ORIGINAL RESEARCH PAPER
Volume - 15 | Issue - 06 | June - 2026 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr
INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

TURNAROUND TIME (TAT) ANALYSIS OF ARTERIAL BLOOD GAS, PROTHROMBIN TIME–INR, AND ELECTROLYTES IN URGENT SAMPLES AT A TERTIARY CARE TEACHING HOSPITAL: A PROSPECTIVE OBSERVATIONAL STUDY

Pathology

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ABSTRACT

Background: Turnaround time (TAT) is a primary key performance indicator (KPI) of clinical laboratory quality, as mandated by ISO 15189:2022. In emergency and critical care settings, even modest TAT prolongation adversely affects clinical decision-making and patient outcomes. Arterial blood gas (ABG), prothrombin time–international normalized ratio (PT-INR), and serum electrolyte estimation are the most time-sensitive investigations ordered from intensive care units (ICUs) and emergency departments (EDs). Despite growing national recognition of TAT benchmarking, phase-granular TAT data from Maharashtra's public tertiary hospitals remain scarce. **Aim:** To prospectively measure and evaluate phase-wise TAT for ABG, PT-INR, and electrolyte tests in urgent samples; benchmark values against AACC/ISO-recommended limits; and identify correctable bottlenecks for quality improvement.**Methods:** A prospective, observational, single-center study was conducted at the Central Clinical Laboratory, MGM Medical College and Hospital, Kamothe, from January to June 2023. A total of 600 consecutive urgent samples (ABG: n=250, PT-INR: n=150, Electrolytes: n=200) from the MICU, SICU, and ED were analyzed after applying pre-defined inclusion/exclusion criteria. Timestamps were extracted from the Hospital Information System (Meditech v6.1). TAT was stratified into three phases: pre-analytical (T0→T1), analytical (T1→T2), and post-analytical (T2→T4). Statistical analysis used IBM SPSS v26; between-group differences were assessed by one-way ANOVA.**Results:** The mean total TAT (±SD) was 18.4 ± 5.1 min for ABG, 46.2 ± 12.3 min for PT-INR, and 52.7 ± 14.8 min for electrolytes. The 90th-percentile TAT values were 26 min, 68 min, and 79 min, respectively. ABG met the 30-minute benchmark in 93.2% of cases. PT-INR exceeded the 60-minute limit in 18.7% of samples; electrolytes in 21.5%. Overall, 88/600 samples (14.7%) exceeded acceptable TAT limits. The pre-analytical phase contributed the greatest proportion of total delay (42%), followed by post-analytical (33%) and analytical (25%). Manual transport time (median 9 min) and phlebotomy wait were the leading pre-analytical determinants ($p<0.001$).**Conclusion:** ABG TAT consistently meets international benchmarks due to point-of-care testing proximity. PT-INR and electrolyte TATs require targeted pre-analytical interventions — including pneumatic tube transport, dedicated STAT phlebotomy, and LIS result-push notifications. A structured continuous quality improvement (CQI) framework aligned with ISO 15189:2022 is recommended to sustain improvement.

KEYWORDS

Turnaround Time; Abg; Pt-inr; Electrolytes; Emergency Laboratory; Quality Indicators; Iso 15189; Pre-analytical Errors; Kpi; Clinical Biochemistry

INTRODUCTION

Quality in laboratory medicine is multidimensional, encompassing analytical accuracy, precision, and timely reporting. Timeliness — quantified as TAT — is particularly critical in time-dependent clinical settings. ISO 15189:2022 mandates that laboratories establish and prospectively monitor clinically meaningful TAT targets. The "brain-to-brain" testing cycle (Lundberg, 1981) highlights that inefficiencies at any step propagate downstream delays. Plebani and Carraro have demonstrated that the pre-analytical phase accounts for 46–68% of total laboratory errors, with direct implications for timeliness.

In the ICU and ED setting, three investigations are especially time-critical: ABG (guides ventilation and acid-base management), PT-INR (directs anticoagulation reversal), and serum electrolytes (manages dyselectrolytaemias). AACC guidelines recommend a TAT of ≤30 minutes for ABG and ≤60 minutes for PT-INR and electrolytes. Published Indian data show wide variability: Wankar (2017) reported mean TATs of 22–78 minutes across test categories; Bhatia et al. (2019) demonstrated a 31% TAT reduction following pneumatic tube transport introduction. MGM Medical College and Hospital, Kamothe — a 750-bed tertiary teaching institution with an annual ED census exceeding 65,000 — served as the study site, given the scarcity of phase-granular TAT data from Maharashtra's public hospitals.

AIMS AND OBJECTIVES

(i) Prospectively measure total and phase-wise TAT for ABG, PT-INR, and electrolyte tests in urgent samples from the ICU and ED. (ii) Determine the proportion of samples exceeding internationally recommended TAT limits. (iii) Identify and quantify root causes of delay across each phase. (iv) Recommend evidence-based corrective interventions to optimize laboratory throughput.

MATERIALS AND METHODS

Study Design and Setting

A prospective, observational, single-center study was conducted at the Central Clinical Laboratory, MGM Medical College and Hospital, Kamothe (750 beds; NABL 2024 accreditation pending), from January 1 to June 30, 2023.

Sample Size and Selection

Assuming 20% of samples exceeding acceptable TAT (95% CI, 5% precision), the required sample size was n ≥ 246 per test. Accounting for ~8% attrition and HIS timestamp gaps, the final targets were ABG: 250, PT-INR: 150, and Electrolytes: 200 (total: 600). Consecutive urgent samples labeled STAT/URGENT in the HIS from MICU, SICU, and ED were enrolled. Samples with corrupted timestamps (n=17), hemolysed/clotted samples (n=9), and repeat requests within 4 hours (n=6) were excluded.

TAT Definition and Timestamps

TAT was defined as the interval from physician order entry (T0) to result availability on the ward HIS terminal (T4). Phase-wise breakdown: pre-analytical (T0→T1: order to lab receipt), analytical (T1→T2: receipt to result validation), post-analytical (T2→T4: validation to report delivery). Timestamps were extracted via HIS audit-trail query (Meditech v6.1 Report Writer).

Acceptable Benchmarks and Statistics

Acceptable limits (AACC/ISO 15189:2022/NABL 112): ABG ≤30 min; PT-INR and Electrolytes ≤60 min. Continuous variables are expressed as mean ± SD and median (IQR). Normality was assessed by Shapiro-Wilk test. Between-group differences were evaluated by one-way ANOVA with post-hoc Tukey HSD; chi-squared test was used for proportions. $p<0.05$ was considered statistically significant. IEC approval was obtained (Ref: MGM/IEC/2022/118); individual consent was waived as only HIS timestamps were extracted.

RESULTS

Sample Characteristics

Of 632 screened samples, 600 met inclusion criteria (exclusion rate 5.1%). Source distribution: MICU 42.3%, SICU 28.2%, ED 29.5%. Most urgent requests were made between 08:00–14:00 hrs (43.7%) and 20:00–02:00 hrs (31.2%).

Table 1: Demographic and Sample Profile of Study Cohort (n=600)

Parameter	ABG (n=250)	PT-INR (n=150)	Electrolytes (n=200)
Male patients, n (%)	148 (59.2)	91 (60.7)	118 (59.0)
Mean age (years ± SD)	51.4 ± 18.2	54.1 ± 16.8	49.7 ± 19.5
MICU origin, n (%)	112 (44.8)	65 (43.3)	77 (38.5)
SICU origin, n (%)	74 (29.6)	43 (28.7)	52 (26.0)
ED origin, n (%)	64 (25.6)	42 (28.0)	71 (35.5)
Night shift samples (20:00–08:00), n (%)	98 (39.2)	61 (40.7)	82 (41.0)

Phase-wise and Total TAT

Mean total TAT was 18.4 ± 5.1 min for ABG (median 17 min), 46.2 ± 12.3 min for PT-INR, and 52.7 ± 14.8 min for electrolytes. The 90th-percentile values were 26, 68, and 79 min respectively. Between-test differences were highly significant (F=381.6; p<0.001).

Table 2: Phase-wise Turnaround Time (minutes) by Test Type

TAT Phase	ABG Mean±SD	ABG Median	PT-INR Mean±SD	PT-INR Median	Elec. Mean± SD	p*
Pre-analytical (T0→T1)	7.0 ± 2.8	6	19.4 ± 7.1	18	22.7 ± 8.3	<0.001
Analytical (T1→T2)	4.6 ± 1.9	4	11.5 ± 4.6	11	13.2 ± 5.4	<0.001
Post-analytical (T2→T4)	6.8 ± 2.6	6	15.3 ± 5.8	14	16.8 ± 6.7	<0.001
Total TAT (T0→T4)	**18.4 ± 5.1**	17	**46.2 ± 12.3**	44	**52.7 ± 14.8**	<0.001
90th Percentile TAT (min)	**26**	—	**68**	—	**79**	—

One-way ANOVA; Elec. = Electrolytes

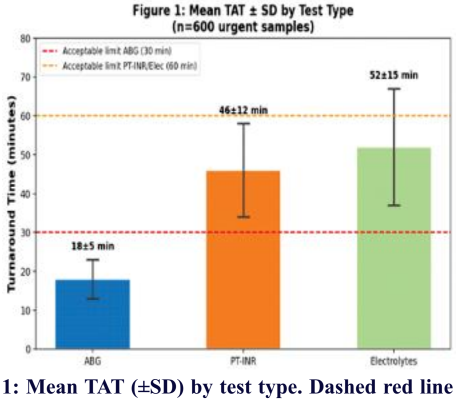


Figure 1: Mean TAT (±SD) by test type. Dashed red line = ABG acceptable limit (30 min); dashed orange = PT-INR/Electrolytes limit (60 min). All values in minutes.

TAT Compliance

ABG exceeded the 30-minute limit in 17/250 samples (6.8%). PT-INR exceeded 60 minutes in 28/150 (18.7%) and electrolytes in 43/200 (21.5%). Overall, 88/600 samples (14.7%) exceeded acceptable limits (χ^2=24.8; df=2; p<0.001).

Table 3: TAT Compliance — Proportion Exceeding Acceptable Limits

Test	n	Acceptable Limit	Exceeded, n (%)	Within Limit, n (%)
ABG	250	≤30 min	17 (6.8%)	233 (93.2%)
PT-INR	150	≤60 min	28 (18.7%)	122 (81.3%)
Electrolytes	200	≤60 min	43 (21.5%)	157 (78.5%)
TOTAL	**600**	—	**88 (14.7%)**	**512 (85.3%)**

Phase-wise Delay Contribution

Among the 88 delayed samples, the pre-analytical phase contributed 42% of excess delay, followed by post-analytical (33%) and analytical (25%). Within the pre-analytical phase, manual transport (median 9 min) and phlebotomy wait (median 6 min) were the dominant factors. Post-analytical delays were primarily due to report printing failures and HIS push errors.

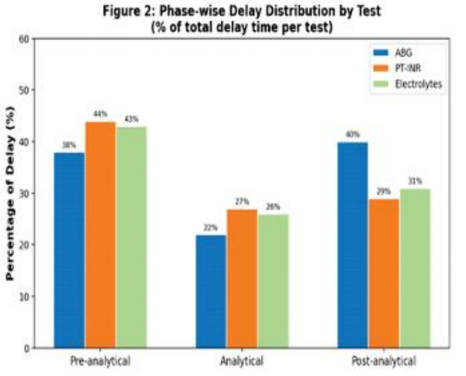


Figure 2: Phase-wise delay distribution (%) by test type. Pre-analytical phase dominates across all three test categories.

Monthly TAT Trend

A progressive decline in TAT exceedance was observed from February to June 2023, coinciding with interim measures introduced in February 2023 (reinforced STAT flagging and dedicated night-shift phlebotomist rostering), providing proof-of-concept for targeted interventions.

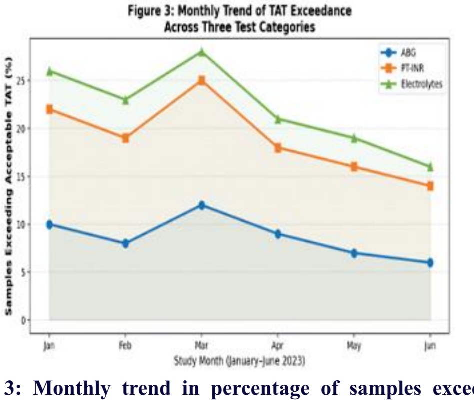
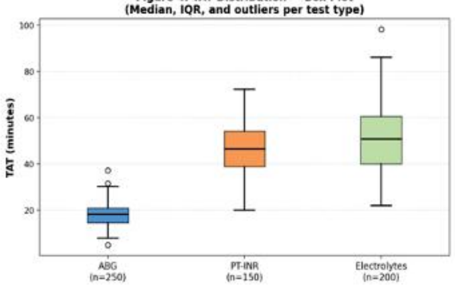


Figure 3: Monthly trend in percentage of samples exceeding acceptable TAT (January–June 2023). Declining trend from February–June reflects interim corrective measures.

TAT Distribution

Box plot analysis (Figure 4) shows ABG has a tight, symmetric distribution with few outliers, consistent with near-bedside point-of-care testing. PT-INR and electrolytes show right-skewed distributions with high-outlier samples, suggesting episodic rather than systemic delays.



PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

Figure 4: Box plot of total TAT distribution per test type. Horizontal line = median; box = IQR (25th–75th percentile); whiskers = 1.5×IQR; circles = outliers.

Root Cause Analysis

Structured root cause analysis of the 88 delayed samples identified manual transport (28.4%) as the single largest cause, followed by report delivery/printing failure (20.5%), instrument downtime (18.2%), sample rejection (13.6%), and phlebotomy staff shortage (12.5%). Miscellaneous causes accounted for 6.8%.

Table 4: Root Cause Analysis of TAT Delays (n=88 delayed samples)

Root Cause	n	%	Phase Affected
Manual transport delay (porter system)	25	28.4%	Pre-analytical
Report printing / HIS push failure	18	20.5%	Post-analytical
Instrument downtime / calibration	16	18.2%	Analytical
Sample rejection (haemolysis/clot)	12	13.6%	Pre-analytical
Phlebotomy wait / staff shortage	11	12.5%	Pre-analytical
Miscellaneous (mislabelling, incomplete forms)	6	6.8%	Pre-analytical
TOTAL	**88**	**100%**	—

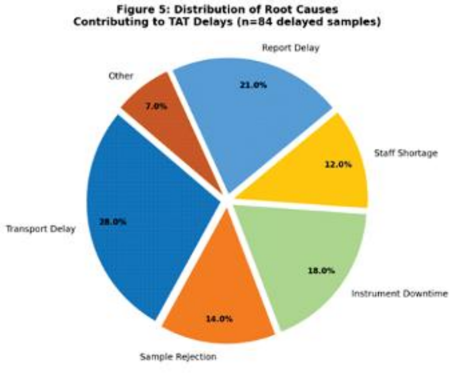


Figure 5: Pie chart showing root cause distribution among the 88 samples that exceeded acceptable TAT limits.

DISCUSSION

This study's principal findings are: ABG TAT conforms to international benchmarks in >93% of samples; PT-INR and electrolyte TATs exceed acceptable limits in ~1 in 5 samples; the pre-analytical phase contributes the largest proportion of delay; and manual transport and phlebotomy waits are the most remediable bottlenecks.

ABG testing at MGM uses Radiometer ABL90 FLEX PLUS point-of-care analyzers stationed in ICU corridors, explaining the markedly shorter TAT (18.4 ± 5.1 min). This aligns with Hawkins (2007), who reported an inverse relationship between transport distance and TAT compliance. PT-INR TAT (46.2 ± 12.3 min) is comparable to Wankar's (2017) findings (mean 48.3 min) and to Bhatia et al. (2019) pre-intervention data (mean 52 min). However, the 90th-percentile PT-INR TAT of 68 minutes represents a clinically significant lag for anticoagulation emergencies.

Electrolyte testing (52.7 ± 14.8 min) on the Beckman Coulter AU5800 processes both routine and urgent samples in a continuous-access queue without algorithmic prioritization — a system-design issue contributing to analytical delays. The pre-analytical contribution of 42% aligns with Plebani (2006) estimates of 46–68% for pre-analytical error burden. Current manual porter-based transport averages 9–17 minutes from different units; pneumatic tube systems have been shown to reduce transport time by 60–75% (Kim et al., 2020). Post-analytical delays (33%) — from HIS push failures and print delays — are amenable to real-time LIS result-broadcasting solutions already deployed in NABH-accredited Indian hospitals. Limitations include the single-center design, potential HIS entry-delay measurement error in post-analytical TAT, and uncollected confounders such as APACHE II scores and individual operator performance. Seasonal variation across the January–June study period was not formally analyzed.

CONCLUSION

ABG TAT (18.4 ± 5.1 min) consistently meets the 30-minute benchmark through point-of-care testing. PT-INR (46.2 ± 12.3 min) and electrolyte (52.7 ± 14.8 min) tests show unacceptable exceedance rates of 18.7% and 21.5%, driven by pre-analytical transport inefficiencies and post-analytical reporting delays. High-impact, achievable interventions — pneumatic tube transport, a dedicated STAT analyzer queue, LIS result-push integration, and round-the-clock STAT phlebotomy — are recommended. A structured CQI framework with monthly TAT KPI review, aligned with ISO 15189:2022, is essential for sustaining improvement. Multicentre replication and a pre-post intervention study following PTS installation are planned as next steps.

ACKNOWLEDGEMENTS

The authors acknowledge laboratory technicians, phlebotomy staff, and the IT team of the Central Clinical Laboratory, MGM Medical College and Hospital, Kamothe. No external funding was received. The authors declare no conflicts of interest. Anonymized data are available from the corresponding author on reasonable request.

REFERENCES

1. Lundberg GD. Acting on significant laboratory results. JAMA. 1981;245(17):1762–1763.
2. Plebani M. Errors in clinical laboratories or errors in laboratory medicine. Clin Chem Lab Med. 2006;44(6):750–759.
3. Carraro P, Plebani M. Errors in a stat laboratory: types and frequencies 10 years later. Clin Chem. 2007;53(7):1338–1342.
4. Hawkins RC. Laboratory turnaround time. Clin Biochem Rev. 2007;28(4):179–194.
5. Shiferaw MB, Yismaw G. Magnitude of delayed turnaround time of laboratory results. BMC Health Serv Res. 2019;19(1):220.
6. Bhatia S, Wahi P, Goyal R. Reducing delay in laboratory reports. BMJ Open Qual. 2019;8(1):e000225.
7. Wankar AD. Study of determination of laboratory turnaround time in tertiary care hospital. Int J Res Med Sci. 2017;5(4):1396–1401.
8. Kim S, Park H, Lee Y, et al. Impact of pneumatic tube systems on laboratory turnaround times. Ann Lab Med. 2020;40(1):45–52.
9. ISO 15189:2022. Medical Laboratories — Requirements for quality and competence. ISO, Geneva.
10. AACC. Guidance document on laboratory turnaround time. 2020.
11. NABL 112. Specific criteria for accreditation of medical testing laboratories. NABL, New Delhi; 2021.
12. Lippi G, et al. Preanalytical quality improvement: in quality we trust. Clin Chem Lab Med. 2013;51(1):229–241.
13. Sciacovelli L, Plebani M. The IFCC Working Group on laboratory errors and patient safety. Clin Chim Acta. 2009;404(1):79–85.
14. Green SF. The cost of poor blood specimen quality. Clin Biochem. 2013;46(13-14):1175–1179.
15. Narayanan S. The preanalytic phase: an important component of laboratory medicine. Am J Clin Pathol. 2000;113(3):429–452.