RJNMSR
Review Journal of Neurological & Medical Sciences Review

Volume 3, Issue 7, 2025

AUTOMATION IN CLINICAL DIAGNOSTIC LABORATORIES IN PAKISTAN: A NARRATIVE REVIEW OF WORKFLOW TRANSFORMATION AND OUTCOMES.

Salman Shah[*1], Arqam Sheraz[2], Zeeshan Sabir[3]

[*1,2,3]*Medical Laboratory Technologist*

[*1]salmanshahmlt06@gmail.com, [2]arqamsheraz2001@gmail.com, [3]zeeshansabirmlt2@gmail.com

Corresponding Author: *
Salman Shah

DOI: https://doi.org/10.5281/zenodo.17638377

Received	Accepted	Published
18 September 2025	06 November 2025	18 November 2025

ABSTRACT

Background: *Total laboratory automation (TLA) integrates pre-analytic, analytic, and post-analytic processes and has been shown to improve throughput and reduce errors in clinical laboratories worldwide. Objective: To evaluate the impact of automation on sample handling, testing throughput, turnaround time (TAT), error rates, and result reporting in Pakistani clinical diagnostic laboratories. Methods: We performed a narrative review of published studies, institutional reports, and indexed articles (2018–2024) describing TLA implementation or automation outcomes in Pakistan and adjacent evidence from international studies where Pakistani data were limited. Results: Pakistani institutions that have implemented TLA report consistent improvements: reduced pre-analytic errors and faster TAT (Shia International Hospital: chemistry TAT reduced from 4 h to 1–2 h; immunoassays from 6–7 h to 3–4 h) and measurable decreases in error frequency. A national professional journal and institutional evaluations also reported improved workflow efficiency and greater capacity following automation. Several analytical platform evaluations (Alinity systems) demonstrated reliable analytical performance and high throughput suitable for TLA integration. Challenges reported in Pakistan include capital cost, infrastructure and power stability, and workforce training needs. Conclusion: Evidence from Pakistan supports that automation improves laboratory efficiency, accuracy, and reporting speed, but scaling will require targeted investments in infrastructure, training, and quality-management frameworks.*

Keywords: *Total laboratory automation, clinical diagnostics, Pakistan, turnaround time, pre-analytical errors, laboratory information system.*

Introduction

Clinical diagnostic laboratories form the backbone of modern patient care. Automation — especially total laboratory automation (TLA) linking sample reception, conveyor-based transport, robotic handling, and laboratory information systems (LIS) — reduces manual handling and can improve speed, reproducibility, and safety (1),(2). International evidence shows TLA reduces turnaround time (TAT), lowers pre-analytical and analytical errors, and allows higher throughput with fewer repetitive tasks for staff (1),(3).

Pakistan's tertiary hospitals and major diagnostic centers have begun implementing TLA and high-throughput automated analyzers (e.g., Abbott

Alinity, Roche/Sysmex, Cobas automation modules). Internal and peer-reviewed reports from Pakistan show measurable workflow benefits and point to common barriers (cost, training, infrastructure) (4)(5). This article synthesizes published Pakistani evidence and relevant international literature to assess the impact of automation on sample handling, testing workflows, result interpretation, and reporting in clinical diagnostic laboratories in Pakistan.

Methods

We conducted a structured narrative review (2018–2024) of English-language sources addressing laboratory automation in Pakistan. Search strategies targeted PubMed/PMC, Google Scholar, and national journals (Pakistan Journal of Medical Research, Pakistan Journal of Pathology) and included institutional web releases from major hospitals (Shifa International Hospital, Indus Hospital, Islamabad Diagnostic Centre). Inclusion criteria: studies or institutional reports documenting measurable outcomes (TAT, error rates, throughput), descriptions of automation implementation, or workforce/training evaluations linked to automation. We also included international, peer-reviewed TLA evaluations to contextualize Pakistani findings when local quantitative data were limited.

Key Pakistani sources selected for data extraction were: a comparative evaluation at a tertiary hospital in Pakistan (Shifa) published in Pak J Med Res (4), a Pakistan Journal of Pathology piece reviewing TLA outcomes (6), institutional automation reports and press releases from Indus Hospital and IDC (7),(5), and recent Pakistan-based analytical performance studies (Alinity platform evaluations) and pre-analytical error assessments (3),(8). International studies on TLA were used for methodologic context (1),(2),(9).

Results

This review included: peer-reviewed comparative study of pre/post-TLA metrics in a Pakistani tertiary lab(4) , a Pakistan Journal of Pathology review and institutional case series on TLA experience(6), institutional reports/press releases from Indus Hospital and IDC describing TLA installations(7),(5) , and analytical/performance evaluations relevant to automated platforms(3),(8). International TLA analyses and workforce impact studies were used to support interpretation where local data were missing (1),(2) ,(9).

Table 1. Comparison of Manual vs Automated Workflow in Pakistani Clinical Labs

Workflow step	Manual process (pre-automation)	Automated process (post-automation)	Reported impact
Sample handling	Manual reception, paper/visual ID checks, manual centrifugation and aliquoting	Automated reception, barcode ID, pneumatic/conveyor transport, automated centrifugation/decapping	Fewer handling-related rejections and misidentifications; reported pre-analytic error reductions (Shifa; Pak J Med Res).(4),(6)
Testing throughput	Batch runs, analyzer scheduling constraints	Continuous walk-away operation, parallel analyzers linked to TLA	Increased capacity (institutional reports cite substantial gains), better stat/urgent prioritization. (7),(5)
Turnaround time (TAT)	Chemistry 4 h; immunoassays 6–7 h (institutional baseline)	Chemistry 1–2 h; immunoassays 3–4 h (post-TLA reported in case study)	2–4× faster TAT reported in Shifa comparative study. (4)

Error rates	ID and transcription errors, sample loss/misplacement	Barcode + LIS + automated handling reduce manual touchpoints	Marked reductions in reported error frequency (Pak J Med Res, Pak J Patho).(4),(6)
Result reporting	Manual validation, data entry into LIS	Automated result routing, rule-based validation, electronic release	Faster, more consistent reporting; reduced transcription errors.(5),(6)

Table 2. Reported Performance Gains After Automation

Institution / City	System / Vendor (reported)	Key reported gains
Shifa International Hospital, Islamabad	Integrated TLA (vendor modules) + LIS	Chemistry TAT 4→1–2 h; immunoassay 6–7→3–4 h; fewer pre-analytic errors; improved workflow metrics (peer-reviewed comparative evaluation). (4)
Indus Hospital, Karachi	Abbott Alinity / TLA installation (institutional report)	Institutional report described capacity increases and ability to manage high-volume caseloads with improved turnaround and continuity. (7)
Islamabad Diagnostic Centre (IDC)	Roche/Sysmex TLA (institutional announcement)	Automated sample flow (pneumatic + conveyors) and rapid reporting emphasized in institutional materials. (5)

Figure 1. Reported pre-analytic / total error reductions after TLA implementation (Shifa comparative study)

Estimated total error rate (%)	
Before TLA	(10–12%)
After TLA	(1–3%)

Interpretation: The Shifa comparative study reported substantial reductions in pre-analytic and total laboratory errors after TLA implementation; absolute values varied by error type but overall error frequency dropped markedly (4)

Discussion

Impact on sample handling and pre-analytic phase

Pakistani evidence indicates that automation significantly reduces manual touches in the pre-analytic phase — the stage most prone to errors (4),(6). The Shifa tertiary hospital comparative evaluation documented fewer sample rejections and improved accessioning accuracy after implementing an integrated TLA belt, consistent with international observations that automation standardizes centrifugation, decapping, and aliquoting and reduces mislabeled or mishandled specimens (1),(4),(9).

Analytical performance and throughput

High-throughput analyzers (e.g., Abbott Alinity) have been validated for accuracy and throughput in regional settings; performance evaluations demonstrate that such platforms are well-suited for

TLA integration and can provide continuous-loading "walk-away" operation that increases capacity while maintaining analytical quality (5),(3). Institutional reports from Indus Hospital and IDC describe improved day-to-day capacity and operational resilience after installing TLA-linked analyzers, though robust peer-reviewed throughput quantification beyond single-center reports is limited (7),(5).

Turnaround times and reporting

Case data from Shifa showed TAT improvements of roughly 2–4× for routine chemistry and immunoassays after automation, attributable to reduced manual batching, faster analyzer access, and automated routing to LIS for validation and release (4),(6). Automated rule-based result validation (depending on lab policy) reduces time to report and reduces transcription errors that were common in manual workflows (1),(6).

Error reduction and patient safety

Automation reduces transcription and identification errors by linking barcode-tracked specimens directly to analyzers and LIS. The Shifa study and the Pak J Pathol review both observed meaningful declines in pre-analytical and total error rates after automation (4),(6). This aligns with international literature quantifying error reductions after TLA deployment (1),(9).

Barriers to adoption in Pakistan

Despite benefits, several barriers limit wider TLA adoption in Pakistan: capital cost for TLA systems and integrated LIS, recurring maintenance and consumable expenses, need for uninterrupted power and climate control, and a workforce trained in informatics and instrument troubleshooting (6),(7),(8). Studies on training needs in Pakistan highlight the necessity of updated curricula and on-the-job training to prepare technologists for automated workflows (8).

Limitations of the current evidence base

Most Pakistani data come from institutional reports and a small number of peer-reviewed studies or case-series reports. Multi-center, prospectively collected data quantifying national-level impacts are scarce. Some high headline figures reported in institutional briefings (e.g., large multiplicative throughput gains) are not consistently validated in peer-reviewed literature; thus, where possible we used peer-reviewed comparative data (e.g., Shifa study) and clearly presented institutional reports as such (4)-(5).

Conclusion

Available Pakistani evidence demonstrates that automation and TLA improve clinical laboratory workflows by reducing pre-analytic errors, increasing throughput, and shortening turnaround times, with direct benefits for patient care and operational efficiency. Scaling these gains nationwide will require investment in infrastructure (power, HVAC, LIS networks), financing strategies for capital expenditure, and strengthened workforce training and accreditation. Future multi-center studies should quantify cost-effectiveness and patient-outcome impacts of laboratory automation in Pakistan.

References

Lippi G, Da Rin G. Advantages and limitations of total laboratory automation: a personal overview. Clinical Chemistry and Laboratory Medicine (CCLM). 2019 May 27;57(6):802–11.

Cherkaoui A, Renzi G, Martischang R, Harbarth S, Vuilleumier N, Schrenzel J. Impact of Total Laboratory Automation on Turnaround Times for Urine Cultures and Screening Specimens for MRSA, ESBL, and VRE Carriage: Retrospective Comparison With Manual Workflow. Frontiers in Cellular and Infection Microbiology. 2020 Oct 28;10.

Kanani FZ, Kazmi AH, Kaleem B. La métrica Sigma del sistema Alinity ci: estudio sobre 39 magnitudes químicas y de inmunoensayo. Advances in Laboratory Medicine / Avances en Medicina de Laboratorio. 2021 May 20;2(2):277–85.

Abbas G, Ul Ain Q, Ahmed IN, Asif N, Hanif W. Open Access Comparative Evaluation of the Laboratory Efficiency before and after Total Lab Automation in Tertiary Care Hospital Laboratory in Pakistan. Vol. 62, Pakistan Journal of Medical Research. 2023.

idc.net.pk. 6. Islamabad Diagnostic Centre (IDC). Total Laboratory Automation (Roche/Sysmex) launch and service brief, 2022. Institutional announcement and technical overview. . islamabad;

Younas A, Haroon ZH, Aamir M, Khalid U Bin, Mubarik S, Raza Jaffar S. TOTAL LAB AUTOMATION: A KEY TO EFFICIENT LABORATORY SERVICES AND BETTER PATIENT CARE. Vol. 32, Original Article Pak J Pathol. 2021.

Dr saba jamal. INDUS HOSPITAL'S NEW TOTAL LAB AUTOMATION SYSTEM WILL CHANGE INDUSTRY'S TESTING PARADIGM; EXPERTS. karachi;

Tasneem A, Zubair M, Rasool Z, Tareen FZ. Frequency and types of pre-analytical errors in a clinical laboratory of a specialized healthcare hospital. Pakistan Journal of Medical Sciences. 2023 Dec 5;40(2(ICON)).

Al Naam YA, Elsafi S, Al Jahdali MH, Al Shaman RS, Al-Qurouni BH, Al Zahrani EM. The Impact of Total Automaton on the Clinical Laboratory Workforce: A Case Study. Journal of Healthcare Leadership. 2022 May;Volume 14:55–62.