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ORIGINAL ARTICLE

Turnaround Time and Performance of the Biochemistry-Toxicology Laboratory at Mohammed V Military Hospital in Rabat, Morocco

Hajar Jamii [1, 2, 3], Hajar Dahou [1, 2, 3], Asmae Biaz [1, 2, 3], Sanae Bouhsain [1, 2, 3], Abdellah Dami [1, 2, 3], Samira Elmachtani-Idrissi [1, 2, 3]

[1] *Biochemistry-Toxicology Laboratory, HMIMV, Rabat, Morocco*
[2] *Faculty of Medicine and Pharmacy, Rabat, Morocco*
[3] *Mohammed V University, Rabat, Morocco*

ABSTRACT

Background: **The Turnaround Time (TAT), or the time taken to deliver results, is a key indicator of medical laboratories' performance. While it ensures rapid and safe patient care, any delay within this timeframe can compromise diagnosis, delay treatment initiation, and negatively impact prognosis, particularly in emergency situations. This study aims to evaluate the TAT within the biochemistry-toxicology laboratory of the Mohammed V Military Hospital in Rabat Morocco to identify the sources of delay and to propose appropriate corrective measures.**
Methods: **This is a retrospective study covering 30,149 samples analyzed between January and December 2023. Four urgent tests were included: potassium, troponin, beta-HCG, and lipase. The intra-laboratory Turnaround Time (TAT) was defined as the period between sample registration and result validation, excluding transport time. Two time slots were distinguished: working hours (9:00 am to 2:00 pm) and on-call hours (2:01 pm to 8:59 am). Data were extracted via the Middleware EVM system and analyzed using SPSS software, with TAT expressed as medians.**
Results: **The distribution of analyses varied by period: potassium and lipase were mostly processed during working hours, whereas troponin and beta-HCG were mainly processed during on-call periods. Median result delivery times differed among tests: 46 minutes for potassium, 52 minutes for troponin, 58 minutes for beta-HCG, and 67 minutes for lipase. The proportion of results delivered within 60 minutes was satisfactory for potassium (73%) and troponin (65%), moderate for beta-HCG (53%), and low for lipase (40%).**
Conclusions: **This study highlights the importance of managing biological tests differently according to clinical urgency. The observed TAT results reveal certain organizational limitations likely to affect laboratory performance. Identifying these discrepancies and implementing corrective actions are essential steps toward continuous improvement.**
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Correspondence:
Hajar Jamii
Faculty of Medicine and Pharmacy
Mohammed V University
Rabat
Morocco
Email: Hajar.jamii7@gmail.com

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INTRODUCTION

Turnaround Time (TAT) constitutes a fundamental indicator for assessing the performance of medical laboratories. The quality of services provided by these facilities

relies on four essential pillars: accuracy, correctness, precision, and timeliness. While the first three criteria ensure the reliability and validity of analytical results, timeliness, embodied by TAT, has gained increasing importance. This temporal dimension is crucial not only for clinicians, who depend on prompt results to guide diagnostic and therapeutic decisions, but also for patients, for whom rapid access to results is synonymous with optimized and safer care [1].

A delay in the transmission of laboratory results can have significant clinical consequences. It may postpone the confirmation or exclusion of a diagnosis, hinder the timely initiation of appropriate treatment, or even compromise the patient's favorable outcome. This impact is particularly critical in emergency settings, where the speed of result delivery determines the responsiveness of healthcare teams and directly influences the quality of care provided [2-5].

Despite major technological advances, particularly the automation of analytical processes, and organizational efforts aimed at streamlining laboratory workflows, managing and reducing TAT remains a persistent challenge. One of the main difficulties lies in the absence of a standardized, universally accepted definition of TAT, which varies across institutions and study contexts. This variability complicates not only the precise evaluation of performance but also the comparison of results among different laboratories or healthcare systems [6, 7]. In general, TAT is defined as the time interval between the collection of the biological sample from the patient and the official communication of validated results to the clinician, thereby encompassing several critical phases: pre-analytical, analytical, and post-analytical [6].

Within this framework, the present study focuses on evaluating turnaround times for analyses performed at the Biochemistry-Toxicology Laboratory of Mohammed V Military Teaching Hospital in Rabat. The primary objective is to analyze the laboratory's temporal performance by identifying the main causes of potential delays in result transmission. Furthermore, the study seeks to propose improvement strategies tailored to this specific context in order to optimize internal processes. Ultimately, this work aims to contribute to the continuous improvement of service quality, thereby enhancing patient management and ensuring safer healthcare delivery.

MATERIALS AND METHODS

This retrospective study was conducted at the Biochemistry-Toxicology Laboratory of Mohammed V Military Teaching Hospital in Rabat. It included a total of 30,149 samples corresponding to four laboratory tests frequently prescribed in emergency settings: potassium, troponin, beta-HCG, and lipase. These analyses were performed between January 1 and December 31, 2023. To account for the laboratory's organizational structure, two time periods were considered. The first corresponded to peak activity, covering working hours from 9:00 am to 2:00 pm. The second corresponded to on-call duty, from 2:01 pm to 8:59 am.

Intra-laboratory turnaround time was defined as the interval between the registration of the sample in the laboratory information system and the final validation of results. Delays related to the transport of samples to the laboratory were not included.

To ensure data reliability and to avoid bias in TAT calculation, certain test requests were excluded from the analysis. These included requests created before the actual sample collection and those added after the sample had already been processed.

Data were automatically extracted from the laboratory information system, Middleware EVM, which records each step of the analytical workflow, from reception to validation. Statistical analysis was performed using SPSS software. Turnaround times were expressed as medians. A comparison of TAT between the two work periods was conducted to identify significant differences in laboratory performance.

RESULTS

The analysis included a total of 30,149 samples distributed among four laboratory tests selected based on their frequency of prescription and clinical relevance in emergency settings: troponin, potassium, beta-hCG, and lipase.

Most analyses were performed during peak activity hours for potassium (98.8%) and lipase (67%), whereas troponin and beta-hCG were more frequently analyzed during on-call periods, at 55.5% and 52.7%, respectively. This distribution likely reflects the nature of these tests, some being more urgent (troponin) or more commonly requested outside regular working hours (β-hCG in the context of pregnancy or gynecological emergencies).

Median processing times varied considerably depending on the type of test. For troponin, the median TAT was 52 minutes, with a minimum of 26 minutes and a maximum of 196 minutes. Among all samples, 65% were processed in under 60 minutes and 95% in under 120 minutes. The median TAT for potassium was 46 minutes, with 73% of results delivered within 60 minutes and 97% within 120 minutes. For beta-hCG, the median turnaround time was 58 minutes, with 53% of samples processed in under 60 minutes and 90% within 120 minutes. Lipase had the longest median processing time, at 67 minutes; only 40% of results were reported within 60 minutes, while 85.5% were released within 120 minutes.

Table 2 highlights significant extreme values, particularly for lipase (maximum: 2,429 minutes, more than 40 hours), suggesting the presence of substantial delays in the TAT for this parameter.

The analysis of Table 3 shows that for potassium and

Table 1. Number of samples analyzed for each type of test.

	Peak activity period	Percentage (%)	On-call period	Percentage (%)	Total
Troponin	5,051	44.5	6,296	55.5	11,347
Potassium	11,808	98.8	147	1.2	11,955
β-HCG	2,359	47.3	2,628	52.7	4,987
Lipase	1,247	67.0	614	33.0	1,861

Table 2. Median, minimum, and maximum processing times of samples.

	Median (min)	Minimum (min)	Maximum (min)
Troponin	52	26	196
Potassium	46	25	163
β-HCG	58	25	282
Lipase	67	20	2,429

Table 3. Percentage of samples processed according to processing time intervals.

Time	Percentage%		
	< 30 minutes	30 - 60 minutes	< 120 minutes
Troponin	3	65	95.7
Potassium	10	73	97.8
β-HCG	3	53	90
Lipase	3.7	40	85.5

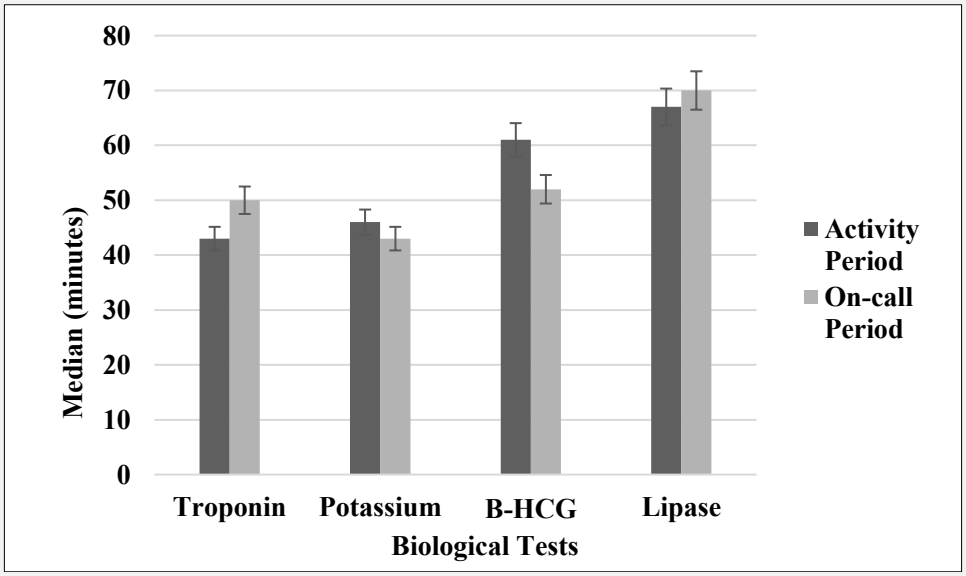

Figure 1. Median turnaround times (TAT) according to the two work periods.

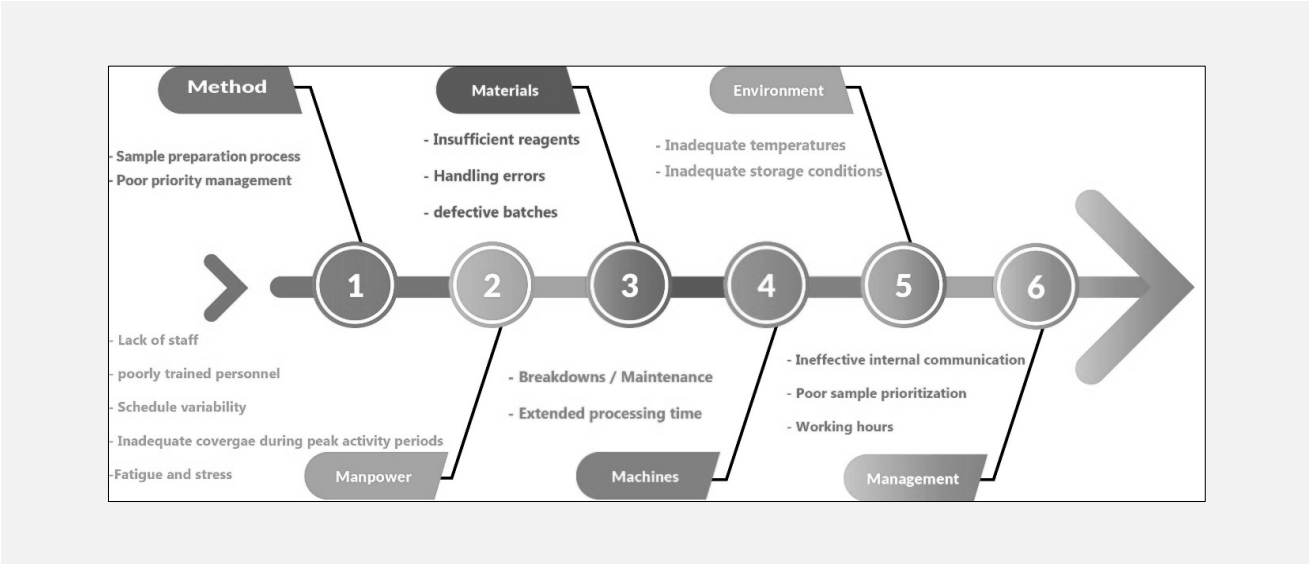

Figure 2. Ishikawa Cause-and-Effect diagram of TAT delays.

troponin tests, more than 95% of results are delivered within 120 minutes, with 73% and 65%, respectively, available in under 60 minutes. β-hCG demonstrates intermediate performance, with 53% of results available within 60 minutes and 90% within 120 minutes. In contrast, for lipase, only 40% of results are reported within 60 minutes, and 85.5% within 120 minutes. This distribution highlights heterogeneity in processing speed depending on the type of test, likely influenced by technical factors (automation, assay methods), organizational factors (emergency prioritization), or human factors (on-call staff).

The comparative diagram of median TATs across operational periods generally shows an increase in turnaround times during on-call hours (notably for lipase and troponin), reflecting reduced laboratory responsiveness outside regular working hours (Figure 1). This phenomenon is commonly observed in hospital settings and is often related to reduced staffing levels, the absence of certain specialized technicians, or an increased workload concentrated on a limited number of personnel.

DISCUSSION

The evaluation of turnaround times (TAT) for laboratory results is a key indicator of quality and performance in medical laboratories, particularly in emergency contexts where rapid result availability can directly impact patient management. Our study, conducted at the Biochemistry-Toxicology Laboratory of the Mohammed V Military Teaching Hospital in Rabat, assessed TAT for four essential laboratory tests: potassium, troponin, beta-hCG, and lipase. It is well established in the literature that reducing TAT is associated with a significant improvement in the quality of care, notably by decreasing emergency department stay duration, facilitating patient admissions, and optimizing overall clinical management [1,2].

Nevertheless, reducing TAT remains a continuous challenge, primarily due to the lack of consensus on its precise definition. According to ISO 15189:2022, TAT is defined as the time elapsed between two specific points in the pre-analytical, analytical, and post-analytical processes, encompassing test ordering, sample collection, transport, analysis, and the transmission of results. Lundberg [8] described TAT as a “brain-to-brain turnaround time” or “total testing cycle,” dividing the process into nine independent steps, each affecting TAT: test ordering, specimen collection, identification, transport, separation, analysis, reporting, interpretation, and clinical action. Others have also used the term “therapeutic TAT” to refer to the interval between test ordering and the therapeutic decision based on the obtained result. Laboratories typically define TAT as the time from sample receipt to result transmission, subdivided into three phases: pre-analytical, analytical, and post-analytical. The time between test prescription and sample collection, as well as between collection and laboratory delivery, generally falls outside the laboratory’s control. Similarly, delays in result interpretation and clinical action are not attributable to laboratory processes [9].

While laboratories often focus on technical and analytical quality to ensure result accuracy and reliability, clinicians and patients place high importance on result timeliness. Although defining TAT precisely is useful, the ultimate goal should be to provide accurate results at the right time. Our findings reveal that median TATs vary significantly by test type, ranging from 46 minutes for potassium to 67 minutes for lipase. These data are consistent with expectations for tests commonly performed

in emergency settings. Potassium testing, in particular, is critical for the immediate management of electrolyte imbalances, justifying the shorter turnaround observed in our laboratory. Troponin, a biomarker of myocardial ischemia, is also processed rapidly, which is essential for guiding acute coronary syndrome management.

In our study, the median processing time for troponin was 52 minutes, with 65% of samples analyzed in under 60 minutes. These results reflect overall satisfactory laboratory performance, consistent with clinical recommendations [10]. However, they also indicate room for improvement, as our values are higher than those reported in international studies. Boelstler, et al. [11] reported a significantly shorter median TAT of 24 minutes in a facility that optimized its pre-analytical processes, while Singer, et al. [12] achieved a median of only 17 minutes through the implementation of an organizational model incorporating point-of-care testing (POC) prior to laboratory confirmation. This comparative analysis highlights potential areas for improvement in our setting, particularly in pre-analytical phases, and emphasizes the influence of organizational and technological choices on laboratory performance [11].

A notable finding in our analysis is that the intra-laboratory TAT for troponin was longer during on-call hours compared to regular service hours. This suggests that workload and organizational factors specific to after-hours periods negatively impact turnaround performance. Raising awareness among on-call technicians about the importance of timely troponin reporting and implementing corrective actions; such as targeted training sessions, staff competency evaluations, regular protocol reminders, and continuous monitoring of on-call performance, could help ensure consistent service quality regardless of the time of day. The median potassium TAT was 46 minutes, with 73% of samples processed within one hour; an acceptable result for a routine hospital setting but still longer than reported in certain international studies. Pati and Singh [7] reported a median TAT of 30 minutes, while Zhang, et al. [3] achieved an optimized TAT of 21 minutes through specific organizational measures and laboratory infrastructure modernization. Several factors may explain this discrepancy: unlike those laboratories, ours lacks full automation of the sample workflow, which can lengthen pre-analytical stages such as centrifugation, sorting, and transfer to analyzers [3,7]. Laboratories with dedicated circuits and personnel for critical tests often report shorter TATs. While our current performance remains within acceptable standards, comparisons with international data highlight concrete opportunities for optimization; particularly through investments in automation, analytical process digitalization, and improved resource allocation. Regular TAT audits and systematic monitoring of delay causes (e.g., equipment downtime, workload surges, scheduling issues) could contribute to continuous improvement in service quality. Certain factors can specifically delay TAT, such as hemolysis, which significantly affects potassium testing. To prevent potential clinical errors, many laboratories systematically reject hemolyzed samples exceeding a defined hemolysis index threshold, requiring recollection and thereby extending TAT. Cadamuro, et al. [12] reported a median delay of 2 hours and 44 minutes in such cases. Thus, the impact of hemolysis extends beyond reporting delays, encompassing critical decision-making implications and underscoring the need to standardize hemolyzed sample management practices [13].

Potassium testing is often performed as part of a comprehensive electrolyte panel. While clinically relevant, this bundled approach can adversely affect TAT since the reporting time is dictated by the slowest analyte in the panel [9]. This highlights the need to minimize potassium TAT prolongation by improving sampling techniques to reduce hemolysis and by implementing analytical decoupling strategies for critical electrolytes [4].

Regarding lipase, it exhibited the longest TAT, with a median of 67 minutes and only 40% of samples processed within 60 minutes. This suggests inefficiencies in the operational workflow of this assay, warranting an in-depth evaluation of its root causes. The analytical pathway involves three successive analyzers, each assigned to specific parameters. This sequential processing extends the lipase turnaround time, especially when technicians overlook routing samples to the appropriate analyzer or when the test requires dilution; forcing the sample to complete the three-analyzer cycle before reanalysis with dilution. Strengthening internal coordination and workflow organization is therefore crucial to streamline processing. Actions such as implementing control procedures, systematic reminders, and targeted training sessions on TAT importance have been shown to reduce lipase reporting delays by up to 50%, directly improving patient management [5].

The median beta-hCG TAT observed was 58 minutes, with 53% of samples processed within 60 minutes, consistent with findings from other facilities where results are generally available within one hour [5], reflecting a performance level aligned with clinical recommendations [10]. A deeper analysis of workflow steps could help identify and implement targeted TAT-reduction strategies, further enhancing overall laboratory performance. In this context, an Ishikawa diagram was developed to identify potential causes of delays (Figure 2). A time-and-motion analysis approach was adopted to establish a baseline for evaluating current and future laboratory TAT performance. The main goal of this analysis is to identify and eliminate sources of waste; defined as any non-value-adding activity or step, thereby focusing processes exclusively on those that contribute to quality service delivery [3].

According to Manor [14] and Rollo and Fauser [15], non-analytical delays are the primary causes of prolonged TAT. Bilwani, Siddiqui and Vaqar [16] reported that 74.2% of delays were due to pre-analytical causes. These findings align with our experience, where manual sample registration, preparation, and result transmission represent major sources of delay. To improve laboratory

turnaround performance, periodic monitoring of prolonged TATs is essential. Coetzee, Cassim and Glencross [17] recommended weekly TAT tracking to enable more accurate detection of delays. Laboratory personnel should adopt this approach to identify issues requiring timely intervention. For hospitalized patients, laboratory results that are accurate, reliable, and delivered promptly can reduce hospital stay duration while improving patient safety and satisfaction. Laboratories therefore have a duty to implement actions aimed at improving TAT performance. However, achieving this goal remains challenging, as TAT optimization is inherently complex. While our study focused on identifying major causes of result transmission delays and proposing areas for improvement, future research is needed to implement and evaluate targeted interventions designed to enhance TAT performance.

CONCLUSION

These results highlight the need for rigorous monitoring of the laboratory's performance, particularly regarding the turnaround time for critical test results, in order to ensure optimal patient care and enhance clinician satisfaction. The application of evaluation methods makes it possible to specifically identify the factors responsible for result reporting delays and to implement appropriate corrective measures aimed at improving the laboratory's overall efficiency.

Declaration of Generative AI in Scientific Writing:
No assistance from artificial intelligence (AI) was used in the preparation, writing, or editing of this document.

Declaration of Interest:
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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