INTERNATIONAL JOURNAL OF
MEDICAL BIOCHEMISTRY

DOI: 10.14744/ijmb.2025.83723
Int J Med Biochem 2026;9(1):1–8

Research Article

Comparative analysis of turnaround times before and after the implementation of a new total laboratory automation system

Berrak Guven, Murat Can

Department of Biochemistry, Zonguldak Bülent Ecevit University School of Medicine, Zonguldak, Türkiye

Abstract

Objectives: This study aimed to evaluate the impact of Total Laboratory Automation (TLA) with the implementation of the Beckman Coulter DxA Fit 5000 on laboratory workload and performance.

Methods: A comparative analysis was conducted at the Biochemistry Laboratory of Zonguldak Bülent Ecevit Hospital, covering the pre-automation period (May 1–June 30, 2024) and the post-automation period (May 1–June 30, 2025). Key performance indicators included mean turnaround time (TAT), median TAT, 90th percentile TAT, the proportion of outliers at 60 and 120 minutes, and achievement of emergency department (ED) benchmarks (≤45 minutes). Test volumes were monitored to ensure stability as a covariate.

Results: Following the introduction of TLA, mean TAT decreased by up to 20%, median TAT by 18%, and 90th percentile TAT by 25% across inpatient and outpatient tests. Outlier rates at 60 minutes declined from 12% to 10% in inpatients and from 83% to 55% in outpatients. For STAT testing, the proportion of samples meeting the 45-minute ED benchmark increased from 65% to 88%.Total test volumes remained largely stable between periods, indicating that observed TAT improvements were attributable to automation rather than changes in sample volume. Glucose exhibited the shortest mean TAT, whereas gamma-glutamyl transferase had the longest. In outpatient testing, C-reactive protein demonstrated the highest compliance with the 60-minute TAT benchmark, while human chorionic gonadotropin showed the lowest; however, all outpatient tests were completed within 120 minutes.

Conclusion: The implementation of TLA significantly improved numerical TAT metrics, reduced outlier frequencies, and increased achievement of ED benchmarks, while maintaining stable test volumes, highlighting enhanced efficiency, predictability, and workflow stability in a high-volume university hospital laboratory setting.

Keywords: DxA Fit 5000, total laboratory automation, tunaround time

How to cite this article: Guven B, Can M. Comparative analysis of turnaround times before and after the implementation of a new total laboratory automation system. Int J Med Biochem 2026;9(1):1–8.

Clinical laboratories are integral components of hospital services, providing critical diagnostic information that guides patient management and treatment. In recent years, the demand for laboratory testing has increased steadily, driven by an aging population, the rising prevalence of chronic diseases, the discovery of novel clinically relevant biomarkers, and the overall growth in healthcare utilization. To meet these demands, laboratories have increasingly adopted advanced automation technologies to accelerate processes, enhance standardization, and improve reliability [1].

One of the most comprehensive applications of such technologies is Total Laboratory Automation (TLA) [2]. TLA integrates all phases of the laboratory workflow—preanalytical (sample acceptance, sorting, centrifugation, aliquoting), analytical,

Address for correspondence: Murat Can, MD. Department of Biochemistry, Zonguldak Bülent Ecevit University School of Medicine, Zonguldak, Türkiye
Phone: +90 532 556 85 02 **E-mail:** drcanmurat@yahoo.com **ORCID:** 0000-0002-1539-3973

Submitted: October 22, 2025 **Revised:** December 03, 2025 **Accepted:** December 06, 2026 **Available Online:** February 18, 2026

and postanalytical (storage and archiving)—within a single continuous platform. By minimizing manual intervention, TLA improves process standardization and reduces overall error rates. Given that the majority of laboratory errors occur in the preanalytical phase, automating these steps plays a crucial role in improving the quality of the total testing process [3]. Furthermore, integration of TLA with a Laboratory Information System (LIS) enables synchronization of analytical results with patient records, thereby enhancing both efficiency and the clinical utility of laboratory data [4].

In an era of increasingly constrained healthcare budgets, investments in TLA must demonstrate clear clinical and operational benefits [5]. Among the most widely recognized indicators of such benefit is the reduction of turnaround time (TAT), defined as the interval between test initiation and result reporting. TAT is a well-established quality metric in laboratory medicine, with shorter TAT consistently associated with faster clinical decision-making and improved patient care [6]. Although multiple definitions of TAT exist, laboratories and accreditation bodies most commonly monitor in-laboratory TAT, which refers to the period between the receipt of a barcoded sample and the release of results [7, 8].

Building on this context, the present study was designed to systematically evaluate the impact of implementing the Beckman Coulter DxA Fit 5000 TLA system in the Medical Biochemistry Laboratory, with particular focus on its effect on in-laboratory TAT.

Materials and Methods

The study was approved by the Zonguldak Bülent Ecevit University Ethics Committee (No: 2025/06, Date: 19/03/2025) following the principles of the Declaration of Helsinki. This study was performed at the Biochemistry Laboratory of the University Hospital of Zonguldak Bülent Ecevit, that is a tertiary care 619-bed hospital equipped with an integrated informatics platform that manages both patient records and laboratory test orders. Laboratory data are treated through a software package, allowing clinicians real-time consultation of laboratory reports after laboratory staff clinical validation.

In this study, TATs were systematically observed and analyzed over a two-month period. Laboratory automation was implemented in April 2025 to improve operational efficiency. To evaluate the impact of automation, we compared data from two distinct periods: The pre-automation phase (May 1 to June 30, 2024) and the post-automation phase (May 1 to June 30, 2025). For the calculation of TAT, the time interval was defined from the moment the sample was received in the LIS to the moment the result was verified and reported. These timestamps were identical in both pre-TLA and post-TLA periods, ensuring consistent measurement of turnaround times. Preanalytical steps, such as sample collection and transportation, were not included, as they were performed uniformly across both periods. Repeat or reflex tests, add-on requests, and failed samples were excluded from the TAT analysis. All tests were processed individually; therefore, the observed TAT outliers are not attributable to differences in processing and measurements were consistent across all test types. This comparative design enabled us to assess the effect of TLA on TATs and overall laboratory performance.

Pre-TLA

Before the implementation of automation, the preanalytical area was equipped with a Cobas p612 system. The analytical section consisted of two Cobas 6000 systems (Roche Diagnostics, Mannheim, Germany), including two Cobas c501 modules and one Cobas e601 module, as well as an additional standalone Cobas e601 module used exclusively for STAT samples (Table 1). Samples were manually registered into the Hospital Information Management System and delivered to the centrifugation stage (NF 1200; Nüve, Turkey) by laboratory personnel. After centrifugation, several manual steps were required, including tube decapping, liquid-level detection, barcode verification, sample quality assessment, and aliquoting of both primary and secondary tubes, all facilitated through the Cobas p612 system.

Automation software (Cobas Infinity, Roche Diagnostics, Mannheim, Germany) allowed staff to manage workload orders from the LIS and monitor the operational status of analytical instruments. At the end of each working day, samples were placed in refrigerated storage and discarded after two business days.

Table 1. Instrument configurations and features in pre- and post-TLA periods

Pre-TLA				Post-TLA			
Instrument	**Number of modules**	**Capacity**	**Throughput**	**Instrument**	**Number of modules**	**Capacity**	**Throughput**
Input Module	1	600 tubes	1400 tubes/hr	Input Module	1	336 tubes	375 tubes/hr
Centrifuge	3 (offline)	144 tubes	288 tubes/hr	Centrifuge	1	56 tubes	325 tubes/hr
Decapper	1	N/A	300 tubes/hr	Decapper	1	N/A	375 tubes/hr
Aliquoter	1	N/A	300 tubes/hr	Aliquoter	---------	----------	----------
e601	3	25 position	170 test/hr	DXI 800	2	50 position	400 test/hr
c501	4	63 position	600 test/hr	AU 5800	2	54 positions	2000 test/hr

N/A: Not applicable.

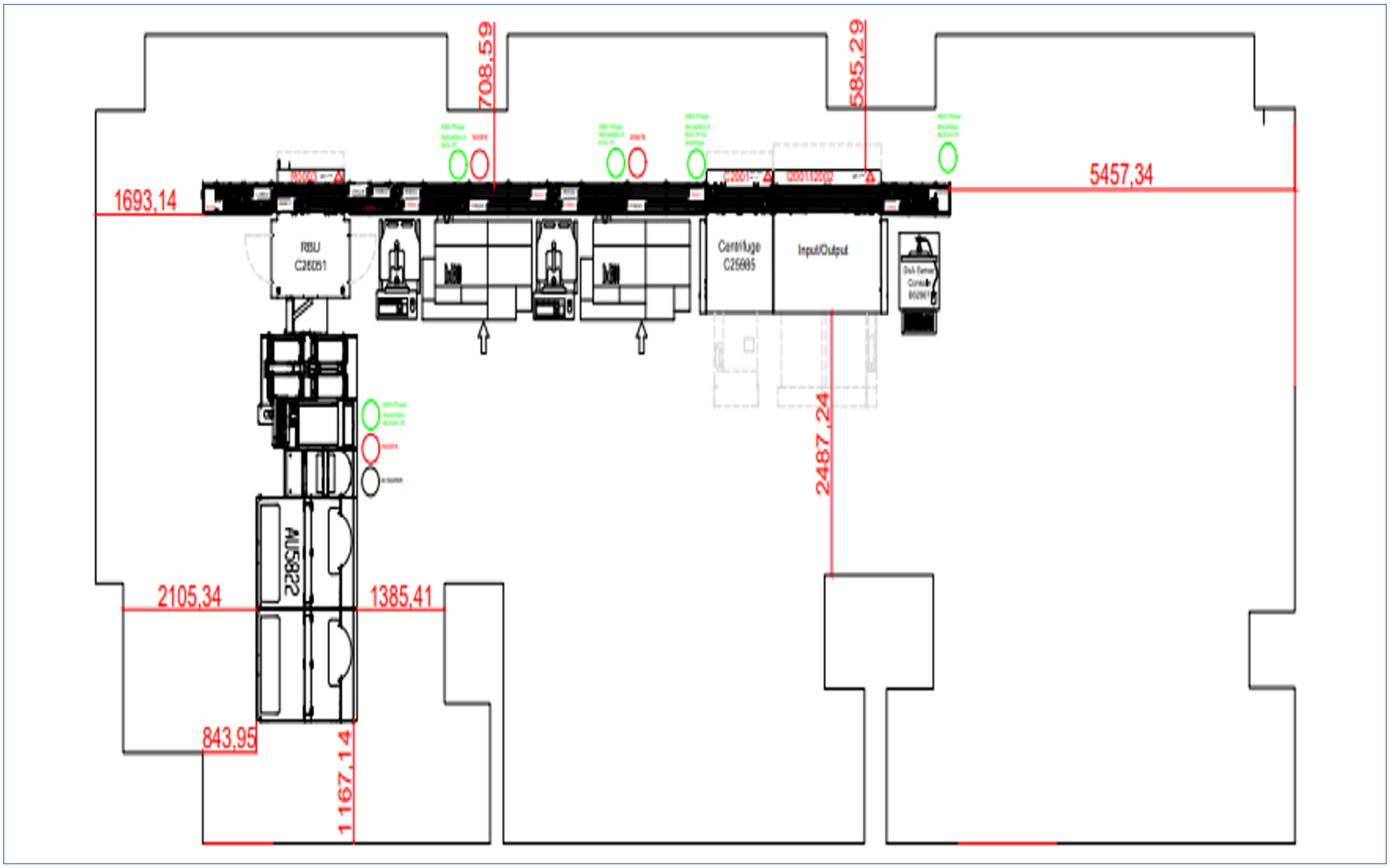

Figure 1. Design of the instruments included along the automation line at the laboratory.

Post-TLA

Following the installation of the TLA system, laboratory workflows were redesigned and centralized. During the preanalytical phase, personnel inspected samples for preanalytical errors (e.g. barcode inconsistencies, or inappropriate tube types) after sample acceptance. Verified samples were then transferred to the sample input area of the DxA Fit 5000 system. The automated laboratory layout included the DxA Fit 5000 Workflow Automation System (Beckman Coulter, CA, USA), two DxI 800 immunoassay analyzers and two AU 5800 clinical chemistry analyzer with an ISE module (Beckman Coulter, CA, USA) (Table 1). This integrated platform allowed standardized handling and management of samples within a unified workstation.

Once the barcode is scanned and work orders are received from the LIS, the automated workflow initiates seamlessly within the system. Robotic arms facilitate the efficient execution of tasks throughout the process. Initially, samples undergo centrifugation, followed by a leveling determination. Upon reaching the lid-opening module, the sample lids are automatically removed and directed towards the analyzers, where hormone and biochemical tests are conducted. The automation software, REMISOL Advance (Beckman Coulter, Brea, CA), empowers staff to effectively manage workload orders from the LIS and monitor the operational status of the associated analytical instruments.

Samples are pipetted into analyzers in precise volumes according to test requirements and subsequently transferred to the DxA Fit 5000 outlet module, which has a storage capacity of 600 tubes. Tubes in this outlet module could be retrieved at any time by staff. Repeat testing is processed automatically without manual intervention, further enhancing efficiency and accuracy. At the end of each day, remaining samples were stored in a refrigerator and discarded after two business days. The schematic layout of the automated system is illustrated in Figure 1.

In this study, predefined outcome measures were established to evaluate the impact of TLA on laboratory performance. The primary outcome was the TAT for outpatient, inpatient, and STAT samples, assessed using mean TAT, median TAT, and 90th percentile TAT for each analyte. These metrics allowed a detailed assessment of the direct effect of TLA implementation on processing times. Secondary outcomes were defined to evaluate workflow quality, stability, and clinical relevance. These included the proportion of samples exceeding accepted TAT limits (outlier rates), the percentage of STAT samples meeting the critical ≤45-minute TAT benchmark, the proportion of samples completed at the 60- and 120-minute marks, and improvements in distribution variability reflected by upper percentile reductions (especially the 90th percentile). This comprehensive approach enabled assessment not only of reductions in average TAT but also of improvements in delay rates, predictability, and performance for emergency testing.

Table 2. Test numbers of inpatient, outpatient and stat samples

	Outpatient		Inpatient		STAT	
	PreTLA (2024)	PostTLA (2025)	PreTLA (2024)	PostTLA (2025)	PreTLA (2024)	PostTLA (2025)
Glucose	9651	9263	16772	11142	2707	1973
Urea	17679	18403	15815	15518	2843	2741
Creatinine	14850	15356	17683	15384	3179	2718
ALT	17839	18079	13588	13467	3172	2709
AST	17306	17261	13532	13467	3168	2706
Total Bilirubin	4680	5162	6752	7374	2052	2129
Potasium	14200	14590	15922	15765	3194	2742
Lipaz	695	764	3633	4364	1139	1049
ALP	7692	7315	6203	7101	772	1043
GGT	9431	8598	7193	8145	623	984
CRP	7371	7539	11408	12918	2239	2131
HCG	1069	1245	345	266	285	236
Troponin I/T	471	529	3359	2777	1817	1972
CK-MB	147	148	3245	2608	1777	1931
TSH	9178	10113	--------	--------	--------	--------
Vit D	3378	3776	--------	--------	--------	--------
B12	5636	7300	--------	--------	--------	--------
Folat	2892	4524	--------	--------	--------	--------
Ferritin	4977	6971	--------	--------	--------	--------
Total	149.142	156.936	135.450	130.296	28.967	27.064

Statistical Analysis

Data analysis was performed using IBM SPSS Statistics version 19.0 (IBM Corp., Armonk, NY, USA). The normality of data distributions was assessed using the Kolmogorov-Smirnov test. Depending on the outcome, comparisons between pre- and post-automation periods were conducted using either a independent-samples t-test for normally distributed variables or the Mann–Whitney U test for non-normally distributed variables. When the t-test was applied, comparisons were based on the mean TAT values, whereas for the Mann–Whitney U test, comparisons were based on the median TAT values. Continuous variables are presented as mean (95% CI), median, and 90th percentile TAT values. All tests were two-tailed, and $p \leq 0.05$ was considered statistically significant.

Results

Upon detailed analysis of the laboratory workload, a noticeable change in the volume of received tubes was observed across all categories, including inpatient, outpatient, and STAT samples. Laboratory performance was evaluated based on 19 outpatient tests and 14 inpatient and STAT tests. Overall, the data indicated a 5% increase in outpatient test volume, a 3.8% decrease in inpatient tests, and a 6.5% reduction in STAT tests between the pre- and post-TLA periods (Table 2). This relative stability in total test numbers supports the interpretation that observed improvements in turnaround time (TAT) primarily reflect workflow efficiency rather than fluctuations in sample volume.

The primary outcomes, defined as mean, median, and 90th percentile TAT, were calculated for each analyte separately for outpatient, inpatient, and STAT samples. For outpatient tests (Table 3), all analytes including Glucose, Urea, Creatinine, ALT, AST, Total Bilirubin, Potassium, Lipase, ALP, GGT, CRP, HCG, Troponin I/T, CK-MB, TSH, B12, Folate, and Ferritin exhibited a significant reduction in TAT across all three metrics ($p<0.001$), except for Vitamin D, which showed only modest changes. Among outpatient tests, Potassium demonstrated the lowest mean TAT at 67 minutes, whereas Vitamin D had the highest mean TAT at 141 minutes. Notably, Vitamin D also showed the highest TAT values at both the 60- and 120-minute time points, while ALT had the lowest values. These results indicate that the impact of automation was observed across both routine and complex assays, with certain analytes demonstrating larger absolute reductions in TAT.

For inpatient and STAT tests (Table 4, 5), the mean TAT ranged from 39 minutes for Glucose to 43 minutes for GGT among inpatient samples. For STAT samples, the mean TAT ranged from 31 minutes for GGT to 39 minutes for HCG. The median and 90th percentile TAT values consistently reflected reductions post-TLA, suggesting both improvements in central tendency and decreased variability. Across outpatient tests, the 60-minute TAT completion rate varied from 5% for HCG to 13% for CRP, whereas by the 120-minute mark, all tests were completed, demonstrating efficient throughput.

Secondary outcomes were systematically assessed to evaluate workflow quality and predictability. Outlier analysis indicated

Table 3. Total Laboratory Automation (TLA), mean, median and 9th percentile laboratory Turnaround Time (TAT), and Percentage of Outlier (OP) at 60 min and 120 min during the study period for outpatient tests

Test	Mean TAT (%95 CI)		Median TAT		90th percentile		OP 60 min		OP 120 min		p
	Pre-TLA	Post-TLA	Pre-TLA	Post-TLA	Pre-TLA	Post-TLA	Pre-TLA	Post-TLA	Pre-TLA	Post-TLA	
Glucose	119.71 (18.8–120.8)	80.3 (79.4–81.3)	115	67	182	146	90.6	56.8	45.1	17.7	<0.001[a]
Urea	107.4 (106.7–108.0)	75.1 (74.5–75.8)	102	63	169	133	83.7	52.3	34.9	13.3	<0.001[a]
Creatinine	104.6 (103.8–105.3)	75.0 (74.3–75.7)	99	62	167	131	81.7	51.9	32.6	12.9	<0.001[a]
ALT	110.1 (109.5–110.8)	67.9 (67.4–68.4)	104	57	172	114	85.3	45.9	37.1	8.6	<0.001[a]
AST	109.3 (108.7–110.1)	68.4 (67.9–69.0)	104	58	171	114	84.9	46.8	36.4	8.5	<0.001[a]
Total Bilirubin	112.1 (110.8–113.4)	77.5 (76.3–78.7)	107	63	173	143	87.1	53.3	39.6	15.6	<0.001[a]
Potasium	106.4 (105.7–107.2)	67.6 (67.0–68.2)	101	57	168	114	83.8	55.1	34.1	8.4	<0.001[b]
Lipaz	109.0 (105.4–112.8)	69.8 (67.2–72.3)	102	58	179	117	85.3	47.5	34.8	9.2	<0.001[a]
ALP	114.3 (113.3–115.4)	70.9 (70.0–71.8)	109	60	178	119	87.1	49.5	40.9	9.7	<0.001[a]
GGT	112.2 (111.3–113.2)	74.7 (71.4–73.2)	107	63	175	127	86.0	53.3	38.8	11.9	<0.001[a]
CRP	112.4 (111.2–113.5)	89.6 (88.5–90.7)	107	77	175	156	86.4	65.2	39.4	23.2	<0.001[a]
HCG	153.2 (149.6–156.8)	114.1 (109.8–118.5)	153	96	224	179	95.2	82.3	68.5	31.4	<0.001[a]
Troponin I/T	151.1 (146.2–155.9)	107.9 (103.4–112.4)	154	98	208	167	94.5	85.1	74.5	33.6	<0.001[a]
CK-MB	136.0 (127.7–144.4)	119.8 (108.2–131.4)	135	100	201	206	90.5	81.1	61.9	39.9	<0.001[a]
TSH	146.9 (145.9–147.9)	118.0 (116.7–119.3)	147	102	20 3	186	97.3	87.8	68.6	38.8	<0.001[a]
Vit D	141.4 (139.4–143.4)	140.9 (138.3–143.6)	144	124	191	222	97.2	94.6	61.8	52.2	>0.05[b]
B12	140.3 (138.8–141.9)	125.4 (123.8–127.0)	141	110	193	197	97.6	92.6	60.6	43.0	<0.001[a]
Folat	138.4 (136.3–140.6)	126.6 (124.6–128.6)	138	113	191	199	97.5	94.4	58.1	45.3	<0.001[a]
Ferritin	134.8 (133.2–136.3)	130.0 (128.3–131.7)	134	114	190	209	96.3	92.4	56.6	66.1	<0.001[a]

95% Confidence Interval (CI); [a]: Mann–Whitney U test, Pre-TLA compared with Post-TLA for non-normally distributed data; [b]: Independent t-test, Pre-TLA compared with Post-TLA for normally distributed data.

a substantial reduction in the proportion of samples exceeding acceptable TAT limits, particularly among STAT samples where the proportion meeting the ≤45-minute ED benchmark increased notably. Troponin I and CK-MB tests, critical for emergency diagnostics, had the highest outpatient TAT values at both 60- and 120-minute intervals; however, automation resulted in a meaningful decrease in outliers and improved adherence to the ED standard. Conversely, creatinine and Potassium tests consistently demonstrated the lowest TAT values, reflecting optimized processing for high-frequency assays.

Discussion

The implementation of a TLA system in our biochemistry laboratory in 2025, comprising the Beckman Coulter DxA Fit

Table 4. Total Laboratory Automation (TLA), Mean, Median and 90th Percentile Laboratory Turnaround Time (TAT), and Percentage of Outlier (OP) at 60 min and 120 min during the study period for inpatient tests

Test	Mean TAT (%95 CI)		Median TAT		90th percentile		OP 60 min		OP 120 min		p
	Pre-TLA	Post-TLA	Pre-TLA	Post-TLA	Pre-TLA	Post-TLA	Pre-TLA	Post-TLA	Pre-TLA	Post-TLA	
Glucose	40.1 (39.7–40.5)	39.2 (38.9–39.4)	37	36	61	58	10.1	8.8	0	0	<0.001[a]
Urea	43.5 (43.3–43.7)	40.1 (39.7–40.4)	41	36	63	60	12.2	10.0	0	0	<0.001[a]
Creatinine	42.9 (42.7–43.2)	41.9 (41.0–41.8)	41	37	62	63	11.5	11.5	0	0	<0.001[a]
ALT	43.3 (43.1–43.6)	41.6 (41.3–42.0)	41	37	63	62	12.5	11.1	0	0	<0.001[a]
AST	44.8 (44.5–45.1)	41.8 (41.4–42.1)	42	37	64	62	13.8	11.0	0	0	<0.001[a]
Total Bilirubin	46.2 (45.8–46.6)	43.2 (42.8–43.8)	44	38	67	63	17.5	11.9	0	0	<0.001[a]
Potasium	42.5 (42.3–42.8)	40.6 (40.2–40.9)	40	36	62	60	11.8	9.8	0	0	<0.001[b]
Lipaz	46.3 (45.4–47.2)	39.9 (39.4–40.5)	42	36	68	58	16.8	8.7	0	0	<0.001[b]
ALP	47.7 (47.2–48.2)	42.9 (42.4–43.4)	45	37	69	63	18.8	11.8	0	0	<0.001[a]
GGT	48.3 (47.8–48.8)	43.3 (42.8 –43.8)	45	38	70	63	19.5	12.2	0	0	<0.001[b]
CRP	46.2 (45.9–46.4)	44.1 (43.7–44.5)	42	39	66	64	16.2	13.3	0	0	<0.001[a]
HCG	42.3 (41.2–43.5)	39.6 (37.4–41.8)	41	34	58	56	8.6	5.5	0	0	<0.001[a]
Troponin I/T	46.1 (45.7–46.6)	40.4 (39.7–41.0)	44	36	60	56	10.1	8.2	0.1	0	<0.001[a]
CK-MB	46.0 (45.5–46.4)	39.9 (39.2–40.6)	44	36	60	55	9.6	7.7	0	0	<0.001[a]

95% Confidence Interval (CI); [a]: Mann–Whitney U test, Pre-TLA compared with Post-TLA for non-normally distributed data; [b]: Independent t-test, Pre-TLA compared with Post-TLA for normally distributed data.

5000, two DxI 800 immunoassay analyzers, and two AU 5800 chemistry analyzers, represents a significant advancement in laboratory modernization. This transition required not only technological upgrades but also a fundamental shift in the philosophy of sample processing. Software customization posed the greatest challenge, highlighting the importance of accurate operational data collection and close collaboration among LIS personnel, IT specialists, and laboratory staff, whereas hardware transition proceeded smoothly.

The primary focus of this study was the impact of TLA on TAT. Our results indicate that automation can substantially reduce TAT and stabilize workflow variability. Tornel et al. [9] reported that online centrifugation within TLA added 9–10 minutes compared with offline methods. In our setting, offline centrifugation alone required at least 10 minutes, resulting in total processing times comparable to online workflows, with a mean of 23 minutes. These observations suggest that while manual processing may be faster for very small STAT sample volumes, TLA provides superior performance for high-volume and accessible STAT testing.

In emergency department (ED) testing, achieving a TAT ≤45 minutes is clinically meaningful [10]. Following TLA implementation, median troponin I TAT decreased from 42 to 34 minutes, reaching this benchmark. Similar improvements have been reported by Angeletti et al. [4], Lam et al. [11], and Chung et al. [12], demonstrating the feasibility and clinical benefit of intra-laboratory TAT <45 minutes.

Potassium TAT, evaluated as a benchmark analyte, showed a substantial reduction in outlier rates, decreasing from 12% to 10% in inpatients and from 83% to 55% in outpatients. This aligns with Holland et al. [13], who reported minimal changes in mean potassium TAT but significant reductions in extreme delays (>40 minutes). These improvements emphasize the value of automation in stabilizing workflow variability, which is highly regarded by clinicians.

Table 5. Total Laboratory Automation (TLA), Mean, Median and 90th Percentile Laboratory Turnaround Time (TAT), and Percentage of Outlier (OP) at 60 min and 120 min during the Study Period for STAT Tests

Test	Mean TAT (%95 CI)		Median TAT		90th percentile		OP 60 min		OP 120 min		p
	Pre-TLA	Post-TLA	Pre-TLA	Post-TLA	Pre-TLA	Post-TLA	Pre-TLA	Post-TLA	Pre-TLA	Post-TLA	
Glucose	37.6 (37.0–38.3)	34.3 (32.7–34.0)	34	30	50	49	5.4	5.2	0.5	0.7	<0.001[a]
Urea	34.9 (34.4–35.3)	32.5 (31.9–33.1)	34	28	47	46	4.7	2.1	0.6	0.6	<0.001[a]
Creatinine	34.5 (34.1–34.8)	32.5 (31.9–33.2)	33	28	46	46	4.7	1.7	0.4	0.1	<0.001[a]
ALT	35.3 (34.8–35.8)	31.6 (31.0–32.2)	34	27	47	45	4.4	2.3	0.6	0.1	<0.001[a]
AST	35.9 (35.4–36.2)	32.1 (31.5–32.7)	35	28	48	46	4.4	2.5	0.6	0.1	<0.001[a]
Total Bilirubin	35.5 (34.8–36.0)	32.3 (31.3–33.3)	35	28	48	46	4.8	2.2	0.7	0	<0.001[a]
Potasium	34.6 (34.0–34.8)	32.1 (31.5–32.7)	34	28	46	45	4.4	1.9	0.6	0	<0.001[b]
Lipaz	35.3 (34.6–36.0)	31.7 (30.7–32.7)	34	28	48	45	4.3	2.6	0.6	0	<0.001[a]
ALP	35.0 (34.2–35.7)	31.6 (29.6–31.7)	34	27	48	45	4.0	2.1	0.4	0	<0.001[a]
GGT	35.7 (34.9–36.7)	31.4 (30.1–32.6)	35	28	49	45	4.5	2.4	0.3	0	<0.001[a]
CRP	36.5 (35.8–37.0)	34.0 (33.3–34.7)	35	30	50	48	5.3	3.0	0.6	0.1	<0.001[a]
HCG	42.4 (40.7–43.5)	39.3 (36.9–41.8)	41	34	55	54	8.1	5.6	0	0	<0.001[a]
Troponin I/T	43.9 (43.3–44.5)	37.6 (36.6–37.9)	42	34	56	49	6.5	5.7	0.3	0.1	<0.001[a]
CK-MB	43.8 (43.2–44.4)	37.8 (36.7–38.1)	43	34	56	50	6.4	5.8	0.2	0	<0.001[a]

95% Confidence Interval (CI); [a]: Mann–Whitney U test, Pre-TLA compared with Post-TLA for non-normally distributed data; [b]: Independent t-test, Pre-TLA compared with Post-TLA for normally distributed data.

Secondary metrics including outlier rates, the proportion of tests meeting ED benchmarks, and percentile-based measures of TAT demonstrated consistent improvements post-TLA. Lam et al. [11], Chung et al. [12], Ellison et al. [14], Kim et al. [15], Osuna et al. [16], and Yıldız et al. [17] similarly report reductions in mean, 90th, 95th, and 99th percentile TAT, improvements in delayed-result frequency, and enhanced workflow predictability. These findings collectively indicate that TLA not only reduces median TAT but also stabilizes extreme delays and improves overall laboratory efficiency.

Although preanalytical TAT could theoretically influence total TAT, accessioning and barcode scanning were identical in both pre- and post-TLA periods; therefore, improvements are predominantly attributable to intralaboratory automation.

The present study has several limitations that should be considered. It is a single-center study with a pre/post design without randomization, which may limit generalizability. Unmeasured seasonal differences could influence TAT. The reliance on LIS time stamps introduces potential measurement bias, and no direct measurement of preanalytical error rates was performed. Economic evaluation was not conducted despite discussion of labor savings.

Conclusion

Overall, the implementation of TLA significantly enhanced efficiency, predictability, and workflow stability. Instrument configuration upgrades increased analytical capacity, which likely contributed indirectly to TAT improvements by enabling the laboratory to manage high sample volumes more effectively. Future studies should investigate the quantitative relationship between throughput and TAT reduction to fully elucidate the operational benefits of automation.

Disclosures

Ethics Committee Approval: The study was approved by the Zonguldak Bülent Ecevit University Ethics Committee (no: 2025/06, date: 19/03/2025).

Informed Consent: Informed consent was obtained from all participants.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

Funding: The authors declared that this study received no financial support.

Use of AI for Writing Assistance: No AI technologies utilized.

Authorship Contributions: Concept – M.C., B.G.; Design – M.C.; Supervision – M.C.; Funding – M.C., B.G.; Materials – M.C., B.G.; Data collection and/or processing – M.C.; Data analysis and/or interpretation – M.C., B.G.; Literature search – M.C.; Writing – M.C.; Critical review – M.C., B.G.

Peer-review: Externally peer-reviewed.

References

1. Nam Y, Park HD. Revolutionizing laboratory practices: Pioneering trends in total laboratory automation. Ann Lab Med 2025;45(5):472–83. [CrossRef]
2. Ialongo C, Porzio O, Giambini I, Bernardini S. Total automation for the core laboratory: Improving the turnaround time helps to reduce the volume of ordered STAT tests. J Lab Autom 2016;21(3):451–8. [CrossRef]
3. Armbruster DA, Overcrash DR, Reyes J. Clinical chemistry laboratory automation in the 21st century – amat victoria curam (victory loves careful preparation). Clin Biochem Rev 2014;35:143–53.
4. Angeletti S, De Cesaris M, Hart JG, Urbano M, Vitali MA, Fragliasso F, Dicuonzo G. Laboratory automation and intra-laboratory turnaround time: Experience at the university hospital campus Bio-Medico of Rome. J Lab Autom 2015;20(6):652–8. [CrossRef]
5. Lou AH, Elnenaei M, Sadek I, Thompson S, Crocker BD, Nassar B. Evaluation of the impact of a total automation system in a large core laboratory on turnaround time. Clin Biochem 2016;49:1254–8. [CrossRef]
6. Holland LL, Smith LL, Blick KE. Reducing laboratory turnaround time outliers can reduce emergency department patient length of stay: An 11-hospital study. Am J Clin Pathol 2005;124:672–4. [CrossRef]
7. Dolci A, Giavarina D, Pasqualetti S, Szőke D, Panteghini M. Total laboratory automation: Do stat tests still matter? Clin Biochem 2017;50(10–11):605–11. [CrossRef]
8. Breil B, Fritz F, Thiemann V, Dugas M. Mapping turnaround times (TAT) to a generic timeline: A systematic review of TAT definitions in clinical domains. BMC Med Inform Decis Mak 2011;11:34. [CrossRef]
9. Tornel PL, Ayuso E, Martinez P. Evaluation of the turnaround time of an integrated preanalytical and analytical automated modular system in a medium-sized laboratory. Clin Biochem 2005;38(6):548–51. [CrossRef]
10. O'Gara PT, Kushner FG, Ascheim DD, Casey DE Jr, Chung MK, de Lemos JA, et al. 2013 ACCF/AHA guideline for the management of ST-elevation myocardial infarction: A report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. J Am Coll Cardiol 2013;61:e78–e140.
11. Lam C, Jacob E. Implementing a laboratory automation system: Experience of a large clinical laboratory. J Lab Autom 2012;17(1):16–23. [CrossRef]
12. Chung HJ, Song YK, Hwang SH, Lee DH, Sugiura T. Experimental fusion of different versions of the total laboratory automation system and improvement of laboratory turnaround time. J Clin Lab Anal 2018;32:e22400. [CrossRef]
13. Holland LL, Smith LL, Blick KE. Total laboratory automation can help eliminate the laboratory as a factor in emergency department length of stay. Am J Clin Pathol 2006;125(5):765–70. [CrossRef]
14. Ellison TL, Alharbi M, Alkaf M, Elimam S, Alfaries M, Nounou RA, et al. Implementation of total laboratory automation at a tertiary care hospital in Saudi Arabia: Effect on turnaround time and cost efficiency. Ann Saudi Med 2018;38(5):352–7. [CrossRef]
15. Kim K, Lee SG, Kim TH, Lee SG. Economic evaluation of total laboratory automation in the clinical laboratory of a tertiary care hospital. Ann Lab Med 2022;42:89–95. [CrossRef]
16. García-Osuna Á, Guiñón Muñoz L, Costa Pallaruelo M, Mansilla Usero A, Cuevas Eduardo B, Llanos Ramos J, et al. Characterization of add-on testing before and after automation at a core laboratory. Heliyon 2023;9(11):e22096. [CrossRef]
17. Yıldız R, Ulman C. Corrective steps in a total laboratory automation: Experience of a university laboratory. Turk Klin Biyokim Derg 2023;21(3):134–44. [CrossRef]