Laboratory-Emergency Department-Nursing Triadic Model: Optimizing Turnaround Times For Critical Laboratory Values In Saudi Arabian Hospitals

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Abstract
Critical laboratory value reporting remains a fundamental component of patient safety in emergency departments, yet prolonged turnaround times continue to compromise clinical outcomes and increase mortality risk. This paper proposes a Laboratory-Emergency Department-Nursing Triadic Model designed to optimize the communication and workflow processes surrounding critical laboratory values in Saudi Arabian hospital settings. Through systematic review of existing literature and analysis of current practices, this study identifies key barriers to timely critical value reporting, including communication breakdowns, technological limitations, workflow inefficiencies, and insufficient interprofessional collaboration. The triadic model emphasizes structured interdisciplinary partnerships among laboratory personnel, emergency department physicians, and nursing staff, supported by standardized protocols, technological integration, and continuous quality monitoring. Findings indicate that implementation of coordinated triadic workflows can significantly reduce turnaround times from laboratory result availability to clinical action. The model addresses contextual challenges specific to Saudi Arabian healthcare systems, including organizational culture, staffing patterns, and resource allocation. Recommendations include establishment of dedicated communication pathways, implementation of real-time notification systems, role clarification among team members, and adoption of quality indicators specific to the triadic interaction. This framework offers a practical, evidence-based approach to enhancing patient safety and clinical efficiency in emergency care settings through optimized laboratory-clinical collaboration.
Keywords: critical laboratory values, turnaround time, emergency department, interprofessional collaboration, patient safety

1. INTRODUCTION

The timely communication of critical laboratory values represents a cornerstone of safe and effective emergency medical care, directly influencing clinical decision-making and patient outcomes (Howanitz et al., 2002). Critical values are defined as laboratory results that indicate life-threatening conditions requiring immediate clinical intervention (Kost, 1990). When delays occur in the communication pathway from laboratory analysis to clinical action, patients face increased risks of adverse events, prolonged hospital stays, and elevated mortality rates (Piva et al., 2010). Despite widespread recognition of this patient

safety imperative, healthcare institutions continue to struggle with optimizing turnaround times for critical laboratory value reporting, particularly in high-acuity emergency department settings (Hawkins, 2013).

The complexity of critical value workflows extends beyond simple laboratory processing times to encompass multiple organizational interfaces, communication channels, and professional roles (Steindel & Howanitz, 2007). Emergency departments face unique challenges in this regard, characterized by high patient volumes, diagnostic uncertainty, time-sensitive clinical decisions, and multidisciplinary team dynamics (Georgiou et al., 2013). Laboratory personnel must navigate technical and analytical phases while simultaneously managing communication protocols, emergency department physicians operate under conditions of cognitive overload and competing priorities, and nursing staff frequently serve as intermediaries in the information transfer process (Dighe et al., 2006). The fragmentation inherent in these separate professional domains creates vulnerability to communication failures and delays (Plebani & Lippi, 2014).

Within the Saudi Arabian healthcare context, additional factors influence critical value reporting processes, including organizational culture, healthcare system structure, workforce composition, and technological infrastructure (Alharbi et al., 2012). Saudi Arabian hospitals have experienced rapid expansion and modernization, yet challenges persist in achieving internationally recognized standards for laboratory quality indicators and patient safety practices (Alkhenizan & Shaw, 2011). Nursing staff in Saudi emergency departments report significant barriers to effective communication regarding critical laboratory results, including unclear protocols, inadequate feedback mechanisms, and role ambiguity (Alharbi et al., 2021). Laboratory automation has advanced substantially in Saudi healthcare facilities, yet integration with clinical workflows remains incomplete (Albalawi et al., 2020). These contextual factors necessitate tailored approaches to optimizing critical value turnaround times that account for local organizational realities while adhering to international best practices.

Existing literature emphasizes the importance of interprofessional collaboration in healthcare delivery, demonstrating that coordinated teamwork improves patient outcomes and reduces medical errors (Reeves et al., 2017). However, current models of critical value reporting often fail to explicitly delineate the collaborative relationships among laboratory professionals, emergency physicians, and nursing staff as a functional triadic unit. Communication breakdowns at any point within this triad can result in delayed recognition of critical conditions and suboptimal patient care (Leonard et al., 2004). The Joint Commission has identified effective communication of critical test results as a National Patient Safety Goal, underscoring the regulatory and ethical imperative to address this issue systematically (The Joint Commission, 2013).

This paper proposes a Laboratory-Emergency Department-Nursing Triadic Model specifically designed to optimize turnaround times for critical laboratory values in Saudi Arabian hospital emergency departments. The model integrates evidence-based practices from laboratory medicine, emergency care, and nursing science within a structured interprofessional framework. The primary objective is to identify key components, processes, and quality indicators necessary for effective triadic collaboration that minimizes delays and enhances patient safety. Through synthesis of existing research and analysis of current practices, this study aims to provide actionable recommendations for healthcare administrators, laboratory managers, emergency department leadership, and nursing supervisors seeking to improve critical value reporting systems.

2. LITERATURE REVIEW

2.1 Critical Value Reporting: Standards and Challenges

Critical laboratory values serve as essential diagnostic markers that demand urgent clinical attention, yet significant variability exists across institutions in defining which values meet critical thresholds, establishing notification protocols, and measuring reporting compliance (Campbell & Horvath, 2014). A landmark study by Howanitz et al. (2002) involving 28 institutions revealed substantial inconsistencies in critical value policies, with notification times ranging widely and documentation practices frequently inadequate. These findings highlighted systemic vulnerabilities in ensuring that critical information reliably reaches clinicians in time to influence patient management decisions.

Turnaround time for critical values encompasses multiple phases within the total testing process, including pre-analytical variables such as specimen collection and transport, analytical processing within the laboratory, and post-analytical communication and documentation (Plebani, 2006). Steindel and Howanitz (2007) conducted an extensive review demonstrating that while technological advances have reduced analytical processing times, communication delays in the post-analytical phase remain the predominant contributor to prolonged total turnaround times. The gap between result availability and clinical action represents a critical weak point in the care continuum (Valenstein et al., 2008).

Benchmarks for acceptable turnaround times vary by clinical setting and analyte type, but emergency department scenarios generally require notification within 30 to 60 minutes from specimen collection (Piva et al., 2010). However, achieving these targets consistently proves challenging, with compliance rates often falling below 80% even in well-resourced institutions (Hawkins, 2013). Quality indicators developed by the International Federation of Clinical Chemistry and Laboratory Medicine emphasize the importance of measuring not only laboratory processing time but also the completeness of the communication loop, including confirmation of result receipt by the responsible clinician (Plebani et al., 2017; Sciacovelli et al., 2017).

2.2 Emergency Department Workflow and Laboratory Integration

Emergency departments operate under conditions of inherent uncertainty, high patient acuity, and resource constraints that significantly impact laboratory utilization patterns and result management (Morley et al., 2018). Patient length of stay in emergency settings correlates directly with laboratory turnaround times, with delays in receiving critical test results contributing to prolonged decision-making intervals and increased departmental crowding (Holland et al., 2005). Steindel and Howanitz (2001) demonstrated that reducing laboratory turnaround time by even modest margins resulted in measurable decreases in overall patient length of stay, underscoring the operational and clinical significance of efficient laboratory services.

Emergency department crowding represents a complex phenomenon influenced by multiple systemic factors, including inadequate staffing, limited inpatient bed availability, and inefficient processes (Pines & Hollander, 2008). Within this environment, delays in laboratory result availability compound existing throughput challenges and compromise quality of care (Georgiou et al., 2013). Point-of-care testing has emerged as one strategy to circumvent traditional laboratory turnaround time barriers, providing rapid results at the bedside for selected analytes (Kendall et al., 1998). However, point-of-care testing introduces distinct quality control challenges, cost considerations, and regulatory requirements that limit widespread implementation (Kost, 1990).

Emergency physicians' responses to critical laboratory values reflect the cognitive demands and competing priorities inherent in their clinical roles (Dighe et al., 2006). When notification systems are inefficient or communication pathways unclear, critical values may not receive the immediate attention required, resulting in treatment delays and potential

patient harm (Campbell & Horvath, 2014). The integration of laboratory information systems with emergency department electronic health records offers potential solutions for real-time result delivery and automated alerting, yet implementation challenges persist (Georgiou et al., 2017). Henricks (2016) noted that while laboratory information systems have evolved significantly in technical capabilities, achieving seamless interoperability with clinical systems requires sustained organizational commitment and resources.

2.3 The Role of Nursing in Critical Value Communication

Nursing staff occupy a pivotal position within the critical value communication pathway, frequently serving as the initial recipients of laboratory notifications and facilitators of information transfer to physicians (Hohenhaus et al., 2006). The effectiveness of nurses in this intermediary role depends on clear protocols, adequate training, appropriate authority to escalate urgent findings, and supportive organizational structures (Hwang & Ahn, 2015). When communication chains involve multiple handoffs, the risk of information loss or delay increases substantially (Moore et al., 2003).

In Saudi Arabian emergency departments, nurses have identified significant challenges in managing critical laboratory value communications, including inconsistent notification practices from laboratory personnel, unclear expectations regarding nursing responsibilities, and insufficient feedback on patient outcomes following critical value reports (Alharbi et al., 2021). These barriers reflect broader issues in interprofessional collaboration and organizational culture within Saudi healthcare institutions (Alahmadi, 2010). Nursing workload and staffing ratios directly influence the capacity of nurses to respond promptly to critical value notifications, with understaffing associated with increased risks of communication failures and adverse events (Hwang & Ahn, 2015).

Documentation practices surrounding critical value communication often prove inadequate, with incomplete records of who received notifications, when information was communicated, and what clinical actions were initiated (Howanitz et al., 2002). Standardized documentation protocols that specify nursing responsibilities in the critical value chain provide essential accountability mechanisms and support quality improvement efforts (Valenstein et al., 2008). The concept of closing the loop in laboratory-clinical communication emphasizes the importance of confirmation that critical information has been received, understood, and acted upon appropriately (Plebani, 2011).

2.4 Interprofessional Collaboration and Teamwork

Effective healthcare delivery in complex clinical environments requires coordinated teamwork among multiple professional disciplines, with communication quality serving as a fundamental determinant of team performance (Manser, 2009). Reeves et al. (2017) synthesized evidence demonstrating that interprofessional collaboration improves patient outcomes, enhances care coordination, and reduces medical errors. However, achieving genuine collaboration extends beyond mere co-location of professionals to encompass shared goals, mutual respect, clear role definitions, and structured communication processes (Leonard et al., 2004).

Communication failures represent a leading cause of sentinel events and preventable adverse outcomes in hospital settings (Singh et al., 2007). In the context of critical laboratory values, breakdowns can occur at multiple interfaces: between laboratory technologists and supervising pathologists, between laboratory personnel and nursing staff, between nurses and physicians, and among members of the emergency department care team (Coiera & Tombs, 1998). Systematic approaches to improving communication, such as standardized handoff protocols, closed-loop verification, and structured escalation pathways, have demonstrated effectiveness in reducing errors and enhancing information transfer reliability (Leonard et al., 2004).

The triadic relationship among laboratory personnel, emergency department clinicians, and nursing staff represents a specific configuration of interprofessional collaboration with unique dynamics and requirements (Plebani & Lippi, 2014). Laboratory professionals possess specialized expertise in analytical processes, quality control, and result interpretation, yet may have limited visibility into clinical contexts and patient acuity (Hawker, 2007). Emergency physicians bring clinical decision-making authority and patient care responsibility but operate under significant time pressure and cognitive load (Dighe et al., 2006). Nurses contribute continuity of patient monitoring, care coordination capabilities, and practical knowledge of workflow realities (Hohenhaus et al., 2006). Optimizing the interaction among these three professional groups requires explicit attention to role clarity, communication protocols, and shared accountability for patient outcomes (Reeves et al., 2017).

2.5 Quality Improvement Methodologies

Healthcare organizations have increasingly adopted systematic quality improvement methodologies to address inefficiencies and enhance patient safety, with Lean principles and Six Sigma approaches demonstrating particular relevance to laboratory operations (Nevalainen et al., 2000). Lean thinking emphasizes elimination of waste, optimization of workflow, and continuous improvement through iterative problem-solving (Improta et al., 2018). Application of Lean principles to laboratory turnaround time reduction has yielded significant improvements in multiple institutional contexts (Gupta et al., 2018).

Process mapping and workflow analysis provide essential tools for identifying bottlenecks, redundancies, and sources of delay within critical value reporting systems (Barenfanger et al., 2002). Manor-Shulman et al. (2008) demonstrated that systems-level interventions targeting multiple phases of the laboratory testing process produced more substantial and sustainable improvements than isolated changes to single process steps. This finding underscores the importance of comprehensive assessment and multi-faceted intervention strategies when addressing complex organizational challenges such as critical value turnaround times.

Quality indicators specific to laboratory medicine have evolved to encompass not only analytical accuracy but also timeliness, communication effectiveness, and clinical appropriateness of testing (Lippi & Plebani, 2018). Simundic et al. (2015) advocated for standardized preanalytical quality indicators that capture vulnerabilities in specimen collection, handling, and transport processes. Plebani et al. (2017) emphasized that quality monitoring must extend beyond laboratory walls to encompass the entire cycle of test ordering, result reporting, and clinical utilization. Metrics relevant to critical value reporting include percentage of results reported within target timeframes, documentation completeness, read-back verification rates, and time from result availability to clinical intervention (Sciacovelli et al., 2017).

2.6 Technology and Automation

Advances in laboratory automation and information technology have fundamentally transformed analytical capabilities and result reporting mechanisms (Hawker, 2007). Automated analyzers process samples with greater speed and precision than manual methods, while laboratory information systems facilitate electronic result transmission and automated alerting for critical values (Albalawi et al., 2020). However, technology alone does not guarantee optimal outcomes; human factors, organizational processes, and system integration determine whether technological capabilities translate into improved clinical performance (Henricks, 2016).

Electronic health records and computerized provider order entry systems offer potential for seamless integration of laboratory data into clinical workflows, with automated notifications and clinical decision support tools enhancing recognition of critical findings

(Georgiou et al., 2017). A systematic review by Georgiou et al. (2017) examining the impact of electronic health records on critical laboratory value notification revealed mixed results, with some studies demonstrating reduced notification times while others found minimal impact or introduced new sources of error. Implementation quality, user acceptance, and system design features emerged as critical determinants of technology effectiveness.

The concept of total laboratory automation envisions fully integrated systems that minimize manual handling and optimize specimen flow from collection through analysis and result reporting (Hawker, 2007). While large reference laboratories have achieved substantial automation, hospital-based laboratories serving emergency departments often face space constraints, diverse test menus, and stat testing requirements that complicate full automation implementation (Albalawi et al., 2020). Point-of-care testing devices represent an alternative technological approach, bringing testing capabilities directly to clinical care areas and potentially reducing turnaround times (Kendall et al., 1998). However, quality assurance requirements, competency maintenance, and cost considerations must be carefully evaluated (Kost, 1990).

2.7 Saudi Arabian Healthcare Context

The Saudi Arabian healthcare system has undergone rapid expansion and modernization over recent decades, characterized by substantial infrastructure investments, adoption of international quality standards, and efforts to enhance patient safety culture (Almalki et al., 2011). Despite these advancements, systematic reviews have identified persistent challenges in achieving consistent quality performance and embedding safety practices across Saudi healthcare institutions (Alkhenizan & Shaw, 2011). Organizational culture in Saudi hospitals demonstrates hierarchical characteristics that may influence communication patterns, interprofessional collaboration, and error reporting behaviors (Alharbi et al., 2012).

Alahmadi (2010) conducted a baseline assessment of patient safety culture in Saudi Arabian hospitals, revealing significant opportunities for improvement in teamwork, communication openness, and non-punitive approaches to error. These cultural dimensions directly impact the feasibility and effectiveness of interventions designed to enhance critical value reporting processes, as successful implementation requires open communication, shared accountability, and willingness to acknowledge and address system vulnerabilities (Alkhenizan & Shaw, 2011). Understanding and addressing cultural context represents an essential component of quality improvement initiatives in Saudi healthcare settings.

Workforce composition in Saudi Arabian hospitals includes both Saudi nationals and international healthcare professionals, creating diverse teams with varying educational backgrounds, language capabilities, and professional socialization experiences (Almalki et al., 2011). This diversity offers advantages in terms of knowledge exchange and exposure to international best practices, yet also introduces potential communication challenges and differences in practice expectations (Alharbi et al., 2012). Laboratory services in Saudi Arabia have achieved substantial automation and technical sophistication, yet integration with clinical care processes remains an area requiring continued development (Albalawi et al., 2020).

Emergency departments in Saudi Arabian hospitals face challenges common to emergency care settings globally, including crowding, variable patient acuity, resource limitations, and complex care coordination demands (Alharbi et al., 2021). The specific configuration of staffing models, physician-nurse role relationships, and organizational support structures influences the feasibility of implementing triadic collaboration models for critical value management. Contextually appropriate interventions must account for local organizational

realities while adhering to evidence-based principles derived from international research (Alkhenizan & Shaw, 2011).

3. METHODS

This study employed a comprehensive literature review methodology to synthesize existing evidence regarding critical laboratory value reporting processes, emergency department laboratory utilization, nursing communication roles, and interprofessional collaboration frameworks. The review focused on identifying best practices, common barriers, quality improvement strategies, and contextual factors relevant to developing a triadic model for optimizing turnaround times in Saudi Arabian hospital settings.

A systematic search strategy was developed to identify relevant peer-reviewed publications from established scientific databases including PubMed, Scopus, and Web of Science. Search terms encompassed combinations of keywords related to critical values, laboratory turnaround time, emergency departments, nursing communication, interprofessional collaboration, patient safety, and healthcare quality improvement. The search was conducted with emphasis on retrieving high-quality evidence from clinical chemistry, laboratory medicine, emergency medicine, nursing, and healthcare management literature.

Inclusion criteria specified empirical research studies, systematic reviews, quality improvement reports, and theoretical frameworks addressing components of the critical value reporting process in hospital settings. Particular attention was directed toward publications examining communication pathways, workflow analysis, technological interventions, and organizational factors influencing laboratory-clinical integration. Studies conducted in diverse international contexts were included to provide comprehensive understanding of generalizable principles and contextually specific considerations. Publications addressing Saudi Arabian healthcare settings were specifically sought to inform culturally and organizationally appropriate model development.

Exclusion criteria eliminated non-peer-reviewed sources, purely technical laboratory methodology papers without clinical context, and publications lacking relevance to hospital-based emergency care settings. The review encompassed literature published from 1990 through 2021, capturing both foundational concepts in critical value reporting and contemporary advances in technology, quality improvement, and interprofessional practice.

Retrieved publications were systematically reviewed to extract key findings, methodological approaches, outcome measures, and recommendations relevant to the research objective. Thematic analysis was employed to organize evidence into coherent domains addressing turnaround time determinants, communication processes, role functions, quality indicators, technological solutions, and organizational influences. Synthesis of findings across studies informed identification of essential components for an integrated triadic model.

The development of the proposed Laboratory-Emergency Department-Nursing Triadic Model was based on integration of evidence-based best practices with consideration of practical implementation requirements in Saudi Arabian hospital contexts. Model components were structured to address identified barriers while leveraging facilitators of effective critical value communication. Quality indicators were specified based on established laboratory medicine standards and patient safety principles. The resulting framework provides a systematic approach to optimizing triadic collaboration for enhanced turnaround times and improved patient outcomes.

4. RESULTS

4.1 Barriers to Optimal Critical Value Turnaround Times

Analysis of the literature revealed multiple categories of barriers that impede timely communication and clinical action regarding critical laboratory values in emergency department settings. Communication-related barriers emerged as predominant, including difficulty reaching physicians, unclear responsibility for result follow-up, ineffective notification methods, and inadequate documentation practices (Howanitz et al., 2002; Valenstein et al., 2008). Studies consistently identified that time elapsed in attempting to contact clinicians represented the largest component of total turnaround time beyond analytical processing (Hawkins, 2013; Piva et al., 2010).

Technological limitations constituted a second major barrier category, particularly in settings lacking integrated laboratory information systems and electronic health record connectivity (Georgiou et al., 2017). Manual result transcription, paper-based reporting, reliance on telephone communication, and absence of automated alerting mechanisms all contributed to delays and increased error risk (Henricks, 2016). Even in technologically advanced settings, poor system design, inadequate user training, and alert fatigue diminished the effectiveness of electronic notification tools (Georgiou et al., 2017).

Workflow inefficiencies within and across departments represented substantial sources of delay, including redundant specimen handling, batch processing rather than continuous analysis, unclear escalation pathways, and fragmented responsibility for result communication (Barenfanger et al., 2002; Steindel & Howanitz, 2007). The absence of standardized protocols specifying who should notify whom under various circumstances created ambiguity and inconsistent practices (Campbell & Horvath, 2014). Emergency department crowding and high nursing workload ratios further compromised capacity to respond promptly to critical value notifications (Hwang & Ahn, 2015; Morley et al., 2018).

Organizational and cultural factors also influenced turnaround times, including hierarchical communication patterns, lack of interprofessional collaboration, inadequate feedback mechanisms, and insufficient prioritization of laboratory-clinical integration (Alharbi et al., 2021; Alahmadi, 2010). In Saudi Arabian contexts specifically, challenges related to organizational culture, role ambiguity, and workforce diversity introduced additional complexity (Alharbi et al., 2012; Alkhenizan & Shaw, 2011). Table 1 summarizes key barriers identified across multiple dimensions of the critical value reporting process.

Table 1. Key Barriers to Timely Critical Laboratory Value Reporting in Emergency Departments

Barrier Category	Specific Barriers	Primary Impact	Representative Sources
Communication	Difficulty contacting physicians; unclear notification protocols; ineffective read-back verification; inadequate documentation	Delays in result transmission; information loss during handoffs	Howanitz et al., 2002; Valenstein et al., 2008; Campbell & Horvath, 2014
Technology	Lack of system integration; manual processes; absence of	Extended notification times; transcription errors; missed critical values	Georgiou et al., 2017; Henricks, 2016

	automated alerts; poor interface design		
Workflow	Batch processing; redundant handling; fragmented responsibilities; unclear escalation pathways	Inefficient specimen flow; delayed analysis; confusion regarding accountability	Steindel & Howanitz, 2007; Barenfanger et al., 2002
Organizational	Emergency department crowding; inadequate staffing; high nursing workload; competing priorities	Reduced capacity to respond promptly; cognitive overload; delayed clinical action	Hwang & Ahn, 2015; Morley et al., 2018; Pines & Hollander, 2008
Cultural	Hierarchical communication patterns; limited interprofessional collaboration; insufficient feedback; role ambiguity	Inhibited information sharing; unclear responsibilities; missed opportunities for improvement	Alharbi et al., 2021; Alahmadi, 2010; Alharbi et al., 2012

Note. Barriers span multiple organizational levels and require multi-faceted intervention strategies for effective resolution.

4.2 Best Practices and Evidence-Based Interventions

The literature identified multiple evidence-based strategies for reducing critical value turnaround times and enhancing communication effectiveness. Standardized protocols specifying critical value thresholds, notification procedures, documentation requirements, and escalation pathways emerged as foundational interventions associated with improved performance (Campbell & Horvath, 2014; Valenstein et al., 2008). Explicit designation of responsibility for each step in the communication chain reduced ambiguity and ensured accountability (Howanitz et al., 2002).

Technological interventions demonstrating positive impact included implementation of automated alerting systems, integration of laboratory information systems with electronic health records, use of secure messaging platforms, and development of clinical decision support tools (Georgiou et al., 2017; Henricks, 2016). Direct communication from laboratory personnel to responsible physicians, bypassing intermediary handoffs when feasible, reduced time to notification and minimized information loss (Hawkins, 2013). Read-back verification protocols enhanced accuracy and confirmed receipt of critical information (Valenstein et al., 2008).

Process improvement methodologies including Lean principles, workflow redesign, and elimination of non-value-added steps yielded substantial turnaround time reductions in multiple institutional contexts (Gupta et al., 2018; Improta et al., 2018). Continuous processing of stat specimens rather than batch analysis, dedicated staff for critical value communication, and streamlined specimen transport systems all contributed to efficiency gains (Steindel & Howanitz, 2007). Point-of-care testing for selected high-priority analytes provided rapid results when implemented with appropriate quality assurance mechanisms (Kendall et al., 1998).

Interprofessional collaboration initiatives emphasizing teamwork, role clarity, shared goals, and structured communication improved coordination among laboratory personnel, emergency physicians, and nursing staff (Reeves et al., 2017). Regular feedback to laboratory staff regarding clinical outcomes following critical value reports enhanced engagement and reinforced the clinical significance of timely reporting (Plebani, 2011). Quality monitoring using standardized indicators enabled identification of performance gaps and evaluation of improvement interventions (Plebani et al., 2017; Sciacovelli et al., 2017).

4.3 The Laboratory-Emergency Department-Nursing Triadic Model

Based on synthesis of identified barriers, best practices, and contextual considerations for Saudi Arabian healthcare settings, a comprehensive triadic model was developed to optimize critical laboratory value turnaround times. The model conceptualizes the relationship among laboratory personnel, emergency department clinicians, and nursing staff as an integrated functional unit with shared responsibility for patient safety outcomes related to critical values. Table 2 presents the core components, specific interventions, responsible parties, and quality indicators comprising the triadic model framework.

Table 2. Components of the Laboratory-Emergency Department-Nursing Triadic Model for Critical Value Optimization

Model Component	Specific Interventions	Primary Responsible Parties	Quality Indicators
Standardized Protocols	Define critical value thresholds; establish notification procedures; specify documentation requirements; create escalation pathways	Laboratory leadership, ED medical director, nursing leadership (collaborative development)	Protocol compliance rate; documentation completeness; time to notification
Communication Infrastructure	Implement secure messaging systems; integrate LIS with EHR; establish direct laboratory-to-clinician communication channels; use read-back verification	Information technology, laboratory informatics, clinical departments	System utilization rate; notification delivery time; communication error rate
Role Clarity	Define specific responsibilities for laboratory personnel, physicians, and nurses; establish authority for escalation; clarify handoff procedures	All triadic members with administrative support	Role understanding assessment; handoff completion rate; escalation appropriateness
Workflow Optimization	Implement continuous stat processing; streamline specimen transport; eliminate redundant	Laboratory operations, ED operations, nursing units	Analytical turnaround time; specimen transport time; total process time

	steps; prioritize critical values		
Technology Integration	Deploy automated critical value alerts; utilize clinical decision support; enable mobile notification; provide real-time result access	Laboratory informatics, IT department, clinical end-users	Alert response time; technology adoption rate; false alert rate
Interprofessional Collaboration	Conduct joint training sessions; establish regular communication forums; create feedback mechanisms; develop shared quality goals	All triadic members	Collaboration quality assessment; meeting attendance; feedback implementation rate
Quality Monitoring	Track turnaround time metrics; measure notification compliance; audit documentation; analyze near-miss events	Quality department with triadic input	Percentage meeting turnaround targets; trend analysis; improvement over time
Cultural Adaptation	Address hierarchical communication patterns; promote open reporting; encourage interprofessional respect; provide language support	Organizational leadership with triadic champions	Safety culture scores; reporting rates; interprofessional collaboration measures

Note. LIS = Laboratory Information System; EHR = Electronic Health Record; ED = Emergency Department. Successful implementation requires commitment from all triadic partners and sustained organizational support.

The triadic model emphasizes several fundamental principles derived from the evidence base. First, communication must be structured, direct, and bidirectional among all three professional groups, with explicit protocols minimizing ambiguity and ensuring accountability (Leonard et al., 2004; Valenstein et al., 2008). Laboratory personnel require clear guidance on whom to contact under various circumstances, appropriate escalation when initial contacts are unavailable, and standardized documentation of all communication attempts (Howanitz et al., 2002).

Second, nursing staff must be recognized as integral partners in the critical value pathway rather than merely passive intermediaries (Hohenhaus et al., 2006). This requires explicit definition of nursing responsibilities, authority to initiate urgent notifications, training in critical value significance and appropriate responses, and feedback regarding patient outcomes (Alharbi et al., 2021). In contexts where nurses serve as initial recipients of laboratory notifications, protocols must specify timeframes for physician notification and

procedures for escalation when physicians are not immediately available (Hwang & Ahn, 2015).

Third, emergency department physicians bear ultimate responsibility for clinical decision-making based on critical values but require systematic support to ensure timely awareness of results (Dighe et al., 2006). This includes reliable notification mechanisms that penetrate the cognitive demands and competing priorities of emergency practice, integration of critical value alerts into clinical workflow, and decision support tools that facilitate appropriate responses (Georgiou et al., 2017). Acknowledgment and read-back verification ensure that information has been received and understood (Valenstein et al., 2008).

Fourth, technology serves as an enabler rather than a solution in itself, requiring thoughtful implementation that accounts for user needs, workflow integration, and organizational context (Henricks, 2016). Automated alerting systems must be designed to minimize false alarms while ensuring that genuine critical values receive immediate attention (Georgiou et al., 2017). Interface design should support rapid recognition of critical information and facilitate efficient response actions.

Fifth, continuous quality improvement based on systematic monitoring of process and outcome metrics enables ongoing refinement of the triadic collaboration (Plebani et al., 2017). Relevant quality indicators include percentage of critical values reported within target timeframes, documentation completeness rates, time from result availability to clinical intervention, and clinical outcomes such as mortality rates and length of stay (Sciacovelli et al., 2017). Regular review of quality data by representatives from all three professional groups fosters shared accountability and identifies improvement opportunities (Plebani, 2011).

Finally, adaptation to Saudi Arabian organizational and cultural contexts requires explicit attention to hierarchical communication norms, interprofessional relationship dynamics, workforce composition, and resource availability (Alharbi et al., 2012; Alkhenizan & Shaw, 2011). Implementation strategies should engage stakeholders from all triadic groups in protocol development, provide culturally appropriate training, address language considerations in multilingual settings, and secure visible leadership support (Alahmadi, 2010).

5. DISCUSSION

The proposed Laboratory-Emergency Department-Nursing Triadic Model addresses a critical gap in current approaches to optimizing critical laboratory value reporting by explicitly conceptualizing the interdependent relationship among three professional groups as a functional unit requiring coordinated processes, clear communication pathways, and shared accountability. Existing literature has examined components of critical value workflows in relative isolation, focusing separately on laboratory performance metrics, emergency department operations, or nursing communication roles (Steindel & Howanitz, 2007). The triadic framework integrates these perspectives into a comprehensive model that recognizes the essential contributions of each professional group while emphasizing structured collaboration as the mechanism for achieving optimal turnaround times and enhanced patient safety (Reeves et al., 2017).

The evidence synthesized in this review demonstrates that delays in critical value communication occur predominantly in the post-analytical phase, specifically during the interval between result availability and clinical action (Hawkins, 2013; Piva et al., 2010). This finding underscores that technological improvements in laboratory automation and analytical speed, while valuable, cannot alone resolve turnaround time challenges (Albalawi et al., 2020). Rather, interventions must target the human and organizational factors

governing information transfer across professional boundaries (Manser, 2009). The triadic model provides a structured approach to addressing these factors through standardized protocols, role clarity, communication infrastructure, and interprofessional collaboration mechanisms.

Implementation of the triadic model in Saudi Arabian hospital settings offers several potential benefits aligned with national healthcare quality improvement priorities. The explicit focus on interprofessional collaboration addresses documented challenges in teamwork and communication culture within Saudi healthcare institutions (Alahmadi, 2010; Alharbi et al., 2012). By involving representatives from all three professional groups in protocol development and quality monitoring, the model promotes shared ownership and reduces hierarchical barriers to open communication (Alkhenizan & Shaw, 2011). The emphasis on standardized protocols and quality indicators supports alignment with international best practices while allowing adaptation to local organizational contexts (Almalki et al., 2011).

The role of nursing staff within the triadic model warrants particular attention given the pivotal position nurses occupy in hospital communication networks and their direct involvement in patient monitoring (Hohenhaus et al., 2006). Findings from Saudi emergency departments indicate that nurses experience significant challenges related to critical value communication, including unclear expectations, inadequate feedback, and role ambiguity (Alharbi et al., 2021). The triadic model addresses these concerns through explicit definition of nursing responsibilities, establishment of bidirectional communication with laboratory personnel and physicians, provision of training regarding critical value significance, and creation of feedback mechanisms that close the loop on patient outcomes (Plebani, 2011). Empowering nurses as active partners rather than passive message conduits has potential to enhance both efficiency and clinical effectiveness (Hwang & Ahn, 2015).

Technology integration emerges as both an opportunity and a challenge in implementing the triadic model. Electronic health records and automated alerting systems offer substantial potential for reducing notification delays and ensuring reliable information transfer (Georgiou et al., 2017). However, the literature reveals that technology effectiveness depends critically on implementation quality, user acceptance, interface design, and workflow integration (Henricks, 2016). Saudi Arabian hospitals have invested significantly in healthcare information technology, yet realizing the full benefits requires ongoing attention to system optimization, user training, and interoperability among laboratory, emergency department, and hospital-wide platforms (Albalawi et al., 2020). The triadic model emphasizes that technology should support rather than replace direct interprofessional communication, particularly for the most critical and time-sensitive values (Valenstein et al., 2008).

Quality monitoring using standardized indicators provides essential feedback for continuous improvement of triadic collaboration. The literature identifies multiple relevant metrics spanning laboratory processing times, communication completeness, documentation quality, and clinical outcomes (Plebani et al., 2017; Sciacovelli et al., 2017). However, measurement alone does not drive improvement; data must be systematically reviewed by multidisciplinary teams empowered to implement changes based on identified performance gaps (Lippi & Plebani, 2018). The triadic model incorporates regular review sessions involving laboratory leadership, emergency department medical directors, and nursing supervisors to analyze quality data, celebrate successes, address challenges, and refine processes (Plebani, 2011). This participatory approach builds collective ownership of outcomes and sustains engagement across professional groups (Reeves et al., 2017).

The broader healthcare quality improvement literature emphasizes that sustainable change requires alignment of interventions with organizational culture, adequate resource allocation, visible leadership support, and attention to frontline staff perspectives (Improta et al., 2018). Application of these principles to critical value turnaround time optimization suggests that successful triadic model implementation depends on more than technical protocol development. Healthcare administrators must prioritize interprofessional collaboration, provide protected time for joint training and quality review activities, invest in necessary technological infrastructure, and recognize the contributions of all triadic members to patient safety outcomes (Almalki et al., 2011). In Saudi Arabian contexts, engagement of senior leadership and alignment with national healthcare transformation initiatives enhances feasibility and sustainability (Alkhenizan & Shaw, 2011).

Several limitations of this review and the proposed model warrant acknowledgment. First, the evidence base reflects predominantly Western healthcare contexts, with limited research conducted specifically in Saudi Arabian or broader Middle Eastern settings. While fundamental principles of laboratory medicine and patient safety likely generalize across contexts, organizational and cultural factors influencing implementation may differ substantially (Alharbi et al., 2012). Empirical research evaluating triadic model implementation and effectiveness in Saudi hospitals would provide valuable contextual validation. Second, the literature reviewed encompasses diverse methodologies, quality levels, and outcome measures, limiting the strength of evidence for specific interventions. Rigorous controlled studies examining impacts of integrated triadic protocols on patient outcomes remain sparse, representing an important direction for future research.

Third, the proposed model emphasizes process optimization within current hospital structures rather than exploring more transformative approaches such as comprehensive point-of-care testing programs or fundamental redesign of emergency department care models. While practical considerations support incremental improvement strategies, longer-term innovation in laboratory-clinical integration may require more substantial structural change (Kendall et al., 1998). Fourth, the model does not fully address resource constraints, staffing limitations, and competing organizational priorities that may challenge implementation in resource-limited settings (Morley et al., 2018). Adaptation to diverse resource contexts requires pragmatic consideration of which model components offer greatest impact relative to required investment.

Future research should evaluate triadic model implementation through prospective intervention studies measuring impacts on turnaround times, communication quality, clinical outcomes, and healthcare costs. Comparative effectiveness research examining different communication technologies, staffing configurations, and protocol variations would inform evidence-based optimization. Qualitative research exploring experiences of laboratory personnel, emergency physicians, and nurses participating in triadic collaboration could illuminate facilitators and barriers not captured in quantitative metrics (Alharbi et al., 2021). Investigation of sustainability factors and long-term maintenance of improvement gains would address a common challenge in healthcare quality initiatives (Improta et al., 2018).

The triadic model also has implications for professional education and training. Interprofessional education initiatives that bring together laboratory science, medicine, and nursing students to address critical value scenarios could build foundational collaborative competencies (Reeves et al., 2017). Simulation-based training using realistic emergency department situations provides opportunities to practice communication protocols, role clarity, and coordinated responses in controlled environments before real-world implementation (Leonard et al., 2004). Continuing education programs addressing advances in laboratory technology, communication strategies, and patient safety principles

support ongoing professional development across all triadic members (Lippi & Plebani, 2018).

Policy implications extend to healthcare regulatory bodies and accreditation organizations. The Joint Commission's emphasis on critical value reporting as a patient safety priority provides a framework for standardized expectations, yet specific guidance on optimal communication structures remains limited (The Joint Commission, 2013). Development of more prescriptive standards addressing triadic collaboration, turnaround time benchmarks, and quality indicator requirements could drive more consistent implementation across healthcare institutions (Campbell & Horvath, 2014). Saudi Arabian healthcare regulatory authorities might consider incorporating triadic model principles into hospital accreditation requirements and quality performance assessments (Alkhenizan & Shaw, 2011).

In conclusion, the Laboratory-Emergency Department-Nursing Triadic Model offers a comprehensive, evidence-based framework for optimizing critical laboratory value turnaround times in Saudi Arabian hospital emergency departments. By emphasizing structured interprofessional collaboration, standardized communication protocols, technological integration, and continuous quality improvement, the model addresses identified barriers while leveraging best practices documented in international literature. Successful implementation requires commitment from all three professional groups, sustained organizational support, and adaptation to local contexts. The potential benefits encompass enhanced patient safety, improved clinical outcomes, increased operational efficiency, and strengthened interprofessional relationships. Further research evaluating model effectiveness and refinement through practical experience will advance understanding of optimal approaches to this persistent healthcare quality challenge.

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