Improving Diagnostic Turnaround Time and Analytical Reliability in Clinical Biochemistry Laboratories: A Quality Management Framework

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ABSTRACT

Clinical biochemistry laboratories play a key role in diagnosis, triage, therapy monitoring and patient-flow decisions. Ongoing delays and inconsistent test reliability weaken their clinical value and cannot be corrected simply by increasing analyser speed. These problems often arise at poorly managed interfaces across the total testing process, including test requesting, patient identification, specimen collection and transport, accessioning, centrifugation, analysis, validation and result reporting.

Objective: To create a comprehensive quality-management framework that shortens diagnostic turnaround time (TAT) while maintaining analytical reliability in clinical biochemistry laboratories.

Methods: A narrative review was conducted using international laboratory quality standards, consensus guidance and peer-reviewed research on TAT, quality indicators, risk-based control, sigma metrics, autoverification and the total testing process.

Findings: Sustainable improvement depends on defining TAT from the user perspective, decomposing it into measurable components, redesigning bottleneck-prone pre- and post-analytical steps, and applying analytical controls matched to method risk, clinical purpose and performance. In one published single-institution blood-gas implementation, rule-based autoverification reduced TAT from 27 to 18 minutes while the reported verification error rate fell from 2.0% to 0.05%, illustrating that speed and reliability can improve together when safeguards are validated and monitored. This review offers an integrated framework linking TAT metrics, risk controls and quality-management-system governance across the full testing cycle.

Conclusion: A high-quality clinical biochemistry laboratory is not merely fast. It is a well-controlled socio-technical system that produces timely, traceable, clinically interpretable and analytically reliable results. Quality management provides the governance needed to improve speed and reliability simultaneously rather than trading one against the other.

Keywords: clinical biochemistry; turnaround time; analytical reliability; ISO 15189; quality indicators; risk-based quality control; total testing process; laboratory quality management; autoverification

INTRODUCTION

The clinical biochemistry laboratory has become one of the most information-dense units in modern healthcare. Electrolytes, renal profiles, liver function tests, cardiac biomarkers, glucose indices, endocrine assays, therapeutic drug monitoring and emergency chemistry panels inform diagnosis and treatment across emergency medicine, intensive care, surgery, obstetrics, oncology, nephrology and primary care. When a potassium result is delayed, when a creatinine value is analytically unreliable, or when a critical result is not communicated promptly, the laboratory failure is no longer an internal technical inconvenience; it becomes a clinical-risk event [5-7].

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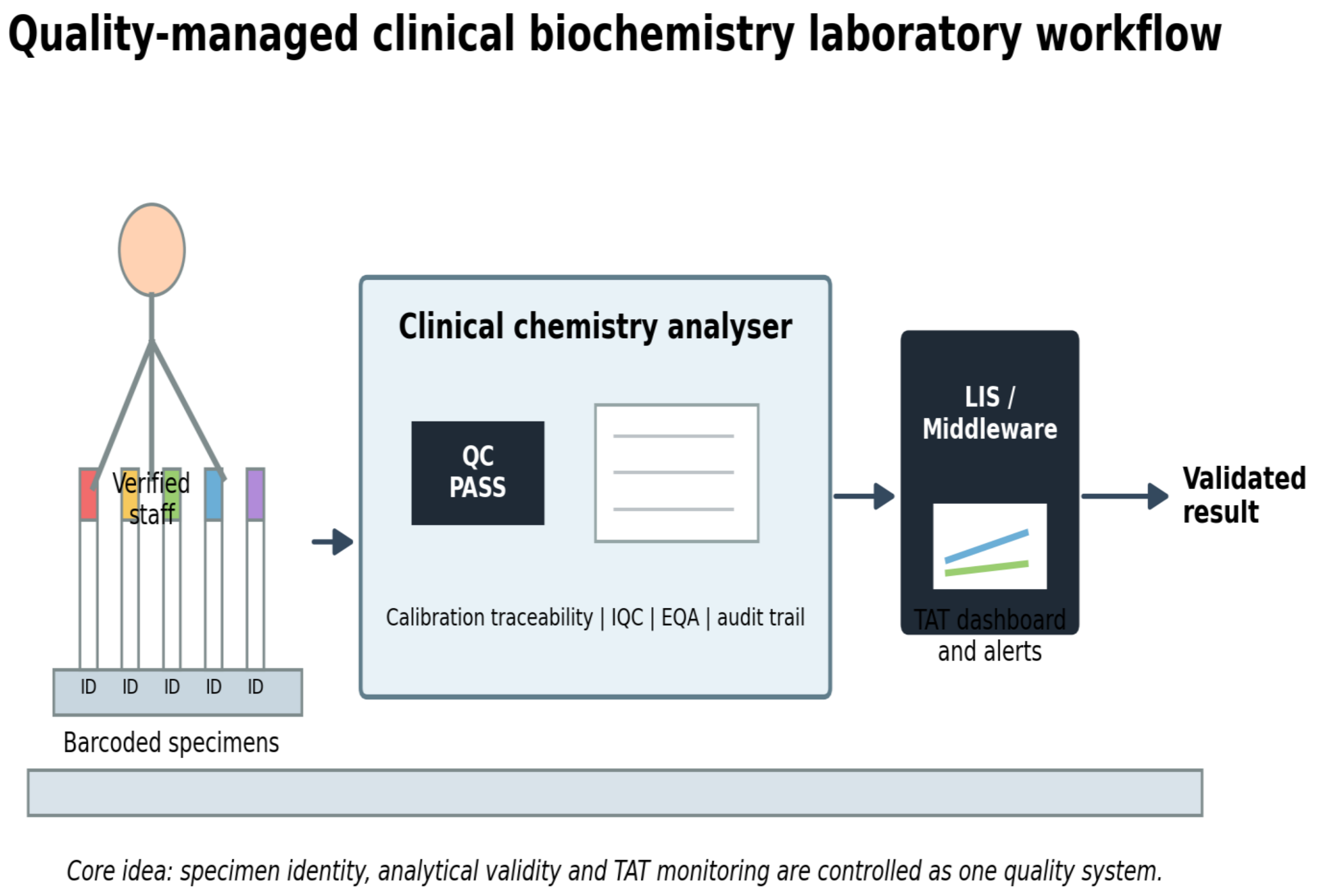
Turnaround time is often restricted to analyser processing time or to the interval between laboratory receipt and technical validation. This restricted definition is operationally inadequate because it ignores major pre-analytical and post-analytical sources of diagnostic delay. From the patient and clinician perspective, TAT is the interval between the clinical decision to request a test and the moment an actionable result is available. In practice, order-entry errors, specimen collection delays, transport batching, centrifugation queues, sample rejection, delayed validation, information-system downtime and poor critical-result communication may dominate the true diagnostic delay [5,6,8,9].

Analytical reliability is equally vulnerable to oversimplification. Daily internal quality control alone does not prove that the laboratory is reliable. Reliability requires method verification, calibration traceability, internal quality control, external quality assessment, lot-to-lot verification, maintenance, staff competence, risk assessment, nonconformity management, corrective action and continual improvement [1-3]. A quality-management system (QMS) is therefore not an administrative ornament for accreditation visits. It is the operating logic of a safe diagnostic service.

This article argues that TAT and analytical reliability should not be managed as competing objectives. Poorly designed attempts to reduce TAT can encourage premature release of results, inadequate governance of repeat testing, or weakened review of abnormal findings. Conversely, excessive analytical conservatism can delay the delivery of clinically urgent results. A mature QMS resolves this tension by defining acceptable risk, designing standardised workflows, using quality indicators and adopting risk-based quality control that matches the clinical consequence of error [1,3,7,8]. The contribution of this review is an integrated framework that connects TAT measurement, analytical risk control, and QMS governance across the entire testing process.



Picture 1. Original illustration of a quality-managed clinical biochemistry workflow linking barcoded specimens, automated analysis, QC acceptance and LIS-based TAT monitoring.

Methods: narrative review approach

This manuscript was developed as a narrative review and practice-oriented quality-improvement framework. Relevant literature was identified through searches of PubMed, Google Scholar, Scopus/Web of Science and institutional guideline repositories using combinations of the terms clinical biochemistry, turnaround time, laboratory quality indicators, ISO 15189, analytical quality, risk-based quality control, sigma metrics, autoverification and total testing process. The literature window prioritised publications from 2007 to 2025, while retaining foundational international standards and guidance documents regardless of publication year.

Priority was given to international standards, consensus guidance and peer-reviewed studies addressing TAT, analytical reliability and laboratory quality management. ISO 15189:2022, the WHO Laboratory Quality Management System handbook, CLSI EP23 guidance and IFCC quality-indicator work were used as core normative sources [1-4,7,8]. Empirical and review literature on laboratory TAT, pre-analytical and post-analytical quality indicators, sigma metrics, automation and benchmarking was used to translate these principles into an operational framework [5-13]. Sources that focused exclusively on non-clinical laboratory systems, research-only assay development or unvalidated local opinions without transferable quality-management content were not prioritised. Because the purpose was to build a clinically usable QMS framework rather than to estimate pooled intervention effects, no meta-analysis was performed. Instead, the synthesis organised the literature around five questions: how should diagnostic TAT be defined, which phases generate measurable delay, which analytical controls protect the reliability of results, how can speed and reliability be governed together, and which indicators should be used to verify sustained improvement.

Screening transparency: the original narrative search was not prospectively registered, and database exports were not retained in a form that permits a reliable reconstruction of the total number of records initially identified. For this revision, the 13 full-text sources in the working evidence set were re-screened against the stated eligibility criteria, and all 13 were included in the final synthesis: four standards or consensus resources and nine peer-reviewed publications. No meta-analysis or formal risk-of-bias assessment was undertaken. These figures should therefore be interpreted as an audit of the evidence actually used in the manuscript, not as a PRISMA-style systematic-review flow.

Conceptual basis: quality management as a diagnostic-control system

A useful way to conceptualise a clinical biochemistry laboratory is as a diagnostic-control system. Inputs are test requests and patient specimens; processes include pre-analytical, analytical, and post-analytical activities; outputs are validated diagnostic results; feedback is provided through quality indicators, internal audits, external quality assessments, incident reviews, user complaints, and management reviews. Without feedback, the laboratory merely performs tests. With feedback, the laboratory learns. ISO 15189:2022 emphasises competence, risk, impartiality, patient focus and the management system needed to sustain valid examination results [1]. The WHO LQMS model similarly organises laboratory quality around coordinated essentials such as personnel, equipment, purchasing and inventory, process control, documents and records, occurrence management, assessment and continual improvement [2]. These are not simply accreditation headings. Each one maps directly onto failures that delay results or damage analytical credibility.

For example, equipment management affects both reliability and TAT through preventive maintenance, downtime planning, backup analysers, service-level agreements and calibration schedules. Personnel management affects the quality of results through competency assessment and authorisation to perform or validate tests. Process control governs collection instructions, sample acceptance criteria, QC rules, auto-verification protocols, and corrective action thresholds. The QMS is therefore the architecture through which laboratory speed becomes safe speed.

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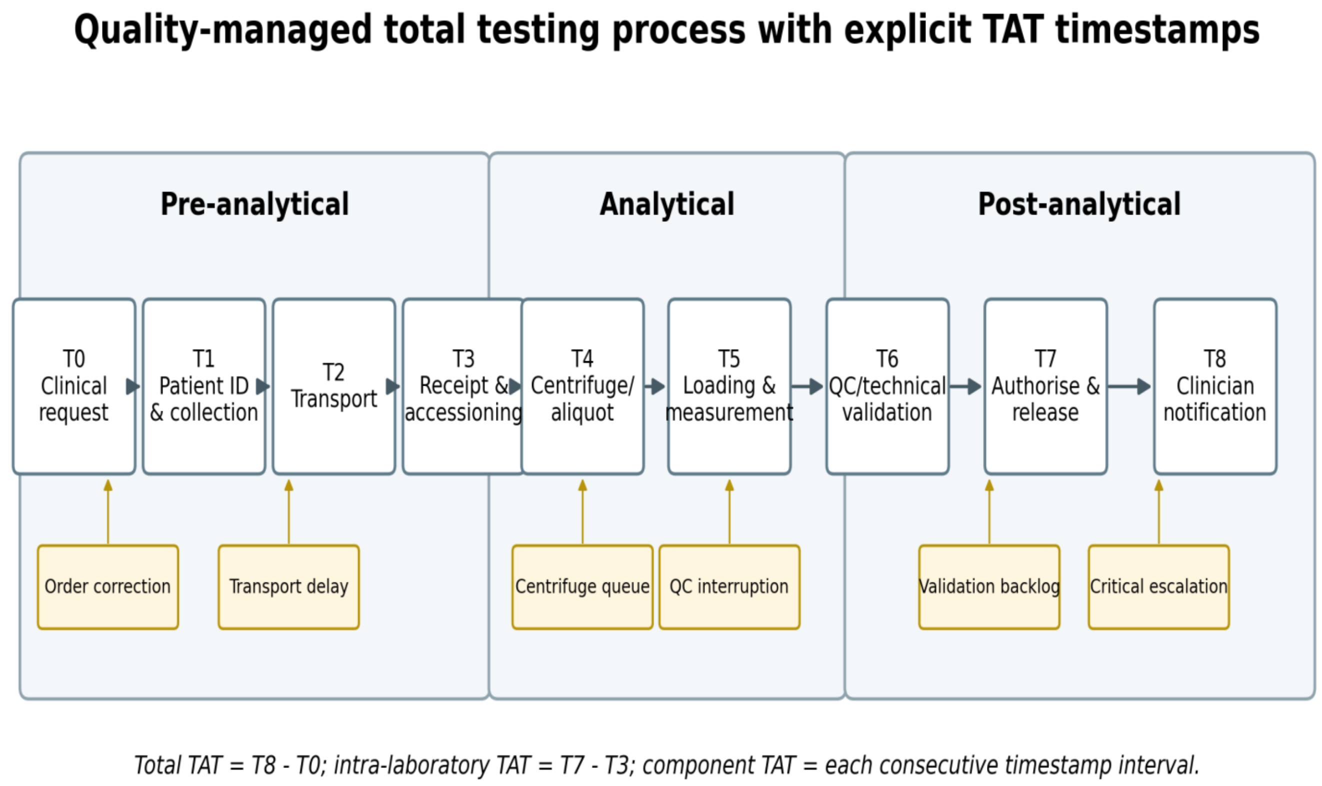

Figure 1. Quality-managed total testing process with explicit timestamps for component-level TAT control. The timestamp structure separates total TAT, intra-laboratory TAT and phase-specific TAT so that delay can be located rather than averaged away.

Table 1. Quality-management system elements and their practical relevance to TAT and analytical reliability.

QMS element	Operational contribution	Failure mode controlled
Leadership and governance	Defines TAT policy, escalation rules, quality objectives, risk appetite and accountability for delayed or unreliable results.	Conflicting priorities, poor ownership of delays and weak incident learning.
Personnel competence	Ensures staff are trained, assessed, authorised and reassessed for collection, analysis, validation and critical-result communication.	Mislabeling, wrong-container errors, unsafe manual dilution and inconsistent result review.
Equipment and maintenance	Controls analyser uptime, calibration status, preventive maintenance, backup capacity and downtime protocols.	Unexpected downtime, extended queues, QC failure and reagent instability.
Process control	Standardises specimen acceptance, centrifugation, prioritisation, QC, validation and repeat-testing logic.	Uncontrolled variation, rework, unnecessary repeats and delayed verification.
Information management	Links HIS, LIS, middleware, analyser interfaces, autoverification, alerts, dashboards and audit trails.	Lost requests, transcription errors, delayed report release and weak traceability.
Occurrence management	Captures nonconformities, performs root-cause analysis, assigns corrective action and verifies effectiveness.	Repeated failures disguised as isolated mistakes.
Internal audit and management review	Tests whether the QMS works in practice and whether indicators are improving.	Accreditation compliance without operational improvement.

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Turnaround time: definition, measurement and managerial control

The first error in many laboratories is to measure the wrong TAT. If a laboratory reports only analyser TAT or laboratory-reception-to-validation TAT, it may show acceptable internal performance while clinicians continue to experience unacceptable diagnostic delay. A serious laboratory should define at least three TAT levels: total TAT from request to result availability, intra-laboratory TAT from specimen receipt to report release, and phase-specific TAT for pre-analytical, analytical and post-analytical subprocesses [5,6].

The second error is over-reliance on averages. Mean TAT is insensitive to patients who experience the longest delays. A laboratory may have an acceptable average while its 90th- or 95th-percentile TAT is clinically unacceptable. Quality management therefore requires median TAT, percentile TAT, breach rate and stratification by priority, ward, test group, time of day, analyser and sample route [5,6,12]. A service that cannot identify the source of the delay cannot credibly claim to be improving.

TAT targets must also differ by clinical context. Emergency results for potassium, glucose, lactate, or troponin require targets that reflect acute diagnostic and treatment decisions. In contrast, routine lipid profiles or stable chronic disease monitoring tests may tolerate longer turnaround times. Therefore, clinical urgency, test purpose, patient location and risk of delayed action should determine the service-level matrix. A single TAT target for all chemistry tests is administratively simple but clinically crude.

The third error is to ignore demand variability. Clinical biochemistry demand is not uniform across the day. Morning inpatient collections, outpatient peaks, emergency department surges, analyser maintenance windows, staff handovers, and transport schedules create queueing effects. Improvement, therefore, requires not only faster equipment but also flow design: staggered collection, priority lanes for urgent specimens, transport redesign, centrifuge capacity matching, middleware autoverification, and clear escalation rules when TAT begins to deteriorate [6,11].

Table 2. Recommended TAT indicators for clinical biochemistry laboratories.

Indicator	Definition	Suggested measurement	Managerial interpretation
Total TAT	Time from electronic test request to the authorised clinician's result availability.	Median, 90th percentile and breach rate by location and priority.	Clinician-facing indicator; best reflects diagnostic delay.
Pre-analytical TAT	Request for specimen receipt in the laboratory, with optional sub-steps for collection and transport.	Order-to-collection, collection-to-receipt and rejected-specimen rate.	Usually contains large hidden delays and specimen-quality failures.
Analytical TAT	Specimen receipt or loading to analytical completion, including centrifugation and QC interruptions.	Receipt-to-analysis, analyser queue time, QC-failure delay and repeat rate.	Sensitive to batching, maintenance, reagent status and analyser capacity.
Post-analytical TAT	Analytical completion to authorised result release and critical-value communication.	Autoverification rate, validation delay and critical-result notification time.	Often improved through middleware rules and escalation protocols.
TAT breach rate	Percentage of specimens or test requests exceeding the agreed service target.	Number delayed divided by number eligible, reported weekly or monthly.	More useful than averages for operational accountability.

Analytical reliability: beyond daily quality control

Analytical reliability means that a reported result is sufficiently accurate, precise, traceable and clinically fit for its intended use. The phrase “fit for intended use” is important. A sodium result in a critically ill patient, a troponin result in chest pain triage, and an HbA1c result for long-term diabetes monitoring do not carry the same immediate clinical risk. Quality control should therefore be matched to clinical consequence and method vulnerability rather than applied as a ritual [1,3,10]. A robust analytical-reliability programme begins before

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routine testing. Method selection and verification should assess the intended clinical use, manufacturer performance claims, local precision, bias, linearity, analytical measuring range, reportable range, carryover, interference, reagent stability, calibration traceability, reference intervals, decision limits, and measurement uncertainty, where relevant [1,3]. New methods should not be released simply because the analyser has been installed and the supplier has provided training. Verification must demonstrate local performance under local conditions.

Routine reliability control then requires an integrated package: internal QC, external quality assessment or proficiency testing, calibration verification, lot-to-lot comparison, temperature monitoring, maintenance records, reagent inventory control, operator competence, delta checks, autoverification rules and incident review [1-3,7,8]. Risk-based QC, as reflected in CLSI EP23 principles, asks what can go wrong, how likely it is, how harmful it would be and what control measure is proportionate [3]. Sigma metrics can help rationalise QC rules and frequency, but they should be interpreted within clinical risk and method context rather than used mechanically [10].

Table 3. Analytical-reliability metrics and their quality-management use.

Metric	Meaning	Typical failure detected	Quality-management action
Bias	Systematic deviation from a reference or peer-comparison value.	Calibration error, lot change or method interference.	Trend EQA/PT and patient medians; investigate persistent directionality.
Imprecision	Random analytical variation, usually expressed as the coefficient of variation.	Pipetting variation, unstable reagent or instrument noise.	Monitor internal QC CV by analyte and level; compare with allowable imprecision.
Linearity/AMR verification	Evidence that the method performs across the clinically relevant measuring range.	Nonlinearity, dilution error or inappropriate reporting beyond the verified range.	Verify analytical measuring range and define repeat/dilution rules.
Total error	Combined effect of bias and imprecision against a defined allowable error.	Multiple small defects that accumulate into a clinical error.	Use allowable total error or biologically derived specifications where available.
Sigma metric	Performance index relating allowable error, bias and imprecision.	Over- or under-controlled QC if rules are not matched to performance.	Use sigma to rationalise QC frequency, rules and number of control measurements.
Patient-result plausibility	Clinical and longitudinal checks on released results.	Wrong specimen, dilution error or ignored analyser flag.	Use delta checks, critical-value rules and review thresholds.

Integrating speed and reliability: a practical QMS framework

The proper objective is not simply faster results. The objective is the faster release of correct, traceable and clinically actionable results. The QMS must therefore impose a sequence of controls that remove waste without removing safeguards. The proposed framework has six connected components: define service requirements, measure the process, diagnose dominant failure modes, redesign bottlenecks, verify that analytical validity has been protected and sustain gains through governance.

First, service requirements should be negotiated with clinical users. Emergency, ICU, outpatient, ward-round and chronic-disease monitoring contexts may require different TAT targets. The laboratory should document which tests are urgent, which specimens have priority routing and which results require immediate communication. An urgent label that applies to everything is not a useful risk-control category. Second,

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laboratories should map the total testing process in sufficient detail to identify controllable delays. A high-level process map is useful for governance, but operational improvement requires timestamps for the following: request, collection, receipt, centrifugation, loading, analytical completion, validation, authorisation, and clinician notification. The LIS and middleware should be configured to capture these points wherever possible.

Third, analytical safeguards should be redesigned intelligently rather than relaxed. Autoverification is not a shortcut for weak staff review; it is a rule-based control system that releases results only when defined quality criteria are met. Suitable criteria include analyser flags, QC status, critical values, delta checks, analytical measuring range, sample indices, panic limits and consistency with related analytes [11].

Fourth, improvement must be tested through Plan-Do-Study-Act (PDSA) cycles. New workflows should be preceded by baseline measurement, tested under controlled conditions, evaluated using pre-specified indicators and reviewed for unintended consequences. Reduced TAT accompanied by increased sample rejection, QC failure, or amended reports is not an improvement; it is risk displacement.

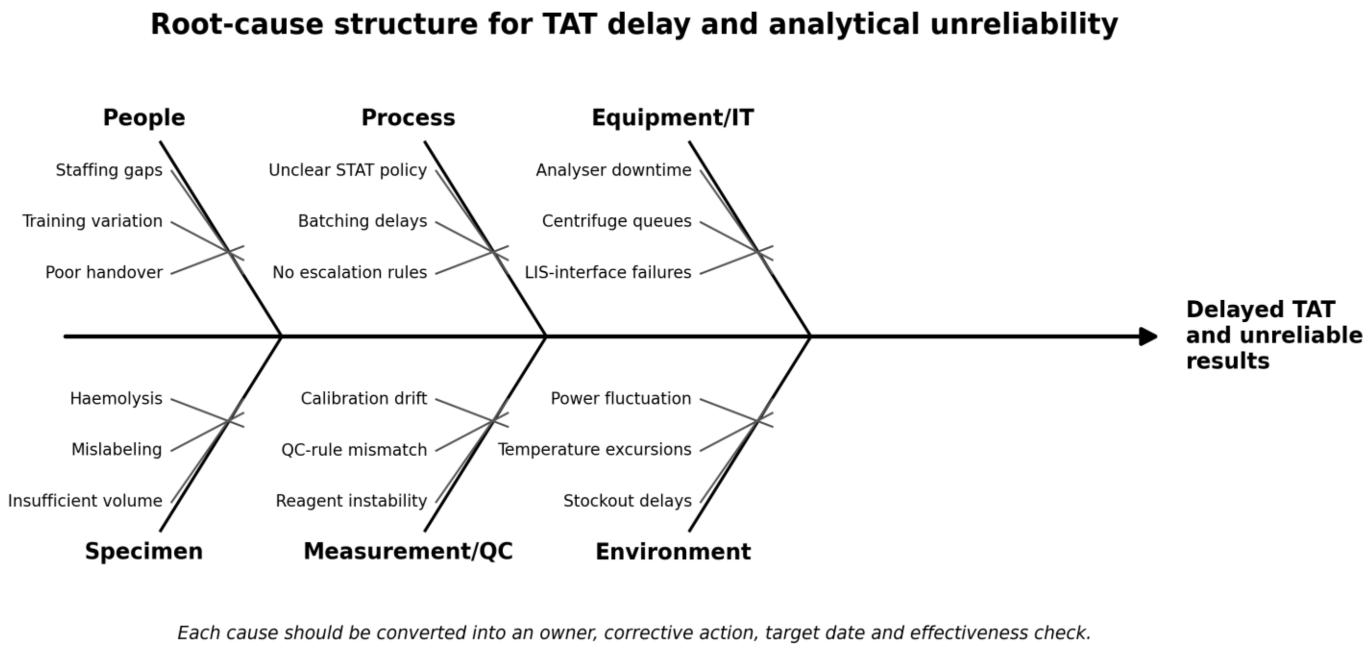

Figure 2. Fishbone analysis of common root causes of delayed TAT and unreliable results. The categories are ordered as People, Process and Equipment/IT above the spine, and Specimen, Measurement/QC and Environment below the spine. Each branch should trigger measurable corrective actions.

Table 4. Six-step QMS framework for improving TAT and analytical reliability.

Step	Core activities	Expected output
1. Define	Agree clinical TAT targets, critical tests, rejection policy, analytical quality specifications and escalation rules.	Approved service-level matrix and risk register.
2. Measure	Capture timestamps and reliability indicators across the total testing process.	Baseline dashboard with median TAT, 90th percentile TAT, breach rate, QC failures, repeats and amended reports.
3. Diagnose	Use Pareto charts, process maps, fishbone analysis and incident review to locate dominant failure modes.	Prioritised list of bottlenecks and reliability hazards.
4. Redesign	Introduce barcoding, priority routing, centrifuge scheduling, autoverification, backup testing and risk-based QC.	Controlled intervention protocol with staff training and change control.

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5. Verify	Compare pre- and post-intervention indicators and check for unintended analytical or safety consequences.	Evidence of reduced delay without increased unreliability.
6. Sustain	Embed indicators into management review, audit, competency assessment and corrective-action tracking.	Monthly governance report and continuous-improvement register.

Recommended interventions for clinical biochemistry laboratories

Pre-analytical interventions

Pre-analytical improvement should begin with demand and specimen quality. Electronic order sets should reduce duplicate and inappropriate requests. Request forms and electronic test catalogues should specify sample type, tube type, volume, fasting requirement, transport conditions, stability, and rejection criteria. Phlebotomy should use positive patient identification and barcode labelling at the bedside or collection point. This is a central control point for preventing wrong-patient and wrong-specimen errors [7-9]. Transport should be treated as a process, not as an afterthought. Scheduled courier routes may be appropriate for routine outpatient work but may be unsuitable for emergency specimens. Pneumatic-tube systems, where available and validated for the analytes in question, may reduce transport time; however, the risk of haemolysis and specimen integrity must be monitored. A transport intervention that shortens time while increasing haemolysis should not be considered successful.

Analytical interventions

Analytical improvements require capacity discipline. Laboratories should match analyser throughput, centrifuge capacity, staffing, maintenance windows and QC schedules to known demand. Performing QC, maintenance or reagent replacement during predictable demand peaks is a preventable scheduling failure that reflects weak alignment between operational planning and demand patterns. Risk-based QC should be adopted for major chemistry assays. Analytes with high sigma performance may be controlled with simpler rules and a lower false-rejection burden. In comparison, assays with weaker performance require stricter rules, more frequent controls, or method improvements [3,10]. The laboratory should document the rationale rather than applying the same multirule package to every analyte. The goal is to detect medically important errors with acceptable operational efficiency.

Post-analytical interventions

Post-analytical delay is frequently underestimated because the sample has already been analysed. Middleware autoverification can reduce avoidable manual review when rules are validated and periodically audited. However, autoverification must exclude results with analyser flags, unacceptable QC status, critical values requiring communication, clinically implausible patterns, sample-index problems or delta-check failures [11]. Critical-result communication should be governed by a written policy defining analytes, thresholds, responsible staff, notification route, read-back requirements, documentation and escalation if the clinician cannot be reached. A critical potassium result that is passively available in an electronic record has not necessarily been communicated. The laboratory must be able to prove who was contacted, when, by whom and what was communicated.

Table 5. Practical interventions and evaluation indicators.

Intervention	Main phase	Primary failure targeted	Evaluation indicator
Specimen barcoding at collection	Pre-analytical	Mislabeling, reception delays and manual transcription.	Mislabeling rate; specimen-reception processing time.
Priority lanes for urgent chemistry	Pre-/analytical	Urgent specimens trapped in routine batch flow.	Urgent median and 90th percentile TAT.
Centrifuge schedule redesign	Analytical	Batching delay before analyser loading.	Receipt-to-load time; queue length by hour.

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Middleware autoverification	Post-analytical	Manual validation backlog.	Autoverification rate; amended-report rate; validation delay.
Risk-based QC plan	Analytical	QC false rejection or missed medically important error.	QC rejection rate; EQA performance; sigma metrics.
Critical-result escalation protocol	Post-analytical	Delayed communication of life-threatening results.	Critical-result notification time; failed-contact rate.
Dashboard and management review	All phases	Improvement not sustained or invisible to leadership.	Monthly indicator trend; corrective-action closure rate.

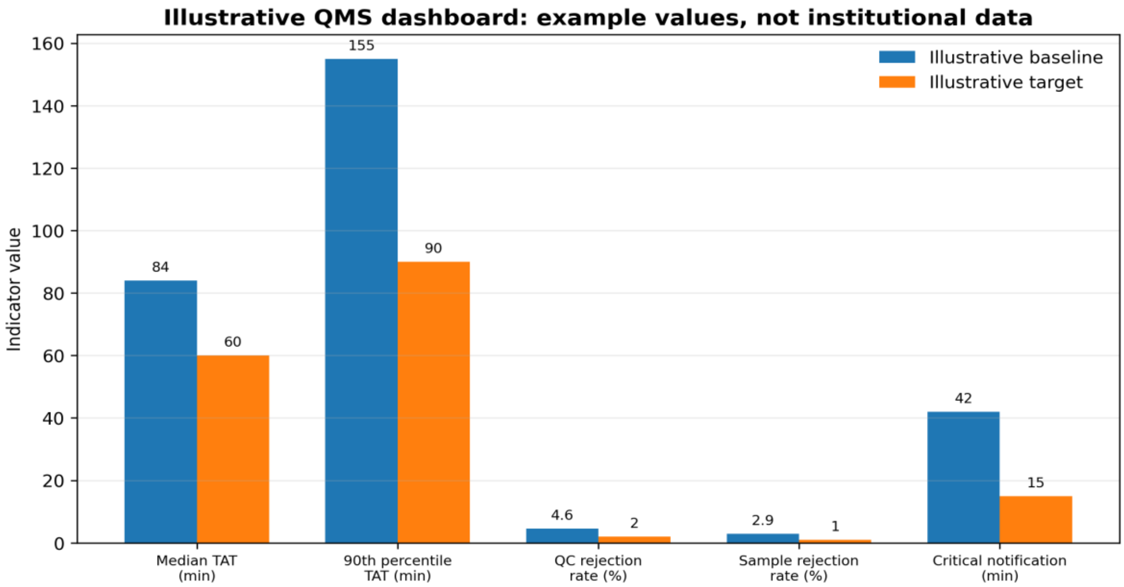

Figure 3. Illustrative quality-indicator dashboard. Values are example values only and must be replaced by local baseline data, test menu, urgency categories and agreed clinical targets before institutional use or publication.

Implementation model for a tertiary clinical biochemistry laboratory

A practical implementation model starts with gathering data. During the first 30 days, establish a baseline dashboard that tracks key metrics such as total TAT, intra-laboratory TAT, 90th-percentile TAT, urgent TAT breaches, sample rejection rate, haemolysis rate, QC rejection rate, calibration failures, repeat-analysis rate, EQA performance, amended reports, and critical-value notification time. This data should be broken down by location, test group, urgency, shift, and analyser because aggregated data can hide local issues [7-9,12]. The following 60 to 90 days should target two or three main bottlenecks. Trying multiple improvements at once can prevent accurate measurement. If specimen receipt from wards is slow, focus on redesigning transport and phlebotomy. If result validation causes delays, improve autoverification and staffing patterns. If QC failures are common, examine method performance and reagent management before blaming staff. Afterwards, the QMS should embed continuous improvement through monthly quality meetings, internal audits, verification of corrective actions, competency reviews, and annual management evaluations. The key question for leadership is not whether a dashboard exists, but whether it influences decision-making.

Table 6. Twelve-month implementation roadmap expanded into an implementable governance tool.

Period	Focus	Key activities	Responsible owner	Data source	Review frequency	Deliverable
Month 1	Baseline mapping and	Confirm TAT definitions; extract LIS timestamps;	Quality manager with	LIS, middleware,	Weekly during baseline	Validated baseline dashboard.

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	timestamp validation	audit sample rejection, QC events, and critical-result notifications.	laboratory lead	QC records, incident log		
Months 2-3	Bottleneck intervention	Implement two high-yield changes, such as priority routing, centrifuge scheduling, or autoverification.	Section lead and operations supervisor	Timestamp dashboard and staff rota	Fortnightly	Pilot report comparing baseline and intervention periods.
Months 4-6	Analytical-risk strengthening	Create risk-based QC plans for high-volume or high-risk analytes and review EQA/PT results and sigma performance.	Senior scientist and quality manager	IQC, EQA/PT, calibration and lot records	Monthly	Documented QC plans and method-risk register.
Months 7-9	Scale and standardise	Expand successful interventions to additional sections and shifts; revise SOPs and provide staff training.	Laboratory manager and training lead	SOPs, competency records and KPI dashboard	Monthly	Revised SOPs, competency records and sustained KPI improvement.
Months 10-12	Governance and accreditation alignment	Integrate indicators into internal audit, management review and quality objectives.	Laboratory director and quality committee	Audit reports, management review minutes, KPI trends	Quarterly	Annual quality report and next-cycle improvement plan.

Published single-institution case example

Wu et al. implemented CLSI-guided autoverification rules for arterial blood-gas testing at the First Affiliated Hospital of Shantou University Medical College. They validated the rules in a live environment using 1,248 patient results before go-live. The autoverification pass rate was 75.5%. Reported TAT fell by 33.3%, from 27 to 18 minutes, while the verification error rate decreased from 2.0% before implementation to 0.05% afterwards; agreement with senior-technician verification was high ($\kappa = 0.92$, $p < 0.01$) [13]. Although this was a single-institution blood-gas service rather than an entire biochemistry department, it demonstrates the framework's central claim: time savings should be assessed together with reliability safeguards. The intervention combined predefined QC, instrument-flag, range, delta-check and logic rules with live validation, exception routing and continued monitoring rather than merely removing manual review.

DISCUSSION

The central argument of this review is that TAT and analytical reliability improve when laboratories manage the total testing process as a controlled system. This conclusion is not technologically fashionable, but it is operationally correct. Many laboratories pursue isolated technological fixes while leaving poor governance untouched. Automation can be valuable, but when applied to poorly defined workflows, it may accelerate poor practice. The correct sequence is process definition, risk assessment, workflow redesign, validation and then automation [12,11]. Evidence from laboratory quality-indicator literature shows that errors and delays are not confined to the analytical bench. Pre-analytical and post-analytical processes remain major sources of

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vulnerability because they span professional boundaries among clinicians, nurses, phlebotomists, transport staff, reception staff, biomedical scientists, pathologists, and information-system teams [7-9]. The QMS is useful precisely because it creates ownership across these boundaries.

Clinical users frequently demand shorter TAT, but the laboratory must respond scientifically. Some delays are a waste and should be eliminated. Other delays are protective controls and should be redesigned rather than removed. Repeating analysis after a flagged result, a delta-check review, or a critical-value read-back may lengthen a single result pathway but reduce patient risk. The mature laboratory distinguishes unnecessary waiting from necessary verification. One important opportunity is using dashboards that combine time and reliability indicators. A TAT dashboard alone may incentivise speed at any cost. A QC dashboard alone may encourage analytical caution without service responsiveness. A balanced dashboard makes trade-offs visible: TAT, sample rejection, haemolysis, QC rejection, autoverification rate, amended reports, EQA performance and critical-value notification should be reviewed together.

LIMITATIONS

This article is a narrative, practice-oriented review rather than a systematic review. The search was not prospectively registered, the complete number of originally identified and excluded records cannot be reconstructed, and no formal risk-of-bias or certainty-of-evidence assessment was applied. Source selection may therefore reflect author judgement, database coverage and publication bias, and the framework should not be interpreted as a pooled estimate of intervention effectiveness. The single-institution case example demonstrates feasibility but remains context-specific; laboratories should establish local baselines, validate rules prospectively and monitor balancing measures such as sample rejection, QC failure, amended reports and critical-result communication before wider implementation.

CONCLUSION

Improving diagnostic turnaround time and analytical reliability in clinical biochemistry laboratories is fundamentally a quality-management problem. Faster analysers, larger test menus and electronic reporting are useful only when embedded in a disciplined QMS that controls the total testing process. The laboratory must define clinically meaningful TAT, measure component delays, remove bottlenecks, protect analytical validity and govern improvement through indicators, audit, risk management and management review. The central standard is simple: a result should be available when clinically needed and reliable enough to act upon. Any laboratory unable to satisfy both conditions has not yet achieved diagnostic quality; it has merely produced numbers.

REFERENCES

1. International Organisation for Standardisation. ISO 15189:2022 Medical laboratories - Requirements for quality and competence. Geneva: ISO; 2022.
2. World Health Organisation. Laboratory Quality Management System: Handbook. Geneva: WHO; 2011.
3. Clinical and Laboratory Standards Institute. EP23: Laboratory Quality Control Based on Risk Management. 2nd ed. Wayne, PA: CLSI; 2023.
4. International Federation of Clinical Chemistry and Laboratory Medicine Working Group on Laboratory Errors and Patient Safety. Quality indicators in laboratory medicine: Model of Quality Indicators and related resources.
5. Hawkins RC. Laboratory turnaround time. Clinical Biochemist Reviews. 2007;28(4):179-194.
6. Goswami B, Singh B, Chawla R, Gupta VK, Mallika V. Turnaround time (TAT) as a benchmark of laboratory performance. Indian Journal of Clinical Biochemistry. 2010;25(4):376-379.
7. Plebani M, Sciacovelli L, Aita A. Quality indicators for the total testing process. Clinics in Laboratory Medicine. 2017;37(1):187-205. doi:10.1016/j.cll.2016.09.015.
8. Sciacovelli L, Lippi G, Sumarac Z, et al. Quality indicators in laboratory medicine: the status of the progress of the IFCC Working Group project. Clinical Chemistry and Laboratory Medicine. 2017;55(3):348-357.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VI, June 2026

9. Zorbozan N, Tuncer I, Kose S, et al. Evaluation of preanalytical and postanalytical phases in clinical laboratory quality indicators. Biochemia Medica. 2022;32(3):030704.
10. Geto Z, Getahun T, Lejisa T, Tolcha Y, Bikila D. Evaluation of sigma metrics and Westgard rule selection and implementation in clinical chemistry. Journal of Multidisciplinary Healthcare. 2021;14:1257-1268.
11. Nam Y, Park H-D. Revolutionising laboratory practices: pioneering trends in total laboratory automation. Annals of Laboratory Medicine. 2025;45(5):472-483. doi:10.3343/alm.2024.0581.
12. Huf W, Mohns M, Almeta E, Lister R, Buchta C, Demyanets S, Buchberger W, Ettl B. Benchmarking medical laboratory performance on a global scale. Frontiers in Public Health. 2024;12:1363957. doi:10.3389/fpubh.2024.1363957.
13. Wu J, Pan M, Ouyang H, Yang Z, Zhang Q, Cai Y. Establishing and evaluating autoverification rules with intelligent guidelines for arterial blood gas analysis in a clinical laboratory. SLAS Technology. 2018;23(6):631-640. doi:10.1177/2472630318775311.