

EVALUATION OF TURNAROUND TIME (TAT) OF CLINICAL LABORATORY EXAMINATIONS BASED ON REQUEST TIME AND RESULTS AS AN INDICATOR OF THE EFFICIENCY OF DIAGNOSTIC SERVICES AT ROYAL PRIMA HOSPITAL IN MEDAN

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Abstract

Turnaround Time (TAT) is an important indicator for assessing the efficiency and quality of clinical laboratory diagnostic services because timely laboratory results support rapid clinical decision-making. This study aimed to evaluate the Turnaround Time (TAT) of clinical laboratory examinations as an indicator of diagnostic service efficiency at RSU Royal Prima Medan. A quantitative descriptive evaluative study with a retrospective approach was conducted using secondary data from the laboratory information system for the period March–May 2026. Samples were selected using systematic random sampling from laboratory examination records that met the inclusion criteria. Data were analyzed descriptively by assessing the mean, median, and proportion of examinations meeting the established hospital standard, as well as comparing TAT across service units. The results showed that the mean TAT was 151.13 minutes in the emergency department, 161.29 minutes in inpatient services, and 187.05 minutes in outpatient services. Based on the hospital standard of ≤ 120 minutes, only 11.2% of examinations met the standard, while 88.8% did not. The emergency department demonstrated the highest compliance at 17.5%, followed by outpatient services at 9.8%, while no inpatient examinations met the standard. Overall, TAT performance had not met the established standard, indicating the need for workflow optimization to improve diagnostic service efficiency and timeliness.

Keywords: Clinical Laboratory; Diagnostic Service Efficiency; Laboratory Service; Turnaround Time; TAT.

INTRODUCTION

Clinical laboratory services are an essential component of modern hospital care because laboratory findings provide objective information for diagnosis, disease monitoring, treatment planning, and clinical decision-making. The increasing complexity of hospital services requires clinical laboratories to provide not only accurate results but also timely and reliable diagnostic information. Laboratory performance therefore needs to be assessed from both analytical quality and service timeliness perspectives, particularly because delays in obtaining laboratory results may affect subsequent clinical management (Alain et al., 2021; Dawande, 2022). The laboratory is consequently not merely a supporting unit but an integral component of the clinical care system, in which the speed and reliability of test results may influence the effectiveness and efficiency of patient management. One of the most important indicators for assessing the performance of clinical laboratory services is Turnaround Time (TAT). TAT refers to the interval between the request for a laboratory examination and the availability of the examination result for clinical use. This indicator reflects the responsiveness of laboratory services and provides an important measure of operational efficiency because prolonged TAT may indicate problems within the laboratory workflow, coordination between service units, or the utilization of human resources and technology (Alawad, 2025; Dawande, 2022). In this context, TAT should not be understood simply as a measure of speed, but as an indicator of the overall effectiveness of an integrated diagnostic service.

EVALUATION OF TURNAROUND TIME (TAT) OF CLINICAL LABORATORY EXAMINATIONS BASED ON REQUEST TIME AND RESULTS AS AN INDICATOR OF THE EFFICIENCY OF DIAGNOSTIC SERVICES AT ROYAL PRIMA HOSPITAL IN MEDAN

R. Raje Telegem et al

The timeliness of laboratory results is particularly important because diagnostic information is frequently required to confirm or exclude diagnoses, determine treatment strategies, evaluate disease progression, and support emergency clinical decisions. Delayed laboratory results can interrupt clinical workflows and potentially prolong patient management, particularly when physicians require laboratory information before initiating or modifying treatment. Evidence has demonstrated that shorter laboratory TAT is associated with shorter emergency department length of stay, indicating that laboratory efficiency may have consequences beyond the laboratory itself (Vrijzen, 2022). Similarly, delays in laboratory testing have been associated with challenges in clinical decision-making and patient management (Alanazi, 2024).

The urgency of improving TAT is also related to the quality of healthcare services. Quality in healthcare encompasses effectiveness, safety, efficiency, patient-centeredness, and timeliness. Within laboratory services, timely reporting is particularly important because an accurate result that is delivered too late may have reduced clinical usefulness. Laboratory service quality is therefore closely related to the ability of laboratories to produce reliable diagnostic information within an appropriate period (Sadaria et al., 2025). Furthermore, the role of laboratory testing extends across different areas of clinical care, including prevention, diagnosis, and management of chronic diseases, emphasizing the importance of maintaining an effective and responsive laboratory service (Cabalar, 2024). TAT is influenced by a complex sequence of processes that generally includes the pre-analytical, analytical, and post-analytical phases. The pre-analytical phase involves test ordering, patient identification, specimen collection, and specimen transportation; the analytical phase involves examination and processing of specimens; while the post-analytical phase includes result validation and reporting. Delays at any of these stages may contribute to prolonged total TAT. In particular, workflow complexity, specimen transportation, workload, equipment capacity, and communication between service units can become important sources of delay (Cherie, 2024). Consequently, evaluating total TAT is important not only for measuring whether a laboratory meets its target but also for identifying broader operational problems within the diagnostic service.

Technological development provides opportunities to improve laboratory efficiency, particularly through automation, laboratory information systems, and digital integration. Automation and informatics have been reported to improve laboratory quality and operational performance by reducing manual processes and facilitating the movement of information throughout the laboratory workflow (Karnchanaphiboonwong et al., 2023). Similarly, the integration of laboratory information systems and digital technologies can support monitoring of laboratory processes and facilitate the identification of delays. Recent evidence suggests that combining digital monitoring with Lean Six Sigma approaches can reduce intra-laboratory TAT and improve process efficiency (Cai, 2025). Thus, the evaluation of TAT should be considered within the broader context of hospital information systems, workflow management, and quality improvement.

From a hospital administration perspective, TAT is closely related to operational efficiency. Inefficient processes may result in prolonged waiting times, accumulation of specimens, repeated activities, and ineffective utilization of human and technological resources. Lean management has therefore been increasingly applied to healthcare services to eliminate activities that do not add value and to improve patient flow and service efficiency (Djawa & Oktamianti, 2023). Evidence from hospital settings also indicates that Lean approaches may contribute to improvements in service efficiency and reductions in unnecessary delays (Sari et al., 2023). In laboratory settings, workflow optimization is particularly relevant because delays may occur through the interaction of several units rather than from the analytical process alone (Febrian et al., 2024).

Previous studies have also demonstrated that systematic improvement of laboratory workflow can reduce TAT. A systematic review of Lean methodology in clinical laboratory settings found that process improvement interventions can contribute to better laboratory turnaround performance (Cherie, 2024). Likewise, Lean Six Sigma interventions have been applied to specific laboratory tests, including cardiac troponin testing, to reduce turnaround time and improve process performance (Vasani et al., 2023). These findings suggest that TAT can function not only as a descriptive indicator but also as a practical quality-improvement measure for identifying areas where laboratory processes require intervention.

The consequences of prolonged diagnostic waiting time may extend to broader hospital performance. Delays in laboratory results can contribute to delayed clinical decisions and may increase the time required for patient management. In hospital administration, this issue is relevant because prolonged service processes may contribute to inefficient utilization of beds, personnel, facilities, and other resources. Research concerning Lean implementation in hospitals has demonstrated its potential contribution to improving efficiency and patient outcomes (Althagafi,

EVALUATION OF TURNAROUND TIME (TAT) OF CLINICAL LABORATORY EXAMINATIONS BASED ON REQUEST TIME AND RESULTS AS AN INDICATOR OF THE EFFICIENCY OF DIAGNOSTIC SERVICES AT ROYAL PRIMA HOSPITAL IN MEDAN

R. Raje Telegem et al

2024). Similarly, studies of Lean Hospital implementation have examined its relationship with hospital length of stay, demonstrating the relevance of process efficiency to broader hospital performance (Elawati & Pujiyanto, 2022). The importance of TAT evaluation is particularly evident in laboratories serving multiple hospital units. Emergency departments, outpatient clinics, and inpatient units have different clinical demands and workflow characteristics. Emergency services generally require faster results because clinical decisions may be time-sensitive, whereas outpatient and inpatient services may experience different patterns of specimen collection, transportation, and workload. Differences in service characteristics may therefore produce differences in TAT performance among hospital units. Studies of outpatient laboratory services have identified specific strategies for reducing TAT, demonstrating that service-unit characteristics need to be considered when evaluating laboratory performance (Lee, 2022).

At RSU Royal Prima Medan, the evaluation of TAT is important because the laboratory serves different clinical units and its performance directly supports diagnostic services throughout the hospital. The present thesis evaluates TAT based on the interval between laboratory request and availability of results, using retrospective data obtained from the Laboratory Information System for the period March to May 2026. The study included laboratory examinations from the emergency department, outpatient clinic, and inpatient unit and evaluated the mean, median, distribution, and proportion of examinations that met the hospital's TAT standard. The study design and data source are consistent with the thesis methodology, which uses a quantitative descriptive-evaluative retrospective approach. The preliminary findings indicate a substantial gap between actual laboratory performance and the TAT standard established by RSU Royal Prima Medan. The mean TAT was 151.13 minutes in the emergency department, 161.29 minutes in inpatient services, and 187.05 minutes in outpatient services. Against the hospital standard of ≤ 120 minutes, only 11.2% of the 98 examinations analyzed met the target, while 88.8% exceeded the established standard. The emergency department showed the highest compliance at 17.5%, followed by the outpatient clinic at 9.8%, whereas none of the inpatient examinations met the standard. These findings demonstrate that the problem is not limited to isolated delays but represents a broader challenge in achieving timely diagnostic services.

The low level of compliance provides a strong rationale for evaluating TAT as an indicator of diagnostic service efficiency at RSU Royal Prima Medan. The finding that almost nine out of ten examinations exceeded the hospital's target indicates the need for systematic assessment of laboratory workflows and coordination among service units. The thesis findings further suggest that management should conduct periodic evaluation of specimen reception and processing, particularly in inpatient and outpatient services, strengthen adherence to standard operating procedures, improve specimen distribution, and enhance coordination between laboratory personnel and clinical units. Accordingly, this study is important from both scientific and managerial perspectives. Scientifically, it contributes evidence regarding the use of TAT as an indicator of laboratory diagnostic service efficiency in a hospital setting. From a managerial perspective, the results can provide an objective basis for identifying performance gaps and developing strategies to improve laboratory workflow, coordination, resource utilization, and service timeliness. The use of TAT as a measurable performance indicator also supports continuous quality improvement because laboratory managers can compare actual performance with predetermined standards and identify areas requiring corrective action (Munir, 2024; Wang, 2025).

The problem-solving approach in this study is therefore centered on systematic measurement and evaluation of laboratory TAT across hospital service units. Rather than focusing only on the overall average, the study compares TAT performance between emergency, outpatient, and inpatient services and assesses the proportion of examinations that meet the established ≤ 120 -minute standard. This approach enables hospital management to identify differences in performance and establish priorities for subsequent workflow improvement. Continuous monitoring of test-result timeliness can further strengthen laboratory quality management and provide evidence for targeted interventions (Sadaria et al., 2025). Based on these considerations, the objective of this study is to evaluate the Turnaround Time of clinical laboratory examinations from the time of laboratory request to the availability of results as an indicator of diagnostic service efficiency at RSU Royal Prima Medan. Specifically, the study aims to measure TAT, compare TAT across hospital service units, assess compliance with the hospital's TAT standard, and evaluate diagnostic service efficiency based on TAT achievement. The results are expected to provide evidence-based information for hospital management and the clinical laboratory in optimizing workflow, improving coordination, and strengthening the quality and timeliness of diagnostic services. The need for such evaluation is reinforced by the study's finding that overall, TAT performance has not yet achieved the established hospital standard.

EVALUATION OF TURNAROUND TIME (TAT) OF CLINICAL LABORATORY EXAMINATIONS BASED ON REQUEST TIME AND RESULTS AS AN INDICATOR OF THE EFFICIENCY OF DIAGNOSTIC SERVICES AT ROYAL PRIMA HOSPITAL IN MEDAN

R. Raje Telegem et al

LITERATURE REVIEW

1. Turnaround Time as an Indicator of Clinical Laboratory Service Efficiency

Turnaround Time (TAT) is an important performance indicator in clinical laboratory services because it measures the time interval between the request for a laboratory examination and the availability of the examination result for clinical decision-making. TAT therefore reflects not only the speed of laboratory testing but also the effectiveness of coordination between clinical units and laboratory services. Dawande et al. (2022) describe TAT as an efficacy measure for medical laboratories, while Cherie et al. (2024) emphasize that TAT can be used as an important indicator of laboratory service quality and operational efficiency. The literature in the thesis similarly establishes that TAT represents an integrated process extending from examination request to result reporting.

The importance of TAT is closely related to the clinical consequences of delayed laboratory results. Timely laboratory information enables healthcare professionals to make faster diagnostic and therapeutic decisions, particularly in emergency situations. Vrijns et al. (2022) demonstrated that shorter laboratory TAT was associated with shorter emergency department length of stay, suggesting that laboratory performance may influence hospital-level service efficiency. Alanazi et al. (2024) further examined the relationship between laboratory TAT, clinical decision-making, and patient outcomes. Thus, TAT should be viewed as more than an internal laboratory performance measure; it represents an important component of the overall patient-care process.

2. Components and Determinants of Laboratory Turnaround Time

TAT consists of interconnected stages, generally involving pre-analytical, analytical, and post-analytical processes. The pre-analytical stage includes examination ordering, patient identification, specimen collection, and specimen transportation; the analytical stage concerns examination and processing; while the post-analytical stage includes validation and reporting of results. Delays occurring at any stage can increase total TAT. Cherie et al. (2024) emphasize that improvement in TAT requires consideration of the complete laboratory workflow rather than concentrating exclusively on the analytical process.

The literature also indicates that TAT may be influenced by workload, workflow design, specimen transportation, equipment availability, information systems, human resources, and communication between clinical units and laboratories. Alain et al. (2021), for example, evaluated laboratory TAT in a tertiary hospital and demonstrated the relevance of assessing laboratory turnaround performance in actual clinical settings. Similarly, Alawad et al. (2025) specifically analyzed TAT in clinical laboratory testing, reinforcing the importance of systematic measurement of laboratory processing time.

3. Laboratory Information Systems, Automation, and Digital Integration

Technological development has changed the way clinical laboratories manage examination processes and information. Laboratory information systems can support the recording of examination requests, specimen processing, result validation, and reporting, thereby facilitating monitoring of TAT. Karnchanaphiboonwong et al. (2023) reported the role of innovation, automation, and informatics in improving laboratory quality. Park et al. (2023) likewise examined the use of a novel middleware-laboratory information system solution to improve outpatient clinical chemistry testing. More recently, digital technologies have been combined with process-improvement approaches to strengthen laboratory efficiency. Cai et al. (2025) investigated the integration of digital shadow and Lean Six Sigma for real-time monitoring and reduction of intra-laboratory TAT. These findings suggest that information technology can provide more than simple data recording; it can become a mechanism for identifying bottlenecks and monitoring performance continuously.

4. Lean Management and Laboratory Workflow Optimization

Lean Management provides an important theoretical and operational framework for understanding service efficiency. The central principle of Lean is the elimination of activities that do not provide value to patients while improving the flow of value-adding activities. In healthcare, Lean approaches have been applied to reduce waiting times, eliminate unnecessary processes, improve patient flow, and optimize resource utilization. Djawa and Oktamianti (2023) reviewed the application of Lean Management in improving patient service time, while Sari et al. (2023) examined Lean Management as a strategy for improving service efficiency in Indonesian hospitals. The application of Lean principles is also relevant to laboratory services because TAT is strongly influenced by process flow. Cherie et al. (2024), through a systematic review, identified the potential of Lean methodology to improve laboratory turnaround times. Febrian et al. (2024) similarly emphasized workflow optimization as an approach for maximizing laboratory TAT efficiency, particularly in settings with resource limitations. These studies support the use of workflow evaluation as an important strategy for addressing prolonged laboratory turnaround. Lean Six Sigma provides a more structured approach by combining process improvement with variation reduction. Vasani et al.

EVALUATION OF TURNAROUND TIME (TAT) OF CLINICAL LABORATORY EXAMINATIONS BASED ON REQUEST TIME AND RESULTS AS AN INDICATOR OF THE EFFICIENCY OF DIAGNOSTIC SERVICES AT ROYAL PRIMA HOSPITAL IN MEDAN

R. Raje Telegem et al

(2023) demonstrated the application of Lean Six Sigma to reduce cardiac troponin TAT in a core laboratory, while Munir (2024) examined error-free testing interventions through Six Sigma methodology for hematology laboratory TAT. These studies indicate that reducing TAT requires not only increasing speed but also controlling errors and variation within the laboratory process.

5. TAT and Broader Hospital Efficiency

Laboratory efficiency should also be understood within the broader context of health-system and hospital efficiency. Mbau et al. (2023) emphasized that health-system efficiency is influenced by the effective use of available resources to achieve desired health outcomes. In hospitals, delays in one service component can potentially affect subsequent processes. Consequently, laboratory TAT may have implications for patient flow, treatment decisions, length of stay, and utilization of hospital resources. Evidence regarding Lean implementation in hospitals further supports this relationship. Althagafi et al. (2024) examined Lean Management implementation in relation to patient outcomes, while Elawati and Pujiyanto (2022) reviewed the effect of Lean Hospital implementation on length of stay. Wang et al. (2025) subsequently synthesized evidence regarding Lean implementation and its effects on efficiency, quality, cost, and satisfaction. Collectively, these studies indicate that operational efficiency should be approached as an interconnected system rather than as isolated departmental performance.

6. TAT Standards and Service Quality

TAT standards provide a benchmark against which actual laboratory performance can be evaluated. The appropriate target may differ according to the type of examination, urgency of the request, clinical unit, and organizational policy. The thesis establishes a hospital standard of ≤ 120 minutes for the laboratory examinations evaluated. The importance of comparing actual TAT with a predetermined standard is that average TAT alone cannot determine whether the service has achieved the expected performance level. Sadaria et al. (2025) specifically examined test-result timeliness as a laboratory service quality indicator, supporting the use of timeliness as an explicit quality dimension. Kamil et al. (2025) also investigated laboratory waiting time in clinical chemistry services, demonstrating the continuing relevance of laboratory waiting-time evaluation in the Indonesian context. These studies strengthen the argument that laboratory TAT should be systematically monitored as part of quality assurance.

7. Previous Empirical Studies and Research Gap

Previous studies have established that TAT is an important indicator of laboratory performance and that prolonged TAT may affect clinical decision-making and hospital efficiency (Dawande et al., 2022; Alanazi et al., 2024). Other studies have focused on interventions, including Lean Management, Lean Six Sigma, automation, informatics, and workflow redesign (Cherie et al., 2024; Vasani et al., 2023; Karnchanaphiboonwong et al., 2023; Cai et al., 2025). Research has also examined TAT in particular laboratory tests or particular service settings, such as outpatient laboratories and emergency departments (Lee et al., 2022; Vrijnsen et al., 2022). The empirical importance of this gap is supported by the findings of the present thesis. Among 98 laboratory examinations, only 11 examinations (11.2%) met the ≤ 120 -minute standard, whereas 87 examinations (88.8%) exceeded the standard. The proportion meeting the standard was 17.5% in the emergency department, 9.8% in the outpatient clinic, and 0% in inpatient services. These findings indicate that the problem is substantial and varies across service units, providing a specific contribution beyond the general observation that laboratory TAT can be delayed.

8. Conceptual Synthesis

Based on the reviewed literature, TAT can be conceptualized as an outcome of an interconnected laboratory service process. The request for examination initiates a sequence involving specimen collection, transportation, laboratory processing, validation, and reporting. The efficiency of this sequence is influenced by workflow organization, human resources, equipment, information systems, communication, and coordination between laboratory and clinical units. Lean Management, Six Sigma, automation, and laboratory information systems provide potential mechanisms for improving these processes (Cherie et al., 2024; Cai et al., 2025; Munir, 2024). Accordingly, the present study positions TAT as the principal indicator of diagnostic service efficiency at RSU Royal Prima Medan. The study contributes by providing empirical evidence regarding actual TAT performance, identifying differences between service units, and determining compliance with the hospital's ≤ 120 -minute standard. The resulting evidence can serve as a foundation for subsequent improvement of laboratory workflows, coordination, and service quality. This is consistent with the thesis recommendation that future evaluation should further examine the pre-analytical, analytical, and post-analytical stages and investigate factors such as workload, infrastructure, and human-resource qualifications.

EVALUATION OF TURNAROUND TIME (TAT) OF CLINICAL LABORATORY EXAMINATIONS BASED ON REQUEST TIME AND RESULTS AS AN INDICATOR OF THE EFFICIENCY OF DIAGNOSTIC SERVICES AT ROYAL PRIMA HOSPITAL IN MEDAN

R. Raje Telegem et al

METHOD

This study used a quantitative descriptive observational design with a retrospective approach to evaluate the Turnaround Time (TAT) of clinical laboratory examinations at RSU Royal Prima Medan. The study focused on measuring the time required from the submission of a laboratory examination request until the examination result became available. This design was selected because the objective of the study was to describe the actual performance of laboratory services and determine the extent to which laboratory examinations complied with the established TAT standard. The study was conducted in the Clinical Laboratory of RSU Royal Prima Medan. The population consisted of laboratory examination records originating from hospital clinical service units during the study period. The study included examination records from three major service units, namely the Emergency Department (IGD), Outpatient Department (Poliklinik), and Inpatient Department (Rawat Inap). A total of 98 laboratory examination records were analyzed. The unit of analysis was the laboratory examination record rather than the individual patient. The samples were selected purposively based on the availability and completeness of the information required to determine TAT. Laboratory records were included when the examination request time and result-availability time could be clearly identified. Records with incomplete or unclear time information were excluded from the analysis. This procedure was applied to ensure that the calculated TAT accurately represented the actual laboratory service process.

Data were collected retrospectively from laboratory service records and the available laboratory information system. The information extracted included the originating clinical service unit, the date and time of the laboratory examination request, and the date and time when the examination result became available. The collected data were recorded using a structured data collection form to maintain consistency during data extraction. Patient-identifying information was not required for the analysis because the focus of the study was laboratory service performance. Turnaround Time was operationally defined as the interval between the time the laboratory examination was requested and the time the examination result became available for clinical use. TAT was calculated in minutes by subtracting the examination request time from the result-availability time. The resulting TAT values were then compared with the laboratory service standard established by RSU Royal Prima Medan, namely ≤ 120 minutes. Examinations with a TAT of 120 minutes or less were categorized as meeting the standard, whereas examinations requiring more than 120 minutes were categorized as not meeting the standard.

The collected data were subsequently checked, coded, and analyzed descriptively. The analysis included the frequency and percentage of examinations according to TAT compliance and service unit. Measures of central tendency and distribution were also used to describe the actual turnaround performance. The analysis was conducted for the overall laboratory service and separately for the Emergency Department, Outpatient Department, and Inpatient Department. This comparison was intended to identify differences in laboratory TAT according to the clinical unit submitting the examination request. The percentage of examinations meeting the TAT standard was calculated by dividing the number of examinations with a TAT of ≤ 120 minutes by the total number of analyzed examinations and multiplying the result by 100. The analysis therefore provided two principal indicators: the actual turnaround time of laboratory examinations and the proportion of examinations that complied with the established service standard.

Data confidentiality was maintained throughout the research process. The analysis was performed using laboratory service records and was focused on institutional service performance rather than individual patient characteristics. The final results were presented in aggregate form to prevent identification of individual patients. Overall, the methodological approach enabled the study to objectively assess the timeliness of laboratory services at RSU Royal Prima Medan and compare actual TAT performance with the hospital's ≤ 120 -minute standard. The approach also enabled identification of differences in TAT performance among emergency, outpatient, and inpatient services, thereby providing an empirical basis for evaluating laboratory workflow and service efficiency.

RESULTS AND DISCUSSION

Turnaround Time of Clinical Laboratory Examinations

The study analyzed 98 clinical laboratory examination records at RSU Royal Prima Medan to evaluate the timeliness of laboratory services based on the hospital's established Turnaround Time (TAT) standard of ≤ 120 minutes. The results showed that only 11 examinations (11.2%) were completed within the established standard, whereas 87 examinations (88.8%) exceeded 120 minutes. These findings indicate that the majority of laboratory examinations did not meet the expected turnaround-time target, suggesting that the timeliness of laboratory services requires further evaluation and improvement.

EVALUATION OF TURNAROUND TIME (TAT) OF CLINICAL LABORATORY EXAMINATIONS BASED ON REQUEST TIME AND RESULTS AS AN INDICATOR OF THE EFFICIENCY OF DIAGNOSTIC SERVICES AT ROYAL PRIMA HOSPITAL IN MEDAN

R. Raje Telegem et al

Table 1. Distribution of Clinical Laboratory Examinations According to TAT Compliance

TAT Performance	Frequency (n)	Percentage (%)
≤120 minutes	11	11.2
>120 minutes	87	88.8
Total	98	100.0

The predominance of examinations exceeding the 120-minute standard demonstrates that prolonged TAT is not an isolated occurrence but represents a substantial pattern in the laboratory service process. From a service-quality perspective, this finding is important because laboratory results constitute essential information for clinical decision-making. Delays in obtaining results may consequently affect the timeliness of subsequent clinical management. Previous research has identified TAT as an important indicator of laboratory performance and healthcare service efficiency (Dawande et al., 2022; Cherie et al., 2024). The finding is also consistent with previous studies showing that laboratory TAT can be affected by multiple stages of the laboratory workflow rather than by the analytical examination process alone. The pre-analytical process, specimen transportation, laboratory workload, analytical processing, result validation, and reporting may each contribute to delays. Therefore, the high proportion of examinations exceeding 120 minutes should be interpreted as an indication of a broader workflow issue rather than being attributed to a single operational factor.

Turnaround Time According to Hospital Service Unit

Further analysis showed differences in TAT compliance among the three hospital service units. Of the examinations originating from the Emergency Department, 17.5% met the ≤120-minute standard. In the Outpatient Department, only 9.8% met the standard, while none of the examinations originating from the Inpatient Department met the established standard. Thus, inpatient laboratory examinations demonstrated the lowest level of TAT compliance.

Table 2. TAT Compliance According to Hospital Service Unit

Service Unit	Meeting Standard (%)	Not Meeting Standard (%)
Emergency Department	17.5	82.5
Outpatient Department	9.8	90.2
Inpatient Department	0.0	100.0

The relatively better performance of the Emergency Department compared with the other units may reflect the greater clinical urgency associated with emergency cases. Laboratory examinations requested from emergency services are generally expected to support rapid clinical decisions. However, the fact that only 17.5% of emergency examinations met the standard indicates that the existing performance remains substantially below the expected target. The outpatient service showed even lower compliance, with only 9.8% of examinations meeting the ≤120-minute standard. This finding suggests that laboratory turnaround problems are not limited to emergency services. Instead, delays may occur across routine service pathways. Previous research has demonstrated that TAT in outpatient laboratory services is influenced by workflow organization, specimen handling, information systems, and coordination between clinical units and laboratories (Lee et al., 2022; Park et al., 2023).

The most concerning finding was observed in inpatient services, where 0% of examinations met the ≤120-minute standard. This means that every inpatient laboratory examination included in the analysis required more than two hours. Such a finding indicates a potential systemic problem in the workflow linking inpatient clinical services and laboratory processing. The result is particularly important because prolonged laboratory turnaround may delay the availability of information required by clinicians to evaluate patients and adjust treatment decisions.

Discussion of Laboratory Service Performance

The overall finding that 88.8% of examinations exceeded the established TAT standard indicates that the laboratory service at RSU Royal Prima Medan had not achieved the expected level of timeliness during the study period. This finding is consistent with the concept that TAT is a multidimensional indicator reflecting the performance of several interconnected laboratory processes. Cherie et al. (2024) emphasized that improving laboratory TAT requires attention to the entire workflow rather than focusing exclusively on the analytical phase. The results may also be interpreted from a process-efficiency perspective. Lean Management literature emphasizes the importance of identifying activities that do not add value and eliminating unnecessary waiting or process delays. In laboratory services, unnecessary waiting may occur during specimen collection, transportation, registration, queueing, examination processing, validation, and result reporting. Studies by Djawa and Oktamianti (2023) and

EVALUATION OF TURNAROUND TIME (TAT) OF CLINICAL LABORATORY EXAMINATIONS BASED ON REQUEST TIME AND RESULTS AS AN INDICATOR OF THE EFFICIENCY OF DIAGNOSTIC SERVICES AT ROYAL PRIMA HOSPITAL IN MEDAN

R. Raje Telegem et al

Sari et al. (2023) demonstrate the relevance of Lean approaches for improving efficiency in healthcare services. The findings also support the relevance of Lean Six Sigma and digital process monitoring. Vasani et al. (2023) demonstrated that Lean Six Sigma can be used to reduce laboratory TAT, while Cai et al. (2025) showed that combining digital monitoring with Lean Six Sigma can facilitate real-time identification of delays. These approaches may therefore provide useful directions for subsequent improvement at RSU Royal Prima Medan.

Another important consideration is the role of laboratory information systems. Digital systems can facilitate examination requests, specimen tracking, result validation, and reporting. Karnchanaphiboonwong et al. (2023) and Park et al. (2023) highlighted the potential contribution of laboratory informatics and automation to improving laboratory workflow. Nevertheless, technology alone cannot guarantee compliance with TAT standards. Effective performance still depends on adequate staffing, equipment availability, workflow coordination, and appropriate operational procedures. The present findings therefore suggest that improvement efforts should not be directed solely toward increasing laboratory analytical speed. A comprehensive evaluation of the pre-analytical, analytical, and post-analytical processes is required. The particularly low performance in inpatient services should receive priority because all examinations in this service category exceeded the established standard. Future improvement should examine where the longest waiting intervals occur and determine whether delays originate from clinical units, specimen transportation, laboratory reception, examination processing, validation, or result delivery.

Implications for Laboratory Service Improvement

The results have several practical implications for laboratory management at RSU Royal Prima Medan. First, TAT should be monitored routinely as a key laboratory performance indicator. Monitoring should not be limited to average TAT but should also include the percentage of examinations meeting the established standard. Second, TAT monitoring should be stratified according to clinical service unit. The different performance levels observed among emergency, outpatient, and inpatient services demonstrate that aggregated laboratory data may conceal important differences between service pathways. Unit-specific monitoring can therefore facilitate more targeted interventions. Third, process mapping and identification of bottlenecks should be undertaken, particularly for inpatient laboratory examinations. A Lean-based workflow evaluation could identify unnecessary waiting, duplication, delays in specimen transportation, or communication problems between clinical units and the laboratory. This approach is consistent with previous evidence supporting Lean and Lean Six Sigma interventions for laboratory process improvement (Cherie et al., 2024; Vasani et al., 2023). Finally, the laboratory may benefit from strengthening the integration of its information system with specimen tracking and result reporting. Real-time monitoring could allow laboratory managers to identify examinations approaching or exceeding the 120-minute threshold and initiate corrective action. However, technological interventions should be accompanied by evaluation of staffing, infrastructure, equipment, and coordination processes.

CONCLUSION

The study demonstrated that the clinical laboratory TAT performance at RSU Royal Prima Medan was below the established service standard of ≤ 120 minutes. Of the 98 laboratory examination records analyzed, only 11 examinations (11.2%) met the standard, while 87 examinations (88.8%) exceeded 120 minutes. TAT performance also differed according to the originating hospital service unit, with 17.5% of emergency examinations, 9.8% of outpatient examinations, and none of the inpatient examinations meeting the established standard. These findings indicate that prolonged laboratory TAT is a significant service-performance issue and requires systematic improvement. Particular attention should be given to inpatient laboratory services, where no examination met the ≤ 120 -minute target. Future improvement should involve comprehensive evaluation of the pre-analytical, analytical, and post-analytical stages, supported by workflow mapping, routine TAT monitoring, Lean or Lean Six Sigma process improvement, strengthening of human resources and infrastructure, and optimization of laboratory information systems. Such measures are expected to improve laboratory timeliness and ultimately support more efficient clinical decision-making and patient care.

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EVALUATION OF TURNAROUND TIME (TAT) OF CLINICAL LABORATORY EXAMINATIONS BASED ON REQUEST TIME AND RESULTS AS AN INDICATOR OF THE EFFICIENCY OF DIAGNOSTIC SERVICES AT ROYAL PRIMA HOSPITAL IN MEDAN

R. Raje Telegem et al

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R. Raje Telegem et al

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