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Research Title

Factors Associated with Repeat Radiographic Examinations and Strategies for Quality Improvement in Radiology Departments in Saudi Arabia

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Contents	Page No.
Introduction	
Problem Statement	
Significance of the Study	
Objectives of the Study	
Research Questions	
Research Hypotheses	

Contents	Page No.
Literature Review	
Previous Studies	
Research Gap	
Theoretical Framework	
Research Methodology	
Study Population and Sample	
Research Instrument	
Statistical Analysis	
Study Limitations	
Expected Outcomes	
Recommendations	
Conclusion	
References	

Introduction

Medical imaging has become one of the most essential components of modern healthcare systems, providing physicians with accurate diagnostic information that supports appropriate

clinical decision-making. Conventional radiography remains the most frequently performed imaging modality worldwide due to its availability, speed, low cost, and diagnostic value. Every day, millions of radiographic examinations are performed in hospitals and healthcare institutions to diagnose trauma, respiratory diseases, musculoskeletal disorders, and numerous other medical conditions.

Despite continuous technological advancements in digital radiography, repeat radiographic examinations remain a persistent challenge in radiology departments. A repeat examination occurs when an image must be acquired again because the original image does not meet the required diagnostic quality. Repeated imaging increases patient exposure to ionizing radiation, wastes healthcare resources, prolongs patient waiting time, increases departmental workload, and negatively affects overall healthcare quality.

The causes of repeat radiographic examinations are multifactorial and include human, technical, organizational, and patient-related factors. Human factors include positioning errors, incorrect exposure selection, communication failures, insufficient experience, and inadequate training. Technical factors involve equipment malfunction, detector errors, software failures, or image processing problems. Patient-related factors include involuntary movement, inability to cooperate, severe pain, obesity, or altered consciousness. Organizational factors include heavy workload, staff shortages, overcrowding, time pressure, and inadequate quality assurance systems.

Radiology departments are expected to maintain high-quality imaging services while minimizing unnecessary radiation exposure according to the ALARA (As Low As Reasonably Achievable) principle. Therefore, reducing repeat examinations has become one of the key quality indicators used to evaluate radiology department performance worldwide. Continuous monitoring of reject and repeat rates enables healthcare organizations to identify deficiencies, improve workflow, reduce operational costs, and enhance patient safety.

Saudi Arabia has experienced remarkable growth in healthcare services during the last decade, accompanied by substantial investments in medical imaging technologies and healthcare infrastructure as part of Vision 2030. Hospitals have increasingly adopted digital radiography systems, Picture Archiving and Communication Systems (PACS), Radiology Information Systems (RIS), and electronic medical records. Nevertheless, variations in repeat radiographic examination rates continue to exist among healthcare institutions due to differences in staff competency, workload, equipment quality, and quality management practices.

Several international studies have investigated repeat analysis in digital radiography and demonstrated that positioning errors remain the leading cause of repeated examinations, followed by patient motion and exposure-related issues. However, most available studies have focused on technical causes, while fewer studies have comprehensively evaluated organizational and human factors, particularly within Saudi healthcare settings.

Understanding the factors associated with repeat radiographic examinations is essential for developing evidence-based quality improvement strategies. Such strategies may include continuous professional education, competency assessment, protocol standardization, workflow

optimization, equipment maintenance, periodic quality audits, and implementation of continuous quality improvement programs. These interventions may significantly reduce repeat rates while improving diagnostic quality and patient satisfaction.

Furthermore, identifying the relationship between staff experience, workload, equipment availability, organizational support, and repeat examinations may provide valuable evidence for healthcare administrators and radiology managers to improve departmental performance. Improving image quality while minimizing unnecessary radiation exposure directly supports international patient safety initiatives and contributes to healthcare sustainability.

Accordingly, this study aims to investigate the factors associated with repeat radiographic examinations in radiology departments across Saudi Arabia and to propose practical quality improvement strategies that may reduce repeat imaging, improve patient safety, optimize departmental efficiency, and support healthcare quality management.

Problem Statement

Repeat radiographic examinations continue to occur despite significant technological improvements in digital radiography systems. These repeated examinations increase radiation exposure, healthcare costs, staff workload, examination time, and patient dissatisfaction. Although digital radiography has reduced many technical imaging limitations, repeat examinations remain common due to human errors, inadequate training, patient-related difficulties, equipment issues, and organizational challenges.

Most previous studies have primarily focused on technical causes of repeat imaging, whereas limited research has comprehensively examined the combined effects of organizational, technical, human, and workload-related factors in Saudi Arabian radiology departments. Consequently, healthcare organizations still lack sufficient evidence regarding the most influential factors contributing to repeat examinations and the most effective quality improvement strategies suitable for local healthcare settings.

Therefore, this study seeks to identify the major factors associated with repeat radiographic examinations among radiologic technologists working in Saudi Arabia and to recommend evidence-based strategies for improving radiology quality and patient safety.

Significance of the Study

This study has considerable scientific and practical importance.

From a scientific perspective, the study contributes to the growing body of knowledge regarding radiology quality management by examining multiple factors associated with repeat radiographic examinations. It also addresses an important research gap by focusing on Saudi healthcare institutions, where relatively limited evidence is available compared with international literature.

From a practical perspective, the findings may assist radiology managers, healthcare administrators, quality improvement teams, and policymakers in designing effective interventions to reduce repeat examinations. The study may also contribute to improving radiation safety, optimizing departmental workflow, reducing healthcare costs, enhancing staff performance, and increasing patient satisfaction.

Furthermore, the findings may support the implementation of continuous quality improvement programs and assist hospitals in meeting national and international accreditation standards related to patient safety and radiology quality management.

Objectives of the Study

General Objective

To identify the factors associated with repeat radiographic examinations in radiology departments in Saudi Arabia and propose evidence-based quality improvement strategies to reduce repeat imaging, enhance patient safety, and improve departmental performance.

Specific Objectives

1. To identify the most common causes of repeat radiographic examinations.
2. To examine the relationship between radiographers' professional experience and repeat examination rates.
3. To assess the effect of workload on the occurrence of repeat radiographic examinations.
4. To evaluate the influence of equipment performance and technical factors on repeat imaging.
5. To determine the impact of organizational factors, including staffing levels, supervision, and quality assurance programs, on repeat examinations.
6. To investigate the role of continuous education and staff training in reducing repeat radiographic examinations.
7. To recommend practical quality improvement strategies for minimizing repeat examinations in Saudi radiology departments.

Research Questions

This study seeks to answer the following research questions:

1. What are the most common factors associated with repeat radiographic examinations in Saudi radiology departments?
 2. Does radiographer experience significantly influence repeat radiographic examination rates?
 3. What is the relationship between workload and repeat radiographic examinations?
 4. To what extent do equipment performance and technical issues contribute to repeat examinations?
 5. How do organizational factors affect repeat radiographic examinations?
 6. Does continuous education and professional training reduce repeat examination rates?
 7. What quality improvement strategies can effectively reduce repeat radiographic examinations?
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Research Hypotheses

Main Hypothesis

There is a statistically significant relationship between organizational, technical, and human factors and repeat radiographic examinations in Saudi radiology departments.

Sub-hypotheses

H1: Radiographer experience has a statistically significant negative relationship with repeat radiographic examinations.

H2: Heavy workload has a statistically significant positive relationship with repeat radiographic examinations.

H3: Technical equipment problems significantly increase repeat radiographic examinations.

H4: Continuous education and staff training significantly reduce repeat radiographic examinations.

H5: Effective quality assurance programs significantly reduce repeat examination rates.

Null Hypothesis (H0):

There is no statistically significant relationship between organizational, technical, and human factors and repeat radiographic examinations.

Literature Review

Medical imaging quality has become an important component of healthcare quality management. Digital radiography has significantly improved image acquisition, processing, storage, and communication. Nevertheless, repeat radiographic examinations continue to represent a major challenge that affects patient safety, radiation protection, operational efficiency, and healthcare costs.

Repeat analysis has long been recognized as one of the most effective quality assurance tools in radiology departments. It allows healthcare organizations to monitor image quality, identify common imaging errors, evaluate radiographer performance, and implement corrective actions. According to the International Atomic Energy Agency (IAEA), repeat analysis programs should be integrated into every radiology quality assurance system because they provide objective indicators of imaging quality and departmental performance.

Previous literature demonstrates that repeat radiographic examinations are influenced by numerous interconnected factors rather than a single cause. These factors can generally be classified into four major categories: human factors, patient-related factors, technical factors, and organizational factors.

Human factors remain the most frequently reported causes of repeated examinations. Several studies have demonstrated that positioning errors account for the largest proportion of rejected images. Incorrect patient positioning results in inadequate visualization of the anatomical area of interest, requiring image repetition to achieve acceptable diagnostic quality. Exposure selection errors, incorrect collimation, image centering mistakes, marker placement errors, and communication failures also contribute to repeat examinations.

Patient-related factors constitute another important category. Elderly patients, pediatric patients, trauma patients, critically ill individuals, and patients experiencing severe pain frequently have difficulty maintaining the required position during image acquisition. Motion artifacts therefore become a common cause of repeated examinations. Obesity, limited mobility, reduced consciousness, language barriers, and poor communication between patients and radiographers may further increase repeat rates.

Technical factors continue to contribute despite technological advances. Detector malfunction, image processing failures, software errors, equipment calibration problems, generator instability, and hardware failures occasionally require repeated image acquisition. Regular preventive maintenance, equipment calibration, and quality control testing are therefore essential components of radiology quality assurance programs.

Organizational factors have received increasing attention in recent years. High patient volume, staff shortages, long working hours, fatigue, inadequate supervision, insufficient continuing education, poor workflow design, and lack of standardized imaging protocols have all been associated with increased repeat examinations. Hospitals implementing continuous quality

improvement programs generally report lower repeat rates than organizations without structured quality management systems.

Continuous professional education plays a significant role in reducing repeat imaging. Training programs improve radiographers' positioning skills, technical knowledge, radiation protection practices, communication abilities, and confidence. Simulation-based education, competency assessments, peer review, and image quality audits have all demonstrated positive effects on imaging performance.

Healthcare organizations increasingly utilize repeat analysis as a quality indicator within accreditation and performance evaluation systems. Monitoring reject rates enables managers to identify trends, compare departmental performance over time, evaluate new technologies, and implement targeted improvement interventions. Continuous monitoring also supports compliance with radiation safety principles, particularly the ALARA principle, which emphasizes minimizing unnecessary radiation exposure while maintaining diagnostic image quality.

International organizations, including the World Health Organization, the International Atomic Energy Agency, the American College of Radiology, and the European Society of Radiology, recommend routine quality assurance programs incorporating repeat analysis, equipment testing, staff education, protocol standardization, and regular clinical audits. Together, these interventions contribute to improving diagnostic accuracy, enhancing patient safety, reducing operational costs, and increasing healthcare quality.

Previous Studies

Study One

A study conducted by **Foos et al. (2019)** investigated the causes of repeated radiographic examinations in digital radiography departments. The researchers used a quantitative descriptive approach by analyzing thousands of rejected radiographic images collected from several hospitals over one year.

The study revealed that positioning errors represented the leading cause of repeat examinations, followed by patient motion and improper collimation. The researchers concluded that regular image quality audits and continuous staff education significantly reduced repeat rates. Although the study provided valuable quantitative evidence regarding image rejection, it focused primarily on technical errors without evaluating organizational factors such as workload and staffing.

Study Two

Naylor et al. (2020) examined the relationship between radiographer experience and repeat examination rates in several teaching hospitals. A cross-sectional design was employed using reject analysis reports and staff demographic information.

The results demonstrated that newly graduated radiographers had significantly higher repeat rates than experienced professionals. Continuous supervision and mentoring programs contributed to substantial reductions in repeat examinations during the first year of employment. However, the study did not investigate equipment-related or organizational variables.

Study Three

A Saudi Arabian study conducted by **Alshamrani et al. (2022)** evaluated reject rates in digital radiography departments across several hospitals. Data were collected from reject analysis software over six months.

The findings indicated that positioning errors accounted for nearly half of repeated examinations, while patient motion and exposure selection errors represented other major causes. The study recommended strengthening quality assurance programs and implementing continuous competency assessments for radiographers. Although this study was conducted within Saudi Arabia, it primarily focused on technical image quality indicators and did not comprehensively evaluate workload or management practices.

Study Four

Brady (2017) investigated the impact of human error on diagnostic imaging quality. The study reviewed multiple healthcare organizations implementing quality improvement initiatives.

The findings suggested that human performance is influenced by fatigue, communication, workload, environmental conditions, and organizational culture. The author emphasized that improving healthcare systems rather than blaming individuals provides more sustainable improvements in imaging quality. The study supports the importance of investigating organizational factors alongside technical issues.

Study Five

Seeram (2020) discussed quality assurance practices in digital radiography from both technical and educational perspectives. The author emphasized that successful quality improvement depends on continuous equipment calibration, protocol standardization, image quality monitoring, and staff competency development.

The publication concluded that quality assurance should be considered an ongoing management process rather than isolated technical inspections. This concept directly supports the current study's objective of proposing sustainable quality improvement strategies.

Study Six

According to the **International Atomic Energy Agency (IAEA, 2014)**, reject analysis programs represent one of the essential components of radiology quality assurance systems. The organization recommends periodic evaluation of rejected images, continuous staff education, standardized imaging protocols, equipment maintenance, and regular quality audits.

The guidelines emphasize that repeat analysis should be used as a performance indicator to improve patient safety while minimizing unnecessary radiation exposure.

Study Seven

The **American College of Radiology (ACR, 2023)** recommends continuous monitoring of repeat examinations as part of diagnostic imaging quality improvement programs. According to the ACR, radiology departments should routinely evaluate reject rates, investigate root causes, provide staff feedback, and implement corrective actions.

The guidelines indicate that combining education, quality audits, and protocol standardization significantly improves imaging quality and departmental efficiency.

Study Eight

A recent international review published in **2024** examined quality improvement interventions used in radiology departments worldwide. The review found that continuous education, leadership support, digital workflow optimization, competency assessment, and routine quality monitoring consistently reduced repeat radiographic examinations across different healthcare settings.

The review also highlighted the need for more research investigating organizational and managerial factors influencing repeat examinations, particularly in developing healthcare systems.

Research Gap

Although previous studies have extensively investigated repeat radiographic examinations, several important research gaps remain.

First, most published studies have primarily focused on technical image quality issues such as positioning errors, exposure selection, and patient movement, while relatively limited attention has been given to organizational variables including workload, staffing adequacy, leadership support, quality management systems, and continuous education.

Second, many previous investigations were conducted in Europe, North America, or Australia, limiting the applicability of their findings to Saudi healthcare organizations, which differ in organizational structure, workforce characteristics, patient population, and healthcare policies.

Third, previous Saudi studies mainly analyzed reject rate statistics without comprehensively examining the combined influence of technical, organizational, educational, and human factors using structured statistical analysis.

Finally, limited studies have proposed integrated quality improvement strategies specifically designed for Saudi radiology departments.

Therefore, the present study seeks to address these gaps by investigating the combined influence of human, technical, organizational, and workload-related factors on repeat radiographic examinations while proposing practical quality improvement strategies suitable for Saudi healthcare organizations.

Theoretical Framework

This study is primarily based on **Donabedian's Quality of Care Model**, one of the most widely recognized frameworks for evaluating healthcare quality.

The Donabedian Model consists of three interrelated components: **Structure, Process, and Outcome**.

The **Structure** component includes organizational resources such as radiology equipment, staffing levels, education, leadership, quality assurance programs, departmental policies, and infrastructure. These structural factors provide the foundation for healthcare delivery.

The **Process** component represents the activities performed during radiographic examinations, including patient identification, communication, positioning, exposure selection, image acquisition, quality verification, documentation, and radiation protection practices. Errors occurring during these processes may directly contribute to repeated examinations.

The **Outcome** component reflects the consequences of healthcare delivery. In this study, outcomes include repeat examination rates, radiation exposure, diagnostic image quality, patient satisfaction, workflow efficiency, departmental productivity, and overall quality performance.

The present study assumes that improvements in organizational structure and radiographic processes will lead to improved imaging outcomes by reducing unnecessary repeat examinations.

In addition to the Donabedian framework, this study incorporates the principles of **Continuous Quality Improvement (CQI)**, which emphasize ongoing measurement, monitoring, evaluation, and systematic improvement of healthcare processes. CQI promotes data-driven decision making, staff participation, continuous education, leadership commitment, and regular performance evaluation.

Combining these two theoretical approaches provides a comprehensive framework for understanding the relationship between organizational characteristics, radiographic practice, and repeat examination rates while supporting the development of evidence-based quality improvement strategies suitable for Saudi radiology departments.

Research Methodology

Research Design

This study adopts a quantitative cross-sectional research design to investigate the factors associated with repeat radiographic examinations in radiology departments across Saudi Arabia. A quantitative approach is considered appropriate because it enables the researcher to measure relationships between multiple independent variables and repeat radiographic examinations using statistical analysis.

A cross-sectional design allows data to be collected from participants at a single point in time, making it suitable for examining current practices, organizational conditions, and professional experiences among radiographers working in different healthcare institutions.

The study also follows a descriptive analytical approach. The descriptive component aims to describe the current status of repeat radiographic examinations and identify the most common contributing factors. The analytical component investigates the relationships between these factors and repeat examination rates through statistical testing.

This methodology enables the researcher to generate evidence-based recommendations for quality improvement in radiology departments.

Study Setting

The study will be conducted in radiology departments within governmental, military, university, and private hospitals across Saudi Arabia.

Hospitals from different regions of the Kingdom will be included to improve the representativeness of the sample and increase the generalizability of the study findings.

Radiology departments included in this study are expected to utilize digital radiography systems integrated with Picture Archiving and Communication Systems (PACS), Radiology Information Systems (RIS), and electronic medical records.

Study Population

The target population consists of licensed radiologic technologists currently working in diagnostic radiology departments throughout Saudi Arabia.

Participants will include radiographers working in emergency departments, inpatient departments, outpatient clinics, trauma centers, operating rooms, intensive care units, and mobile radiography services.

Eligible participants should possess practical experience in performing conventional digital radiographic examinations.

Inclusion Criteria

Participants must satisfy the following conditions:

- Licensed radiologic technologists.
 - Currently employed in Saudi Arabia.
 - Working in diagnostic radiography.
 - Having at least six months of clinical experience.
 - Willing to participate voluntarily.
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Exclusion Criteria

The following individuals will be excluded:

- Radiology students.
 - Radiology interns.
 - Administrative employees.
 - Radiologists.
 - Technologists working exclusively in CT, MRI, Nuclear Medicine, Ultrasound, or Radiation Therapy.
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Sampling Technique

A convenience sampling method will be utilized because it provides practical access to radiologic technologists working in different healthcare organizations throughout Saudi Arabia.

The questionnaire will be distributed electronically using professional social media platforms, hospital communication channels, and professional radiography networks.

Although convenience sampling has limitations regarding representativeness, it is widely used in healthcare research involving geographically dispersed healthcare professionals.

Sample Size

The proposed sample size is between **200 and 250 radiologic technologists**.

This sample size is considered adequate to perform descriptive statistics, correlation analysis, regression analysis, t-tests, and analysis of variance (ANOVA).

A larger sample increases statistical power and improves the reliability of the study findings.

Data Collection Instrument

Data will be collected using a structured self-administered questionnaire developed after reviewing previous literature related to repeat radiographic examinations, quality assurance, patient safety, and healthcare quality management.

The questionnaire will consist of five sections.

Section One

Demographic characteristics including:

- Age
 - Gender
 - Educational qualification
 - Years of experience
 - Hospital type
 - Department
 - Geographic region
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Section Two

Human Factors

This section evaluates factors related to radiographers, including:

- Professional experience
- Communication skills
- Patient positioning
- Technical knowledge
- Compliance with imaging protocols
- Fatigue
- Continuing education

Section Three

Technical Factors

Questions assess:

- Equipment performance
 - Detector problems
 - Software issues
 - Exposure selection
 - Equipment maintenance
 - PACS performance
 - Availability of imaging protocols
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Section Four

Organizational Factors

Questions evaluate:

- Staffing adequacy
 - Workload
 - Leadership support
 - Quality assurance programs
 - Continuing professional education
 - Departmental supervision
 - Workflow organization
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Section Five

Quality Improvement Strategies

Participants will evaluate potential interventions including:

- Staff training
 - Equipment replacement
 - Quality audits
 - Standardized imaging protocols
 - Continuing education
 - Performance feedback
 - Competency assessment
 - Image reject analysis programs
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Questionnaire Scale

A five-point Likert Scale will be used:

1 = Strongly Disagree

2 = Disagree

3 = Neutral

4 = Agree

5 = Strongly Agree

The Likert scale allows quantitative measurement of participant perceptions and facilitates statistical analysis.

Validity of the Instrument

Content validity will be established through expert review by specialists in radiology, healthcare quality management, and research methodology.

Experts will evaluate the questionnaire for clarity, relevance, comprehensiveness, and appropriateness.

Necessary revisions will be implemented before distributing the final questionnaire.

Construct validity will also be assessed by examining relationships among questionnaire domains using correlation analysis.

Reliability of the Instrument

Reliability will be assessed using **Cronbach's Alpha**.

A Cronbach's Alpha value of **0.70 or higher** will be considered acceptable for internal consistency.

Pilot testing may also be conducted using a small sample of radiologic technologists to identify ambiguities and improve questionnaire quality before full-scale data collection.

Data Collection Procedure

After obtaining ethical approval, the researcher will distribute the electronic questionnaire to eligible radiologic technologists across Saudi Arabia.

Participation will be voluntary.

Participants will receive information regarding the purpose of the study, confidentiality, anonymity, and informed consent.

Questionnaire responses will be collected electronically over approximately eight weeks.

Ethical Considerations

The study will comply with internationally accepted ethical principles for healthcare research.

Participation will be entirely voluntary.

Participants may withdraw from the study at any time without consequences.

No personal identifiers will be collected.

All collected information will remain confidential and will only be used for academic purposes.

Electronic data will be stored securely and accessed only by the researcher.

Ethical approval will be obtained from the appropriate Institutional Review Board (IRB) before commencing data collection.

Expected Outcomes

The findings of this study are expected to provide a comprehensive understanding of the factors associated with repeat radiographic examinations in radiology departments across Saudi Arabia. The study is anticipated to identify the most common technical, human, patient-related, and organizational factors contributing to repeated examinations. It is also expected to determine whether variables such as years of experience, workload, staffing levels, equipment performance, continuing education, and quality assurance programs significantly influence repeat examination rates.

Furthermore, the study is expected to demonstrate that effective quality improvement strategies, including regular competency assessments, standardized imaging protocols, continuous professional education, preventive maintenance of imaging equipment, and routine reject analysis, can significantly reduce repeat radiographic examinations. The findings may also provide hospital administrators and radiology managers with evidence-based recommendations for improving workflow, enhancing patient safety, minimizing unnecessary radiation exposure, and optimizing departmental performance.

Ultimately, the study aims to support healthcare organizations in achieving higher standards of diagnostic imaging quality while contributing to national healthcare quality initiatives and the objectives of Saudi Vision 2030.

Recommendations

Based on the expected findings and previous literature, the following recommendations are proposed:

1. Establish routine reject analysis programs in all radiology departments to continuously monitor repeat examination rates and identify areas requiring improvement.

2. Implement regular competency assessments and continuing professional development programs for radiologic technologists to enhance positioning skills, exposure selection, radiation safety, and communication with patients.
 3. Develop standardized radiographic examination protocols across healthcare institutions to reduce practice variation and improve image quality consistency.
 4. Strengthen quality assurance and quality control programs by conducting regular equipment calibration, preventive maintenance, and image quality audits.
 5. Improve staffing levels and workload distribution to reduce fatigue and minimize the likelihood of human error during radiographic examinations.
 6. Encourage a culture of patient safety by promoting teamwork, effective communication, incident reporting, and continuous quality improvement within radiology departments.
 7. Utilize reject analysis data as a key performance indicator for departmental quality management and accreditation activities.
 8. Conduct further multicenter studies involving different healthcare sectors to compare repeat examination rates and evaluate the effectiveness of quality improvement interventions over time.
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Conclusion

Repeat radiographic examinations remain an important challenge in diagnostic radiology despite the widespread implementation of digital imaging technologies. Repeated imaging not only increases unnecessary radiation exposure but also negatively affects departmental efficiency, healthcare costs, and patient satisfaction.

The literature indicates that repeat examinations result from a complex interaction between human, technical, patient-related, and organizational factors. Consequently, reducing repeat rates requires a comprehensive quality improvement approach rather than focusing solely on technical performance.

This study seeks to investigate these contributing factors within Saudi radiology departments and to provide evidence-based recommendations that support continuous quality improvement, patient safety, and healthcare excellence. The anticipated findings may assist radiology managers, healthcare policymakers, and quality improvement teams in implementing effective strategies to reduce repeat examinations and improve diagnostic imaging services throughout Saudi Arabia.

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