying common radiographic errors, although academic level played a greater role than gender. Interns demonstrated superior awareness in identifying errors related to non-visualization of lung apices, consistent with (Kumar et al., 2022)who reported that real-time exposure to rejected images enhances perceptual learning. The significant improvement in recognizing image-quality criteria among postgraduate students parallels findings by(Lundvall et al., 2021),

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who emphasized that advanced learners develop a holistic approach to image evaluation beyond single technical faults.

The modest gender difference observed in recognizing motion blur affecting heart borders may reflect differences in perceptual interpretation rather than knowledge gaps. Similar subtle variations were reported by(Parker et al., 2023), though the authors concluded that such differences do not translate into clinical incompetence. The lack of significant variation across academic years for recognizing patient motion artifacts suggests that this awareness is consistently reinforced early, supporting findings by(Vayani et al., 2025).

One of the most important findings of this study is the uniformly positive professional attitude observed across all participants(Anand et al., 2025). High agreement scores for patient comfort and dignity, radiation protection (ALARA), communication, ethical responsibility, and self-learning were consistent regardless of gender or academic year. These results strongly align with reports by (Al Balushi et al., 2024a; Strudwick, 2021)who found that attitudes toward radiation safety and ethics are deeply embedded in modern radiography education.

The absence of academic-year differences in professional attitude supports the observations of (Hale & Wright, 2021; Mazaheri & Tahmasbi, 2024)who emphasized that professional values are introduced early and reinforced continuously rather than acquired progressively. This consistency is encouraging, as it suggests that radiography programs are successful in fostering ethical and patient-centered mindsets from the outset.

Taken together, the findings suggest that while professional attitude is stable and strong, knowledge and awareness continue to mature with clinical exposure. This supports the competency-based education model advocated by (Al Balushi et al., 2024b; Rawle et al., 2023b; Umpar & Sison, 2025)which emphasizes early theoretical grounding followed by structured clinical reinforcement. The observed gaps among junior students in technical precision and error recognition indicate a need for enhanced simulation-based training, image critique sessions, and early exposure to rejected image analysis.

In comparison with existing literature, this study confirms global trends while contributing region-specific evidence from an Indian academic setting. The results affirm that academic progression and internship training are pivotal in refining technical knowledge and perceptual awareness, whereas professional attitudes remain consistently positive across all levels. These findings underscore the importance of integrating structured clinical mentorship and reflective learning strategies to bridge the gap between theory and practice. This study has several notable strengths that enhance the credibility and applicability of its findings. First, the inclusion of a relatively large sample size (n = 301) with representation across different academic levels second year, third year, internship, and postgraduate allowed for meaningful comparison of knowledge, awareness, and attitude across stages of professional development. Second, the study adopted a comprehensive KAA (Knowledge–Awareness–Attitude) framework, enabling a holistic evaluation of radiography students that goes beyond technical knowledge alone and incorporates perceptual skills and professional behavior. Third, the questionnaire was content-validated by three experienced professors in Radiology and Imaging Technology, ensuring strong content validity, relevance, and alignment with academic and clinical learning outcomes. Additionally, the use of standardized statistical methods (independent t-test, one-way ANOVA, and Tukey post-hoc analysis) strengthened the rigor of data interpretation. Finally, the focus on chest PA radiography, a universally performed and clinically critical examination, enhances the practical relevance of the findings for radiography education and clinical practice.

Despite these strengths, certain limitations should be acknowledged. The cross-sectional design restricts the ability to establish causal relationships or track individual improvement over time; longitudinal studies would better capture knowledge and skill progression. The study relied on a self-administered questionnaire, which may introduce response bias, as participants could overestimate their attitudes or awareness. Clinical performance was not directly observed; therefore, the findings reflect perceived knowledge and awareness rather than actual hands-on competency. Additionally, the study was conducted within a single regional academic context, which may limit generalizability to other institutions or countries with different curricula and training structures. Lastly, although content validity was ensured, psychometric measures such as test–retest reliability or internal consistency were not formally assessed.

CONCLUSION

This cross-sectional study demonstrates that radiography students possess adequate foundational knowledge of standard chest posteroanterior (PA) radiography and exhibit consistently strong professional competency related to patient-centered care, radiation protection (ALARA), communication, ethics, and self-directed learning. While professional attitudes were uniformly positive across gender and academic levels, technical knowledge and perceptual awareness of image-quality criteria and error recognition improved significantly with academic progression and clinical exposure, with interns and postgraduate students showing higher competency in key areas such as central ray centering, kVp selection, and comprehensive image evaluation. These findings highlight that clinical mentorship and structured competency-based reinforcement are essential to bridge early-stage gaps in technical precision and perceptual image assessment, thereby improving diagnostic image quality, reducing repeat exposures, and strengthening patient safety in routine chest radiography practice.

Authors' Contributions

AS and DK conceptualized and designed the study. **AS** collected the data. **AS and DK** performed data analysis and interpretation. **AS** drafted the manuscript. **DK** critically revised the manuscript and supervised the study. **KS** assisted with data collection, manuscript review, and editing. **All authors** read and approved the final manuscript and accept responsibility for its content.

Ethical Consideration: Study is ethically approved by the institution **HEC Reference No 2025-Dec-002.**

Conflict of Interest: The authors declare that there is no conflict of interest related to this study.

Declaration of Generative AI Use:

The authors declare that no generative artificial intelligence (AI) or AI-assisted tools were used in the preparation, writing, analysis, or editing of this manuscript.

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