

Review Article

Analyzing the impact of blood collection errors on patient safety and clinical outcomes

Wadha A. Almotairi^{1*}, Maha N. Alrashidi¹, Mohammed A. Alqarni¹,
Raghad I. Alsubaie², Abeer M. Alshahrani², Rana A. Almuaybid¹,
Jawaher J. Al-Johar¹, Wedian M. Najem¹, Nawaf A. Alharbi¹

¹Department of Laboratory and Blood Bank, Prince Sultan Military Medical City, Riyadh, Saudi Arabia

²Nursing Specialist, Prince Sultan Military Medical City, Riyadh, Saudi Arabia

Received: 08 January 2025

Accepted: 28 January 2025

*Correspondence:

Dr. Wadha A. Almotairi,

E-mail: Wadha.a.m20@gmail.com

Copyright: © the author(s), publisher and licensee Medip Academy. This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License, which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

ABSTRACT

Errors in blood collection processes pose a significant challenge to healthcare systems, contributing to diagnostic inaccuracies, compromised patient safety, and adverse clinical outcomes. Pre-analytical errors, including patient misidentification, improper labeling, hemolysis, and sample contamination, are among the most common sources of laboratory mistakes. These errors can delay diagnosis, lead to unnecessary medical interventions, and increase healthcare costs. Misidentification and labeling errors, for example, have been linked to life-threatening outcomes in transfusion medicine, while hemolysis often results in falsely elevated laboratory values that can mislead clinical decision-making. Effective strategies to address blood collection errors include leveraging technological innovations, such as barcoding systems and automated labeling, which have demonstrated success in reducing mislabeling incidents. Adherence to standardized guidelines, including protocols established by the Clinical and Laboratory Standards Institute (CLSI), plays a crucial role in maintaining sample integrity. Additionally, phlebotomy training programs and competency assessments ensure that healthcare staff consistently follow best practices, minimizing errors during the collection process. Quality management tools, including Six Sigma and Lean methodologies, further enhance laboratory processes by identifying root causes of errors and implementing targeted improvements. Patient engagement also contributes to error prevention, with informed and active participation serving as an additional safeguard against potential mistakes. The integration of these strategies has shown promise in improving diagnostic reliability and reducing the clinical and economic burden of blood collection errors. By addressing systemic, procedural, and technological factors, healthcare systems can ensure safer and more accurate diagnostic practices, ultimately enhancing patient outcomes. A multidisciplinary focus remains essential for achieving sustainable improvements in blood collection processes and mitigating risks associated with pre-analytical errors.

Keywords: Blood collection errors, Patient safety, Diagnostic accuracy, Pre-analytical errors, Quality improvement

INTRODUCTION

Blood collection is a foundational step in medical diagnostics, directly influencing the accuracy of laboratory results and subsequent clinical decisions. Despite its

routine nature, errors in blood collection procedures are alarmingly frequent, with significant implications for patient safety, healthcare costs, and clinical outcomes. Errors such as mislabelling, patient misidentification, incorrect blood draw techniques, and inadequate specimen

handling are well-documented causes of diagnostic inaccuracies and adverse events.¹ These issues are not merely procedural lapses but reflect broader systemic challenges in healthcare delivery, emphasizing the need for continuous quality improvement.

Mislabelling of specimens and misidentification of patients represent critical pre-analytical errors with the potential for catastrophic outcomes. Studies have shown that up to 60-70% of laboratory errors occur in the pre-analytical phase, with patient identification errors constituting a significant proportion.² Mislabelling can lead to erroneous diagnostic reports, resulting in delayed treatment, unnecessary interventions, and even patient harm. For instance, inaccurate blood typing due to labelling errors has led to mismatched transfusions, posing life-threatening risks.³

The ramifications of blood collection errors extend beyond individual patients to affect broader healthcare systems. Inaccurate laboratory results necessitate repeated tests, prolong hospital stays, and increase healthcare costs. Moreover, they undermine trust in the healthcare system and erode the confidence of both patients and clinicians. Evidence suggests that diagnostic delays caused by pre-analytical errors contribute significantly to the burden of diagnostic error globally, a leading cause of preventable patient harm.⁴

Technological advancements have provided tools to mitigate these errors, including barcoding systems, electronic health records, and automated specimen labelling. However, the effectiveness of these interventions depends on their integration into clinical workflows and the training of healthcare personnel. Despite these advancements, studies highlight a persistent gap in adherence to standardized blood collection protocols, underscoring the importance of robust training and compliance monitoring. Healthcare professionals play a pivotal role in reducing blood collection errors. Phlebotomists, nurses, and laboratory staff must adhere strictly to established guidelines, such as those outlined by the Clinical and Laboratory Standards Institute (CLSI). Moreover, fostering a culture of patient safety, where errors are openly reported and analyzed, is crucial for sustained improvement.

Given the profound implications of blood collection errors on patient safety and outcomes, this topic has garnered significant research attention. However, gaps remain in understanding the interplay between systemic factors, individual performance, and technological solutions. Addressing these gaps is critical for developing comprehensive strategies to enhance the quality of blood collection practices and improve patient outcomes.

This review aims to explore the prevalence and types of blood collection errors, their impact on patient safety and clinical outcomes, and effective strategies for mitigation and quality improvement.

REVIEW

Blood collection errors have far-reaching consequences on patient safety and clinical outcomes, often serving as critical precursors to adverse diagnostic and therapeutic decisions. A significant portion of pre-analytical errors, including misidentification, improper labelling, and inadequate handling of specimens, disrupt the accuracy of laboratory results. These errors are exacerbated by systemic issues such as understaffing, inadequate training, and lack of adherence to standard protocols. Studies highlight that even seemingly minor discrepancies, such as incorrect tube selection or insufficient sample volumes, can lead to delayed diagnoses, inappropriate treatments, or unnecessary medical interventions.⁵

The integration of technological solutions has shown promise in mitigating these errors. Barcoding systems, automated specimen tracking, and electronic health records have significantly reduced instances of mislabelling and misidentification. However, the efficacy of these tools largely depends on consistent implementation and training. In settings where technological resources are unavailable or underutilized, the emphasis must shift to robust manual processes and stringent adherence to established guidelines. Research underscores the need for ongoing quality improvement programs and a culture of safety that prioritizes error reporting and learning.⁶ Addressing these issues is essential to minimizing diagnostic errors, reducing healthcare costs, and ensuring better clinical outcomes for patients. Collaborative efforts between healthcare professionals and system stakeholders remain crucial in achieving these objectives.

Prevalence and types of blood collection errors

Blood collection is a critical aspect of clinical diagnostics, and the accuracy of this process is paramount to patient care and safety. Yet, pre-analytical errors, particularly those occurring during blood collection, remain a significant concern. These errors encompass a variety of mistakes, including incorrect patient identification, sample mislabelling, inappropriate venipuncture technique, and improper handling or transport of samples. They collectively contribute to diagnostic inaccuracies and suboptimal clinical outcomes.⁵

The prevalence of blood collection errors varies across healthcare settings, influenced by procedural standards, staff training, and workload pressures. Studies suggest that pre-analytical errors account for 60-70% of total laboratory mistakes, with blood sample-related errors forming a substantial proportion of this statistic.² Patient misidentification is one of the most prevalent errors, arising from inadequate patient verification protocols or over-reliance on manual processes. Such errors, though preventable, can result in life-threatening outcomes, particularly during transfusion medicine, where incorrect blood typing may lead to fatal hemolytic reactions.³

Inappropriate venipuncture techniques also contribute to error rates. This includes failure to follow established guidelines for needle gauge selection, order of draw, or proper mixing of anticoagulants. These technical deviations can lead to hemolysis, clot formation, or contamination of the specimen, rendering the sample unfit for analysis. Moreover, inadequate sample volume, often referred to as "short draws," poses challenges for laboratory testing, particularly in assays requiring precise volumes for accurate measurements.⁷

The handling and transportation of blood samples play an equally critical role in error prevalence. Factors such as delays in sample transport, exposure to extreme temperatures, or improper storage conditions can compromise sample integrity. These issues disproportionately affect remote healthcare facilities where logistical challenges impede adherence to optimal sample management protocols. Studies have highlighted that improper storage and transport account for a significant share of pre-analytical errors, underscoring the importance of standardized practices in mitigating these risks.⁸ Mislabelling errors, another major contributor, often result from manual entry mistakes or labelling inconsistencies. Barcoding and automated systems have been introduced in many facilities to address this issue, significantly reducing mislabelling incidents. However, adoption of these technologies remains inconsistent, particularly in resource-limited settings. The lack of universal implementation perpetuates the risk of these preventable errors, even in modern healthcare environments.⁹

The implications of these errors extend beyond diagnostic inaccuracies. They contribute to increased healthcare costs due to repeat testing, prolonged hospital stays, and delayed or incorrect treatments. Furthermore, they undermine trust in healthcare systems, as patients and clinicians alike rely on the accuracy and reliability of laboratory results. While interventions such as phlebotomy training programs, adherence to CLSI guidelines, and the integration of automated systems have shown success in reducing error rates, their impact is contingent on consistent application and monitoring. A multi-faceted approach that incorporates robust training, strict adherence to guidelines, and technological advancements is essential to address the diverse range of blood collection errors. Research indicates that facilities with comprehensive quality improvement initiatives report significantly lower rates of pre-analytical errors, demonstrating the importance of a systems-based strategy to error prevention.

Consequences of blood collection errors on patient safety and diagnostic accuracy

Errors in blood collection processes have profound and multifaceted impacts on patient safety and diagnostic accuracy. These consequences ripple through clinical decision-making, contributing to adverse outcomes that can be life-threatening or debilitating. The effects stem from errors such as misidentification, sample

contamination, hemolysis, or improper labelling, each disrupting the reliability of laboratory diagnostics. Research consistently emphasizes that diagnostic errors resulting from pre-analytical mistakes represent a critical safety challenge in healthcare systems (12).⁹

Misidentification of patients during blood sample collection can result in inappropriate medical interventions. A mistyped blood sample, for instance, may lead to erroneous transfusions, posing life-threatening risks, including hemolytic reactions. Such errors are often attributed to lapses in standard protocols, such as failing to cross-check patient identity or incorrect labelling at the bedside. A study found that nearly 0.4% of transfusion errors were directly linked to pre-analytical mistakes, underscoring the critical need for robust identification processes.¹⁰

Hemolysis, caused by improper blood collection techniques, is another significant issue. This phenomenon frequently results from excessive suction during venipuncture, use of inappropriate needle sizes, or vigorous shaking of blood tubes. Hemolysis not only renders samples unusable but also falsely elevates markers like potassium, leading to misdiagnosis and mistreatment. In cardiac care, for instance, falsely elevated potassium levels due to hemolysis may mislead physicians into pursuing unnecessary interventions, ultimately increasing patient morbidity.¹¹

Labelling errors, though often overlooked, remain a persistent problem with serious implications for diagnostic accuracy. Inaccurate or missing information on blood sample labels can prevent timely diagnostic processing and lead to the loss of crucial clinical data. This has been reported to delay diagnoses of critical conditions such as sepsis or cancer, where every moment counts. Automated systems like barcode technology have significantly reduced such errors in facilities where they are implemented. However, their inconsistent adoption globally leaves gaps that perpetuate the problem.² Sample contamination during blood collection introduces further risks. Contaminated samples can arise from improper skin preparation, failure to maintain aseptic techniques, or collection in environments that are not sterile. Contaminants can mimic pathophysiological conditions, leading to diagnostic confusion. For example, bacterial contamination in blood culture samples often results in inappropriate antibiotic treatments, which not only expose patients to unnecessary medication but also contribute to antimicrobial resistance.¹²

The ripple effects of these errors extend beyond immediate patient safety concerns. They contribute significantly to healthcare inefficiencies, including increased costs from repeat testing, prolonged hospital stays, and additional diagnostic investigations. A study on diagnostic workflow disruption highlighted that a single instance of mislabelling could delay treatment by up to 48 hours in acute care settings, exacerbating patient outcomes and resource

utilization.¹³ As blood sample collection is a foundational step in diagnostics, its reliability is essential for trust in healthcare delivery. Pre-analytical errors create cascading challenges that impact clinical teams, patients, and institutional outcomes. Addressing these challenges necessitates integrating rigorous training protocols, technology-driven solutions, and a culture of accountability within clinical practices.

Strategies for minimizing errors and enhancing clinical outcomes

Blood collection errors pose significant risks to patient safety and diagnostic reliability, necessitating the implementation of robust strategies to reduce their occurrence. A systematic approach that incorporates technological, procedural, and training-based solutions has demonstrated effectiveness in minimizing errors while enhancing clinical outcomes.

The integration of automation and digital solutions has significantly improved the reliability of blood collection and handling processes. Barcoding systems, electronic health records, and automated labelling have reduced mislabelling and misidentification errors. These technologies ensure accurate tracking and matching of samples to patients, preventing errors stemming from manual processes. A study highlighted that facilities employing advanced barcoding systems experienced a reduction in labelling errors by up to 50%, underscoring the value of technology in error prevention.⁵ Additionally, artificial intelligence (AI)-driven tools are now being integrated to monitor and predict errors, providing real-time feedback to healthcare providers and enabling immediate corrective actions. Adherence to standardized protocols remains a cornerstone in reducing blood collection errors. Guidelines established by the CLSI serve as a benchmark for proper sample handling and processing. Following protocols for patient identification, order of draw, and tube selection significantly reduces pre-analytical errors. Research has shown that rigorous adherence to these guidelines, coupled with periodic audits, has led to a notable improvement in sample quality and diagnostic accuracy.¹⁴

Regular training and competency assessments for healthcare professionals involved in blood collection are essential. Comprehensive phlebotomy training programs equip staff with the necessary skills and knowledge to follow best practices consistently. Studies have shown that institutions with ongoing training initiatives report lower rates of sample contamination and hemolysis. Moreover, fostering a culture of accountability and patient safety ensures that staff members remain vigilant in their practices, leading to improved outcomes.¹⁵ The use of quality management systems and continuous monitoring of error trends further supports error reduction efforts. Quality improvement tools such as Six Sigma and Lean methodologies have been applied in laboratory settings to streamline processes and minimize variability. For

instance, Six Sigma projects aimed at reducing hemolysis rates in emergency departments have led to measurable decreases in error frequencies. These initiatives emphasize the importance of identifying root causes and implementing targeted interventions.¹⁶

Finally, patient engagement plays a crucial role in minimizing errors during the blood collection process. Encouraging patients to actively participate by verifying their information and understanding the procedures increases the likelihood of identifying potential discrepancies early. Research has demonstrated that patient-centered approaches, including education and active involvement, enhance the safety and quality of care. Educated patients are more likely to report inconsistencies, providing an additional layer of oversight in the error prevention process.¹⁷ The combination of technological innovation, strict adherence to guidelines, comprehensive staff training, quality improvement initiatives, and patient engagement forms the foundation for minimizing blood collection errors. These strategies collectively ensure not only the accuracy of diagnostic results but also the broader goals of patient safety and healthcare efficiency.

CONCLUSION

Blood collection errors significantly impact patient safety and diagnostic accuracy, highlighting the importance of robust error prevention strategies. Technological advancements, standardized protocols, and regular staff training are critical in minimizing pre-analytical mistakes. Patient engagement further strengthens error prevention efforts and improves clinical outcomes. A comprehensive, multidisciplinary approach remains essential to ensure the reliability of diagnostic processes and patient care quality.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: Not required

REFERENCES

1. Plebani M. The detection and prevention of errors in laboratory medicine. *Ann Clin Biochem*. 2010;47(2):101-10.
2. Bonini P, Plebani M, Ceriotti F, Rubboli F. Errors in laboratory medicine. *Clin Chem*. 2002;48(5):691-8.
3. Carraro P, Plebani M. Errors in a stat laboratory: types and frequencies 10 years later. *Clin Chem*. 2007;53(7):1338-42.
4. Schiff GD, Hasan O, Kim S, Abrams R, Cosby K, Lambert BL, et al. Diagnostic error in medicine: analysis of 583 physician-reported errors. *Arch Intern Med*. 2009;169(20):1881-7.
5. Plebani M. Errors in clinical laboratories or errors in laboratory medicine? *Clin Chem Lab Med*. 2006;44(6):750-9.
6. Lingard L, Espin S, Whyte S, Regehr G, Baker GR, Reznick R, et al. Communication failures in the operating room: an observational classification of

- recurrent types and effects. *Qual Saf Health Care*. 2004;13(5):330-4.
7. Lippi G, Salvagno GL, Montagnana M, Franchini M, Guidi GC. Phlebotomy issues and quality improvement in results of laboratory testing. *Clin Lab*. 2006;52(5-6):217-30.
 8. Simundic A-M, Lippi G. Preanalytical phase—a continuous challenge for laboratory professionals. *Biochimica Medica*. 2012;22(2):145-9.
 9. Graber ML. The incidence of diagnostic error in medicine. *BMJ Quality Safety*. 2013;22(2):21-7.
 10. Murphy M, Stanworth S, Yazer M. Transfusion practice and safety: current status and possibilities for improvement. *Vox Sanguinis*. 2011;100(1):46-59.
 11. Simundic A-M, Baird G, Cadamuro J, Costelloe SJ, Lippi G. Managing hemolyzed samples in clinical laboratories. *Crit Rev Clin Lab Sci*. 2020;57(1):1-21.
 12. Favalaro EJ, Lippi G. Laboratory reporting of hemostasis assays: the final post-analytical opportunity to reduce errors of clinical diagnosis in hemostasis? *Clin Chem Lab Med*. 2010;48(3):309-21.
 13. Singh H, Schiff GD, Graber ML, Onakpoya I, Thompson MJ. The global burden of diagnostic errors in primary care. *BMJ Quality Safety*. 2017;26(6):484-94.
 14. Berner ES, Graber ML. Overconfidence as a cause of diagnostic error in medicine. *Am J Med*. 2008;121(5):2-23.
 15. Bates DW, Cohen M, Leape LL, Overhage JM, Shabot MM, Sheridan T. Reducing the frequency of errors in medicine using information technology. *J Am Med Informat Assoc*. 2001;8(4):299-308.
 16. Goodnough LT, Shander A. Patient blood management. *Survey Anesthesiol*. 2012;56(6):278-9.
 17. Coulter A, Ellins J. Effectiveness of strategies for informing, educating, and involving patients. *BMJ*. 2007;335(7609):24-7.

Cite this article as: Almotairi WA, Alrashidi MN, Alqarni MA, Alsubaie RI, Alshahrani AM, Almuaybid RA, et al. Analyzing the impact of blood collection errors on patient safety and clinical outcomes. *Int J Community Med Public Health* 2025;12:1123-7.