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Systematic Review

# Radiographer Targeted Education To Reduce Repeat Exposure In Routine Chest Digital Radiography

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## Abstract

**Background**: Repeat and reject images in routine chest digital radiography increase patient dose and workload. International benchmarks recommend very low repeat rates, still local audits report higher figures. Improving radiographer performance is a plausible lever for reduction. We aimed to evaluate whether radiographer targeted education and related workflow strategies reduce technically avoidable repeats in routine chest radiography. **Methods:** We conduct a PRISMA aligned systematic review of electronic databases (MEDLINE, PubMed, Embase, Scopus, Web of Science, CINAHL, CENTRAL) from 2012 to 2025. Eligible designs assessed radiographer focused interventions (education modules, checklists, communication aids, QI bundles) against usual practice or pre intervention periods. Primary outcomes were repeat and reject rate or extra images; secondary outcomes included image acceptance and operational effects. Risk of bias was appraised with ROBINS-I, JBI, and NIH tools. Heterogeneity precluded meta-analysis; a structured narrative synthesis was performed. No prospective registration. **Results:** Six studies met inclusion criteria, including multi hospital quasi experimental programs, single site QI bundles, and an observer study. Education modules improved knowledge, motivation, and skills with significant, sustained reductions in repetition. A chest radiography bundle

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lowered extra frontal images from 4.6% to 3.3% (p=0.001). A multilingual instruction protocol improved inspiration quality, cutting poor inspiration rejects from 26% to 9% and increasing fully inspired images from 57.8% to 92.3%. An observer study showed radiologists accepted images more often than radiographers, indicating value in harmonized acceptance criteria and feedback. **Conclusions:** Radiographer targeted education, simple checklists, and language appropriate patient instructions reduce technically avoidable repeats in routine chest radiography.

Keywords: Chest digital radiography; repeat/reject rate; radiographer-targeted education; positioning checklists; patient

## Introduction

High quality routine radiographs must depict anatomy adequately; when image quality is insufficient, the examination must be repeated. Foos et al. define (repetition) as performing another radiograph because the original was clinically unacceptable (1). Repeat imaging is a key quality and safety concern. Guidance generally recommends keeping repeat rates very low: less than 5% (2–7), 5 to 7% per the Diagnostic Imaging Quality Assurance Committee (8), less than 6% according to the American Association of Physicists in Medicine with corrective action at 10% (9), and 2% acceptable but not exceeding 5% per the Australian College of Radiologists (10).

Saudi data indicate repeat rates above these thresholds. Khafaji and Hagi reported an average rate of 14.9% in local hospitals (11). Another evaluation in three Ministry of Health hospitals found rates between 7.4% and 9.7%, with chest radiography showing the highest repetition compared with other examinations (12). Radiographer related errors are a prominent contributor to repeats (12).

Image quality is tightly linked to radiographer practice. The World Health Organization notes that practice is shaped by knowledge, motivation, and skills (13). In Saudi Arabia, Alsharif et al. found limited ability among radiographers to recognize image errors (14), while Ahmed et al. reported variability in radiation protection knowledge, with 58% indicating poor knowledge (15). Low motivation has also been linked to poorer image quality (16). Deficits in knowledge and motivation undermine skills, and skill gaps have been associated with higher repeat rates (17). Radiographers with stronger skills are better at preventing errors through effective patient communication and precise equipment handling.

Repeating radiographs carries both health and economic costs, notably increased radiation exposure for patients and staff (11). Khafaji and Hagi, and Khoshinani and Heidari, further observed that elevated repeat rates can reduce the effective lifespan of digital equipment by roughly two months per year, increasing staff workload, prolonging patient waiting times, and hindering organizational performance targets (18).

Most interventions described in the literature have focused on technical measures and, while generally beneficial for reducing digital radiography repeat rates, often exclude direct radiographer involvement despite their central role (19). This study aims to design, implement, and assess the effect of printed educational materials on reducing repeat rates in routine digital chest radiography in radiographers.

## Methods

Design and registration: I conducted a systematic review following PRISMA 2020 guidance. No protocol was prospectively registered.

**Eligibility criteria**

**Population**

Radiographers performing routine chest radiography (adult or pediatric; portable CR or installed DR) and patients undergoing these exams.

Interventions and exposures

Radiographer targeted strategies to reduce technically avoidable repeats (educational modules, checklists, quality improvement bundles, communication aids) and studies evaluating determinants of repeat, acceptance decisions.

Comparators
Usual practice, pre intervention periods, or parallel control sites.

Outcomes: Repeat, reject rate, extra images, image quality acceptance, and operational impacts (costs, workflow).

**Study designs**

Randomized and non-randomized comparative studies controlled before–after, interrupted time series, cohort, and relevant observer studies. I excluded editorials, letters, narrative reviews, conference abstracts without full data, nonchest modalities, and non-original work.

**Information sources**

I searched electronic databases from 2012 to 2025: MEDLINE, PubMed, Embase, Scopus, Web of Science Core Collection, CINAHL, and Cochrane CENTRAL. I also screened reference lists of included studies and relevant reviews.

Selection process

After de duplication, I screened titles, abstracts against PICOS, retrieved potentially eligible full texts, and recorded reasons for exclusion. A PRISMA flow diagram was prepared to document identification, screening, eligibility, and inclusion.

Data collection process: Using a piloted extraction form, I collected citation details, country, setting, design, imaging platform, population, intervention components, comparators, outcome definitions, effect estimates, follow up, and implementation notes.

**Risk of bias assessment**

I appraised nonrandomized comparative studies with ROBINS I, cross sectional, observer studies with the appropriate JBI checklist, and before after, quality improvement designs with the NIH tool for pre post studies. Judgments were recorded by domain and overall.
Effect measures and synthesis

The primary effect measure was change in repeat, reject rate. When designs and outcomes were sufficiently homogeneous, I planned random effects meta-analysis; I performed structured narrative synthesis, grouping by intervention type (education, workflow, checklists, communication aids), platform (CR vs DR), and setting (portable vs installed; adult vs pediatric). Small study effects and reporting bias were not assessed due to the limited number of eligible studies. Certainty of evidence was considered narratively with GRADE

principles where pooling was feasible

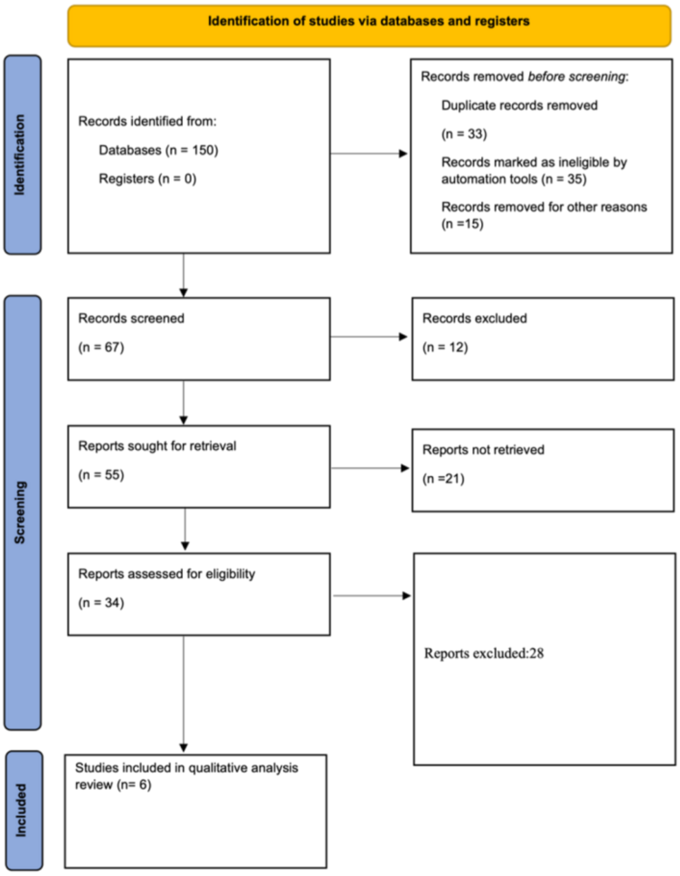

Fig 1: PRISMA consort chart

**Results**

Six studies met inclusion criteria, including quasi experimental multi hospital interventions, single site quality improvement initiatives, and an observer study of image quality judgments. Populations included routine adult chest radiography in inpatient and emergency settings, pediatric mobile examinations, and radiographers working in tertiary hospitals. Interventions targeted radiographer education, workflow prompts, and communication aids to reduce technically avoidable repeats.

Education centered programs in tertiary hospitals produced significant, sustained reductions in repetition rates. Knowledge, motivation, and practical skills improved in parallel, and effects persisted at follow up assessments. A single institution bundle that embedded a dictation macro, refresher tutorials, and technologist checklists reduced extra frontal chest images from 4.6% to 3.3%, while lateral projections showed smaller, nonsignificant change. These structured cues integrated easily into daily practice and supported ongoing monitoring.
Targeted communication also yielded marked gains, in an emergency isolation setting serving non-English-speaking patients, a multilingual, stepwise audio and pictorial instruction protocol improved inspiratory effort and lowered reject rates for poor inspiration from 26% to 9%. Fully inspired images increased from 57.8% to 92.3%, demonstrating that language appropriate guidance can directly reduce repeats.

Platform characteristics influenced baseline performance, portable computed radiography and installed digital radiography displayed different repeat patterns, with motion artifact a prominent driver. A multidisciplinary response, refining positioning, exposure technique, and device specific practices, achieved durable reductions in repeats and related costs without compromising image quality.

Table 2. Characteristics and outcomes of the included studies.

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| Citation | Study design | Population | Study aim |
|---|---|---|---|
| Fintelmann et al., 2012 (20) | Before after quality improvement program measuring chest radiograph repeat rates and implementing technical, teaching fixes. | ED, inpatient chest radiographs at a large teaching hospital; technologists covering 24 h; CR (portable) and DR (installed) systems. | Determine RR for portable CR vs installed DR and develop strategies to decrease RR. |
| Lee, Rafferty and Zigmund, 2018 (21) | Single institution QI: baseline tracking via dictation macro tutorials + posted checklists, 12 week post intervention audit. | All chest radiography exams in the study periods at one hospital (frontal, lateral extra views recorded). | Measure chest radiograph repeat rate, collaborate with technologists to reduce extra images, and embed process in QC. |
| Almalki et al., 2017 (22) | Quasi experimental time series with control in four tertiary hospitals; pre, post, follow up assessments. | Radiographers in Makkah tertiary hospitals; 56 per intervention and 56 per control group. | Evaluate impact of a printed educational module on reducing routine digital chest radiography repetition rate. |
| Almalki, 2019 (23) | Quasi experimental repeated measures with control (two hospitals per arm); baseline, post intervention, and follow up phases. | Radiographers in Makkah Region tertiary hospitals (n 56 per group). | Develop, implement, and determine effects of an educational intervention on chest radiography repetition rate. |
| Saade et al., 2021 (24) | IRB approved retrospective observer study; 4 radiologists and 4 radiographers independently rated pediatric mobile CXRs. | Random sample of 131 pediatric portable chest radiographs from a university medical center. | Assess how years of experience relate to image quality perception and repeat decisions between radiologists vs radiographers. |

Table 2. Characteristics and outcomes of the included studies.

| Citation | Main findings | Outcomes |
|---|---|---|
| Fintelmann et al., 2012 (20) | DR systems showed higher repeat rates than CR; motion artifact was a frequent cause. Multidisciplinary technical plus educational steps emphasized. | Sustainable reduction in repeats and costs while preserving image quality reported after targeted interventions. |
| Lee, Rafferty and Zigmund, 2018 (21) | Bundle (dictation macro, refresher tutorials and technologist checklists) to curb extra images. | Frontal CXR extra images fell 4.6% to 3.3% (p value 0.001); lateral change not significant. Authors state durable quality, patient care improvement potential. |
| Choong et al., 2021 (25) | Three step, multilingual audio, pictorial instruction targeting inspiratory effort for portable CXR. | Rejects for poor inspiration dropped 26% to 9%; fully inspired images rose to 92.3% (vs 57.8% baseline). |
| Saade et al., 2021 (24) | Radiologists rated image quality higher and chose not to repeat more often than radiographers (all p value less than 0.05); highlighted need for better communication, collaboration. | Years of experience correlated with both image quality ratings and repeat decisions. |

| | | |
|---|---|---|
| Almalki, 2019 (23) | Quasi experimental (intervention vs control) educational module improving knowledge, motivation, skills; repetition rates tracked baseline, post, follow up. | Significant reductions in repetition rate with concurrent gains in knowledge, motivation, skills (Wilks tests p value 0.001); intervention effective. |

Reader factors affected repeat decisions, in pediatric mobile chest radiographs, radiologists assigned higher image quality scores and recommended fewer repeats than radiographers; greater experience correlated with both quality ratings and acceptance. These findings suggest that shared acceptance criteria and two-way feedback between radiographers and radiologists can align thresholds and further limit unnecessary repeats.

According to the included articles, radiographer focused education, checklist-based workflow cues, and patient communication tools reduce technically driven repeats in routine chest radiography. Combining educational reinforcement with device specific technique optimization and cross disciplinary feedback offers the greatest potential for sustained system level improvement. Characteristics of the included studies were presented in Table 1, and main findings presented in Table 2.

**Discussion**

In DR services, image rejection is a non trivial quality and safety issue, driven by modifiable technical factors. Large audits from emergency departments report average reject rates 9 to 10%, with chest projections contributing substantial absolute numbers of rejects; AP chest on wireless detectors can exhibit high reject percentages (17%), underscoring projection and workflow specific challenges in routine practice. Overall and multiple reject audits further show that repeat clusters concentrate in difficult projections (horizontal beam knee, hip) and that most multiple rejects are due to positioning and anatomy cut off, highlighting technique as the principal lever for improvement (26,27).

Between department comparisons confirm meaningful variability: two DDR departments recorded overall rejection rates of 7.86% vs 5.91%, with positioning errors accounting for 77 to 79% of rejections and patient movement contributing variably across sites. These data argue for locally tailored countermeasures informed by each department's pattern of errors. Beyond system differences, reject rates vary among individual radiographers, reflecting heterogeneous technical thresholds and experience, again reinforcing the need for structured education and feedback (27,28).

Targeted quality improvement interventions demonstrate measurable benefit. In a single site chest radiography program, combining simple monitoring (dictation macro) with refresher tutorials and posted positioning checklists reduced extra frontal views from 4.6% to 3.3% ($p=0.001$), while lateral repeats were unchanged, evidence that focused training and visible cues can curb avoidable repeats without disrupting workflow. The same report details why extra images matter, added dose, technologist time, radiologist reading inefficiency, supporting continuous monitoring as part of routine QA (21).

Departments should prioritize high risk projections for targeted coaching, protocol refinement, and competency checks, because these contribute disproportionately to rejects and multiple rejects. Standardizing acceptance criteria and re-establishing bidirectional feedback between radiographers and radiologists can further reduce subjective variation; reduced day to day interaction in the DR era may otherwise allow positioning errors to persist (27,28).

## Conclusion

Radiographer focused education and simple workflow tools, checklists, standardized acceptance criteria, and language appropriate patient instructions, reduce technically avoidable repeats in routine chest digital radiography. Projection specific audit and continuous monitoring help target the highestyield errors and sustain gains over time. Embedding joint radiologist, radiographer feedback further minimizes unnecessary repeats while preserving diagnostic adequacy and reducing dose. Future multicenter, controlled studies with standardized metrics are needed to confirm generalizability and quantify cost effectiveness

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