

THE ROLE OF LABORATORY PROFESSIONALS IN IMPROVING DIAGNOSTIC ACCURACY

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Abstract

Laboratory medicine plays a fundamental role in modern healthcare, with diagnostic testing influencing approximately 70% of medical decisions. Despite technological advancements, diagnostic errors continue to present significant challenges to patient safety and healthcare quality. This study examines the critical role of laboratory professionals in enhancing diagnostic accuracy across the total testing process (TTP), encompassing pre-analytical, analytical, and post-analytical phases. Laboratory professionals contribute specialized expertise in test selection, specimen handling, quality control, result interpretation, and collaborative communication with clinicians. The integration of innovative technologies such as automation, artificial intelligence, and molecular diagnostics has revolutionized laboratory operations, improving efficiency and reducing error rates. However, several challenges persist, including pre-analytical variability, test utilization issues, interpretation errors, and workforce shortages. Strategies to improve diagnostic accuracy include establishing diagnostic management teams, implementing quality indicators, utilizing decision support systems, and enhancing professional education. Through these efforts, laboratory professionals can significantly contribute to diagnostic excellence, ultimately improving patient outcomes and healthcare system performance.

INTRODUCTION

Accurate and timely diagnosis remains one of the most complex and challenging processes in medicine, with laboratory medicine serving as a cornerstone of effective diagnostic evaluation. Clinical laboratory testing provides essential data that guides approximately 70% of medical decisions, from initial diagnosis to treatment monitoring and disease management (Adekoya et al., 2025; Lippi et al., 2025). Despite significant technological advancements in recent decades, diagnostic errors continue to pose substantial burdens on patients and healthcare systems worldwide. The laboratory testing process is traditionally divided into three critical phases: pre-analytical, analytical, and post-analytical. Each phase presents distinct challenges and opportunities for error mitigation. Laboratory professionals play a vital role throughout this continuum, applying specialized expertise to ensure reliable results that support

professionals bring unique knowledge regarding the availability, limitations, and appropriate utilization of tests, which can help clinicians navigate increasingly complex diagnostic pathways.

According to Lippi et al. (2025), the landmark 2015 report "Improving Diagnosis in Health Care" established that diagnostic errors have been underappreciated as threats to healthcare quality and safety. This report emphasized that most diagnostic errors are preventable through systematic approaches that include improved laboratory processes. Ten years after this publication, significant progress has been made in addressing laboratory-related diagnostic errors, yet substantial challenges remain.

This study examines the multifaceted role of laboratory professionals in enhancing diagnostic accuracy, from optimizing pre-analytical processes to leveraging advanced technologies and fostering interprofessional collaboration. By understanding these contributions and implementing evidence-based strategies for improvement, healthcare systems can work toward achieving diagnostic excellence and improving patient outcomes.

The Total Testing Process and Error Vulnerabilities

The concept of the Total Testing Process (TTP) provides a comprehensive framework for understanding the lifecycle of laboratory testing, from test selection to result utilization in clinical decision-making. This framework, originally conceptualized by Lundberg in 1981 and subsequently expanded upon, encompasses all activities that influence the quality and reliability of laboratory results (Lubin et al., 2021).

Pre-Analytical Phase

The pre-analytical phase represents the most vulnerable stage of the testing process, accounting for approximately 60-70% of all laboratory errors (Lippi et al., 2018; Sciacovelli et al., 2011). This phase includes test selection, patient preparation, sample collection, specimen identification, transportation, and processing before analysis. Common errors include inappropriate test ordering, patient misidentification, improper sample collection techniques, and suboptimal specimen handling.

Research has consistently demonstrated that pre-analytical errors can significantly impact diagnostic accuracy. For instance, hemolyzed samples can falsely elevate potassium levels, potentially leading to unnecessary interventions for pseudohyperkalemia (Lippi et al., 2006). Similarly, failure to observe fasting requirements before glucose testing may result in misdiagnosis of diabetes or prediabetes. Delayed sample processing can cause clinically significant decreases in glucose concentrations (approximately 5-7% per hour) and increases in potassium levels due to cellular metabolism and leakage (Lippi et al., 2018).

Laboratory professionals play a crucial role in mitigating these errors through the development and implementation of standardized procedures, staff education, and quality monitoring systems. According to Alsalami et al. (2024), advanced specimen tracking systems and automated pre-analytical processing have significantly reduced error rates in modern laboratory settings. However, continued vigilance and process improvement remain essential, particularly for specimens collected in areas not directly supervised by laboratory staff.

Analytical Phase

The analytical phase involves the actual measurement of analytes using various technological platforms. While historically a major source of laboratory errors, advancements in automation, standardization, and quality control have significantly improved the reliability of this phase. Modern laboratories typically maintain analytical error rates below 15% of total errors (Lippi et al., 2025).

Quality control practices are fundamental to analytical excellence. Laboratory professionals must ensure proper instrument calibration, reagent validation, method verification, and continuous performance monitoring. According to Braga et al. (2015), metrological traceability—the property of measurement results being related to reference standards through an unbroken chain of calibrations—is essential for ensuring result comparability across different laboratories and methods.

Internal quality control (IQC) and external quality assessment (EQA) programs provide structured frameworks for monitoring analytical performance. Laboratory professionals must carefully evaluate quality control data to detect trends, biases, or systematic errors that could impact diagnostic accuracy. When deviations occur, prompt troubleshooting and corrective actions are necessary to maintain result reliability.

Post-Analytical Phase

The post-analytical phase encompasses result verification, reporting, interpretation, and clinical utilization. This phase accounts for approximately 15-20% of laboratory errors (Plebani, 2009) and involves challenges such as delayed result reporting, transcription errors, failure to identify critical values, and inadequate result interpretation.

Laboratory professionals contribute to post-analytical quality through critical value notification protocols, result verification procedures, and interpretative commenting. Advanced laboratory information systems with automated result flagging and clinical decision support functionalities can further enhance this phase (Fadan et al., 2019). Additionally, laboratory professionals often collaborate with clinicians to interpret complex or unusual results, particularly in specialized areas such as molecular diagnostics, therapeutic drug monitoring, and hematological disorders.

Advancing Diagnostic Accuracy Through Technology and Innovation

Technological innovation has revolutionized laboratory medicine, creating new opportunities for improving diagnostic accuracy. Laboratory professionals must continually adapt to these advancements, applying their expertise to optimize the implementation and utilization of emerging technologies.

Laboratory Automation and Process Optimization

Automation has transformed laboratory operations, significantly reducing manual errors and enhancing process reliability. According to Lippi et al. (2025), modern laboratories routinely integrate multiple levels of automation that address specimen check-in, preparation, and analysis. Automated sample verification systems can detect hemolysis, icterus, lipemia, and sample integrity issues, enabling standardized assessment of pre-analytical quality.

The development of total laboratory automation (TLA) systems has further enhanced operational efficiency and error reduction. These integrated platforms manage specimen routing, centrifugation, aliquoting, and analysis, minimizing human intervention in routine processes. Automated sample storage and retrieval systems enable efficient specimen management for downstream testing or future reference, maintaining sample integrity and traceability (Lippi et al., 2025).

Laboratory professionals play a crucial role in selecting, implementing, and optimizing automated systems to meet specific institutional needs. Their expertise ensures appropriate technology application, workflow integration, and quality monitoring to maximize the benefits of automation while minimizing potential risks.

Artificial Intelligence and Machine Learning

Artificial intelligence (AI) and machine learning (ML) applications are increasingly being incorporated into laboratory medicine, offering new approaches to data analysis, quality monitoring, and clinical decision support. According to Fadan et al. (2019), AI can enhance laboratory data verification, validation, and interpretation by identifying patterns and anomalies that may be difficult for human observers to detect.

In hematology, AI-driven digital systems have improved blood cell classification accuracy by detecting subtle morphological abnormalities that might otherwise be overlooked. These systems standardize morphological assessment while reducing inter-observer variability (Lippi et al., 2025). Similarly, AI applications in microbiology can enhance pathogen identification and antimicrobial susceptibility prediction, potentially accelerating diagnosis of infectious diseases.

Laboratory professionals must develop sufficient understanding of AI principles to effectively oversee these systems, interpret their outputs, and recognize their limitations. As AI technologies continue to evolve, laboratory experts will increasingly serve as the critical interface between automated analyses and clinical applications, ensuring appropriate implementation and utilization of these powerful tools.

Molecular and Genetic Diagnostics

Advances in molecular and genetic testing have revolutionized diagnostic capabilities, enabling earlier and more accurate diagnosis of various conditions. Next-generation sequencing (NGS), polymerase chain reaction (PCR), and other molecular techniques have expanded the laboratory's role in precision medicine, infectious disease diagnosis, and cancer management (Lippi et al., 2025).

The COVID-19 pandemic highlighted the essential role of molecular diagnostics in public health response. Laboratory professionals rapidly implemented and validated novel testing methods, established quality control procedures, and scaled testing capabilities to meet unprecedented demand (Alsalamy et al., 2024). This experience demonstrated both the potential of molecular diagnostics and the importance of laboratory expertise in ensuring reliable results during healthcare crises.

Liquid biopsy represents another innovative approach that laboratory professionals are increasingly implementing. This technique allows non-invasive detection and monitoring of cancer biomarkers through simple blood draws, offering significant advantages over traditional tissue biopsies in terms of safety, patient comfort, and longitudinal monitoring capabilities (Lippi et al., 2025).

Laboratory professionals must maintain current knowledge of rapidly evolving molecular technologies, understand their clinical applications and limitations, and communicate effectively with clinicians regarding appropriate test utilization and interpretation. This specialized expertise is essential for translating technical innovations into meaningful clinical benefits.

Collaborative Approaches to Enhance Diagnostic Excellence

Laboratory professionals do not operate in isolation; rather, they function as integral members of the healthcare team. Collaborative approaches that strengthen connections between laboratory specialists and clinicians are essential for maximizing diagnostic accuracy and patient outcomes.

Diagnostic Management Teams

The diagnostic management team (DMT) concept represents a structured approach to integrating laboratory expertise into clinical decision-making. DMTs bring together laboratory professionals, pathologists, clinicians, and other specialists to collaborate on complex diagnostic challenges (Lubin et al., 2021). These teams can be particularly valuable in specialized areas such as hematological malignancies, infectious diseases, and genetic disorders.

The DMT approach has demonstrated significant benefits in several healthcare contexts. For example, antimicrobial stewardship programs that incorporate laboratory professionals have improved the timeliness and accuracy of infection diagnosis, enabling more appropriate antibiotic use and better patient outcomes (Lubin et al., 2021). Similarly, tumor boards that include laboratory specialists facilitate comprehensive interpretation of complex diagnostic data for cancer patients.

Laboratory professionals contribute specialized knowledge to these collaborative efforts, including insights regarding test selection, result interpretation, and diagnostic algorithms. By engaging directly with clinical teams, laboratory experts can enhance understanding of test limitations, potential interferences, and optimal testing strategies.

Quality Indicators and Performance Monitoring

Systematic measurement of laboratory performance is essential for continuous improvement in diagnostic accuracy. Quality indicators provide structured metrics for assessing various aspects of the TTP, enabling laboratories to identify improvement opportunities and monitor progress over time.

The International Federation of Clinical Chemistry and Laboratory Medicine (IFCC) has developed a Model of Quality Indicators (MQI) that spans key laboratory processes, support activities, and outcomes (Sciacovelli et al., 2011). These indicators address pre-analytical, analytical, and post-analytical phases, providing a comprehensive framework for quality assessment.

Laboratory professionals must actively engage with these quality monitoring systems, regularly reviewing performance data and implementing improvement initiatives when deficiencies are identified. By establishing clear benchmarks and systematically tracking progress, laboratories can demonstrate their commitment to diagnostic excellence and patient safety.

Clinical Decision Support Systems

Clinical decision support systems (CDSS) represent a promising approach to improving test utilization and result interpretation. These systems can guide appropriate test selection based on clinical indications, detect potential testing errors, and provide interpretive guidance for complex results (Lubin et al., 2021). Laboratory professionals contribute significantly to CDSS development and implementation by defining appropriate testing algorithms, establishing critical value thresholds, and creating interpretive guidelines. Their specialized knowledge ensures that these systems reflect current best practices and scientific evidence.

For example, the "SureNet" program developed within the Kaiser Permanente healthcare system uses laboratory and clinical data to identify patients who may have missed follow-up testing for significant abnormalities (Lubin et al., 2021). This approach has successfully identified numerous patients with undiagnosed chronic kidney disease who would otherwise have experienced delayed diagnosis and treatment.

Challenges and Future Directions

Despite significant advancements, laboratory medicine continues to face challenges that affect diagnostic accuracy. Understanding these challenges is essential for developing effective improvement strategies.

Test Utilization Management

Inappropriate test utilization—including overuse, underuse, and misuse—remains a significant concern in laboratory medicine. Studies have documented substantial rates of unnecessary testing across various healthcare settings, contributing to increased costs and potential diagnostic confusion (Zhi et al., 2013). Laboratory professionals can address these issues through utilization management initiatives that promote evidence-based test ordering practices. Approaches include developing clinical practice guidelines, implementing electronic order entry systems with decision support features, and conducting regular audits of testing patterns (Lubin et al., 2021). Educating clinicians about test characteristics, limitations, and appropriate indications is also essential for improving utilization.

Felemban (2025) highlights the importance of laboratory professionals as consultants in specialized areas such as diabetes management, where appropriate test selection and interpretation can significantly impact patient outcomes. By providing expertise on topics such as glycemic marker selection, monitoring frequency, and result interpretation, laboratory specialists can enhance diagnostic accuracy and treatment effectiveness.

Workforce Development and Education

Maintaining a well-trained laboratory workforce is crucial for diagnostic excellence. The increasing complexity of laboratory testing requires continuous professional development to ensure that staff members remain current with emerging technologies and best practices.

Laboratory professionals must engage in lifelong learning through formal education, professional certifications, and ongoing training. Specialized knowledge in areas such as molecular diagnostics, mass spectrometry, and bioinformatics is increasingly important for modern laboratory practice. Additionally, development of "soft skills" such as communication, team collaboration, and clinical consultation enhances the laboratory professional's ability to contribute effectively to the healthcare team.

The emergence of advanced practice roles, such as the Doctorate in Clinical Laboratory Science (DCLS), reflects the evolving nature of laboratory professional practice. These specialized practitioners are trained to bridge the gap between laboratory operations and clinical applications, serving as consultants to healthcare providers and advocates for appropriate test utilization (Lubin et al., 2021).

Integration of Laboratory Expertise into Healthcare Systems

Despite their critical role in diagnostic processes, laboratory professionals often remain relatively isolated from broader healthcare teams. Enhancing the integration of laboratory expertise into clinical workflows represents an ongoing challenge and opportunity for improving diagnostic accuracy.

Strategies for addressing this challenge include implementing laboratory consultation services, involving laboratory representatives in clinical committees and quality improvement initiatives, and developing shared educational programs for laboratory and clinical staff. Electronic health record systems can facilitate communication between laboratory professionals and clinicians, enabling more effective collaboration in test selection and result interpretation.

The concept of "laboratory stewardship"—analogous to antimicrobial stewardship—provides a framework for systematic integration of laboratory expertise into healthcare delivery (Lubin et al., 2021). This approach emphasizes the laboratory's role in guiding appropriate test utilization, ensuring result quality, and supporting clinical decision-making throughout the diagnostic process.

CONCLUSION

Laboratory professionals play an indispensable role in improving diagnostic accuracy across the healthcare continuum. Their specialized expertise in test selection, specimen handling, quality control, result interpretation, and clinical consultation contributes significantly to patient safety and healthcare quality. By addressing vulnerabilities throughout the total testing process and embracing innovative technologies and collaborative practices, laboratory professionals can help reduce diagnostic errors and enhance clinical outcomes.

The future of laboratory medicine will likely be characterized by increasing automation, broader application of artificial intelligence, expansion of molecular and genetic testing capabilities, and stronger integration with clinical care teams. Laboratory professionals must continue to evolve their knowledge and skills to effectively navigate this changing landscape while maintaining their essential focus on diagnostic excellence.

As healthcare systems worldwide strive to improve diagnostic accuracy and patient safety, the contributions of laboratory professionals will remain fundamental to success. By recognizing and enhancing the laboratory's role in the diagnostic process, healthcare organizations can better leverage this vital resource in their pursuit of high-quality, patient-centered care.

REFERENCES

1. Adekoya, A., Okezue, M. A., & Menon, K. (2025). Medical laboratories in healthcare delivery: A systematic review of their roles and impact. *Laboratories*, 2(1), 8.
2. Alsalami, S. H. H., Almalki, A. A., Albogami, H. A., Faghih, A. M., Alzhrani, M. I., Alotaib, M. A. A., ... & Alrasheed, S. H. O. (2024). The Role of Laboratory and Radiology in Enhancing Diagnostic Accuracy Through Innovative Practices. *Journal of International Crisis and Risk Communication Research*, 7(S4), 25.
3. Braga, F., Infusino, I., & Panteghini, M. (2015). Role and Responsibilities of Laboratory Medicine Specialists in the Verification OF Metrological Traceability of in vitro Medical Diagnostics. *Journal of medical biochemistry*, 34(3), 282–287. <https://doi.org/10.1515/jomb-2015-0004>
4. Carraro, P., & Plebani, M. (2007). Errors in a stat laboratory: types and frequencies 10 years later. *Clinical Chemistry*, 53(7), 1338–1342.
5. Fadan, O. Y., Abunaian, A. S., Alanizi, M. A., Alenezi, A. N., Otaibi, A., Rashed, M., ... & Shujaa, M. A. (2019). The Role of Artificial Intelligence in Laboratory Medicine: Enhancing Diagnostic Accuracy and Efficiency. *International journal of health sciences*, 3(S1), 57-70.
6. Felemban, A. A. (2025). The Role of Clinical Laboratory Professionals and Diabetes Educators in Enhancing Diagnostic Accuracy and Patient Outcomes in Diabetes Management. *Saudi J Med Pharm Sci*, 11(7), 631-641.
7. Lippi, G., et al. (2006). Influence of hemolysis and sample handling on clinical chemistry testing. *Clinical Chemistry and Laboratory Medicine*, 44(3), 311–316.
8. Lippi, G., et al. (2018). Preanalytical variability: the dark side of the moon in laboratory testing. *Clinical Chemistry and Laboratory Medicine*, 56(3), 313–322.
9. Lippi, G., Jackson, B., & Plebani, M. (2025). Improving diagnosis in health care: laboratory medicine. *Diagnosis (Berlin, Germany)*, 12(4), 570–577. <https://doi.org/10.1515/dx-2025-0052>

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10. Lubin, I. M., Astles, J. R., Shahangian, S., Madison, B., Parry, R., Schmidt, R. L., & Rubinstein, M. L. (2021). Bringing the clinical laboratory into the strategy to advance diagnostic excellence. *Diagnosis (Berlin, Germany)*, 8(3), 281–294. <https://doi.org/10.1515/dx-2020-0119>
 11. Plebani, M. (2009). Exploring the iceberg of errors in laboratory medicine. *Clinical Chimica Acta*, 404(1), 16–23.
 12. Sciacovelli, L., et al. (2011). Quality indicators in laboratory medicine: from theory to practice. *Clinical Chemistry and Laboratory Medicine*, 57(9), 1203–1211.
 13. Zhi, M., et al. (2013). The landscape of inappropriate laboratory testing: a 15-year meta-analysis. *PLoS One*, 8(11), e78962.