RESEARCH ARTICLE

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Improving Turnaround Times and Operational Efficiency in Radiology Services: Quality Improvement Study in Oman

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Abstract

Background: Turnaround time (TAT) in radiology reflects operational efficiency and impacts patient outcomes, particularly in time-sensitive fields like oncology, where timely diagnostics are essential for effective care. **Purpose:** This study aimed to evaluate the impact of targeted interventions on improving TAT and operational efficiency in radiology services in Oman. **Methods:** A pre- and post-intervention design was used to assess the effectiveness of implementing standardized operating procedures (SOPs), triage systems, staff training, and regular interdepartmental case discussions. Data were collected before and after the interventions to measure changes in TAT. Statistical analyses, including linear regression, were performed to assess trends in TAT performance over the intervention period. **Results:** The study observed a significant improvement in TAT, increasing from 88% in June 2023 to 95% in March 2024 ($p < 0.05$). A linear regression model demonstrated a steady monthly increase of 0.6% in TAT, with an R^2 value of 0.88, indicating that 88% of the variation in TAT was explained by the implemented interventions. **Conclusion:** The study confirms that structured workflow modifications, automation, and interdepartmental collaboration significantly enhance TAT and operational efficiency in radiology services, providing insights into sustainable healthcare improvements.

Keywords: Turnaround time- radiology efficiency- workflow optimization- automation- interdepartmental collaboration

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Introduction

Turnaround Time (TAT) in radiology refers to the period from when an imaging study is requested to the moment a final report is available to the requesting physician [1, 2]. It plays a critical role in healthcare delivery, reflecting not only operational efficiency but also the quality of care and patient outcomes. Timely access to diagnostic information is crucial, particularly in time-sensitive fields like oncology, where early diagnosis, treatment planning, and disease monitoring are key to improving patient survival and quality of life [2, 3].

In the context of oncology, delays in radiology reporting can have significant implications. Prolonged TAT can lead to treatment delays, resulting in disease progression, poorer patient outcomes, and increased patient anxiety. Rapid imaging processes are integral to enabling swift clinical decisions for cancer staging and response evaluations [3-5]. As demonstrated by Succi et al. [2], patients undergoing non-acute oncologic imaging often experience longer TATs compared to non-oncologic imaging in emergency settings, complicating their care pathways and delaying treatment initiation.

Improving TAT not only enhances clinical efficiency but also alleviates pressure on healthcare providers. Faster TAT can reduce hospital stays, streamline patient throughput, and support clinicians in making informed therapeutic decisions without unnecessary delays [6-8]. As highlighted by Rao et al. [3], interventions such as web-based workflow systems can significantly reduce TAT by automating radiology processes and integrating them into hospital information systems [3].

A reduction in TAT directly impacts operational efficiency and patient outcomes by ensuring that radiologists have the tools to prioritize urgent cases appropriately. Effective communication and coordination

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among clinical teams and radiology departments are essential for success. Interventions, such as automated systems, workflow managers, and comprehensive triaging, have been shown to improve efficiency in oncologic imaging workflows [7-10].

Many studies showed the significant improvement in oncology setting through conducting quality improvement initiatives that service patients, hospital, and staff [11-18]. The significance of this study lies in addressing these bottlenecks through a comprehensive quality improvement approach in Oman. Optimizing radiology workflows not only ensures timely access to care but also supports interdepartmental collaboration, improving overall operational efficiency. Successful interventions in TAT management are associated with better patient outcomes and enhanced staff satisfaction [2-7]

Improving turnaround time (TAT) in radiology requires a multi-faceted approach, starting with comprehensive staff training to ensure that all personnel understand the significance of TAT and workflow optimization [1, 2]. Training enhances efficiency by reducing miscommunication, procedural errors, and unnecessary delays. Regular education sessions on time management, imaging prioritization, and effective coordination among technologists, radiologists, and referring physicians can significantly improve process flow [7, 8]. Additionally, process optimization through regular case discussions fosters collaboration across departments, allowing teams to identify bottlenecks and implement solutions proactively. Streamlining operations through such discussions helps align radiology services with clinical needs, improving overall efficiency.

Another key strategy is triaging scans based on clinical urgency, which prioritizes critical cases and prevents backlogs. Implementing a structured triage system ensures that urgent cases receive immediate attention while maintaining efficiency for routine scans. Similarly, improving the completion of radiology requests minimizes errors and omissions, reducing the need for repeat imaging and unnecessary delays [7-9]. Developing a detailed policy for standardized operations further enhances consistency by establishing clear guidelines for imaging protocols, reporting timelines, and communication pathways. Together, these interventions create a structured and efficient radiology workflow, ultimately improving patient outcomes and satisfaction [10-13].

The purpose of this study is to investigate how targeted interventions can improve TAT and operational efficiency within radiology services in Oman. By identifying and addressing key workflow inefficiencies, the study aims to implement sustainable solutions that enhance service delivery, ensuring timely and accurate diagnostic support for oncology care.

Materials and Methods

Study Design

This study employed a quality improvement design focused on enhancing turnaround times (TAT) and operational efficiency within radiology services. The design emphasized identifying workflow inefficiencies, streamlining processes, and implementing targeted interventions, such as comprehensive staff training, triage protocols, and regular case discussions. A pre- and post-intervention approach was used, comparing data from before and after the interventions to assess their impact on TAT improvement.

Setting

The study was conducted in the radiology department of a healthcare facility in Oman, which provides essential diagnostic imaging services. The setting involved collaboration across multiple clinical departments, including radiology, nuclear medicine, and quality assurance. This collaborative approach ensured that all phases of the imaging workflow—from request submission to report generation—were covered, fostering a coordinated and comprehensive quality improvement initiative.

Process clarification

Figure 1 illustrates the step-by-step process for managing radiology requests within the Hospital Information System (HIS). The workflow begins with the treating physician initiating the request and completing the required form in the HIS. If the request requires specialist input, a consultation with a radiologist or nuclear medicine (NM) physician takes place. If no consultation is needed, the request proceeds directly to the review phase. At this stage, the justification for the examination is evaluated. If the justification is not approved, the request is placed on hold or canceled, and the treating physician is notified with recommendations for further action. The physician can then decide to cancel the request or submit a new one.

Once justification is approved, the request advances to scheduling within the HIS. The examination is performed as scheduled, and upon completion, a report is generated. The report is then made available for the treating physician, marking the final step in the process. This workflow ensures that radiology services are effectively managed through structured decision points, such as consultations, justification reviews, and proper scheduling, thereby minimizing delays and optimizing patient care.

Incident investigation and auditing results

Despite the implementation of Standard Operating Procedures (SOPs), audits often reveal variability in how staff follow standardized procedures, resulting in inconsistencies in turnaround times (TAT) and operational efficiency. Staff adherence appears to require continuous reinforcement to maintain consistency. Errors or missing clinical information in radiology requests persist as a common issue, even after training efforts. These gaps often lead to delays as follow-up queries or rework are needed to complete the requests properly.

Audits also uncover discrepancies in the application of triage protocols across departments, with some cases being incorrectly prioritized or downgraded, which can delay urgent care. While regular case discussions are planned, not all departments hold them consistently or address key operational bottlenecks, reducing the potential impact of these meetings on improving workflows.

Additionally, staff turnover and onboarding challenges create gaps in training, leaving new employees unaware of best practices. Some staff members also miss scheduled training sessions, further exacerbating these issues.

Communication breakdowns between departments, especially between radiology and other clinical units, are another frequent problem uncovered in audits. These barriers disrupt workflows and delay TAT, impacting coordination and overall efficiency.

Root cause analysis

Figure 2 identifies key factors contributing to delays and inefficiencies in turnaround times (TAT). The analysis highlights six primary areas: SOP adherence issues, errors in radiology requests, triage protocol issues, training and onboarding challenges, communication breakdowns, and operational bottlenecks. Variability in SOP compliance, incorrect or incomplete radiology requests, and discrepancies in triaging protocols across departments are notable sources of inefficiency. Additionally, staff turnover, missed training, and inadequate onboarding practices create further gaps in operational consistency. Poor communication between radiology and clinical units causes workflow disruptions, while irregular case discussions and ineffective meetings limit the opportunity for meaningful improvements. These interconnected issues collectively hinder the smooth operation of radiology services, impacting both efficiency and patient outcomes.

Interventions

Table 1 summarizes various interventions aimed at improving operational efficiency and ensuring timely radiological services. Each intervention targets specific areas, such as staff training, process optimization, triage implementation, and policy development. The table outlines the description of these interventions, the processes or people involved, and the methods applied, such as regular training sessions, workflow optimization, and the development of Standard Operating Procedures (SOPs). These interventions are developed based on process investigation and previous studies [15-30]

The interventions aimed at optimizing radiology workflows included structured training sessions, process modifications, and automation tools. Comprehensive staff training involved monthly sessions (2 hours each) for approximately 30 staff members, using case studies and workflow simulations. Regular case discussions, held weekly with around 15 participants, facilitated collaboration and urgent case prioritization using digital dashboards. A triage system was implemented by 15 radiology staff members, utilizing an automated clinical urgency scoring tool integrated into the hospital's Radiology Information System (RIS). To minimize errors in radiology requests, quarterly training sessions (1.5 hours each) were conducted for 20 staff members, incorporating digital checklists and automated validation within the Electronic Medical Record (EMR) system. Lastly, a standardized operations policy was developed, covering approximately 30 staff members, supported by workflow diagrams, digital integration, and mandatory

Table 1. Interventions to Optimize Radiology Workflow and Improve Turnaround Times (TAT)

Area	Intervention	Description	Target Process or People	Methods
Comprehensive Staff Training	Improve staff understanding of TAT importance and workflow optimization.	Staff training sessions were conducted, covering best practices in scheduling, reporting, and interdepartmental communication to equip team members with the necessary knowledge for efficient operations.	All staff involved in scheduling, reporting, and interdepartmental coordination.	Training sessions conducted focusing on best practices; frequency: monthly sessions.
Process Optimization through Regular Case Discussions	Streamline operations and foster communication across departments.	Regular meetings were introduced to review cases, prioritize urgent scans, and resolve workflow issues promptly, promoting collaboration and reducing operational delays.	Departments involved in case discussions and operational workflows.	Process modification through regular case discussions held weekly to prioritize urgent cases.
Triaging of Scans Based on Clinical Urgency	Ensure timely processing of urgent cases and avoid backlogs.	A triage system was implemented to prioritize scans based on clinical urgency, ensuring that high-priority cases were processed without unnecessary delays.	Radiology staff responsible for triaging and prioritizing cases.	Process modification via introduction of triage system for clinical prioritization (see figure 3)
Improving Completion of Radiology Requests	Minimize errors and omissions in radiology requests.	Targeted training was provided to staff involved in request submissions, focusing on including all necessary clinical information upfront to reduce follow-ups and expedite the request process.	Staff involved in submitting radiology requests.	Training sessions provided on request submission; held every quarter to minimize errors.
Development of a Detailed Policy for Standardized Operations	Enhance consistency and reduce variability in radiology workflows.	A comprehensive policy was developed, outlining SOPs for different workflow aspects to ensure standardized practices, improve consistency, and optimize TAT.	All personnel following SOPs across radiology workflows.	Development of detailed SOPs with workflow optimization to standardize operations.

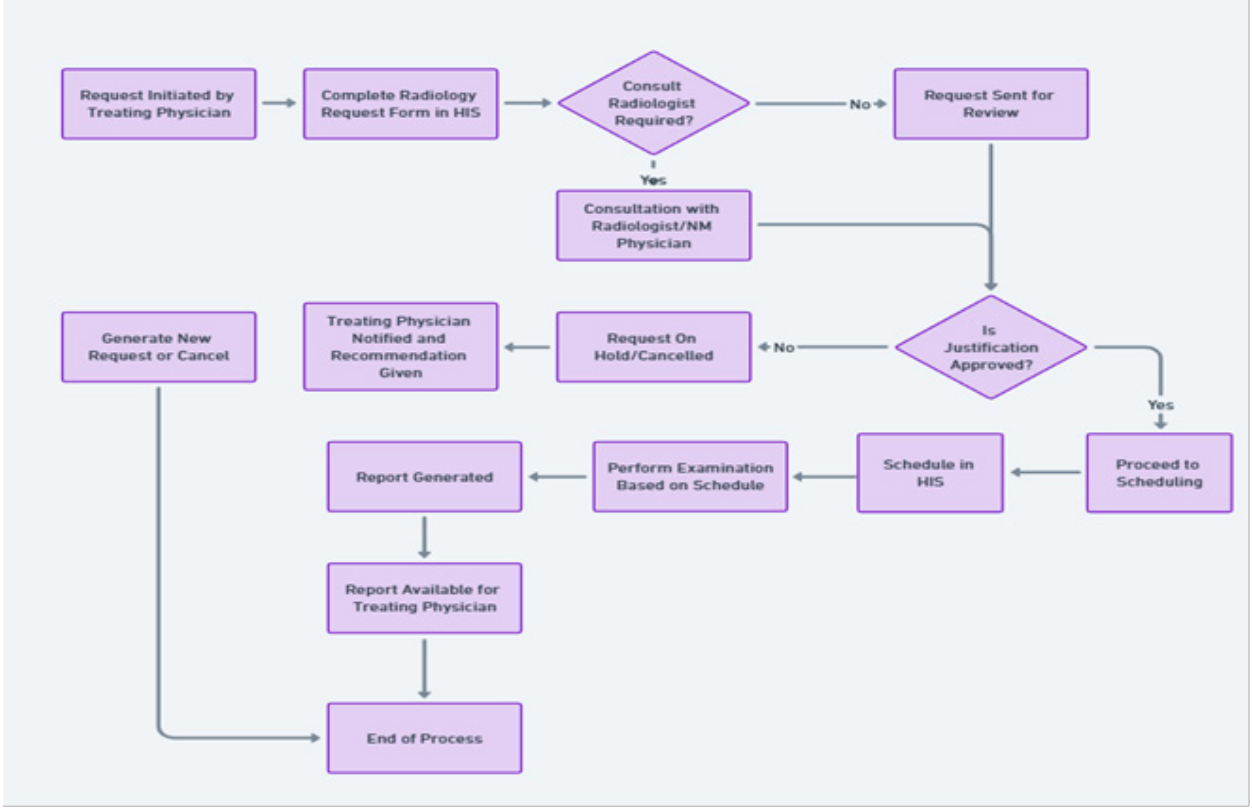

Figure 1. Radiology Request Workflow for Examination Processing

training for new employees (Figure 3).

Results

Figure 4 shows the progression of turnaround time (TAT) percentages from June 2023 to May 2024, highlighting the impact of implemented interventions. Initially, TAT percentages were lower, starting at 88% in June 2023, and fluctuating through the early months. However, following the introduction of interventions, there is a noticeable improvement beginning in September 2023, with a steady upward trend. By January 2024, the TAT reached around 93%, and subsequent months show consistent performance, peaking at 95% in March 2024.

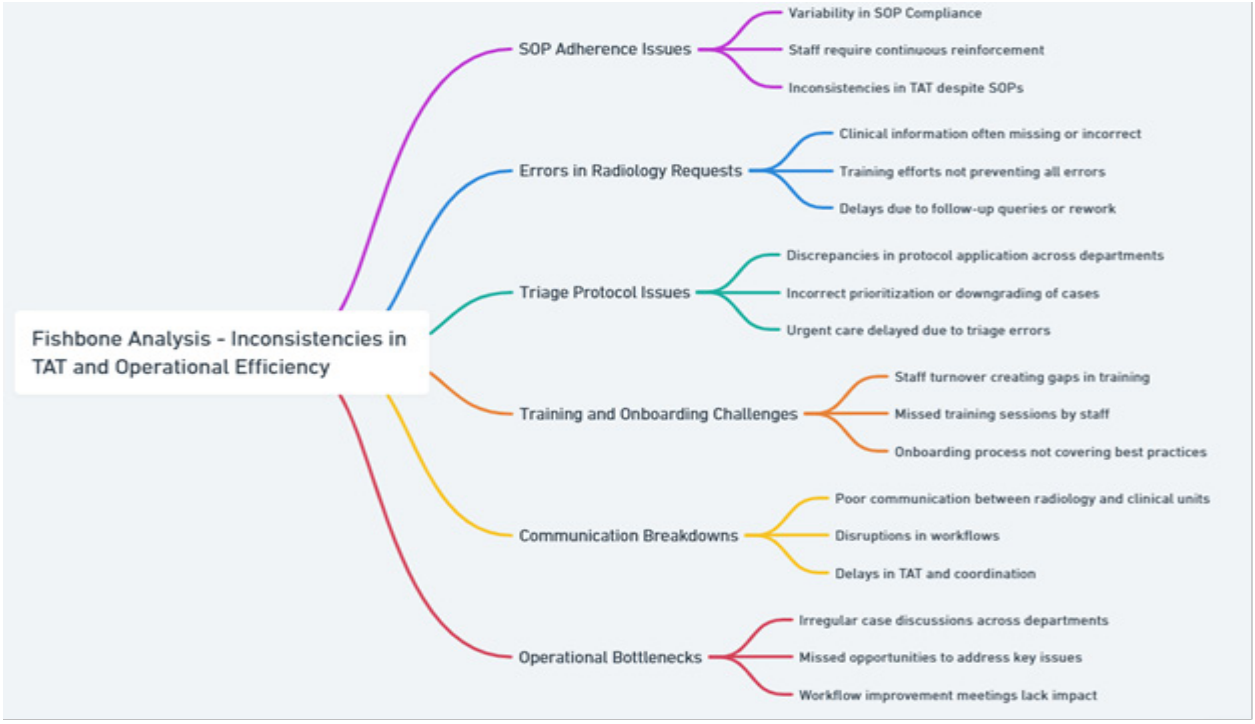

Figure 2. Fishbone Analysis - Inconsistencies in TAT and Operational Efficiency

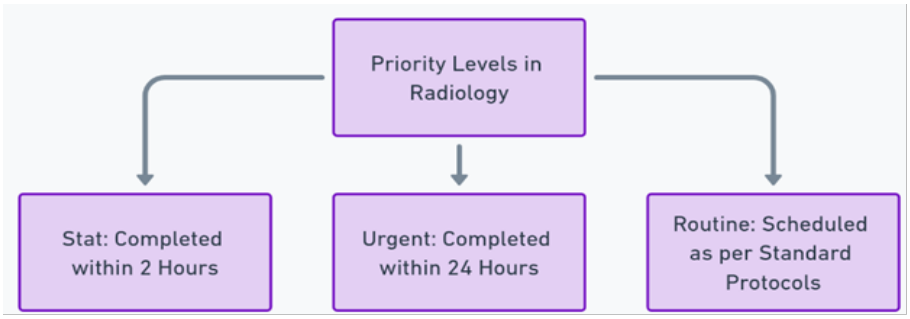

Figure 3. Priority Levels Workflow in Radiology Examination

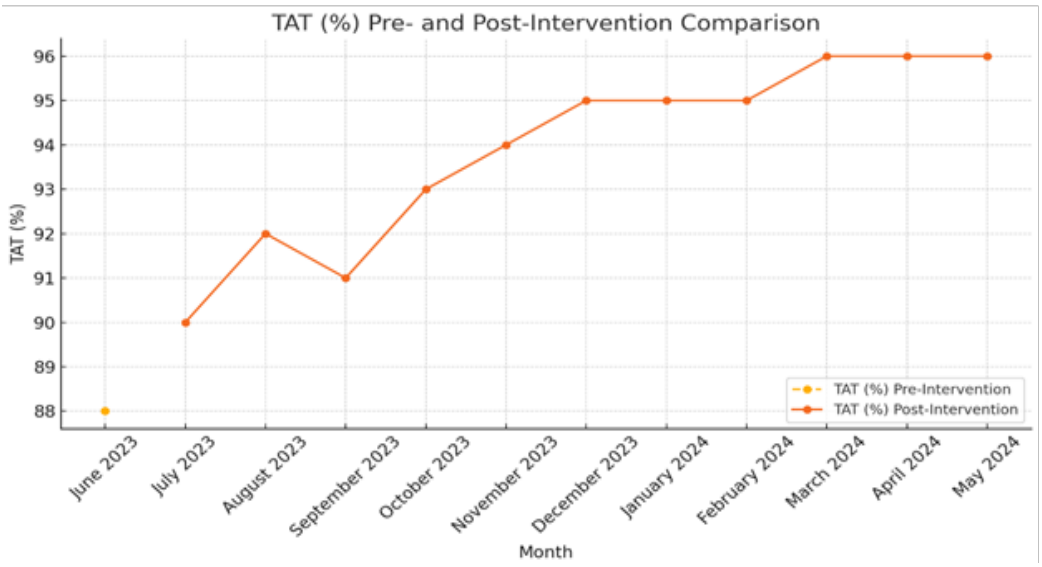

Figure 4. TAT (%) Pre- and Post-Intervention Comparison

This level of efficiency is sustained through April and May 2024, reflecting the success of the interventions in stabilizing and enhancing operational performance over time. The figure illustrates the effectiveness of process improvements in achieving higher and more consistent TAT percentages.

Figure 5, Linear Regression: TAT Trend with Model Statistics, shows the upward trend in TAT percentages over time, with a linear regression model fitted to the data points from July 2023 to May 2024. The regression line has a slope of 0.60, indicating that the TAT percentage increases by 0.6% each month on average. The intercept

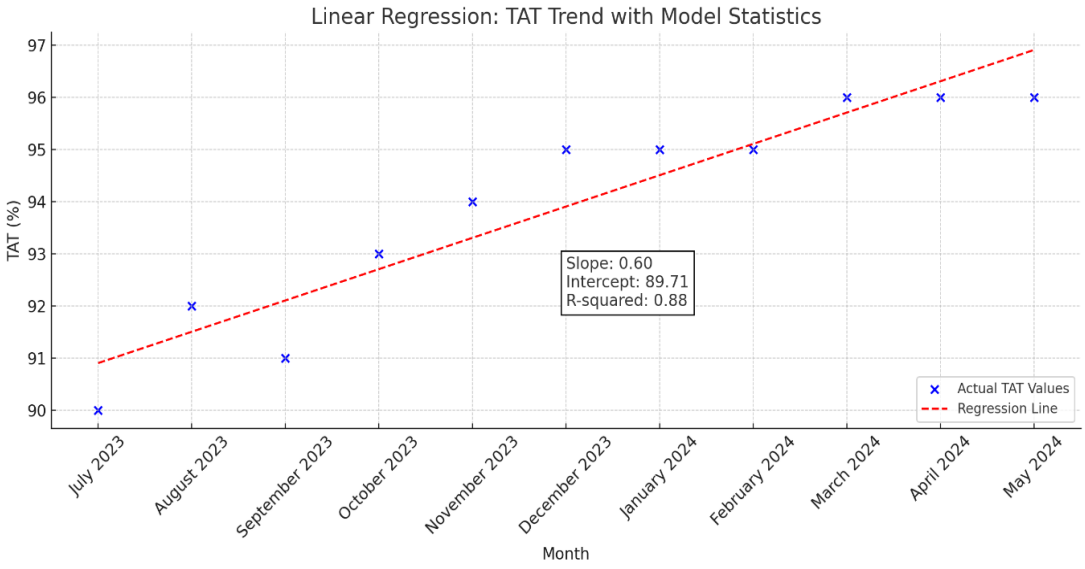

Figure 5, Linear Regression: TAT Trend with Model Statistics

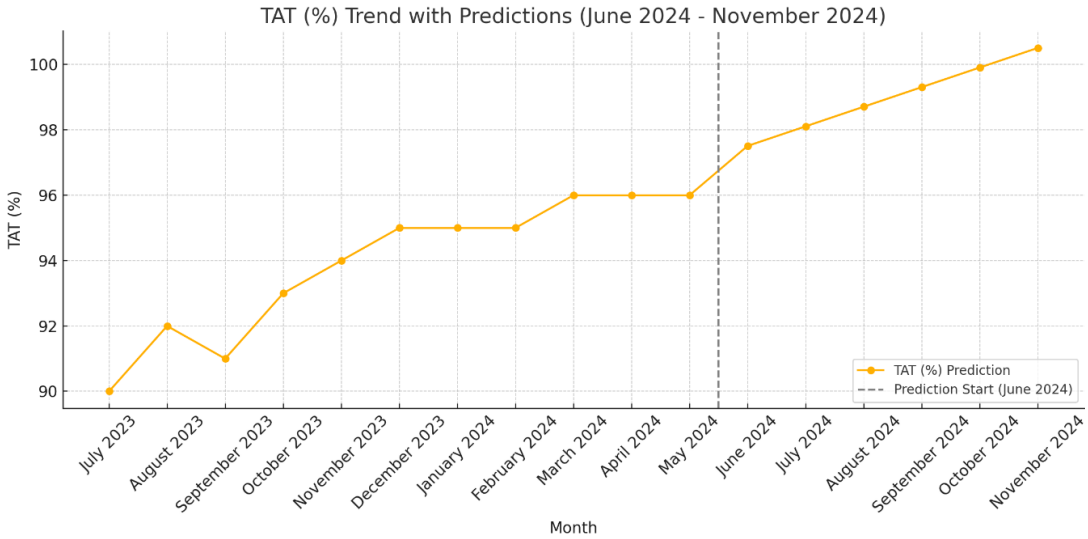

Figure 6. TAT (%) Trend with Predictions (June 2024 - November 2024)

of the model is 89.71%, which represents the starting TAT level when no additional time has passed. The R-squared value of 0.88 suggests that 88% of the variation in TAT percentages over this period can be explained by the linear model, demonstrating a strong fit and highlighting the consistency of improvements over time.

Figure 6 extends the trend line beyond the observed data to project future TAT values. From the prediction starting point in June 2024, the TAT is expected to continue increasing steadily, maintaining the upward trajectory. By November 2024, the TAT is forecasted to reach 100%, reflecting optimal turnaround performance if current trends and interventions persist. This predictive model provides a forward-looking perspective, emphasizing the importance of sustaining recent improvements to achieve consistent high-performance levels across radiology operations.

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Discussion

This study demonstrated the effectiveness of targeted interventions in improving turnaround time (TAT) and operational efficiency in radiology services. Timely diagnostic reporting is critical, especially in fields like oncology, where delayed imaging results can impact treatment decisions and patient outcomes [19, 20]. The quality improvement initiative in Oman highlights how workflow optimization, automated triaging, and enhanced interdepartmental communication collectively contribute to more efficient and reliable healthcare delivery. This aligns with broader frameworks of patient-centered care, where streamlined processes not only improve efficiency but also enhance patient satisfaction by ensuring faster access to diagnostic results [21, 22]. Additionally, e-health solutions have played a significant role in enhancing healthcare delivery, particularly during crises like the COVID-19 outbreak, by improving control and management through real-time data access, remote diagnostics, and better coordination between healthcare teams [22].

A key outcome was the steady improvement in TAT performance following the implementation of structured interventions. Standardized operating procedures (SOPs) and regular case discussions helped reduce bottlenecks and ensured high-priority cases were processed efficiently [1, 23]. The implementation of a triage system based on clinical urgency allowed radiologists to prioritize critical cases, preventing delays in urgent care. These workflow modifications demonstrated how systematic approaches to radiology management can enhance both efficiency and consistency [24]. Additionally, lean management principles, such as eliminating inefficiencies and reducing process variation, have been effective in improving quality of service and time management [24, 25]. Applying these principles to radiology could further optimize workflows and reduce unnecessary delays [24-26].

Automation played a pivotal role in optimizing radiology operations. Automated triaging systems reduced radiologists' workloads, minimized manual errors, and ensured systematic prioritization of cases [27-29]. As healthcare demands increase, automation not only improves workflow efficiency but also reduces burnout among healthcare providers by handling repetitive administrative tasks [30-32]. AI-powered workflows have also been shown to enhance radiology efficiency, particularly in report generation and scan prioritization [33-35]. The implications of artificial intelligence (AI) in healthcare services extend beyond automation, with AI being instrumental in predictive analytics and real-time decision support, reducing cognitive overload among radiologists and enhancing diagnostic accuracy

[36, 37]. AI-driven tools can further optimize workflow efficiency by automatically flagging critical cases, assisting in anomaly detection, and generating preliminary radiology reports [29-33]. Additionally, the use of electronic collaborative tools has been shown to enhance team effectiveness in hospitals, fostering improved communication, data-sharing, and decision-making in radiology and other diagnostic services [37-38].

Interdepartmental collaboration was another critical success factor. Effective communication between radiology and clinical teams facilitated smooth transitions between imaging, diagnosis, and treatment planning [39]. Regular interdisciplinary meetings and discussions helped address operational bottlenecks promptly, ensuring that imaging results were available without unnecessary delays [40]. These collaborative efforts reinforce the importance of teamwork in delivering timely and effective patient care [41].

Beyond efficiency, a patient-centered approach in radiology services ensures that patients receive timely results and better communication regarding their diagnostic procedures. A comprehensive evaluation of patient-centered care in oncology settings revealed that efficiency in diagnostic services significantly impacts patient satisfaction and engagement [21, 22]. In radiology, patient-centered improvements could include real-time updates on scan status, reduced waiting times, and clearer communication of results. Moreover, the effectiveness of shared governance councils in nursing practice has been shown to enhance professional work environments, encourage participatory decision-making, and improve patient care quality [39-43]. Implementing similar governance structures in radiology could foster better workflow management and service efficiency.

Implementing workflow optimization strategies must also consider the impact on healthcare professionals' well-being. Studies have shown that innovation practices are correlated with occupational fatigue in healthcare settings, particularly in high-demand environments such as radiology [44]. Excessive workload, lack of automation, and inefficient processes contribute to burnout among radiologists and technologists, potentially affecting diagnostic accuracy and increasing the risk of errors. Ensuring a balanced workload through strategic automation, task redistribution, and flexible scheduling can mitigate fatigue and improve both efficiency and employee satisfaction [44-47]. Emotional intelligence (EI) also plays a crucial role in radiology and oncology settings, particularly in reducing stress and enhancing leadership effectiveness and patient care outcomes [41-42]. Radiologists and technologists equipped with high EI skills are better able to manage high-pressure environments, communicate effectively, and adapt to workflow changes [48-51].

Additionally, organizational citizenship behavior (OCB) has been identified as a key driver of healthcare efficiency and quality [40, 50]. A culture of proactive engagement, teamwork, and voluntary efforts to improve processes can significantly contribute to TAT improvements by fostering a workplace culture that prioritizes patient care and efficiency. Encouraging radiology staff to participate in quality improvement initiatives and share innovative solutions can further optimize workflow efficiency and enhance diagnostic services [39-42].

Patient satisfaction is strongly influenced by their understanding of diagnostic procedures and test results. Studies in oncology settings highlight the importance of health literacy and learning needs assessments in improving the patient experience [51, 52]. In radiology, this translates to educating patients about the purpose, process, and expected outcomes of imaging studies. Machine learning approaches have been utilized to predict and classify patients' perceptions of learning needs in cancer care, emphasizing the necessity of personalized education strategies to enhance engagement and satisfaction [51, 52]. Providing patients with accessible and comprehensible imaging reports, integrating visual aids, and implementing digital patient portals can enhance health literacy and reduce anxiety associated with diagnostic uncertainties.

Limitations

While the study achieved positive outcomes within the specific context of Oman, the tailored nature of interventions might not yield similar results in different healthcare environments with varying infrastructure or workflows. Maintaining operational efficiency over time requires continuous staff engagement and monitoring. Without consistent reinforcement, improvements may regress due to staff turnover or lapses in compliance.

Recommendations

Ongoing training is crucial to ensure that staff remain competent and engaged. Case studies from other healthcare systems can provide practical insights, enhancing staff motivation and improving their understanding of best practices. Integrating AI-based triaging and reporting systems can further enhance workflow efficiency and reduce the cognitive burden on radiologists. Automation can streamline routine tasks, allowing healthcare providers to focus on critical cases

In conclusion, this study highlights the importance of optimizing radiology workflows to improve turnaround times and operational efficiency. By implementing structured interventions such as standardized protocols, automated systems, and enhanced communication, the study demonstrated positive trends in diagnostic service delivery. While challenges related to sustainability and generalizability persist, the findings underscore the need for continuous monitoring and engagement to maintain performance. Future studies should explore the potential of AI integration in radiology services to further enhance service quality and operational outcomes.

Author Contribution Statement

All authors contributed significantly to the study. Project Leader and Coordinator: Badriya Al Qassabi, Omar Ayaad. Data Collection and Analysis: Shima Alajmi, Ahmed Sheikh Omar, Aed Abdelqader Banibak. Study Supervisor: Rashid AlSukaiti, Khalid Al-Baimani. Project Implementation: Badriya Al Qassabi, Rashid AlSukaiti,

Shima Alajmi , Ahmed Sheikh Omar. Writing Manuscript: Omar Ayaad, Rawan Ibrahim, Nasr Al-Riyami. Manuscript Review: Aref Zribi, Salim Nasser AlDhahli, Mohamad Majed, Mashan Mohammed AlGhaithi, Nabiha Said AlHasni, Sara Al Sheedi, Huda Shinoon Al-Awaisi.

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Data Availability

The datasets generated during the study are available from the corresponding author upon reasonable request, following institutional guidelines and ethical standards.

Scientific Approval

The study proposal underwent review and approval by the research committee at the Sultan Qaboos Comprehensive Cancer Care and Research Centre (SQCCCRC) in Muscat, Oman.

Ethical Declaration

Institutional Review Board (IRB) approval for conducting and publishing the project was obtained from the research office at the Sultan Qaboos Comprehensive Cancer Care and Research Centre (SQCCCRC) in Muscat, Oman with approval reference number CCCRC-116-2024.

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Conflict of Interest

The authors declare no conflict of interest in the conduct and publication of this research.

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