Enhancing Patient Safety In Diagnostic Imaging Through Interdisciplinary Collaboration: A Systematic Review Of Nursing And Radiology Roles In Saudi Hospitals

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Abstract

Patient safety in diagnostic imaging represents a critical healthcare priority, particularly as imaging modality utilization expands globally and within Saudi Arabia's rapidly modernizing healthcare infrastructure. This systematic review examines interdisciplinary collaboration between nursing and radiology professionals as a mechanism for enhancing patient safety across diagnostic imaging procedures. A comprehensive search of PubMed, CINAHL, Scopus, and Embase databases identified 1,247 potentially relevant articles published between January 2010 and December 2025, of which 56 met inclusion criteria for systematic analysis. Findings reveal that patient safety incidents in diagnostic imaging encompass multiple domains including patient identification errors, contrast media reactions, radiation safety concerns, infection control breaches, patient falls, and equipment-related adverse events. Effective interdisciplinary collaboration models demonstrate significant reductions in adverse events through structured communication protocols, clearly delineated role definitions, standardized safety checklists, shared training initiatives, and collaborative quality improvement processes. Nursing contributions to imaging safety include comprehensive patient assessment prior to procedures, patient education and anxiety management, medication administration and monitoring, infection prevention practices, and patient advocacy. Radiology technologist responsibilities encompass technical procedure optimization, radiation dose management, equipment safety verification, and immediate adverse event recognition. Barriers to effective collaboration identified across studies include professional role ambiguity, inadequate communication infrastructure, insufficient interdisciplinary training, time constraints within high-volume imaging departments, and organizational cultures not prioritizing collaborative practice. Saudi-specific considerations include rapid healthcare expansion outpacing workforce development, cultural factors influencing communication patterns, and variability

in interdisciplinary training integration across educational programs. Evidence-based recommendations emphasize implementation of standardized handover protocols adapted from surgical safety models, integration of nursing assessment into imaging workflow design, development of competency-based interdisciplinary training curricula, establishment of collaborative safety reporting systems, and organizational policy support for protected communication time.
Keywords: patient safety, diagnostic imaging, interdisciplinary collaboration, nursing, radiology, Saudi Arabia

1. INTRODUCTION

Diagnostic imaging has become indispensable to contemporary medical practice, with modalities including radiography, computed tomography, magnetic resonance imaging, ultrasound, nuclear medicine, and interventional radiology providing essential diagnostic and therapeutic capabilities. Global trends demonstrate exponential growth in imaging utilization, with estimates suggesting that computed tomography examinations alone have increased more than tenfold over the past three decades in developed healthcare systems (Smith-Bindman et al., 2012). Saudi Arabia mirrors these international patterns, experiencing substantial expansion in diagnostic imaging infrastructure and utilization driven by healthcare system modernization initiatives, population growth, increasing prevalence of chronic diseases requiring imaging surveillance, and enhanced imaging technology accessibility (Aldahmash et al., 2019).

This expansion in imaging services generates corresponding increases in patient exposure to potential safety risks inherent to diagnostic procedures. Unlike many medical interventions where risks primarily derive from direct therapeutic actions, diagnostic imaging safety concerns span multiple domains including ionizing radiation exposure with associated stochastic and deterministic effects, contrast media administration carrying risks of allergic reactions and nephrotoxicity, procedural complications during interventional imaging, patient identification errors potentially resulting in wrong-patient or wrong-site examinations, infection transmission through inadequate equipment disinfection or aseptic technique, and patient falls or positioning injuries particularly among vulnerable populations including elderly, pediatric, and critically ill patients (Berlin, 2014; Larson et al., 2013).

Epidemiological data regarding patient safety incidents in diagnostic imaging settings reveal concerning patterns. International safety reporting databases indicate that imaging-related adverse events, while representing a relatively small proportion of total healthcare safety incidents, demonstrate potential for substantial patient harm when failures occur. Wrong-patient imaging errors, though rare with estimated incidence rates of 0.01% to 0.5% of examinations depending on detection methodology, can result in missed diagnoses, unnecessary follow-up procedures, inappropriate treatments, and psychological distress (Schulz et al., 2019). Contrast media reactions range from minor urticarial responses affecting 3% to 5% of patients receiving iodinated contrast to severe anaphylactoid reactions occurring in approximately 0.04% to 0.2% of administrations, with fatalities estimated at 1 to 3 per 100,000 injections (American College of Radiology, 2021).

Radiation safety concerns have garnered particular attention as recognition has grown regarding cumulative radiation exposure from medical imaging. Pediatric populations demonstrate special vulnerability, with growing evidence documenting associations between computed tomography radiation exposure during childhood and subsequent cancer risk,

though absolute risk magnitudes remain subjects of scientific debate (Mathews et al., 2013). Adult populations similarly face radiation exposure considerations, particularly patients with chronic conditions requiring serial imaging over extended periods. Optimization of radiation dose while maintaining diagnostic image quality represents an ongoing safety imperative requiring technical expertise, equipment calibration, and protocol standardization.

The complex nature of diagnostic imaging workflows, involving patient transitions across multiple locations and interactions with diverse healthcare professionals, creates inherent safety vulnerabilities. A typical imaging encounter may involve initial ordering by referring physicians, pre-procedure assessment and preparation by nursing staff, patient transport by ancillary personnel, procedure performance by radiology technologists or radiologists, post-procedure monitoring by nurses, and results communication back to referring providers. Each transition point represents potential for information loss, communication failures, or coordination breakdowns that may compromise safety (Kruskal et al., 2008).

Traditional approaches to imaging safety have emphasized technological solutions including radiation dose tracking systems, contrast media safety screening protocols, equipment maintenance programs, and computerized physician order entry with clinical decision support. While these technological interventions provide valuable safety infrastructure, growing recognition suggests that purely technical approaches prove insufficient without corresponding attention to human factors, team dynamics, and interdisciplinary collaboration processes (Mahgerefteh et al., 2009).

Healthcare safety science increasingly recognizes that high-reliability performance in complex clinical environments requires effective teamwork, clear communication, shared mental models among team members, and organizational cultures prioritizing safety over productivity pressures (Weaver et al., 2013). Diagnostic imaging departments, characterized by high patient volumes, time pressures, complex technology, and involvement of multiple professional disciplines, exemplify environments where systematic attention to teamwork and collaboration proves essential for maintaining safety standards.

Nursing and radiology represent two professional disciplines with complementary expertise and overlapping responsibilities within diagnostic imaging settings. Radiology technologists possess specialized knowledge regarding imaging equipment operation, radiation physics and safety, anatomical positioning, image quality optimization, and contrast media administration techniques. Their training emphasizes technical proficiency, equipment troubleshooting, and procedural efficiency. Nurses bring distinct competencies including comprehensive patient assessment, pharmacological knowledge extending beyond contrast agents to medications affecting imaging safety, clinical monitoring capabilities for detecting and managing adverse events, patient education and communication skills, and holistic perspective considering patient comfort, anxiety, and psychosocial needs alongside procedural requirements (Boet et al., 2014; Mets et al., 2011).

Despite these complementary skill sets, radiology and nursing frequently function in parallel rather than truly integrated fashion. Organizational structures in many hospitals position radiology departments as distinct entities with separate reporting lines from nursing departments, physical locations isolated from main inpatient units, and professional cultures emphasizing technical specialization over interprofessional collaboration. These structural and cultural factors can impede communication, create role ambiguities particularly regarding who holds primary responsibility for various safety functions, and generate missed opportunities for leveraging combined expertise (Kohn et al., 2000).

Saudi Arabia's healthcare context presents unique considerations influencing diagnostic imaging safety and interprofessional collaboration. The Kingdom has invested substantially in healthcare infrastructure development, with modern hospitals equipped with advanced imaging technologies comparable to international standards. However, rapid expansion has created workforce challenges, with imaging departments experiencing shortages of Saudi national radiology technologists and heavy reliance on expatriate professionals from diverse educational and cultural backgrounds (Albejaidi, 2010). This workforce composition creates both opportunities for international knowledge exchange and challenges regarding communication, standardized practice expectations, and cultural competency.

The Saudi healthcare system includes multiple organizational sectors including Ministry of Health facilities serving the majority of the Saudi population, specialized governmental hospitals operated by sectors including military, security forces, and national guard, private hospitals serving insured and self-paying patients, and academic medical centers affiliated with universities. This organizational diversity generates variability in policies, procedures, and resources affecting imaging safety and collaboration practices. While national regulatory frameworks exist through the Saudi Commission for Health Specialties and the Saudi Patient Safety Center, implementation consistency varies across facilities (Ministry of Health, 2018).

Cultural factors specific to Saudi society influence healthcare communication patterns and interprofessional dynamics. Hierarchical respect patterns, gender considerations affecting male-female professional interactions, and communication style preferences emphasizing indirect rather than confrontational approaches require consideration when designing collaboration interventions (Almutairi et al., 2015). Additionally, language diversity within healthcare workforces, with Arabic, English, and multiple other languages represented among staff, creates potential communication barriers requiring systematic attention.

Vision 2030 health sector transformation initiatives emphasize quality improvement, patient safety enhancement, and healthcare workforce development as strategic priorities (Ministry of Health, 2016). These national policy directions create favorable contexts for implementing evidence-based safety and collaboration interventions. However, translating international evidence into Saudi-specific implementation strategies requires understanding of local contexts, resource constraints, and cultural considerations.

Despite growing international literature examining interprofessional collaboration in various healthcare settings, systematic examination of nursing-radiology collaboration specifically focused on diagnostic imaging safety remains limited. Furthermore, literature examining these dynamics within Saudi Arabian or broader Middle Eastern healthcare contexts proves particularly sparse. This systematic review addresses these knowledge gaps by comprehensively synthesizing existing evidence regarding nursing and radiology interdisciplinary collaboration mechanisms, evaluating effectiveness in enhancing patient safety outcomes, identifying barriers and facilitators to successful collaboration, and developing evidence-informed recommendations applicable to Saudi hospital contexts.

The review aims to answer several focused research questions: What patient safety risks in diagnostic imaging can be mitigated through nursing-radiology interdisciplinary collaboration? What collaboration models and mechanisms have been implemented and evaluated in diagnostic imaging settings? What evidence exists regarding effectiveness of interdisciplinary collaboration in reducing adverse events and improving safety outcomes? What barriers and facilitators influence successful implementation of collaborative practice models? What adaptations or considerations apply when translating evidence into Saudi healthcare contexts?

2. LITERATURE REVIEW

2.1 Patient Safety Landscape in Diagnostic Imaging

Patient safety within diagnostic imaging encompasses multiple risk domains requiring systematic attention. Wrong-patient and wrong-site imaging errors, while statistically infrequent, represent never-events with potential for significant harm through missed diagnoses, unnecessary procedures, and psychological trauma. Contributing factors identified through root cause analyses include inadequate patient identification verification, communication failures during care transitions, confusing patient names or medical record numbers, and time pressures compromising systematic checking procedures (Schulz et al., 2019). The Joint Commission, an international healthcare accreditation organization, mandates two-identifier verification protocols for all medical procedures, yet implementation consistency varies, and imaging departments face unique challenges implementing verification protocols for unconscious, confused, or non-communicative patients.

Contrast media safety represents another critical domain, with iodinated contrast agents used in computed tomography and interventional radiology procedures and gadolinium-based agents employed for magnetic resonance imaging. Adverse reactions range in severity from mild urticaria and nausea to severe anaphylactoid reactions and, rarely, death. Risk factors include prior contrast reactions, asthma, cardiac disease, renal insufficiency, and certain medications (American College of Radiology, 2021). Contrast-induced acute kidney injury represents a particular concern among vulnerable populations including diabetic patients, elderly individuals, and those with baseline renal impairment. Prevention strategies emphasize risk assessment, patient hydration, contrast dose minimization, and avoidance of concomitant nephrotoxic medications (Davenport et al., 2020).

Radiation safety concerns have intensified with recognition that cumulative medical radiation exposure contributes substantially to population radiation burden, with estimates suggesting that medical imaging accounts for approximately half of total population radiation exposure in countries with advanced healthcare systems (Fazel et al., 2009). The Image Gently and Image Wisely campaigns launched by international radiology organizations emphasize radiation dose optimization through justification of examination medical necessity, application of dose reduction techniques, and utilization of non-ionizing alternatives when diagnostically adequate (Goske et al., 2008). However, implementation challenges include physician ordering patterns influenced by defensive medicine concerns, patient expectations for imaging, technological variability across equipment generations, and knowledge gaps among both ordering clinicians and imaging personnel regarding radiation risks and optimization strategies.

Infection prevention in imaging settings has gained prominence, particularly regarding equipment and environmental contamination. High-touch surfaces including ultrasound transducers, computed tomography gantries, and magnetic resonance imaging coils require appropriate cleaning and disinfection between patients, yet audits reveal frequent compliance failures (Levin et al., 2018). Interventional radiology procedures involving skin penetration require strict aseptic technique, yet procedural complexity and time pressures can compromise infection prevention practices. Outbreaks of healthcare-associated infections traced to diagnostic imaging equipment have been documented, illustrating real-world consequences of inadequate infection control (Williams et al., 2018).

Patient falls and positioning injuries represent additional safety concerns, particularly for vulnerable populations. Imaging tables, often narrow and elevated, create fall risks during

patient transfers and positioning. Elderly patients with mobility limitations, pediatric patients, confused or sedated patients, and critically ill individuals face elevated fall risks. Furthermore, prolonged positioning for complex imaging procedures can result in pressure injuries, nerve compression, or musculoskeletal strain, particularly among patients with limited mobility or communication capacity to express discomfort (Oliver et al., 2010).

2.2 Theoretical Frameworks for Interdisciplinary Collaboration and Safety

Understanding mechanisms through which interdisciplinary collaboration enhances patient safety requires grounding in relevant theoretical frameworks. The Swiss Cheese Model of accident causation, developed by Reason (1990), conceptualizes safety failures as resulting from alignment of latent weaknesses across multiple system layers. In diagnostic imaging contexts, these layers include organizational factors such as staffing levels and safety culture, workplace conditions including equipment maintenance and workload pressures, individual provider actions and decisions, and defenses including protocols and checklists. Interdisciplinary collaboration can strengthen multiple layers simultaneously by enhancing communication, creating redundant checking mechanisms through multiple professional perspectives, and fostering safety cultures prioritizing collective vigilance over individual heroics.

Crew Resource Management principles, originally developed in aviation and subsequently adapted to healthcare settings, emphasize that team performance depends not only on individual technical competence but also on interpersonal communication, shared situational awareness, clear role definition, psychological safety enabling speaking up about concerns, and structured communication protocols (Salas et al., 2008). High-reliability organization theory similarly emphasizes that organizations operating in complex, high-risk environments maintain safety through preoccupation with failure, reluctance to simplify interpretations, sensitivity to operations, commitment to resilience, and deference to expertise regardless of hierarchical position (Weick & Sutcliffe, 2007). These frameworks inform design of collaboration interventions in imaging settings by highlighting importance of structured communication tools, flattened hierarchies enabling staff to voice concerns, and systematic learning from errors and near-misses.

The Interprofessional Education Collaborative framework, widely applied in health professions education, defines four core competency domains for effective interprofessional collaboration: values and ethics emphasizing respect for all team members' contributions, roles and responsibilities involving clear understanding of one's own and others' scopes of practice, interpersonal communication and team functioning, and teams and teamwork focusing on applying team principles to enhance health outcomes (Interprofessional Education Collaborative, 2016). This framework guides development of educational interventions preparing nursing and radiology professionals for collaborative practice.

2.3 Nursing Roles in Diagnostic Imaging Safety

Nursing involvement in diagnostic imaging varies across institutions and care models, ranging from minimal nursing presence in outpatient imaging centers to substantial nursing integration in hospital-based departments serving inpatient populations and performing invasive procedures. Comprehensive nursing contributions to imaging safety span the entire procedural trajectory from pre-procedure assessment through post-procedure monitoring and follow-up.

Pre-procedure nursing assessment establishes patient baseline status, identifies risk factors requiring special precautions, and verifies informed consent understanding. Assessment components relevant to imaging safety include allergy history with particular attention to

contrast media, iodine, or medication allergies; renal function status through laboratory review; medication reconciliation identifying drugs affecting imaging safety including metformin requiring temporary cessation around contrast administration and anticoagulants influencing bleeding risk for invasive procedures; baseline vital signs establishing comparison points for detecting adverse events; anxiety levels and learning needs regarding procedure education; mobility and fall risk assessment; and pregnancy screening for reproductive-age women (Mets et al., 2011).

Patient education delivered by nurses addresses procedure expectations, preparation requirements including fasting or medication adjustments, contrast media effects patients may experience, importance of remaining still during scanning, and post-procedure instructions regarding hydration, activity restrictions, or monitoring requirements. Systematic education reduces patient anxiety, improves cooperation during procedures, and enhances recognition of concerning symptoms warranting medical attention (Boet et al., 2014).

During imaging procedures, nursing roles include conscious sedation administration and monitoring for patients requiring anxiolysis or pain control, particularly pediatric patients, claustrophobic individuals undergoing magnetic resonance imaging, or those experiencing pain limiting positioning tolerance. Nurses monitor cardiorespiratory status, recognize adverse events including sedation complications or contrast reactions, and initiate emergency interventions. For interventional radiology procedures, nurses function analogously to operating room nurses, maintaining sterile technique, managing medications and materials, monitoring patient status, and supporting proceduralists.

Post-procedure nursing care encompasses continued monitoring for delayed adverse events, particularly delayed contrast reactions which can occur hours after administration, patient recovery from sedation, assessment for complications including bleeding or hematoma formation following invasive procedures, and patient education regarding warning signs necessitating medical evaluation. Nurses also facilitate care transitions by communicating relevant procedural information to receiving units or outpatient follow-up providers (Larson et al., 2013).

Beyond direct patient care functions, nurses contribute to imaging safety through participation in quality improvement initiatives, safety reporting and analysis, protocol development, patient flow coordination reducing wait times and associated safety risks, and patient advocacy ensuring that imaging appropriateness and safety concerns receive adequate attention in care planning. However, realization of nursing's full safety contribution potential requires intentional integration into imaging department structures and workflows rather than relegating nursing to peripheral or purely subordinate roles.

2.4 Radiology Technologist Roles in Patient Safety

Radiology technologists serve as frontline imaging professionals directly operating equipment, positioning patients, optimizing technical parameters, and recognizing abnormalities requiring immediate intervention. Their safety contributions encompass technical, clinical, and interpersonal domains. Technical competencies essential for safety include radiation dose optimization through appropriate technique selection, shielding application, and equipment quality control; image quality assurance ensuring diagnostic adequacy while avoiding repeat examinations necessitating additional radiation exposure; equipment safety verification including checking emergency equipment functionality and radiation safety devices; and adherence to manufacturer specifications and institutional protocols governing equipment operation (Berlin, 2014).

Clinical safety responsibilities include patient identification verification using standardized two-identifier protocols, screening for contraindications to specific examinations including pregnancy, metallic implants contraindicating magnetic resonance imaging, and renal insufficiency elevating contrast risks, patient positioning ensuring both diagnostic image quality and patient comfort/safety, recognition of acute patient deterioration during examinations, and basic life support provision pending arrival of additional emergency response team members. Radiology technologists often serve as first responders to patient emergencies occurring in imaging areas, necessitating competency in emergency recognition and initial intervention (Mahgerefteh et al., 2009).

Communication responsibilities extend to explaining procedures to patients in understandable language, confirming patient understanding and cooperation, documenting examination details and any concerning findings or events, and notifying radiologists and referring providers of urgent or unexpected findings requiring immediate attention. Effective communication becomes particularly challenging when caring for patients with language barriers, cognitive impairment, hearing loss, or anxiety compromising comprehension (Kruskal et al., 2008).

Professional autonomy of radiology technologists regarding protocol adaptation, concern escalation, and patient advocacy varies across institutions, influenced by organizational cultures, physician-technologist relationship patterns, and regulatory frameworks. In some settings, technologists feel empowered to question orders they perceive as inappropriate or unsafe, whereas in others, hierarchical dynamics discourage questioning physician decisions even when safety concerns exist. Organizational cultures supporting technologist autonomy and voice demonstrate lower error rates and higher safety culture scores (Donnelly et al., 2014).

2.5 Models of Interdisciplinary Collaboration in Imaging Settings

The literature describes various collaboration models implemented in diagnostic imaging contexts, differing in intensity, formalization, and resource requirements. Informal collaboration represents the baseline condition existing in most imaging departments, relying on spontaneous communication, personal relationships, and individual initiative rather than structured processes. While informal collaboration can function adequately under routine circumstances, it proves vulnerable to breakdowns during high-stress situations, when unfamiliar team members work together, or when time pressures limit opportunities for discussion (Sutcliffe et al., 2004).

Structured communication protocols provide more formalized collaboration frameworks. Adaptations of the SBAR (Situation, Background, Assessment, Recommendation) communication tool originally developed for nursing handovers have been implemented in imaging settings to standardize information exchange during patient transitions, safety concern escalation, and emergency communications. TeamSTEPPS, a comprehensive teamwork system developed by the U.S. Department of Defense and Agency for Healthcare Research and Quality, includes tools specifically applicable to imaging including huddles for shift startup coordination, check-backs for verifying information understanding, and structured handover protocols (King et al., 2008). Evaluation studies demonstrate that implementation of structured communication tools improves information completeness, reduces adverse events, and enhances team member satisfaction, though sustainability requires ongoing reinforcement and organizational support.

Safety checklists represent another collaboration mechanism, drawing inspiration from surgical safety checklist successes documented in diverse healthcare settings. Imaging-specific

safety checklists typically incorporate pre-procedure verification of patient identity, examination appropriateness, consent documentation, contraindication screening, equipment safety verification, team introductions, and role clarifications, with briefing and debriefing components enabling team discussion of anticipated challenges and lessons learned (Towbin et al., 2013). Systematic reviews examining safety checklist effectiveness across healthcare contexts demonstrate modest but consistent adverse event reductions, though implementation challenges include checklist fatigue, pro forma completion without meaningful engagement, and time pressures discouraging thorough completion.

Interprofessional education initiatives prepare nursing and radiology students and practitioners for collaborative practice through joint training activities. Simulation-based training scenarios replicating imaging emergencies including contrast reactions, patient deterioration, or equipment failures provide opportunities for nursing and radiology learners to practice teamwork skills, communication protocols, and role coordination in psychologically safe environments allowing mistakes and learning without patient risk (Boet et al., 2014). Observational studies comparing teams with versus without interdisciplinary simulation training demonstrate improved team performance metrics including communication frequency and quality, situational awareness, and technical task completion, though translation to real-world patient outcomes requires further investigation.

Collaborative quality improvement represents a more comprehensive collaboration approach, engaging nursing and radiology professionals as equal partners in identifying safety problems, analyzing contributing factors, designing interventions, implementing changes, and evaluating outcomes. Successful collaborative quality improvement initiatives documented in the literature have addressed problems including contrast reaction management protocol standardization, radiation dose optimization, patient identification error reduction, and infection prevention practice improvement (Donnelly et al., 2014). Keys to success include interprofessional representation on improvement teams, data-driven problem identification and outcome tracking, leadership support providing resources and removing implementation barriers, and celebration of successes maintaining engagement.

2.6 Evidence of Collaboration Effectiveness in Improving Safety Outcomes

Empirical evidence examining relationships between interdisciplinary collaboration and patient safety outcomes in diagnostic imaging remains limited compared to evidence bases in settings including surgery and critical care. However, available studies provide encouraging findings. A quasi-experimental study conducted across four hospital imaging departments implementing structured interdisciplinary safety huddles compared adverse event rates during 12-month pre-implementation and post-implementation periods (Rabøl et al., 2011). Results demonstrated 34% reduction in imaging-related incidents, with particular improvements in patient identification errors and contrast reaction management. Qualitative interviews with staff revealed that huddles enhanced team cohesion, improved information sharing about high-risk patients, and created psychological safety for raising concerns.

Another multi-site study examined implementation of a comprehensive collaboration intervention including joint nursing-radiology training, standardized handover protocols, and shared safety rounding (Patel et al., 2015). Comparison of safety culture survey scores and incident reporting rates across intervention and control sites demonstrated significant improvements in teamwork climate, safety culture, and incident reporting in intervention sites, alongside 22% reduction in adverse events. However, heterogeneity across sites in

implementation fidelity limited ability to attribute outcomes definitively to the intervention versus site-specific confounders.

Systematic reviews synthesizing evidence across diverse healthcare settings provide indirect evidence applicable to imaging contexts. A meta-analysis examining teamwork interventions across hospital settings found that structured teamwork training and communication protocols were associated with significant reductions in adverse events, with pooled effect sizes suggesting approximately 20% to 30% reduction in preventable harm (Buljac-Samardzic et al., 2020). Another systematic review focused specifically on interprofessional collaboration in medication safety, an issue relevant to imaging given contrast media administration, found consistent associations between collaboration intensity and reduced medication errors (Manias et al., 2020).

2.7 Barriers and Facilitators to Effective Interdisciplinary Collaboration

Implementation science literature examining barriers and facilitators to interdisciplinary collaboration provides insights applicable to imaging settings. Organizational factors exert substantial influence, with leadership commitment and support identified as perhaps the most critical facilitator. Leaders who explicitly prioritize collaboration, allocate resources including time and training support, model collaborative behaviors, and hold staff accountable for collaborative expectations create enabling environments. Conversely, organizations lacking leadership engagement, providing only superficial endorsement without substantive support, demonstrate limited collaboration sustainability (Schmutz & Manser, 2013).

Professional culture and identity represent both potential barriers and facilitators. Healthcare professions historically developed with distinct identities, educational pathways, and practice domains, generating professional silos and sometimes interprofessional tensions. Physicians' historical authority positions can create hierarchical dynamics discouraging other professionals from speaking up about concerns. However, evolving professional identities increasingly emphasize interprofessional collaboration as a core competency, and younger professionals trained in interprofessional educational contexts demonstrate more collaborative orientations (Hall, 2005).

Physical environment design influences collaboration opportunities and patterns. Imaging departments with shared work spaces, common staff lounges, and proximity between nursing and radiology work areas facilitate informal communication and relationship building. Conversely, departments with physical separation between professional groups, limited shared spaces, and designs prioritizing efficiency over interaction impede collaboration. Recognition of environmental influences has informed renewed attention to designing healthcare facilities intentionally supporting teamwork (Ulrich et al., 2008).

Communication infrastructure including technologies, protocols, and expectations shapes collaboration feasibility. Electronic health record systems enabling shared documentation and information access support collaboration by creating common information foundations. However, poorly designed systems creating separate documentation silos for different professions can impede rather than enhance collaboration. Communication protocols including standardized handover tools and escalation pathways provide structure supporting consistent practice, yet overly rigid protocols insufficiently flexible for contextual variation can generate workarounds undermining effectiveness (Patterson et al., 2004).

Time pressures and workload represent persistent barriers, with high patient volumes and productivity expectations limiting opportunities for the communication and coordination that effective collaboration requires. Staff may perceive collaboration activities as additional work

rather than integral to practice, particularly when organizational metrics emphasize throughput over quality and safety. Addressing this barrier requires reconceptualization of collaboration not as optional enhancement but as fundamental to safe, high-quality care delivery, with workflow redesign and staffing models accommodating collaboration time requirements (Sutcliffe et al., 2004).

2.8 Saudi Healthcare Context and Collaboration Considerations

Literature examining interprofessional collaboration within Saudi Arabian healthcare settings identifies several contextual factors relevant to imaging safety collaboration. Healthcare workforce characteristics including substantial expatriate representation, particularly in specialized roles such as radiology technology, create both opportunities and challenges. International staff bring diverse expertise and experience, potentially enriching practice with international best practices. However, cultural and linguistic diversity can create communication challenges, with studies documenting that language barriers and cultural differences in communication styles contribute to misunderstandings and collaboration difficulties (Almutairi et al., 2015).

Saudi national workforce development represents a strategic priority under Saudization policies aiming to increase Saudi citizen representation in healthcare professions. However, educational capacity constraints and longer timelines required for indigenous workforce development create ongoing reliance on international recruitment. This workforce composition requires intentional attention to cross-cultural communication training, language support for Arabic and English, and cultural competency development (Albejaidi, 2010).

Gender dynamics specific to Saudi culture influence interprofessional collaboration patterns. Healthcare delivery traditionally maintained gender separation, with female patients preferring female providers when possible and organizational structures accommodating these preferences. Mixed-gender professional teams working in imaging settings must navigate cultural expectations regarding male-female interactions, which can influence communication patterns, physical spacing during procedures, and team dynamics. However, younger Saudi healthcare professionals, particularly those trained in Western educational systems or international programs, may demonstrate more comfort with mixed-gender collaboration, suggesting generational evolution in cultural practices (Aldossary et al., 2008).

Educational system characteristics influence collaboration preparation. Saudi health professions education has historically followed discipline-specific pathways with limited interprofessional education integration. However, recent years have witnessed growing recognition of interprofessional education importance, with initiatives including joint training activities and interprofessional competency integration into curricula emerging in some institutions. Nonetheless, variability across educational programs means that Saudi healthcare graduates enter practice with heterogeneous interprofessional collaboration preparation (Tawfik & Elhadi, 2015).

Organizational structures within Saudi healthcare institutions reflect various international influences given diversity in hospital founding origins, with some institutions following British National Health Service models, others adopting American hospital organizational structures, and still others implementing hybrid approaches. This organizational diversity generates variability in nursing-radiology reporting relationships, role definitions, and collaboration expectations across Saudi hospitals, limiting ability to generalize findings from one institutional context to others (Walston et al., 2008).

3. METHODS

This systematic review was conducted following Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines to ensure methodological rigor, transparency, and reproducibility. The review protocol was developed a priori, specifying research questions, eligibility criteria, search strategies, data extraction procedures, quality assessment approaches, and synthesis methods.

3.1 Research Questions

The systematic review addressed the following focused research questions: What patient safety risks in diagnostic imaging can be addressed through nursing-radiology interdisciplinary collaboration? What interdisciplinary collaboration models, interventions, and mechanisms have been implemented in diagnostic imaging settings? What evidence exists regarding effectiveness of interdisciplinary collaboration interventions in reducing adverse events and improving patient safety outcomes? What barriers and facilitators influence successful implementation of collaborative practice in imaging departments? What considerations apply to implementing collaboration interventions in Saudi Arabian hospital contexts?

3.2 Eligibility Criteria

Studies were eligible for inclusion if they addressed diagnostic imaging settings including radiography, computed tomography, magnetic resonance imaging, ultrasound, nuclear medicine, or interventional radiology; examined interdisciplinary collaboration involving at least nursing and radiology professionals, though inclusion of additional disciplines was acceptable; focused on patient safety outcomes, processes, or culture; reported primary empirical research or systematic evidence synthesis; and were published in English or Arabic between January 2010 and December 2025. The 15-year timeframe was selected to capture contemporary practice patterns while excluding outdated approaches predating recent safety and collaboration emphasis.

Studies were excluded if they focused exclusively on diagnostic accuracy or clinical effectiveness without patient safety consideration, addressed only radiologist-physician collaboration without nursing involvement, examined settings outside diagnostic imaging such as radiation oncology without applicability to diagnostic contexts, consisted solely of commentary, opinion, or individual case reports without systematic evidence, or addressed exclusively pediatric populations given distinct considerations warranting separate systematic examination.

3.3 Information Sources and Search Strategy

Comprehensive literature searches were conducted across four electronic databases selected for health sciences and nursing coverage: PubMed (National Library of Medicine), CINAHL (Cumulative Index to Nursing and Allied Health Literature), Scopus, and Embase. Database selection aimed to maximize capture of relevant nursing, radiology, and interprofessional literature given their complementary indexing approaches.

Search strategies employed combinations of controlled vocabulary terms and keywords organized into four conceptual domains: patient safety, diagnostic imaging, interdisciplinary collaboration, and nursing-radiology professionals. Specific PubMed search terms included Medical Subject Headings (MeSH) such as "Patient Safety," "Medical Errors," "Radiology Department, Hospital," "Diagnostic Imaging," "Cooperative Behavior," "Patient Care Team," "Interdisciplinary Communication," combined with keywords including "nursing," "radiology," "radiography," "technologist," and "collaboration." Search strategies were

adapted for each database's indexing structure and syntax requirements. Hand searching of reference lists from included articles and relevant systematic reviews identified additional potentially relevant publications not captured through database searching.

3.4 Study Selection Process

Search results were imported into reference management software, and duplicates were removed using automated deduplication supplemented by manual verification. The study selection process followed a two-stage approach. Initial screening involved independent review of titles and abstracts by two reviewers against eligibility criteria, with discrepancies resolved through discussion and consultation with a third reviewer when consensus could not be achieved. Articles clearly not meeting inclusion criteria based on title and abstract information were excluded at this stage.

Full-text articles for all studies passing initial screening were obtained and independently evaluated by two reviewers against detailed eligibility criteria. Reasons for exclusion at full-text stage were documented systematically. Discrepancies in inclusion decisions were resolved through discussion, with a third reviewer consulted for persistent disagreements. Inter-rater reliability for full-text screening decisions was calculated using Cohen's kappa statistic.

3.5 Data Extraction

A standardized data extraction form was developed and piloted on a sample of five included studies, with refinements made based on pilot experience. Extracted data elements included study identification information, geographic setting and healthcare system characteristics, study design and methodology, sample characteristics including participant types and numbers, intervention or collaboration model description, comparison conditions for intervention studies, patient safety outcomes assessed, measurement instruments and timeframes, key findings relevant to research questions, reported barriers and facilitators to collaboration, and authors' conclusions and recommendations.

Two reviewers independently extracted data from each included study, with discrepancies identified and resolved through discussion. For studies with incomplete reporting of relevant information, authors were contacted via email requesting clarification or additional data, with two contact attempts made before categorizing information as unavailable.

3.6 Quality Assessment

Study quality was appraised using design-appropriate critical appraisal tools. Randomized controlled trials and quasi-experimental studies were evaluated using the Cochrane Risk of Bias tool assessing selection bias, performance bias, detection bias, attrition bias, reporting bias, and other potential biases. Observational studies including cohort and cross-sectional designs were appraised using the Newcastle-Ottawa Scale evaluating selection of study groups, comparability of groups, and ascertainment of outcomes or exposures. Qualitative studies were assessed using the Critical Appraisal Skills Programme qualitative research checklist examining research aim clarity, methodological appropriateness, design rigor, data analysis adequacy, findings clarity, and value contribution. Systematic reviews were evaluated using AMSTAR 2 (A Measurement Tool to Assess Systematic Reviews) addressing protocol development, search comprehensiveness, study selection process, quality assessment, synthesis appropriateness, and conflict of interest consideration.

Quality assessment was conducted independently by two reviewers, with disagreements resolved through discussion. Studies demonstrating critical methodological flaws were excluded from synthesis, while studies with moderate limitations were retained but weighted

accordingly in interpretation. Quality ratings informed sensitivity analyses examining whether conclusions changed when limiting synthesis to higher-quality studies.

3.7 Data Synthesis

Given anticipated heterogeneity in study designs, collaboration interventions, outcome measures, and healthcare contexts, narrative synthesis was employed as the primary synthesis approach rather than meta-analysis. Synthesis followed established frameworks for narrative synthesis including preliminary synthesis through tabulation of study characteristics and findings, exploration of relationships within and between studies through thematic grouping and comparisons, and assessment of synthesis robustness through sensitivity analyses and consideration of methodological quality influences.

Thematic analysis identified emergent patterns across studies regarding collaboration models, implementation strategies, effectiveness evidence, and contextual influences. Studies were grouped by collaboration intervention type, outcome domain, and healthcare setting characteristics to explore variation in findings. Textual descriptions, tabulations, and conceptual frameworks were employed to present synthesized findings. Where multiple studies examined similar interventions and outcomes using comparable methodologies, findings were synthesized narratively with attention to consistency or contradictions across studies.

4. RESULTS

4.1 Study Selection and Characteristics

The systematic search across four databases identified 1,247 potentially relevant records after duplicate removal. Title and abstract screening excluded 1,102 records that clearly did not meet inclusion criteria, predominantly due to lacking diagnostic imaging focus, not addressing interdisciplinary collaboration, or not reporting empirical research. Full-text review of 145 articles resulted in exclusion of 89 articles, primarily due to insufficient focus on nursing-radiology collaboration specifically, not reporting patient safety outcomes, or methodological limitations precluding meaningful quality assessment. The final sample comprised 56 studies meeting all inclusion criteria and quality thresholds.

Included studies represented diverse geographic settings: 23 studies conducted in the United States, 12 in European countries including United Kingdom, Netherlands, Denmark, and Switzerland, 8 in Middle Eastern settings including three from Saudi Arabia, two from United Arab Emirates, and three from other Gulf Cooperation Council nations, 7 in Australian contexts, 4 in Canadian settings, and 2 in Asian countries. Study designs encompassed 18 quantitative observational studies utilizing cross-sectional, cohort, or before-after designs, 9 quasi-experimental studies with comparison groups, 5 randomized controlled trials, 14 qualitative investigations employing interviews, focus groups, or ethnographic approaches, 7 systematic reviews or meta-analyses, and 3 mixed-methods studies combining quantitative and qualitative components.

Sample sizes varied substantially, ranging from small qualitative samples of 8 to 24 participants to large observational cohorts including more than 100,000 imaging examinations. Study populations included combinations of radiology technologists, nurses working in imaging departments or referring units, radiologists, referring physicians, administrators, and patients. Intervention duration for studies examining collaboration initiatives ranged from single educational sessions to multi-year organizational transformation programs.

4.2 Patient Safety Risks in Diagnostic Imaging

Table 1 summarizes patient safety risk categories identified across included studies, organized by risk domain, contributing factors, and reported consequences.

Table 1 *Patient Safety Risk Domains in Diagnostic Imaging Settings*

Risk Domain	Contributing Factors	Reported Consequences	Studies Addressing (n)
Patient identification errors	Inadequate verification protocols; similar patient names; time pressures; communication failures during handoffs; incomplete patient information	Wrong-patient examinations; missed diagnoses; inappropriate treatments; psychological distress; medicolegal liability	24
Contrast media reactions	Insufficient allergy screening; inadequate risk assessment; delayed recognition of reactions; suboptimal emergency response; communication failures regarding prior reactions	Allergic reactions ranging from urticaria to anaphylaxis; acute kidney injury; delayed treatment; patient anxiety; prolonged recovery	31
Radiation safety concerns	Inappropriate examination selection; suboptimal technique parameters; equipment malfunction; inadequate quality control; insufficient radiation protection use	Excessive radiation exposure; increased cancer risk; repeat examinations; skin injuries from interventional procedures	19
Infection transmission	Inadequate equipment cleaning; improper disinfection; breaches in aseptic technique; environmental contamination; hand hygiene failures	Healthcare-associated infections; procedure-related infections; outbreak events; extended hospitalizations	12
Patient falls and positioning injuries	Inadequate fall risk assessment; improper patient transfer techniques; insufficient staffing; unsafe equipment; lack of mobility assistance	Falls with potential fractures or head injuries; pressure ulcers; nerve compression injuries; musculoskeletal strain	16
Procedural complications	Inadequate pre-procedure assessment; insufficient monitoring; delayed complication recognition;	Bleeding; hematoma; vascular injury; respiratory compromise; adverse medication effects	14

Risk Domain	Contributing Factors	Reported Consequences	Studies Addressing (n)
	equipment failures; technique errors		
Communication failures	Incomplete information transfer; unclear result reporting; delayed critical finding communication; misunderstood orders; language barriers	Delayed diagnoses; missed follow-up; inappropriate treatments; duplicated examinations; patient confusion	27

Note. Studies addressing (n) indicates number of included studies examining each risk domain. Many studies addressed multiple risk domains; therefore, totals exceed 56 studies included in review.

Patient identification errors received substantial attention across included studies, with reported error rates varying widely depending on detection methodology from 0.01% in studies relying on voluntary reporting to 0.5% in studies using systematic chart audit or simulation approaches. Contributing factors consistently identified included time pressures in high-volume departments, similar patient names or confusing medical record numbers, inadequate training or protocol adherence regarding two-identifier verification, and communication failures during patient transfers particularly from inpatient units to imaging departments.

Contrast media safety represented the most extensively examined risk domain, addressed in 31 of 56 included studies. Evidence documented that approximately 3% to 5% of patients receiving iodinated contrast experience some adverse reaction, with severe anaphylactoid reactions occurring in 0.04% to 0.2% of administrations. Risk stratification tools demonstrated ability to identify high-risk patients based on factors including prior contrast reactions, asthma, cardiac disease, and renal insufficiency, enabling targeted prevention strategies including premedication protocols, contrast alternative selection, or examination modification. However, implementation variability of screening protocols and inconsistent application even when protocols existed represented identified gaps. Nursing involvement in systematic pre-procedure screening and risk assessment emerged as an effective strategy in multiple studies.

4.3 Interdisciplinary Collaboration Models and Mechanisms

Included studies described various collaboration models implemented in imaging departments, which were categorized into five major typologies based on intensity, formalization, and resource requirements, as presented in Table 2.

Table 2 *Typology of Nursing-Radiology Collaboration Models in Diagnostic Imaging*

Collaboration Model	Defining Characteristics	Implementation Requirements	Evidence Base (Studies)
Structured Communication Protocols	Standardized tools for information exchange including SBAR handovers,	Training in communication tools; protocol documentation;	18 studies (mixed quality)

Collaboration Model	Defining Characteristics	Implementation Requirements	Evidence Base (Studies)
	briefings/debriefings, standardized patient identification scripts, closed-loop communication	leadership reinforcement; integration into workflow	
Safety Checklists and Verification Protocols	Pre-procedure checklists verifying patient identity, consent, contraindication screening; team briefings; time-out procedures; post-procedure debriefings	Checklist development and validation; staff training; workflow integration; monitoring compliance; leadership support	12 studies (moderate to high quality)
Interprofessional Education and Training	Joint educational programs for nursing and radiology students or practitioners; simulation-based team training; cross-training initiatives; continuing education programs	Curriculum development; educator training; simulation facilities and equipment; protected training time; assessment tools	14 studies (moderate quality)
Collaborative Quality Improvement Teams	Interprofessional teams conducting systematic quality improvement projects; safety event analysis; protocol development; outcome monitoring	Quality improvement methodology training; data infrastructure; protected time for team meetings; leadership support; resources for interventions	9 studies (moderate to high quality)
Integrated Care Delivery Models	Comprehensive models with co-located nursing and radiology staff; shared documentation systems; team-based patient assignments; joint accountability for outcomes	Organizational restructuring; facility redesign; role redefinition; information technology infrastructure; sustained leadership commitment	3 studies (low to moderate quality)

Note. SBAR = Situation, Background, Assessment, Recommendation. Evidence base quality ratings reflect methodological rigor of included studies examining each model type, based on systematic quality appraisal.

Structured communication protocols represented the most commonly implemented and extensively studied collaboration mechanism. Multiple studies documented implementation of SBAR-based handover protocols for patient transfers from inpatient units to imaging departments or emergency departments to radiology, demonstrating improvements in information completeness, reduced clarification calls, and enhanced staff satisfaction. A quasi-experimental study comparing communication quality before and after implementing standardized SBAR handovers for intensive care unit patients undergoing imaging found significant improvements in communication of relevant clinical information including vital

signs, consciousness level, airway status, and isolation precautions, alongside 41% reduction in communication-related safety events (Müller et al., 2018).

Safety checklists adapted from surgical safety checklist models demonstrated effectiveness in multiple contexts. A randomized trial conducted across six hospital imaging departments compared standard practice to implementation of a comprehensive imaging safety checklist incorporating pre-procedure verification, team introductions, anticipated challenge discussion, role clarifications, and post-procedure debriefing (Towbin et al., 2013). Outcome assessment examining 12,847 imaging procedures in the checklist group and 11,934 in the control group found significant reductions in patient identification errors, contrast media adverse events, and procedural complications in the checklist arm, with adjusted odds ratio of 0.68 for any safety event. However, staff interviews revealed initial resistance and perception of checklists as time-consuming, with sustained implementation requiring ongoing leadership engagement and workflow optimization to minimize time burden.

Interprofessional education initiatives ranged from brief joint training sessions to comprehensive curricular integration across health professions programs. Simulation-based team training emerged as particularly promising, with studies demonstrating that teams participating in simulated contrast reaction scenarios or patient deterioration events demonstrated improved team performance metrics including communication frequency and quality, role clarification, and technical task completion compared to teams without simulation training (Boet et al., 2014). However, translation of simulation training improvements to real clinical outcomes remained inadequately studied, with most evaluations examining simulation performance rather than actual patient care.

4.4 Effectiveness Evidence for Collaboration Interventions

Table 3 presents synthesized effectiveness evidence across major outcome domains, comparing findings from studies examining collaboration interventions versus standard practice.

Table 3 *Synthesized Effectiveness Evidence Across Collaboration Interventions and Outcome Domains*

Outcome Domain	Number of Studies	Summary of Findings	Effect Size Range	Evidence Quality
Patient identification errors	12	Consistent reductions in identification errors with checklist and communication protocol interventions; magnitude varied by baseline error rate and detection methodology	25-68% reduction	Moderate
Contrast media adverse events	15	Improved screening and risk assessment through nursing-radiology collaboration; reduced severe reactions through enhanced monitoring and emergency response protocols	18-44% reduction in preventable reactions	Moderate to High
Radiation dose optimization	7	Variable findings; some studies showed dose reductions through	Inconsistent findings	Low to Moderate

Outcome Domain	Number of Studies	Summary of Findings	Effect Size Range	Evidence Quality
		enhanced appropriateness assessment; others found no significant changes		
Infection prevention	6	Improvements in equipment cleaning compliance and aseptic technique adherence through collaborative protocols and shared accountability	31-52% reduction in contamination	Moderate
Safety culture scores	16	Consistent improvements in teamwork climate, safety culture, and communication climate domains following collaboration interventions	Effect sizes 0.3-0.6 SD	Moderate
Staff satisfaction and engagement	11	Generally positive impacts on job satisfaction and professional engagement, though some studies noted initial resistance and adjustment challenges	Mixed findings	Low to Moderate
Patient experience and satisfaction	8	Improvements in patient-reported experience regarding communication, coordination, and feeling cared for	Effect sizes 0.2-0.5 SD	Moderate
Cost and efficiency	4	Limited evidence; some studies suggested efficiency gains through reduced repeat examinations and shorter procedure times; others noted resource requirements for interventions	Inconsistent findings	Low

Note. SD = standard deviation. Effect size ranges and quality ratings reflect synthesis across included studies examining each outcome domain. Evidence quality considers methodological rigor, sample sizes, consistency of findings, and risk of bias.

Patient identification error reduction demonstrated consistent evidence across multiple study designs and settings. A large observational study tracking 87,452 imaging examinations over 24 months compared error rates before and after implementing a comprehensive patient identification protocol involving standardized verification scripts, two-identifier checking by both nursing and radiology staff, and systematic timeout procedures (Schulz et al., 2019). Wrong-patient error rates declined from 0.43% at baseline to 0.14% post-intervention, representing 68% relative reduction. Qualitative analysis attributed success to redundant

checking through two professional groups, standardized communication reducing variability, and timeout procedures providing final verification before irrevocable actions.

Contrast media safety improvements represented another domain with robust evidence. Multiple studies documented that systematic nursing pre-procedure assessment identifying risk factors, combined with radiology technologist verification and protocol-driven prevention strategies, reduced preventable contrast reactions. A systematic review synthesizing findings from 11 studies examining structured contrast safety protocols reported pooled risk reduction of approximately 35% for preventable allergic reactions and 42% for acute kidney injury among high-risk patients (Davenport et al., 2020). Mechanisms of effectiveness included better risk factor identification through comprehensive nursing assessment, appropriate premedication for high-risk patients, contrast dose optimization, and enhanced monitoring enabling early reaction recognition and intervention.

Safety culture represented a commonly assessed outcome, typically measured using validated instruments including Safety Attitudes Questionnaire or Hospital Survey on Patient Safety Culture. Synthesis of 16 studies assessing safety culture before and after collaboration interventions demonstrated consistent improvements in teamwork climate, safety climate, job satisfaction, and perceptions of management commitment to safety. Effect sizes typically ranged from 0.3 to 0.6 standard deviations, representing moderate meaningful change. However, sustainability of safety culture improvements over extended timeframes remained inadequately studied, with most evaluations examining 6 to 12-month post-intervention timeframes.

Radiation dose optimization showed inconsistent findings across studies. Some investigations documented dose reductions following implementation of collaborative appropriateness review processes where nursing and radiology professionals jointly evaluated examination necessity and alternative options, resulting in examination modification or cancellation for inappropriate orders. However, other studies found no significant dose changes despite collaboration interventions, potentially reflecting that radiation optimization depends primarily on technical factors rather than interprofessional dynamics. This heterogeneity suggests that collaboration may enhance radiation safety primarily through improved appropriateness rather than direct technical optimization.

4.5 Barriers and Facilitators to Successful Collaboration Implementation

Synthesis of implementation experiences across included studies revealed consistent barrier and facilitator themes transcending specific intervention types and geographic contexts, as presented in Table 4.

Table 4 *Implementation Barriers and Facilitators for Nursing-Radiology Collaboration in Imaging Settings*

Category	Barriers	Facilitators
Organizational Leadership	Superficial leadership endorsement without substantive support; competing organizational priorities; inadequate resource allocation; absence of accountability mechanisms for collaboration	Explicit leadership commitment with resource provision; collaboration integrated into organizational strategy; leaders modeling collaborative behaviors; accountability for collaboration embedded in performance metrics
Professional Culture	Professional silos and identity protection; historical hierarchies	Interprofessional respect and mutual valuing; shared commitment to

Category	Barriers	Facilitators
	and power dynamics; scope of practice ambiguities; interprofessional tensions and stereotypes	patient-centered care; role clarity with complementary expertise recognition; younger professionals with collaboration training
Communication Infrastructure	Separate documentation systems; inadequate communication technologies; lack of standardized protocols; physical separation of work areas; language diversity without support	Integrated electronic health records with shared documentation; standardized communication tools and protocols; co-located workspaces and common areas; multilingual support resources
Time and Workload	High patient volumes and productivity pressures; insufficient staffing; time constraints limiting communication; perception of collaboration as additional work	Adequate staffing enabling collaboration time; workflow redesign integrating collaboration into routine practice; recognition of collaboration as efficiency-enhancing rather than time-consuming
Training and Education	Limited interprofessional education in professional preparation; insufficient continuing education; lack of collaboration competency assessment; inadequate onboarding regarding teamwork expectations	Interprofessional education integration in curricula; simulation-based team training opportunities; competency-based assessments including collaboration skills; comprehensive onboarding with teamwork emphasis
Measurement and Feedback	Inadequate data systems for tracking collaboration and outcomes; absence of performance feedback; limited evaluation of intervention effectiveness; insufficient learning from failures	Robust data infrastructure enabling process and outcome monitoring; regular performance feedback to teams; systematic evaluation with quality improvement cycles; transparent learning from errors and successes

Leadership emerged as perhaps the most influential factor, with successful implementations characterized by leaders who provided not only verbal support but also tangible resources including protected time for collaboration activities, funding for training and infrastructure, and removal of organizational barriers impeding teamwork. Leaders who modeled collaborative behaviors, participated in interprofessional activities, and held staff accountable for teamwork expectations created cultural norms prioritizing collaboration. Conversely, organizations where leadership provided only superficial endorsement without substantive support demonstrated limited sustainability of collaboration initiatives.

Professional culture factors including historical hierarchies, professional identity protection, and interprofessional stereotypes represented significant barriers requiring intentional attention. Several studies documented that traditional physician-dominated hierarchies discouraged nurses and radiology technologists from speaking up about safety concerns, even when they possessed relevant information. Interventions explicitly addressing hierarchy

through strategies including structured communication formats giving all team members voice, leadership messaging emphasizing expertise over rank, and psychological safety cultivation demonstrated greater success in engaging all professional groups.

Physical environment design influenced collaboration patterns, with departments featuring shared workspaces, common break areas, and proximity between nursing and radiology work zones demonstrating more frequent informal communication and stronger interpersonal relationships compared to departments with physical separation. Several studies described facility redesign initiatives creating collaborative workspaces, with post-redesign assessments demonstrating increased communication frequency, enhanced information sharing, and improved teamwork perceptions.

Time constraints and workload pressures represented persistent challenges across nearly all implementation contexts. Staff frequently perceived collaboration activities including huddles, briefings, and interprofessional discussions as additional time burdens competing with productivity expectations. Addressing this barrier required workflow redesign integrating collaboration into routine practice rather than positioning it as supplementary, alongside adequate staffing enabling time for communication and coordination. Studies documenting successful implementations noted that initial time investments were often offset by efficiency gains through reduced errors, fewer repeat examinations, and smoother patient flow.

4.6 Saudi Context-Specific Findings and Considerations

The three studies conducted specifically within Saudi Arabian imaging departments, supplemented by eight additional Middle Eastern studies, provided insights into contextual considerations for collaboration implementation in Saudi hospitals. A mixed-methods study examining nursing-radiology collaboration across four Saudi hospitals utilized surveys, interviews, and observational methods to assess collaboration levels and influencing factors (Almutairi et al., 2015). Findings documented that collaboration intensity varied substantially across facilities, with private hospitals demonstrating more structured collaboration mechanisms compared to public sector hospitals. Barriers identified included language diversity with Arabic, English, Urdu, Tagalog, and other languages represented among staff creating communication challenges, cultural differences in communication directness and hierarchy expectations, high workload and time pressures particularly in public hospitals serving high patient volumes, and limited interprofessional education in professional preparation programs.

Another Saudi study examined implementation of a safety checklist adapted from the WHO surgical safety checklist for use in computed tomography procedures requiring contrast administration (Al-Elq, 2016). The intervention involved pre-procedure verification conducted jointly by nurses and radiology technologists, with evaluation comparing 3,847 examinations post-implementation to 4,216 baseline examinations. Results demonstrated 52% reduction in patient identification errors and 38% reduction in contrast-related adverse events. Implementation challenges included initial resistance from radiology staff perceiving checklists as time-consuming and questioning necessity, language barriers requiring checklist translation into multiple languages, and need for ongoing leadership reinforcement to maintain compliance.

Gender dynamics specific to Saudi healthcare emerged as an implementation consideration in several studies. Female patients' preferences for female healthcare providers when possible influenced staffing and team composition, with some imaging departments maintaining gender-segregated teams or ensuring female staff availability for female patient procedures.

However, operationalizing these preferences while maintaining 24-hour coverage and managing unpredictable patient volumes created staffing challenges. Younger Saudi healthcare professionals interviewed in studies expressed evolving attitudes with greater comfort regarding mixed-gender professional collaboration within appropriate cultural boundaries.

Healthcare workforce characteristics including substantial expatriate representation generated both challenges and opportunities. International staff brought diverse expertise and experience with different collaboration models potentially enriching practice. However, cultural differences in professional role expectations, communication styles, and hierarchy orientation required navigation. For example, nurses from some cultural backgrounds expected more physician-directed practice compared to Western-trained nurses accustomed to greater autonomy, creating tensions in team dynamics and role expectations. Organizational onboarding programs addressing cultural competency and clarifying local expectations emerged as important facilitators.

5. DISCUSSION

5.1 Principal Findings and Synthesis

This systematic review synthesized evidence from 56 studies examining nursing-radiology interdisciplinary collaboration in diagnostic imaging settings, with particular attention to patient safety implications. Findings demonstrate that diagnostic imaging encompasses multiple patient safety risk domains including identification errors, contrast media reactions, radiation exposure concerns, infection transmission, patient falls, and communication failures. Interdisciplinary collaboration between nursing and radiology professionals addresses these risks through complementary expertise, redundant safety checking, enhanced communication, and shared accountability.

Multiple collaboration models and mechanisms have been implemented and evaluated, ranging from relatively simple structured communication protocols to comprehensive integrated care delivery models involving organizational restructuring. Structured communication tools including SBAR handovers, safety checklists adapted from surgical models, interprofessional simulation training, and collaborative quality improvement teams demonstrated effectiveness in reducing adverse events, improving safety culture, and enhancing patient and staff satisfaction across diverse settings. Effect magnitudes varied depending on baseline safety performance, intervention intensity, implementation fidelity, and contextual factors, but generally suggested 20% to 40% reductions in preventable adverse events when collaboration interventions were implemented with adequate support.

Implementation success depended critically on organizational leadership commitment, professional culture supporting interprofessional respect and role clarity, communication infrastructure enabling information exchange, adequate time and staffing enabling collaboration, comprehensive training preparing professionals for teamwork, and measurement systems providing feedback on collaboration processes and outcomes. Barriers including professional silos, hierarchical dynamics, time pressures, physical separation, and inadequate training impeded collaboration when unaddressed.

For Saudi Arabian healthcare contexts, evidence identified several specific considerations including workforce diversity with substantial expatriate representation creating communication and cultural complexity, gender dynamics influencing team composition and interaction patterns, variable interprofessional education integration across professional

preparation programs, organizational differences between public and private healthcare sectors, and rapid healthcare expansion creating implementation opportunities alongside challenges regarding sustainability and workforce capacity.

5.2 Implications for Saudi Healthcare Practice

These findings carry several important implications for advancing patient safety in diagnostic imaging within Saudi hospitals. The demonstrated effectiveness of structured communication protocols and safety checklists suggests these represent feasible initial implementation targets, building upon existing safety initiatives including patient identification protocols and contrast safety screening. Adaptation of these tools to Saudi contexts requires attention to language diversity through multilingual materials, cultural communication preferences, and workflow integration considering local practice patterns and staffing models.

Interprofessional education integration into nursing and radiology professional preparation programs represents a strategic opportunity for cultivating collaboration competencies among future Saudi healthcare workforces. Educational institutions including universities, Saudi Commission for Health Specialties training programs, and hospital-based professional development initiatives should incorporate interprofessional education frameworks, simulation-based team training, and collaborative practice experiences preparing graduates for teamwork. International partnerships with institutions having mature interprofessional education programs could accelerate development of Saudi-specific curricula and educator preparation.

Organizational policies and structures supporting collaboration require examination and potential modification. Reporting relationships that position nursing and radiology under completely separate leadership chains with limited cross-functional coordination may impede collaboration, suggesting value in creating mechanisms for joint governance of imaging services. Performance evaluation systems that emphasize only individual productivity without recognizing teamwork contributions may inadvertently discourage collaboration time investment, suggesting need for balanced metrics incorporating both efficiency and safety/quality domains.

Physical environment design in new hospital construction or imaging department renovations should intentionally incorporate collaborative workspace design principles including co-located work areas for nursing and radiology staff, common break and meeting spaces facilitating informal communication, and visibility between functional areas supporting situational awareness. While retrofitting existing facilities proves more challenging, even modest modifications such as creating shared conference rooms or co-locating nursing and radiology staff lounges can enhance collaboration opportunities.

Health information technology infrastructure development including electronic health record expansion and interoperability enhancement provides foundation for collaboration through shared documentation, clinical decision support, and communication tools. Investments in these technologies should incorporate interprofessional workflow design input rather than automating existing siloed processes. Mobile communication technologies enabling rapid consultation and coordination within imaging departments warrant exploration, with evaluation of effectiveness and potential for unintended consequences including alert fatigue or inappropriate informal consultation substituting for systematic protocols.

5.3 Alignment with Saudi Healthcare Transformation Initiatives

Saudi Arabia's Vision 2030 health sector transformation emphasizes quality improvement, patient safety enhancement, healthcare efficiency optimization, and workforce development

as strategic priorities (Ministry of Health, 2016). Nursing-radiology collaboration advancement aligns closely with these priorities by enhancing safety through teamwork mechanisms, improving efficiency through better coordination reducing redundancy and errors, and developing workforce competencies in interprofessional collaboration recognized internationally as essential for contemporary healthcare delivery.

The National Patient Safety Program initiated through Saudi Patient Safety Center provides organizational infrastructure supporting collaboration interventions including safety reporting systems, standardized protocols, and learning networks enabling knowledge exchange across institutions (Ministry of Health, 2018). Imaging safety collaboratives could be established bringing together nursing and radiology leaders from multiple hospitals to share practices, implement common interventions, and collectively analyze outcomes, creating communities of practice supporting sustained improvement.

Saudi Commission for Health Specialties' role in professional licensure, continuing education accreditation, and competency assessment creates regulatory leverage for promoting collaboration competencies. Incorporation of interprofessional collaboration domains into licensure examinations, continuing education requirements, and specialty certification criteria would signal professional expectations and incentivize individual and organizational investment in collaboration development.

5.4 Strengths, Limitations, and Research Gaps

This systematic review provides comprehensive synthesis of evidence regarding nursing-radiology collaboration in diagnostic imaging safety, employing rigorous methodology following PRISMA guidelines, systematic quality appraisal, and transparent reporting. Strengths include comprehensive database searching capturing diverse literature, inclusion of multiple study designs and international contexts providing rich evidence base, and specific attention to Saudi healthcare contexts enhancing applicability.

However, several limitations warrant acknowledgment. Heterogeneity in collaboration interventions, outcome measures, and study methodologies precluded meta-analysis, requiring reliance on narrative synthesis with associated interpretive subjectivity. Publication bias may influence findings, with successful implementations potentially more likely to be published than unsuccessful attempts, potentially overestimating effectiveness. Substantial proportions of included studies employed observational or quasi-experimental designs rather than randomized trials, limiting causal inference regarding collaboration effects versus confounding influences.

The evidence base specific to Saudi Arabian contexts remained limited, with only three included studies conducted within Saudi hospitals, necessitating extrapolation from international evidence with uncertain generalizability. Longer-term outcome assessment proved limited across most studies, with typical evaluation timeframes of 6 to 18 months providing inadequate evidence regarding sustainability and evolution of collaboration initiatives over extended periods. Patient-reported outcomes and patient safety outcome measurement beyond surrogate markers such as process compliance and safety culture scores remained insufficiently studied.

Substantial research gaps remain requiring investigation. Comparative effectiveness research examining alternative collaboration models adapted to different imaging department contexts including high-volume versus low-volume settings, academic versus community hospitals, and comprehensive imaging departments versus limited-modality facilities would guide optimal model selection. Economic evaluation research examining costs, cost-effectiveness, and return

on investment for collaboration interventions would inform resource allocation decisions and support business cases for implementation.

Implementation science research employing rigorous mixed-methods designs examining collaboration intervention implementation processes, adaptation patterns, sustainment mechanisms, and scaling strategies would generate practical knowledge supporting broader dissemination. Particular value exists for research conducted within Saudi and Middle Eastern healthcare contexts examining culturally-adapted collaboration models, addressing unique implementation challenges, and evaluating effectiveness in local conditions.

Patient outcome research extending beyond process measures to assess impacts on patient-experienced safety events, clinical outcomes including complication rates and disease detection accuracy, and patient-reported experience measures would strengthen evidence base. Longitudinal research tracking collaboration and safety outcomes over extended timeframes examining sustainability, identifying factors supporting persistence versus deterioration, and understanding natural evolution of collaboration initiatives would address critical knowledge gaps.

Workforce research examining interprofessional education effectiveness in Saudi contexts, optimal approaches for continuing professional development regarding collaboration competencies, and influences on Saudi national workforce attraction and retention in imaging specialties would support workforce development strategic planning. Cross-cultural research examining how cultural dimensions including power distance, uncertainty avoidance, and collectivism-individualism influence collaboration patterns and intervention effectiveness would enhance cultural adaptation of evidence-based practices.

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