Original Article

Evaluation of Laboratory Turnaround Time and Determinants for Hematology and Clinical Chemistry Tests in Emergency and Trauma Centers, Addis Ababa

Bethlehem Adbib[1, 2], Semira Rahmeto[2], Fatuma Hassen[2*]

Abstract

Background: Laboratory tests are a critical component of clinical decision-making in the emergency department. Reporting results within an acceptable turnaround time (TAT) is a vital indicator of laboratory quality. International standards recommend the laboratories to establish and periodically evaluate TAT benchmarks to ensure patient safety.

Objective: To determine laboratory turnaround time and associated factors for complete blood count (CBC) and clinical chemistry tests at Addis Ababa Burn, Emergency and Trauma Hospital (AaBET).

Method: A cross-sectional study was conducted from January to April, 2022. All emergency patient samples requiring at least a CBC and/or clinical chemistry panel were followed consecutively upon receipt. Statistical analysis was performed using version 23 SPSS. Bivariate and multivariate regression analyses were conducted to assess the relationship between turnaround time and the suggested associated factors. For all statistical tests, $P < 0.05$ was considered significant.

Results: Data regarding the specimen receipt to verification time data were obtained for 4132 tests. Of which, 2309 (55.9%) of them were complete blood count, and 1823 (44.1%) were chemistry tests. The 90th percentile completion times were **105 minutes** (SD: 53.9) for CBC and **457 minutes** (SD: 257.4) for chemistry. Over 28% of the tests failed to meet the TAT benchmarks set by international standards. Significant contributors to delayed TAT included:

- Specimens received during **Sunday night shifts** ($P < 0.001$) for both test types.
- CBC tests requested without concurrent blood group or cross-match tests ($P = 0.009$).
- **Equipment failure** (chemistry analyzer breakdown).

Conclusion: Laboratory turnaround times were prolonged and did not comply with established international benchmarks. Targeted improvements in personnel allocation and equipment maintenance are necessary to minimize delays in test results.

Key words: Turnaround time (TAT), Complete Blood Count (CBC), Clinical chemistry, Emergency department

Introduction

Evaluation of TAT for basic emergency parameters one of the most common and critical quality assessments performed in the clinical laboratory [1]. The global burden of injuries and violence is substantial; in 2019, these causes claimed 4.4 million lives, accounting for 8% of all deaths worldwide. Major injury-related causes of death include road traffic crashes, drowning, falls, burns, poisoning, and interpersonal or self-inflicted violence [2].

As emergency departments (EDs) face increasing patient overflow and subsequent bed scarcity, the demand for reduced laboratory TAT has intensified [3]. TAT remains a cornerstone metric for measuring the efficiency of the laboratory and is a primary indicator used by hospital administration to evaluate the quality of laboratory services [4].

The overuse of laboratory tests in the Emergency Department (ED) creates significant operational challenges, necessitating a more selective approach to diagnostic ordering. To address this, it is essential to implement education and training programs for physicians focused on strategies to reduce unnecessary test requests. Data indicates that the most frequently utilized tests in the emergency setting include:

- **Hematology:** Complete Blood Count (CBC) and Fibrinogen.
- **Renal Function & Electrolytes:** Creatinine, Blood Urea Nitrogen (BUN), Potassium (K^+), and Sodium (Na^+).
- **Liver Function & Enzymes:** Aspartate Aminotransferase (AST) and Alanine Aminotransferase (ALT).
- **Inflammatory Markers & Others:** C-Reactive Protein (CRP) and Ferritin [5-7].

While multiple factors influence length of stay (LOS), various studies have demonstrated that reducing the time patients wait for laboratory results in the emergency department (ED) significantly decreases overall waiting time [8]. However, logistical issues, staffing constraints, and technical issues related to specific test performance often prevent hospital laboratories from providing timely service. [9]. Examining **TAT outliers** (results that fall outside the expected range) provides critical insight into specific causes of delay and highlights areas for systemic improvement. In emergency scenarios—especially for life-threatening conditions—the speed of diagnostic processing is a decisive factor in saving lives [4, 10].

[1] St. Paul's Hospital Millennium Medical College, AaBET Hospital, Addis Ababa, Ethiopia.
[2] Department of Medical Laboratory Sciences, College of Health Sciences, Addis Ababa University, Addis Ababa, Ethiopia.
***Corresponding author Email**: fatumahassen2000@gmail.com; fatuma.hassen@aau.edu.et

The Context of Emergency Care in Ethiopia

- **Prolonged LOS:** A systematic review in Ethiopia found that the pooled prevalence of prolonged ED length of stay was **63.67%** [11].
- **Laboratory Dissatisfaction:** Over 80% of laboratories receive complaints regarding TAT, with the ED specifically identifying laboratory delays as a major source of discontent [12].
- **The Burden of Trauma:** Global estimates indicate that injuries claim nearly 14,000 lives every day [13].

Despite the high mortality associated with trauma and the impact of overcrowding, there is a lack of statistical reporting on the specific factors influencing these delays. Nevertheless, evidence suggests that even minor reductions in laboratory TAT can significantly improve ED outcomes [6, 14].

While poor TAT performance has been documented in certain hospitals in Gondar and Addis Ababa [15, 16], there is a notable dearth of published data specifically focusing on dedicated **emergency and trauma hospitals**. This study aims to fill that gap, providing essential information to foster prompt care and prevent the psychological or physical harm caused by avoidable diagnostic delays.

Materials and methods

Study setting

A prospective cross-sectional study was conducted from January to April 2022 at the Addis Ababa Burn Emergency and Trauma (AaBET) Hospital. Established in 2015 as affiliate of St. Paul's Hospital Millennium Medical College (SPHMMC), AaBET serves as Ethiopia's premier trauma treatment center [17]. The AaBET hospital laboratory is strategically organized into four specialized units to handle high-acuity cases:

- **Emergency Laboratory**
- **Blood Bank**
- **Microbiology**
- **Central Laboratory** [18]

The facility utilizes the **Cobas c311** analyzer for clinical chemistry. To ensure efficient data flow and minimize manual entry errors, the laboratory employs the **Polytech Laboratory Information System (LIS)**, which is fully interfaced with the analytical equipment [19].

Study Population

Complete blood counts and clinical chemistry test requests for emergency patient specimens that the laboratory received during the study period served as the study populations.

Sample size and Sampling method

A total of 4132 test requests ordered for the CBC and clinical chemistry tests were included in the study. Since AaBET was established to provide a fully dedicated emergency and trauma service in the country, this study site was selected based on purposive sampling. Additionally, a convenience sampling technique was used to select the testing samples for CBC and clinical chemistry tests.

Inclusion and exclusion criteria

In this study, all chemistry (organ function, electrolyte, and/or glucose) and/or hematological (CBC) tests performed during the study period were included. However, tests from rerun samples, tests for medical checkup purposes only, test requests that met sample rejection criteria, and test results that were not made public within 24 hours of receipt were excluded.

Measurement and Data collection

Structured sample and test request information collection forms, and daily work area evaluation or observational checklists, were developed and distributed to trained data collectors. As blood samples for CBC and/or clinical chemistry tests arrived at the laboratory specimen reception unit, the receipt time and any possible factors for rejection were recorded. In addition, the laboratory's daily work-related conditions such as the adequacy of the work area, equipment and reagent, internal quality controls, staff number, and other significant events were observed and documented 24 hours a day. The principal investigator, together with the laboratory quality manager, extracted every 24 hours patient records containing the required test and time-related information from the laboratory information system (LIS) and aligned them with the pre-collected data.

Chemistry and CBC analyzers:

The CBC was analyzed by using Sysmex XN-550 hematology analyser. The XN 550 hematology abalyser is an, automated, compact, haematology analyser designed to generate a full blood count with a standard 5-part white blood cell differential, an immature granulocyte count, optical platelet counts as well as optional reticulocyte (RET) testing using an aspiration sample volume of 25µl. The XN-550 has a small footprint, making it suitable for small hospital laboratories, physician offices labs, and as a backup analyzer for large laboratories [20].

The Cobas c311 (Roche Diagnostics, Germany) analyzer, which performs 300 photometric and 150 ISE measurements per hour, was utilized for clinical chemistry measurements [21].

Measurement of laboratory turnaround time

A) Laboratory work processes and data recording points

I) Sample accessioning time recording*: Patient* information and ordered test are recorded on the Polytech Laboratory Information System database. Specimen were evaluated according to established acceptance criteria and labeled with printed barcodes containing the reception time; the accessioning time was recorded at this stage.

II) Sample Workflow and time data points:
All samples, accompanied by their respective request forms, were handed over to the core laboratory where hematology and chemistry tests were performed. Based on the generated worksheets, assigned laboratory staff in the specimen processing area segregated samples according to whether they required serology testing and processed them accordingly.

III) CBC and Chemistry Test Analysis: For clinical chemistry analysis, samples were loaded manually onto the Cobas c311 analyzer. Similarly, for CBC analysis, samples were loaded onto the Sysmex XN-550 (Sysmex Corporation, Kobe, Japan) analyzer. Results were then transmitted to the LIS for validation. Any necessary reruns or dilutions were managed by the laboratory technologists. Finally, reports were generated and printed from the LIS database. The result verification time was recorded from these two workstations.

B) Evaluation of laboratory TAT
For the purpose of this research, the total laboratory turnaround time was defined as the time from receipt of a sample by the laboratory to the availability of a validated result [22]. TAT data were extracted from the LIS, which captured the duration from specimen accessioning to test reporting. The 90th percentile of these values was utilized as the cutoff, representing the time within which 90% of the processes were completed [4]. The TAT findings of this study were compared against the AaBET laboratory benchmark TATs and other recommended emergency laboratory standards (<60 min for CBC and <240 min for chemistry tests) [23, 24].

Data Quality Assurance
A) Pre analytical phase; Data collection tools were pre-tested for the accuracy and consistency prior to the actual data collection. Comprehensive training was provided to all data collectors before the actual data collection commenced.

B) Analytical phase: The laboratory turnaround time was recorded at each process start and end point. Digital clocks, data collector's time recording device, instrument timers and computers designated for the LIS were synchronized to automatic time format and checked for consistency at regular intervals.

C) Post analytical phase; The completion, accuracy and clarity of the collected data were carefully checked on a regular basis. Furthermore, the principal investigator provides feedback and corrections to the data collectors to ensure data integrity.

Data analysis and interpretation
Data analysis was performed using SPSS (Statistical Package for social sciences statistical software) version 23. The mean, standard deviation, interquartile range (IQR) with 90^{th} percentile, time intervals (in minutes) and frequency of the outcome variables were calculated accordingly. A one-way ANOVA test was used to compare time differences across different shifts and days of the week. To test for an association between time delay and potential factors responsible for prolonged TAT, bivariate association analyses were conducted. Variables that were significant in the bivariate analyses were then entered into multivariate logistic regression models to identify factors collectively predictive of delayed TAT. Each TAT (> 60min for CBC and >240min for chemistry tests) outcome was modeled separately, and stepwise selection was used to identify the variables with the most predictive value for each outcome. P-values of less than 0.05 were considered statistically significant.

Operational definitions;-

- **Turnaround time**; is the interval between the receipt of a sample in the laboratory and the time of result verification [21].
- **90% Completion TAT**;- When receipt-to-report TAT values are arranged from shortest to longest, the 90% completion time represents the TAT within which 90% of tests were completed [4].

Shifts of the day; - A 24 hour time format was utilized. Each day begins at 00:00 (06:00AM local time). The shifts were defined as follows: **Night** (00:00 – 06:59), **Morning** (07:00 – 11:00), **Mid-day** (11:01 – 14:00), **Afternoon** (14:01 – 17:59), and **Evening** (18:00 – 23:59).

Ethical considerations
This study was conducted following ethical approval from the Department of Medical Laboratory Science Research and Ethics Review Committee, College of health sciences, Addis Ababa University. The Institutional Review Board of St. Paul's Hospital Millennium Medical College also approved this study after additional review. Formal permission was subsequently obtained from AaBET hospital laboratory Administration.

Result
Characteristics of study samples
During the study period, time-related data were obtained for 4132 tests physician-ordered tests. Of these, 2309 (55.9%) were hematology tests (CBC) and 1823 (44.1%) were clinical chemistry tests (including Electrolyte, RFT, LFT, Lipid profile and/or others) .Regarding timing, 79.1% of CBC and 78.2% chemistry samples were received at the laboratory specimen accessioning area during week days. Additionally, approximately 30% of daily workload CBC and chemistry samples arrived during the mid-day shift (11:00 and 14:00) Approximately 78.1% CBC tests and 69.2% of chemistry tests were performed under normal condition (days free of equipment, reagent and personnel related issues). Notably, about 38% of samples were processed during periods when supportive staffs (porters) were unavailable, and more than 63% of the tests were done on days with high sample volumes [Table 1].

Table 1 Frequency and percentage distributions of complete blood count and chemistry test samples within observed characteristics in AaBET Hospital, Addis Ababa 2022. (N= 4132)

Variables		**CBC test sample F(%)**	**Chemistry test sample F(%)**
Days of week	Monday	399 (17.3)	285 (15.6)
	Tuesday	352 (15.2)	292 (16.0)
	Wednesday	398 (17.2)	297 (16.3)
	Thursday	342 (14.8)	266 (14.6)
	Friday	336 (14.6)	285 (15.6)
	Saturday	223 (9.7)	186 (10.2)
	Sunday	259 (11.2)	212 (11.6)
Days of shifts	Night (00:00-06:59)	118 (5.1)	97 (5.3)
	Morning (07:00-11:00)	526 (22.8)	445 (24.4)
	Mid-Day (11:01-14:00)	682 (29.5)	553 (30.3)
	Afternoon (14:01-17:59)	581 (25.2)	430 (23.6)
	Evening (18:00-23:59)	402 (17.4)	298 (16.3)
Sample porters are available	Yes	1438 (62.3)	1128 (61.9)
	No	871 (37.7)	695 (38.1)
Daily work load	Lees than daily average*	850 (36.8)	587 (32.2)
	Higher than daily average	1459 (63.2)	1236 (67.8)
Additional test requested	Yes**	1268 (54.9)	1760 (96.5)
	No	1041(45.1)	63 (3.5)
Daily condition or event	Usual event	1804 (78.1)	1261 (69.2)
	Not usual**	505 (21.9)	562 (30.8)

*NB: F= Frequency, %= Percent, CBC=Complete Blood Count, *below 50 for CBC and 30 for Chemistry test sample per day, ** serology with chemistry test, Blood group, compatibility test with CBC, ***Chemistry= (QC fail, equipment problem, Weekly and/or Monthly preventive maintenance, staff short), CBC= (Equipment, Computer, and Reagent problems, Service day, staff short).*

Determination of Turnaround Time
In this study, the **90th percentile completion time** was 105 minutes for CBC and 457 minutes for clinical chemistry tests. The TAT demonstrated significant variability; while some tests were completed in less than 10 minutes, others required several hours, with maximum durations reaching 6 hours for CBC and 24 hours for chemistry. Overall, the **mean (±SD)** total TAT was 53.9 ± 53.4 minutes for CBC and 257.4 ± 287.9 minutes for chemistry [Table 2].

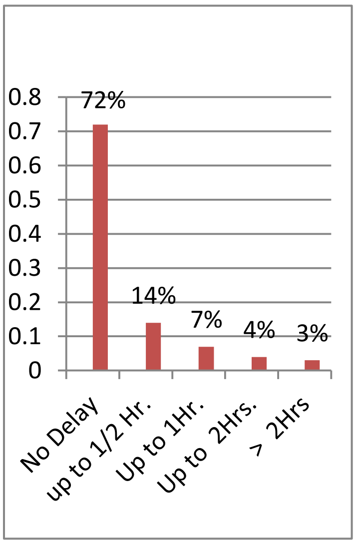
The CBC TAT was primarily affected by **shifts of the day** rather than differences between the days of the week. Among the weekdays, the longest mean CBC TAT was recorded on Wednesdays (58.5 ± 54.0 minutes), while the shortest was on Saturdays ($49.5 pm 47.7$ minutes). However, no statistically significant difference in average TAT was observed between weekdays ($P > 0.05$). Regarding the shifts of the day, a relatively small number of CBC samples were received during the **night shift (00:00 to 06:59)**; notably, these samples recorded the longest TAT (72.8 ± 72.7 minutes) with a 90th percentile of 145 minutes [Table 2]. The TAT for clinical chemistry tests was longer and was significantly affected by both the day of the week and the shift of the day. Samples received on Saturdays accounted for a relatively small proportion (10.2%) of the workload but recorded a longer TAT (338.8 ± 365.0 minutes; median [IQR]: 210 [148–301]) and a 90th percentile completion time of 949 minutes. Based on shifts, 30% of chemistry samples were received during **mid-day (11:00–14:00)**, with 90% of those tests completed within 301 minutes. Overall, significant ($P < 0.05$) variations in average chemistry TAT were observed across both weekdays and shifts [Table 2].

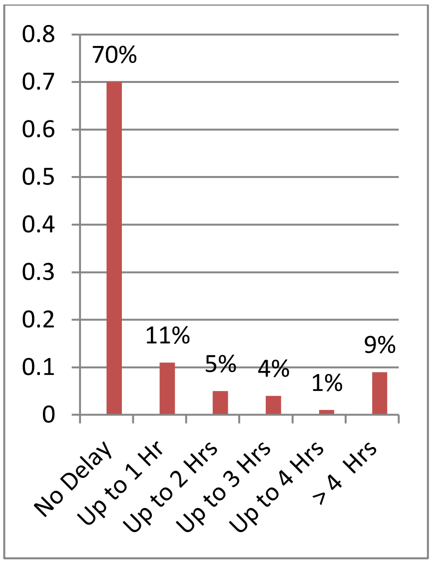
Table 2 Statistics for complete blood count and chemistry tests TAT in Minute from receive to verification according to the Shift and Day of the week in AaBET hospital, Addis Ababa 2022.

	CBC test TAT per min			**Chemistry test TAT per min**		
Test and TAT	**Mean (SD)**	**90th time**	**P value**	**Mean (SD)**	**90th time**	**P value**
Day of the week			0.245			0.002
Monday	54.6 (57.6)	101		238.3 (254.7)	394	
Tuesday	53.5 (57.6)	110		229.9 (249.5)	430	
Wednesday	58.5 (54.0)	112		249.0 (284.1)	410	
Thursday	49.9 (51.8)	107		272.0 (315.8)	509	
Friday	52.3 (47.8)	104		260.2 (287.5)	502	
Saturday	49.5 (47.7)	99		338.8 (365.0)	949	
Sunday	57.5 (52.9)	110		239.5 (260.7)	410	
Shift of day			0.001			0.001
Morning	50.6 (50.4)	106		217.5 (263.8)	358	
Mid-Day	53.4 (53.0)	101		228.8 (221.1)	301	
Afternoon	51.5 (53.7)	100		316.6 (363.3)	977	
Evening	56.9 (49.4)	101		273.0 (292.2)	696	
Night	72.8 (72.7)	145		293.7 (293.5)	532	
Total	**53.9 (53.4)**	**105**		**257.4 (287.9)**	**457**	

NB: CBC=Complete Blood Count, TAT= Turnaround time, SD=Standard Deviation, IQR=Inter Quartile Range, 90th = 90%.

The AaBET hospital laboratory has targeted is to complete 90% of CBC and chemistry tests with in 60 min (1hr) and 240 min (4hrs), respectively. However, this study found that only 72.0% of CBC and 69.9% of chemistry were completed within these pre-determined TAT benchmarks. The majority of CBC test delays (13.9%) were limited to the first 30 minutes beyond the target, while 6.7%, 4.0% and 3.4% were delayed within 30 – 60 minutes, 60 – 120 minutes, and more than 120 minutes (2 hours), respectively. Regarding clinical chemistry tests, of the total results 192 (35.0%) were delayed up to 1 hour, 185 (33.8%) by 1-4 hours and 171 (31.2%) by 4 – 24 hours [Figure 1].





A. For Complete Blood count tests **B. For chemistry tests**

Figure 1: Breakup report for delayed TAT for Complete Blood count and Chemistry tests at AaBET hospital Laboratory 2022

Factors associated with delay in Turnaround Time

As indicated in Table 3, the bivariate logistic regression analysis revealed that specific weekdays, shifts, porter unavailability, and CBC test requests without blood group and/or compatibility tests were significantly associated ($p < 0.05$) with prolonged CBC TAT.After adjustment using multivariate logistic regression analysis, CBC tests received during the evenings and nights shifts, as well as CBC tests requested without blood group and compatibility testing, were identified as independent predictors of delayed results. Significantly higher proportion (40.7%) of CBC test results delays was observed in samples received during night shifts (AOR = 2.32; $p < 0.001$), followed by in evening shifts (32.1%) (AOR = 1.58; P = 0.03), compared to the first (morning) shifts. In addition, CBC tests requested without BG and/or cross-match tests showed significantly (AOR = 1.57, P =0.009) significant proportion of result delay as compared to samples received for CBC, BG and cross-match tests [Table 3].

Table 3 Association of independent characteristics with magnitude of TAT delay among complete blood count test performed in AaBET hospital, Addis Ababa 2022.

Characteristics		TAT Delay N/%	COR (95% C.I.)	P-value	AOR (95% C.I.)	P-value
Days of week	Monday	115/28.8	1		1	
	Tuesday	82/23.3	0.75 (0.54-1.04)	0.086	0.74 (0.53-1.03)	0.071
	Wednesday	129/32.4	1.18 (0.88-1.60)	0.272	1.18 (0.87-1.61)	0.277
	Thursday	84/24.6	0.80 (0.58-1.12)	0.192	0.78 (0.56-1.08)	0.139
	Friday	98/29.2	1.02 (0.74-1.40)	0.918	1.00 (0.72-1.37)	0.976
	Saturday	52/23.3	0.75 (0.51-1.10)	0.138	0.71 (0.49-1.05)	0.084
	Sunday	87/33.6	1.25 (0.89-1.75)	0.195	1.23 (0.88-1.73)	0.230
Days of shifts	Morning	134/25.5	1		1	
	Mid-Day	192/28.2	1.15 (0.89-1.48)	0.299	1.18 (0.91-1.53)	0.219
	Afternoon	144/24.8	0.96 (0.73-1.27)	0.791	1.04 (0.78-1.37)	0.807
	Evening	129/32.1	1.38 (1.04-1.84)	0.027	1.58 (1.17-2.13)	0.003
	Night	48/40.7	2.01 (1.32-3.04)	0.001	2.32 (1.51-3.57)	<0.00
Porters available	Yes	374/26.0	1			
	No	273/31.3	1.30 (1.08-1.56)	0.006		
Work load	Lower*	241/28.4	1			
	Average	406/27.8	0.97 (0.81-1.18)	0.786		
Additional test	BG, XM	52/22.6	1		1	
	BG	213/26.3	1.22 (0.86-1.72)	0.262	1.15 (0.81-1.64)	0.444
	CBC only	382/30.1	1.48 (1.06-2.06)	0.021	1.57 (1.12-2.21)	0.009
Daily condition or event**	No event	483/26.8	1			
	Equipment fail	18/36.0	1.54 (0.86-2.77)	0.150		
	Computer	45/34.6	1.45 (0.99-2.11)	0.054		
	Reagent	33/36.7	1.58 (1.02-2.46)	0.041		
	Service	13/31.7	1.27 (0.65-2.47)	0.482		
	Tech. Short	55/28.4	1.08 (0.78-1.50)	0.638		

NB: ** lower than 50 test, BG= blood group, XM=Compatibility test, CBC=Complete Blood Count, ** CBC Analyzer not working, Computer connected to CBC failed, Reagent short, technologist short. COR= Crud Odds Ratio, AOR= Adjusted Odds Ratio, CI Confidence interval, Additional test= BG and/or XM ordered along CBC test.*

In the clinical chemistry work unit, 548 (30.1%) of the results were not ready on predefined time (240 min or 4hr) due to various possible factors. Among the weekdays, the highest proportions (43%) of delayed test result were observed on Saturdays, which significantly ($p = 0.004$) contributed to chemistry TAT delays. Shifts also showed a significant ($P < 0.001$) association with result delays. Samples received during the **afternoon** and **evening** shifts were significantly more likely to have a delayed TAT compared to those received during the morning shift (COR = 2.88, $P < 0.001$ and COR = 3.64, $P < 0.001$, respectively). Similarly, chemistry tests analyzed on days with **quality control (QC) failures** or **equipment malfunctions** were two to three times more likely to have a delayed TAT than those performed under normal conditions (COR = 2.05, $P = 0.006$ and COR = 3.03, $P < 0.001$, respectively).

While the **unavailability of porters** to transport samples was significantly associated with delays ($P = 0.020$), variations in daily workload and the presence of additional serological tests did not show a significant association. Overall, mid-day, afternoon, and night shifts, as well as workload variation, QC issues, and equipment problems, were identified as predictors of chemistry result delays. However, based on the **multivariable logistic regression** results, only the **night shift** and **equipment failure** remained the most significant ($P < 0.001$) independent predictors of TAT delays for clinical chemistry tests [Table 4].

Table 4 Association of independent characteristics with magnitude of TAT delay among chemistry test performed in AaBET hospital, Addis Ababa 2022.

Characteristics		**TAT Delay N/%**	**COR (95 C.I.)**	**P-value**	**AOR (95 C.I.)**	**P-value**
Days of week	Monday	85/29.8	1			
	Tuesday	73/25.0	0.78 (0.54-1.13)	0.194		
	Wednesday	87/29.3	0.97 (0.68-1.39)	0.888		
	Thursday	73/27.4	0.89 (0.61-1.29)	0.537		
	Friday	88/30.9	1.05 (0.74-1.50)	0.785		
	Saturday	80/43.0	1.78 (1.21- 2.61)	0.004		
	Sunday	62/29.2	0.97 (0.66-1.44)	0.889		
Days of shifts	Morning	92/20.7	1		1	
	Mid-Day	146/26.4	1.38 (1.02-1.85)	0.035	1.38(1.02-1.87)	0.035
	Afternoons	185/43.0	2.88 (2.15-3.91)	<0.001	2.94 (2.17-3.98)	<0.001
	Evening	79/26.5	1.38 (0.98-1.95)	0.065	1.32 (0.93-1.87)	0.122
	Night	46/47.4	3.46 (2.19-5.48)	<0.001	3.50 (2.20-5.57)	**<0.001**
Porters available	Yes	317/28.1	1			
	No	231/33.2	1.27 (1.04-1.56)	0.020		
Work load	Average	354/28.6	1			
	Lower	194/33.0	1.23 (1.00-1.52)	0.055	1.35 (1.07-1.69)	0.010
Additional test	Yes	18/28.6	1			
	No	530/30.1	1.08(0.62-1.88)	0.793		
Daily condition or event**	Usual event	362/28.7	1		1	
	QC fail	28/45.2	2.05 (1.22-3.42)	0.006	2.22 (1.31-3.76)	0.003
	Equipment fail	39/54.9	3.03 (1.87-4.91)	<0.001	3.27 (1.98-5.39)	**<0.001**
	PM Weekly	80/29.2	1.02 (0.77-1.37)	0.871	1.07 (0.80-1.44)	0.659
	PM Monthly	13/33.3	1.24 (0.63-2.44)	0.531	0.81 (0.40-1.64)	0.550
	Tech. short	26/22.4	0.72 (0.46-1.13)	0.151	0.71(0.45-1.13)	0.152

*NB: * lower than 30 test, ** Equipment not working, Quality control failed, technologist short. PM= preventive maintenance, COR= Crud Odds Ratio, AOR= Adjusted Odds Ratio, CI Confidence interval, Additional test= Serology test order along chemistry test.*

Discussion

A laboratory that is both efficient and effective aims to deliver consistently accurate results in a "timely manner" while making the most economical use of its resources [25]. The findings of the study show that the 90th percentile completion times for clinical chemistry and CBC tests were 457 and 105 minutes, respectively. Both durations exceed the current international standards and the AaBET laboratory benchmarks [23,24]. Furthermore, this result is higher than that of a study conducted in Iran, which reported a 90% completion time of 3.5 hours [26]. Such discrepancies may be attributed to differences in technology, the number of available analyzers, and labor capacity.

In this study, the average TAT for CBC was 53.9 ± 53.4 minutes with a median (IQR) of 37 (22–66) minutes, whereas chemistry tests had an average TAT of 257.4 ± 287.9 minutes with a median (IQR) of 173 (110–267) minutes. Interestingly, our results were lower than those reported in another Iranian study, where serum potassium had a median TAT of 225 minutes and hemoglobin had a median of 170 minutes [27]. These differences likely stem from varying definitions of TAT; our investigation defined TAT from **specimen receipt to result release**, whereas the previous study measured from **test ordering to result delivery** [27]. Our findings for chemistry tests were comparable to a study from Gondar University Hospital, which reported an average TAT of 262.28 minutes [16].

The longest mean TAT for CBC occurred during the **night shift (00:00–06:59)**, while the longest for chemistry was observed during the **afternoon shift (14:00–17:59)** and on **Saturdays**. This contrast with the findings of Mahdaviazad H. et al., who observed the shortest mean TAT during the night shift due to a lower workload [26]. In our investigation, TAT was paradoxically longer during periods of lower sample flow. This may be explained by the frequent use of **batch analysis** for chemistry tests and the fact that analyzer maintenance or shutdown times typically occur during the night shift (between 03:00 and 06:00).

Other factors contributing to extended TATs during these shifts include technologists being assigned to multiple tasks and a shortage of sample porters. These insights, supported by the research of Jalil M. et al. and Blick E., indicate that a lack of dedicated personnel for specimen transport, coupled with traditional batch management methods, complicates laboratory workflows and significantly increases TATs [24,27].

Approximately 28.0% of CBC results and 30.1% of chemistry test failed to meet the turnaround time (TAT) targets set by the AaBET laboratory quality policy. While this represents a high delay rate, it is an improvement compared to a study from Nepal, where 38.7% of EM and ICU samples experienced extended TAT [29 In contrast, research from South Korea reported delays in only 2.0% of results, with 98.0% of specimens processed within 60 minutes [14]. Such variations are likely due to differences in infrastructure, internal policies, laboratory information systems, and staffing characteristics across institutions.

In this research, evening shifts (18:00-00:00), night shifts (00:01-06:59), and requests for CBC without blood glucose and/or compatibility testing were recognized as independent predictors of delays in CBC test results In contrast, research from South Korea reported delays in only 2.0% of results, with 98.0% of specimens processed within 60 minutes [14]. Such variations are likely due to differences in infrastructure, internal policies, laboratory information systems, and staffing characteristics across institutions.

Our findings regarding shift-based delays contrast with a study from India, where the majority of delays occurred during lunch breaks (59.22%) and early mornings (29.33%) due to staff shortages during peak workloads [30]. At our facility, although workloads were lower during evening and night shifts, the reduction in available staff—combined with the traditional **batch method** of analysis—led to increased TAT. Under the batch method, higher sample volumes often trigger more frequent processing, whereas lower volumes lead to samples being held until a full batch is ready [24].

Notably, CBC specimens submitted alongside compatibility tests were less likely to be delayed. Given that our facility is a trauma hospital, the laboratory processes 275–325 cross-match tests monthly. These combined requests are treated as **high-priority**, which explains why CBC tests requested *without* concurrent blood grouping or cross-matching were significantly more likely to experience delays.

Finally, a major contributor to chemistry delays was **equipment failure**, specifically related to the **water purification component** of the analyzers. These delays are exacerbated by a lack of spare parts in the local market and a shortage of qualified maintenance technicians, a challenge that aligns with similar research conducted in Kinshasa [31].

Limitations of the Study

This study did not evaluate the specific TAT for individual testing phases (pre-analytical, analytical, or post-analytical), nor did it differentiate between various types of clinical chemistry tests. Furthermore, there was a lack of sufficient literature focusing specifically on emergency department laboratory TAT in the local context, which limited the depth of comparison with other domestic studies.

Conclusion

In this study, a significant percentage of both hematology and chemistry tests exhibited turnaround times that exceeded the pre-established benchmarks of the hospital laboratory. Key factors—including the night shift, equipment failure, and CBC tests requested without concurrent blood grouping or cross-matching—were identified as major contributors to these delays. The reliance on the traditional batch method for specimen analysis and a lack of available backup equipment are primary drivers of prolonged TAT.

To address these issues, laboratory management should optimize shift scheduling and staffing levels while providing targeted personnel orientation for different work areas and shifts. There is also a critical need to reassess and adjust preventive maintenance schedules and internal quality control protocols, ensuring that backup instrumentation is available to mitigate downtime. Finally, given that TAT delays in an emergency hospital are already significant, the delays in non-emergency facilities may be even more pronounced. Future research should focus on these settings to bridge the current information gap.

Declarations

Author's contributions

All authors are equally involved in the conception of the study, data extraction, analysis interpretation and the drafting of the manuscript.

Acknowledgments: The authors would like to thank St. Paul's Hospital Millennium Medical College and AaBET Hospital for their collaboration and for providing the opportunity to conduct this research. We also extend our gratitude to Addis Ababa University for its financial support.

Ethical statement

Ethical approval was obtained from Department of Medical Laboratory Science Research and Ethics Review Committee, College of health sciences, Addis Ababa University and the Institutional Review Board of St Paul's Hospital Millennium College.

Conflict of interest

The authors declare that they have no conflict of interest

Data availability: All relevant data are included within the manuscript.

References

1. Patel D, Sharma D. Turnaround Time (TAT): The Critical Link Between Laboratory Testing and Patient Outcome. Department of Biochemistry, Gujarat Adani Institute of Medical Sciences, GAIMS J Med Sci 2025; 5(2): 51-57.
2. WHO. Preventing injuries and violence: an overview. World Health Organization key facts, 2022. https://www.who.int/publications/i/item/9789240047136.
3. Nagar R. Delivering Quicker Reports for Laboratory Tests Ordered in Emergency Department. Journal of Pharmaceuticals and Biomedical Science. 2015; 05(06):505 – 515.
4. Pati H, Singh G. Turnaround time (TAT): difference in concept for laboratory and clinician. Indian Journal of Hematology and Blood Transfusion. 2014; 30(2):81-84.
5. Alshehri A. Alzaylaee MA, Algethami AS, Alotaibi AW, Alshahrani HA, Aburukbah SK. Emergency physician Practice of laboratory tests requesting at King Faisal Hospital Taif, KSA, World Family Medicine. 2020; 18(8): 13-20 DOI: 10.5742MEWFM.2020.93840.
6. Kaushik N, Khangulov V, O'Hara M, Arnaout R. Reduction in laboratory turnaround time decreases emergency room length of stay. Open access Emerg Med. 2018; 10:37 - 45. doi: 10.2147/OAEM.S155988.
7. Beştemir A, Berikol GB. Clinical laboratory testing in the emergency department: a six-year analysis. Turk J Biochem 2023; 48(5): 467–474. doi: 10.14196/mjiri.31.79.
8. Hashemi S, Asiabar A, Rezapour A, Azami-Aghdash S, Amnab H, Mirabedini S. Patient waiting time in hospital emergency departments of Iran: A systematic review and meta-analysis. Medical journal of the Islamic Republic of Iran. 2017;31:79. doi: 10.14196/mjiri.31.79
9. Lee-Lewandrowski E, Corboy D, Lewandrowski K, Sinclair J, McDermot S, Benzer T. Implementation of a point-of-care satellite laboratory in the emergency department of an academic medical center: impact on test turnaround time and patient emergency department length of stay. Archives of pathology & laboratory medicine. 2003; 127(4):456-60.
10. Chauhan A. Understanding Turnaround Time: Key Metrics in Laboratory Testing, 2024. https://flabslis.com/blogs/what-is-turnaround-time.
11. Ayenew T, Gedfew M, Fetene MG, Telayneh AT, Adane F, Amlak BT et al. Prolonged length of stay and associated factors among emergency department patients in Ethiopia: systematic review and meta-analysis. BMC Emergency Medicine. 2024; 24:212: 1-10. doi.org/10.1186/s12873-024-01131-6.
12. Dawande PP, Wankhade RS , Akhtar FI, Noman O.Turnaround Time: An Efficacy Measure for Medical Laboratories2022 Sep 6;14(9):e28824. doi: 10.7759/cureus.28824.
13. Wiler JL, Welch S, Pines J, Schuur J, Jouriles N, Stone-Griffith S. Emergency department performance measures updates: proceedings of the 2014 emergency department benchmarking alliance consensus summit. AcadEmerg Med. 2015;22 (5):542–553.
14. Lu Y, Leong W, Wei B, Yu P, Wang C, Ying Y, et al. An evaluation of laboratory efficiency in Shanghai emergency by turnaround times level. Journal of clinical laboratory analysis. 2015;29 (4):334-41.
15. Gebreyes M, Sisay A, Tegen D, Asnake A, Wolde M. Evaluation of Laboratory Performance, Associated Factors and Staff Awareness Towards Achieving Turnaround Time in Tertiary Hospitals, Ethiopia. Ethiopian Journal of Health Sciences. 2020 1;30 (5): 2020;30(5):767–776.
16. Belay W, Dere T. Laboratory Turnaround Time for Clinical Chemistry Tests in Outpatient Department at University of Gondar Specialized Hospital, Gondar, North West Ethiopia. Journal iopia, 2019. J Clin Chem Lab Med. 3.140. DOI: 10.35248/clinical-chemistry-laboratory-medicine. 20.3.14.
17. Zewdie A. Assessment of Trauma Care in Tertiary Center, Addis Ababa Ethiopia: An Observational Study. EC Emergency Medicine and Critical Care. 2020;4: 01-8.
18. Sysmex™ XN-550 Automated Hematology Analyzer General Information. Instrument Specifications Revised edition; Sysmex Corporation; 2014.
19. Comp ProDed™ Computer Professional in Medicine. Polytech Laboratory Information System Manual.Comp Pro Med, Inc. USA.https//www.comppromed.com.
20. Tailor H , Mackie I , Mellick A , Machin S. Evaluation of the Sysmex XN-550, a Novel

Compact Haematology analyser from the XN-L® series, compared to the XN-20 system. Int J Lab Hematol.2017; 39(6):585-589. doi: 10.1111/ijlh.12701.
21. Roche Diagnostics™.cobas c 311 analyzer Operator's Manual Software Version 01-04. Hitachi High-Technologies Corporation 24-14.Nishi-shimbashi.1-chome.Minato-ku Tokyo. 105-8717 JAPAN;2010.
22. Paul V. Laboratory Turnaround Time. American Journal of Clinical Pathology. 1996; Special article: 676-686. Available from; https://www.academic.oup.com/ajcp/article/.
23. McKillop D, Auld P. National turnaround time survey: professional consensus standards for optimal performance and thresholds considered to compromise efficient and effective clinical management. Annals of Clinical Biochemistry. 2017; 54 (1):158–164.
24. Blick K. Providing critical laboratory results on time, every time to help reduce emergency department length of stay: how our laboratory achieved a Six Sigma level of performance. American journal of clinical pathology. 2013 1; 140(2):193-202.
25. CLSI. Quality Management System: A model for Laboratory service; Approved Guideline – fourth edition. CLSI document QMS01-A4. Wayne, PA: Clinical and Laboratory Standards Institute: 2011.
26. Mahdaviazad H, JavidialesaadiF, Hosseinzadeh M, Masoompour S. Turnaround times for hematology and chemistry tests in the emergency department: experience of a teaching hospital in Iran. Shiraz University of Medical Sciences E-Medical Journal. 2016; 17:4-5.
27. Jalili M, Shalileh K, Mojtahed A, Mojtahed M, Moradi-Lakeh M. Identifying causes of laboratory turnaround time delay in the emergency department. Archives of Iranian medicine. 2012; 15(12):759 – 763.
28. Mwogi T, Mercer T, Tran DN, Tonui R, Tylleskar T, Were MC. Therapeutic turnaround times for common laboratory tests in a tertiary hospital in Kenya. PloSone. 2020; 8;15(4):e0230858. https://doi.org/10.1371/journal. pone.0230858
29. Bhatt R, Shrestha C, Risal P. Factors affecting turnaround time in the clinical laboratory of the Kathmandu University Hospital, Nepal. The journal of the international federation of clinical chemistry and laboratory medicine. 2019; 30 (01):014 – 024.
30. Archetti C, Montanelli A, Finazzi D, Caimi L, Garrafa E. Clinical laboratory automation: a case study. Journal of Public Health Research. 2017; (6)881:31 – 36.
31. Alain B, Rostin M, Joel K, Hypolite M, Donatien N, Koffi T, Et al. Valuation of Clinical Laboratory Tests' Turnaround Time in a Tertiary Hospital in Democratic Republic of the Congo. Journal of Biosciences and Medicines. 2021; 9:96-111.