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Integrated Emergency Care Pathways: The Collaborative Roles of Medical Laboratory Scientists, EMS Professionals, Pharmacists, Nurses, and Resident Physicians in Time-Critical Patient Management

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Abstract
Time-critical emergency conditions — including acute ischemic stroke, ST-elevation myocardial infarction (STEMI), sepsis, and major trauma — demand coordinated, rapid responses in which delays of minutes translate into measurable increases in morbidity and mortality. This narrative review synthesizes contemporary evidence (2016–2024) on integrated emergency care pathways and the collaborative roles of medical laboratory scientists, emergency medical services (EMS) professionals, pharmacists, nurses, and resident physicians in time-critical patient management. A systematic literature search was conducted across PubMed, Scopus, and CINAHL databases. Evidence demonstrates that targeted deployment of interprofessional pre-hospital teams significantly reduces mortality risk (AOR 0.80; 95% CI [0.68, 0.91]) and increases survival (AOR 1.49; 95% CI [1.31, 1.69]) compared with paramedic-only care. Point-of-care testing guided by laboratory specialists reduces time to treatment, while emergency pharmacists prevent up to 45% of medication errors and generate substantial cost avoidance. Nurse-led rapid response systems improve rescue success rates from 66.5% to 86.6% and reduce cardiac arrest rates. Structured communication tools such as SBAR significantly enhance team task performance. This review proposes an integrated framework emphasizing parallel processing, shared situational awareness, and interprofessional training to optimize emergency care outcomes.

Keywords: interprofessional collaboration, emergency care pathways, time-critical patient management, point-of-care testing, rapid response systems.

Introduction

Emergency department (ED) overcrowding is a persistent and growing global healthcare challenge associated with delayed treatment, reduced quality of care, disrupted patient flow, and operational inefficiency (Kelen et al., 2021). In time-sensitive emergency conditions such as acute ischemic stroke, ST-elevation myocardial infarction (STEMI), sepsis, and major trauma, delays in treatment can substantially increase morbidity and mortality (Seymour et al., 2016). The traditional model of emergency care — characterized by sequential assessment, diagnostic testing, and treatment initiation — has proven inadequate for meeting the demands of time-critical patient management, where the "golden hour" concept underscores that early intervention dramatically improves outcomes (Alotaibi et al., 2024). Over the past decade, healthcare systems worldwide have increasingly recognized that optimizing emergency care requires not merely technological advancement but fundamental redesign of care pathways to enable parallel processing, shared situational awareness, and seamless interprofessional collaboration (Otudi et al., 2024).

The concept of integrated emergency care pathways represents a paradigm shift from fragmented, profession-specific workflows to coordinated, patient-centered systems in which multiple healthcare professionals work simultaneously toward shared goals (Lammers et al., 2023). This

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integration spans the entire continuum of emergency care — from pre-hospital assessment by EMS professionals through ED triage by nurses, diagnostic testing by medical laboratory scientists, medication management by pharmacists, and clinical decision-making by resident physicians and attending physicians (Schouten et al., 2023). Each profession contributes unique expertise, yet the synergy created through structured collaboration exceeds what any single profession can achieve in isolation (Gunderson et al., 2020).

The evidence supporting integrated care pathways has accumulated substantially in recent years. A systematic review and meta-analysis of 23 studies found that targeted deployment of physician-led interprofessional pre-hospital teams significantly reduced mortality risk compared with paramedic-only care (adjusted odds ratio [AOR] 0.80; 95% CI [0.68, 0.91]; $p = 0.001$) and increased survival rates (AOR 1.49; 95% CI [1.31, 1.69]; $p < 0.00001$) (Lammers et al., 2023). These findings underscore that the composition and coordination of emergency care teams directly influence patient outcomes. Similarly, a synthesis of 54 studies demonstrated that multidisciplinary teamwork significantly improves ED performance, including reductions in mortality, adverse events, and patient dissatisfaction (Rosen et al., 2018). This review synthesizes contemporary evidence on integrated emergency care pathways, examining the collaborative roles of five key professional groups — medical laboratory scientists, EMS professionals, pharmacists, nurses, and resident physicians — in time-critical patient management. Table 1 provides an overview of the key operational mechanisms and associated outcomes of integrated emergency care pathways.

Table 1. Key Operational Mechanisms and Outcomes of Integrated Emergency Care Pathways

Mechanism	Description	Associated Outcomes
Fast-track pathways	Early patient routing based on presenting condition	Reduced door-to-needle, door-to-balloon times
Parallel processing	Simultaneous diagnostic and therapeutic tasks	Decreased time-to-treatment
Multidisciplinary activation	Coordinated team response to clinical triggers	Improved compliance with care bundles
Resource prioritization	Dynamic allocation of critical resources	Reduced ED length of stay
Structured communication	Standardized handoff protocols (SBAR)	Enhanced team performance and safety
Point-of-care testing	Bedside laboratory analysis	Faster clinical decision-making

Note. ED = emergency department; SBAR = Situation, Background, Assessment, Recommendation. Adapted from Samadbeik et al. (2024), Otudi et al. (2024), and Lammers et al. (2023).

The Role of Medical Laboratory Scientists in Emergency Care

Rapid Diagnostics and Turnaround Time

Medical laboratory scientists (also known as clinical laboratory scientists) play a foundational yet often underappreciated role in emergency care pathways. Their contributions extend far beyond the physical performance of laboratory tests to encompass test selection, quality assurance, result interpretation, and consultation with clinical teams. The concept of turnaround time (TAT) — the interval from test ordering to result reporting — has become a central quality metric in emergency laboratory medicine. A position paper by the German Society for Clinical Chemistry and Laboratory Medicine and the German Interdisciplinary Association for Intensive Care and Emergency Medicine established a tiered framework for emergency testing: Emergency Level 1 parameters (those with potentially life-threatening consequences) should have a TAT of no more than 15 minutes; Emergency Level 2 parameters should be available within 60 minutes; and urgent case parameters should be reported within four hours (Waydhas et al., 2024). This framework underscores the critical importance of laboratory responsiveness in time-sensitive clinical scenarios.

The clinical impact of rapid laboratory TAT is well documented. A study conducted at a UK National Health Service trust found that achieving 95% of biochemistry samples within 60 minutes in the ED supported faster clinical decision-making and reduced unnecessary delays in patient treatment (Öztürk & Demirci, 2023). More dramatically, implementation of automated blood testing systems has reduced TAT for urgent samples from 50 minutes to 16 minutes, with overall test TAT decreasing from 80 minutes to 44 minutes (Mazzone, 2024). These improvements translate directly into clinical benefit: faster identification of elevated troponin enables earlier activation of cardiac catheterization laboratories for STEMI patients, rapid lactate measurement facilitates timely sepsis recognition, and prompt coagulation studies guide appropriate blood product administration in trauma resuscitation (Strandmark et al., 2015).

Point-of-Care Testing and Laboratory Collaboration

The integration of point-of-care testing (POCT) into emergency settings has expanded the reach of laboratory science beyond the central laboratory. POCT enables laboratory analysis at the patient's bedside within minutes rather than hours, fundamentally altering the diagnostic paradigm in emergency care (Strandmark et al., 2015). However, the successful implementation of POCT requires close collaboration between laboratory scientists and clinical teams. A study examining POCT implementation in emergency pre-hospital settings found that POCT significantly reduced time to treatment, decreased adverse events, and shortened hospital stays (Strandmark et al., 2015). Thematic analysis of qualitative interviews with healthcare professionals identified enhanced decision-making and improved interprofessional collaboration as key benefits, while also highlighting challenges related to logistical barriers, training requirements, and the need for robust quality assurance systems (Kobayashi et al., 2018).

The role of laboratory scientists in POCT extends to governance, quality control, and interpretation support. A study from the University of Cincinnati demonstrated that pre-hospital POCT blood gas analysis provided valuable prognostic information in out-of-hospital cardiac arrest (OHCA), with a pH ≥ 7.1 serving as an independent predictor of return of spontaneous circulation at ED admission (adjusted odds ratio 3.68; 95% CI 1.37–9.89; $p = 0.010$) (Sirikul et al., 2022). This finding illustrates how laboratory specialists can contribute to pre-hospital decision-making even when they are not physically present, through the validation of testing protocols and interpretation frameworks that EMS professionals apply in the field.

Laboratory Parameters Guiding Pharmacological Interventions

The intersection of laboratory science and pharmacology in emergency care represents a particularly important domain of interprofessional collaboration. Laboratory parameters — including blood glucose, lactate, electrolytes, coagulation studies, and cardiac biomarkers — guide a substantial proportion of pharmacological interventions in time-critical emergencies (Kobayashi et al., 2018). Hypoglycemia requires immediate glucose administration; hyperkalemia necessitates calcium and insulin-dextrose therapy; elevated lactate signals the need for early antibiotic administration in sepsis; and elevated troponin triggers antiplatelet and anticoagulant therapy in acute coronary syndrome.

The integration of laboratory diagnostics into pre-hospital care, either through POCT or rapid communication with hospital-based laboratory specialists, allows for more targeted pharmacological approaches that potentially reduce complications and improve outcomes (Kobayashi et al., 2018). For example, pre-hospital POC lactate measurement has been shown to add predictive value in general EMS populations, enabling earlier identification of patients with occult hypoperfusion who may benefit from aggressive fluid resuscitation and early antibiotic therapy (Magnusson et al., 2024). The laboratory scientist's expertise in test performance characteristics, reference ranges, and interpretation of results in the context of pre-analytical variables is essential for ensuring that POCT results are both accurate and clinically actionable.

The Role of EMS Professionals in Pre-Hospital Care

Pre-Hospital Assessment and Stabilization

Emergency medical services professionals constitute the first link in the chain of survival for time-critical emergencies. Their role has evolved dramatically from simple transport to comprehensive pre-hospital assessment, stabilization, and treatment (Morgan et al., 2021). The pre-hospital phase of emergency care is particularly critical because the majority of deaths from trauma and critical illness occur before patients reach the hospital, highlighting the importance of early advanced clinical decision-making and interventions beyond the scope of basic paramedic practice (Lammers et al., 2023). EMS professionals must rapidly assess patients, identify time-sensitive conditions, initiate appropriate treatments, and determine the most appropriate destination facility based on patient needs (Otudi et al., 2024).

The scope of EMS practice varies considerably across jurisdictions, with some systems authorizing advanced interventions including endotracheal intubation, surgical airways, chest decompression, and administration of a wide range of pharmacological agents (Morgan et al., 2021). In systems with physician-staffed pre-hospital teams, the integration of senior clinical decision-making with advanced interventions has been shown to improve outcomes for critically ill and injured patients (Lammers et al., 2023). The meta-analysis by Morgan et al. (2021) provided the most robust evidence to date: the mortality benefit associated with physician-led interprofessional pre-hospital teams (AOR 0.80) was consistent across studies conducted in diverse healthcare systems, suggesting that the integration of advanced clinical expertise into pre-hospital care is broadly beneficial.

Integration with Laboratory and Diagnostic Services

The integration of laboratory and diagnostic services into EMS operations represents a frontier in pre-hospital emergency care. POCT devices now enable EMS professionals to obtain blood glucose, lactate, blood gas, electrolyte, and coagulation results at the point of care, transforming the ambulance into a mobile diagnostic unit (Kunze-Szikszay et al., 2016). Pre-hospital troponin testing has been piloted in several systems, with early results suggesting that it can accelerate identification of acute coronary syndrome and facilitate direct transport to cardiac catheterization facilities (Alghamdi et al., 2019). The successful integration of these technologies requires close collaboration with laboratory medicine specialists who provide oversight, training, and quality assurance for POCT programs.

A narrative review of trauma care pathways emphasized that integrating prehospital paramedic assessment with diagnostic imaging, laboratory testing, blood bank services, and nursing management is essential for optimizing outcomes during the critical "golden hour" (Alotaibi et al., 2024). The review highlighted that point-of-care viscoelastic testing for goal-directed hemostatic resuscitation — enabling real-time assessment of clot formation and lysis — represents a particularly promising advance that bridges the pre-hospital and in-hospital phases of trauma care (Alotaibi et al., 2024). These developments underscore the evolving role of EMS professionals as diagnosticians as well as treaters, requiring expanded training in laboratory science, imaging interpretation, and pharmacotherapy.

Data Sharing and Handoff Communication

Effective handoff communication between EMS and receiving ED teams is essential for continuity of care. The National EMS Management Association has issued a position statement calling for bilateral exchange of data between EMS and hospitals, recognizing that fragmented information transfer contributes to diagnostic delays, redundant testing, and medication errors (Gunderson et al., 2020). Studies have identified that the transmission of patient information between EMS and hospital teams is often ineffective, resulting in prolonged handover times and incomplete information transfer across all acuity levels (Vitale & Cannito, 2020). Structured handoff protocols that standardize the content and sequence of information transfer can improve both efficiency and completeness. The use of SBAR (Situation, Background, Assessment, Recommendation) communication during emergency handoffs has been shown to improve team performance and reduce information loss (Lee & Kim, 2020). As Figure 1 illustrates, the integrated emergency care pathway connects pre-hospital assessment, rapid diagnostics, pharmacological intervention, and definitive care through structured communication and parallel processing.

Figure 1. Integrated Emergency Care Pathway from Pre-Hospital to Definitive Care

Note. This figure depicts the sequential and parallel processes involved in integrated emergency care, from EMS pre-hospital assessment through ED triage, rapid diagnostics, pharmacological intervention, and definitive treatment. Bidirectional arrows represent communication and data exchange between phases. Adapted from Alotaibi et al. (2024), Otudi et al. (2024), and Lammers et al. (2023).

The Role of Pharmacists in Emergency Care

Medication Reconciliation and Error Prevention

Pharmacists have become increasingly integral members of emergency care teams, contributing expertise in medication reconciliation, error prevention, and therapeutic optimization. The ED represents one of the highest-risk settings for medication errors due to the acuity of patient presentations, the frequent need for rapid therapeutic decisions, and the high prevalence of polypharmacy among emergency patients (Goulas et al., 2023). A prospective observational study of pharmacist involvement in a French ED found that 28% of patients who received medication reconciliation had at least one medication error identified, with omissions (51%) and dose errors (28%) accounting for 79% of all errors (Thomas et al., 2022). The proactive mode of medication reconciliation was significantly more efficient than retrospective reconciliation (0.22 versus 1.66 errors per patient), highlighting the importance of pharmacist presence at the point of ED entry (Thomas et al., 2022).

The impact of emergency pharmacists on medication safety has been quantified in several studies. The presence of emergency medicine pharmacists has been associated with a reduction in medication errors of up to 45% (Al Mansour et al., 2022). A study examining pharmacist tracking and correction of medication errors in an ED observation ward found a favorable benefit-to-cost ratio for the hospital, demonstrating that pharmacist involvement is both clinically effective and economically sustainable (Raymond et al., 2023). These findings have led professional organizations to recommend the inclusion of clinical pharmacists on emergency care teams to ensure patients' medication needs are appropriately met, lead system changes to reduce medication errors, and evaluate the cost-effectiveness of medication therapy (Ortmann et al., 2021).

Cost Avoidance and Therapeutic Optimization

The economic value of emergency pharmacist services has been comprehensively documented. The PHARM-EM study — the first multicenter, prospective study to classify interventions performed by emergency medicine pharmacists and quantify potential cost avoidance — found that pharmacist recommendations generated over $7.5 million in potential cost avoidance across 13,984 interventions at 88 pharmacist shifts (Rech et al., 2021). The average potential cost avoidance was $539 per intervention, $876 per patient, and $8,214 per emergency medicine pharmacist shift, with an annualized potential cost avoidance of $1,971,262 per pharmacist (Rech et al., 2021). The areas of greatest cost avoidance were major adverse drug event prevention ($1,232,561; 16.4%), antimicrobial therapy initiation and streamlining ($846,244; 11.2%), and blood factor stewardship ($683,590; 9.1%) (Rech et al., 2021).

Beyond cost avoidance, emergency pharmacists contribute to therapeutic optimization in time-critical conditions. In sepsis, pharmacists facilitate rapid administration of broad-spectrum antibiotics within the one-hour bundle target (Seymour et al., 2016). In acute coronary syndrome, they ensure appropriate loading doses of antiplatelet agents and anticoagulants. In stroke, they prepare and administer thrombolytic agents within the narrow therapeutic window. Pharmacists also participate in emergency code blue, code stroke, and code sepsis responses, with PHARM-EM data showing that pharmacist participation in these critical events is associated with high acceptance rates of recommendations (96.2–98.5%) (Rech et al., 2021). Table 2 summarizes the cost avoidance and clinical impact of emergency pharmacist interventions.

Table 2. Emergency Pharmacist Interventions: Cost Avoidance and Clinical Impact

Intervention Category	Cost Avoidance (USD)	Percentage of Total	Clinical Impact
Adverse drug event prevention	$2,225,049	29.5%	Reduced patient harm
Hands-on care (code participation)	$2,836,811	37.7%	Direct resuscitation support
Individualization of patient care	$1,787,170	23.7%	Optimized dosing
Antimicrobial stewardship	$846,244	11.2%	Appropriate antibiotic use
Resource utilization	$310,582	4.1%	Reduced unnecessary testing
Administrative/supportive	$342,881	4.6%	Protocol management

Note. Data from Rech et al. (2021). Cost avoidance values represent 2019 U.S. dollars.

The Role of Nurses in Emergency Care

Triage and Rapid Assessment

Emergency nurses serve as the frontline of ED operations, conducting rapid triage assessments that determine patient acuity, prioritize care, and initiate time-critical interventions. Triage is a critical component in the delivery of emergency care, representing the first point of contact and assessment in the patient's ED journey (Al Dhefeeri et al., 2024). The triage process involves rapid patient assessment, interpretation of clinical history and physiological parameters, and objective discrimination between urgency categories. For time-critical conditions such as non-traumatic chest pain, adherence to ECG within 10 minutes and early troponin targets is essential, yet inconsistent (Alotaibi et al., 2024). Nurse-led interventions such as the "First Look" nurse role — where a dedicated nurse conducts rapid initial assessments to identify life-threatening conditions and escalate care as needed — have been shown to reduce door-to-triage times and improve recognition of critically ill patients (Rogers, 2020).

The nurse-led rapid response system (RRS) represents a particularly important innovation in emergency care. A quasi-experimental study conducted in a Chinese ED found that implementation of a nurse-led RRS and activation criteria significantly improved rescue success rates from 66.5% to 86.6% and reduced cardiac arrest rates from 72.6% to 33.6% (Massey et al., 2015). The effective rescue time was shortened from 58.67 ± 13.73 minutes to 46.98 ± 12.01 minutes ($p < 0.05$). The nurse-led RRS included four level 1 indicators, 14 level 2 indicators, and 88 level 3 indicators, providing a comprehensive framework for identifying and responding to patient deterioration (Sprogis et al., 2021). These findings demonstrate that nurses can effectively lead rapid response systems when equipped with appropriate activation criteria and team support.

Care Coordination and Communication

Beyond direct patient care, emergency nurses serve as care coordinators, facilitating communication among physicians, laboratory scientists, pharmacists, and other team members. The nurse's role as care coordinator positions them to ensure that medication decisions consider the full clinical picture, particularly for patients with pre-existing medical conditions receiving care from multiple providers (Giles et al., 2024). In rapid response team activations, nurses often serve as the first responders who assess the patient, initiate interventions, and mobilize additional resources (Wu et al., 2022). Qualitative interviews with nurses and physicians have highlighted how the collaborative rapid response team model improves patient safety and optimizes early detection and management of patient deterioration (Shiell et al., 2022).

Effective communication is central to the nurse's coordination role. A study of interprofessional communication in simulated emergencies found that SBAR-R (Situation, Background, Assessment, Recommendation, and Read-Back) communication was significantly associated with team task performance (Lee & Kim, 2020). SBAR with the physician correlated positively with initial team performance, while read-back communication correlated positively with team performance without error (Lee & Kim, 2020). These findings underscore that structured communication tools enhance both the efficiency and accuracy of information transfer during critical events. A survey of nurses found that 76.5% believed structured communication improves collaboration between nurses and physicians, a finding particularly significant in busy emergency and intensive care settings where concise and standardized communication is essential (Lamba et al., 2015).

Nurse-Led Interventions and Outcomes

The evidence for nurse-led interventions in emergency care extends beyond rapid response systems. A study examining the role of intensive care nurses in medical emergency teams found that these nurses are essential members of rapid response systems, contributing expertise in continuous monitoring, early recognition of deterioration, and initiation of time-critical interventions (Weatherburn, 2023). The development of a comprehensive model for the rapid response team nurse role identified seven key functions: screening of patients with acute exacerbation, professional support for emergencies, education for service users, consultation for high-risk patient care, support for patient and family decision-making, coordination between departments, and management of the rapid response team (Won & Kang, 2022). This multifaceted role requires advanced clinical assessment skills, interprofessional communication competence, and the ability to make rapid decisions under pressure.

The Role of Resident Physicians in Emergency Care

Clinical Decision-Making and Supervision

Resident physicians occupy a unique position in emergency care, functioning simultaneously as learners and as frontline providers responsible for clinical decision-making. The degree of resident autonomy in the ED varies based on training level, institutional policy, and patient acuity. A retrospective study of emergency department residents in Taiwan found that attending physicians delegated approximately two-thirds of patient care to residents and postgraduate year physicians, with 45% of these patients receiving close supervision during treatment (Chen et al., 2022). In community hospitals, 65% of patients were treated under close supervision by an attending physician, compared with a lower proportion in academic centers (Chen et al., 2022). These findings reflect the balance between ensuring patient safety through appropriate supervision and allowing residents to develop clinical judgment through progressive independence.

The relationship between resident autonomy and patient outcomes has been a subject of investigation. The Taiwan study found that close supervision did not yield lower mortality rates, suggesting that residents appropriately identify critically ill patients and seek early help from attending physicians (Chen et al., 2022). However, patients treated by residents practicing independently for more than 400 minutes had an increased risk of mortality, indicating that fatigue and prolonged independent practice may compromise patient safety (Chen et al., 2022). These findings suggest that optimal resident supervision involves graduated autonomy that increases with experience while maintaining appropriate safeguards for patient safety. As Figure 2 illustrates, the integration of resident physicians within the interprofessional emergency team involves dynamic interaction among multiple professional domains.

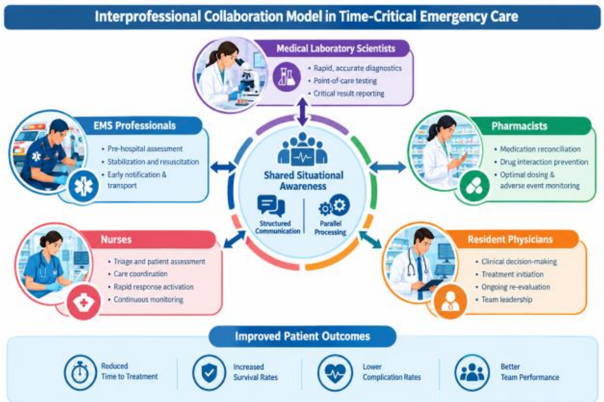

Figure 2. Interprofessional Collaboration Model in Time-Critical Emergency Care

Note. This figure illustrates the collaborative interaction among medical laboratory scientists, EMS professionals, pharmacists, nurses, and resident physicians in time-critical emergency care. Central elements include shared situational awareness, structured communication, and parallel processing. Bidirectional arrows represent information exchange and collaborative decision-making. Adapted from Lammers et al. (2023), Rech et al. (2021), and Sprogis et al. (2021).

Interphysician Collaboration and Learning

The emergency department presents unique challenges for interphysician collaboration and workplace learning. A focused ethnography examining interphysician collaboration around hip fracture patients in the ED found that interactions between residents lacked coordination and integration, and that complex contextual factors influenced collaboration and learning (Cross et al., 2024). The study concluded that facilitating workplace learning of residents and supervisors within the complex ED context can improve interprofessional collaboration (Cross et al., 2024). These findings highlight the need for structured educational interventions that explicitly address interphysician communication and collaboration.

The development of entrustable professional activities (EPAs) in emergency medicine has been proposed as a framework for assessing resident competence and determining appropriate levels of autonomy (Caretta-Weyer et al., 2024). An analysis of specialty-wide EPAs in emergency medicine highlighted that the EPAs receiving the most attention had collaborative elements, including EPA1 (performing focused assessment), EPA8 (managing critically ill patients), and EPA21 (leading interprofessional teams) (Caretta-Weyer et al., 2024). This emphasis on collaborative competence reflects the recognition that effective emergency care requires physicians to work skillfully within interprofessional teams, not merely as autonomous decision-makers.

Integration, Communication, and Team Performance

Structured Communication Protocols

The evidence for structured communication protocols in emergency care is compelling. SBAR (Situation, Background, Assessment, Recommendation) has become the most widely adopted standardized communication tool in acute care settings, with research demonstrating its effectiveness in improving team performance and reducing communication errors (Lee & Kim, 2020). A study of 49 nursing student teams participating in simulated emergencies found that SBAR-R communication scores differed significantly according to overall team task performance (Lee & Kim, 2020). The addition of "Read-Back" to the traditional SBAR framework ensures that the receiver of information confirms understanding, a critical element in high-stakes emergency communication where miscommunication can have fatal consequences (Lee & Kim, 2020).

Despite the evidence supporting SBAR, implementation in practice remains inconsistent. An observational study of handover using the SBAR method at an Italian polyclinic found that the transmission of patient information was not effective, resulting in prolonged handover times and a low percentage of information provided across all triage categories (Vitale & Cannito, 2020). This finding suggests that training and reinforcement are necessary to achieve fidelity to structured communication protocols. The quality improvement literature indicates that SBAR implementation requires ongoing education, audit and feedback, and integration into clinical workflows rather than simple introduction of the tool (BMJ Open, 2020).

Simulation-Based Interprofessional Training

Simulation-based interprofessional education (IPE) has emerged as a vital methodology for fostering communication, addressing hierarchical dynamics, and improving team cohesion in critical care settings (Chae & Shon, 2024). A simulation-based IPE program conducted at a Taiwanese hospital between 2018 and 2023 significantly enhanced interprofessional collaboration and clinical competencies among participants (O'Brien et al., 2023). The program aimed to improve teamwork, communication, and collaboration among healthcare professionals in high-acuity environments such as emergency departments and intensive care units, with results demonstrating sustained improvements in team performance (Chae & Shon, 2024).

The effectiveness of simulation training extends to resource-limited settings. A pilot simulation training program at an emergency center in Burundi demonstrated improvements in interdisciplinary closed-loop communication and reduced time to critical actions (Azadi et al., 2023). The four-week in-situ simulation training series was conducted with existing staff and resources, demonstrating that simulation-based team training is feasible and effective even in low-resource settings (Duran, & McIvor, 2021). These findings have important implications for global emergency care, where the burden of time-critical conditions is highest and resources are most constrained. The Emergency Crisis Resource Management (E-CRM) framework has been developed specifically for interprofessional emergency teams, addressing non-technical skills including leadership, communication, situational awareness, and decision-making under pressure (Escribano et al., 2024). Studies of E-CRM-based simulation have demonstrated improvements in participants' perception of non-technical skills and immediate learning outcomes, supporting the value of interprofessional education in developing essential competencies for handling urgent and emergency clinical situations (Escribano et al., 2024).

Clinical Activation Codes and System-Level Integration

Clinical activation codes have emerged as system-level operational strategies for optimizing emergency care pathways. A systematic review of 12 studies covering activation systems for stroke, STEMI, sepsis, and trauma identified four major operational mechanisms: fast-track pathways and early patient routing; parallel processing and workflow acceleration; multidisciplinary team activation and care coordination; and resource prioritization and reduction of operational delays (Samadbeik et al., 2024). Activation systems consistently reduced door-to-needle, door-to-balloon, door-to-CT, and other time-to-treatment indicators, with several studies also reporting improved throughput, shorter length of stay, enhanced compliance with emergency care bundles, and better interdepartmental coordination (Schouten et al., 2023).

The integration of clinical activation codes with interprofessional team structures represents the most advanced model of emergency care pathway optimization. In stroke care, activation of a code stroke mobilizes neurologists, radiologists, nurses, pharmacists, and laboratory scientists to work in parallel rather than sequentially (Samadbeik et al., 2024). This parallel processing model reduces door-to-needle times for thrombolytic therapy, which is directly associated with improved functional outcomes at 90 days (Seymour et al., 2016). In sepsis, the "Sepsis Six" bundle — including blood cultures, broad-spectrum antibiotics, intravenous fluids, lactate measurement, urine output monitoring, and oxygen therapy — is most effectively delivered when multiple professionals work simultaneously toward bundle completion within the first hour (Seymour et al., 2016). These examples illustrate how integrated care pathways transform emergency care from a linear sequence of professional consultations into a coordinated, simultaneous effort in which each professional contributes expertise within a shared framework.

Barriers and Facilitators to Integrated Emergency Care

Organizational and Cultural Barriers

Despite the evidence supporting integrated emergency care, implementation faces persistent barriers. Professional silos, hierarchical structures, and traditional role boundaries can impede collaboration even when organizational structures support integrated care (Otudi et al., 2024). A systematic review of teamwork in rapidly deployed interprofessional teams in intensive and acute care found that managers and team leaders need to pay attention to reducing pre-existing occupational identities and power dynamics by emphasizing skill mix rather than professional hierarchy (Schilling et al., 2022). The emergency department's fast-paced, high-stakes environment can amplify these dynamics, particularly when residents, nurses, and pharmacists must make rapid decisions under conditions of uncertainty.

Logistical barriers also impede integration. The implementation of POCT in pre-hospital settings faces challenges related to device availability, connectivity, training requirements, and quality assurance systems (Kobayashi et al., 2018). Communication barriers between paramedics and laboratory teams, and the need for specialized training to interpret laboratory data accurately, represent additional obstacles to effective interprofessional collaboration (Kunze-Szikszay et al., 2016). In resource-limited settings, these barriers are compounded by workforce shortages, equipment limitations, and infrastructure deficiencies that constrain the implementation of integrated care pathways (Duran, & McIvor, 2021).

Facilitators and Implementation Strategies

Several factors facilitate successful implementation of integrated emergency care pathways. Leadership commitment at both organizational and team levels is essential for establishing and sustaining collaborative practice (Samadbeik et al., 2024). Shared protocols and standardized communication tools provide the structure within which interprofessional collaboration can occur, reducing ambiguity about roles and responsibilities (Lee & Kim, 2020). Interprofessional education and simulation training build the competencies and relationships necessary for effective teamwork, creating a foundation of mutual trust and understanding that carries into clinical practice (Chae & Shon, 2024). The co-location of team members — whether physically in the ED or virtually through integrated information systems — facilitates the rapid communication and shared situational awareness that time-critical care demands (Otudi et al., 2024). The use of clinical activation codes provides a shared trigger for team mobilization, ensuring that the right professionals arrive at the right time with the right information (Samadbeik et al., 2024).

Future Directions and Recommendations

The evidence reviewed here supports several recommendations for advancing integrated emergency care pathways. First, healthcare systems should invest in interprofessional education and simulation training as core components of emergency care competency development, recognizing that effective teamwork is not automatic but must be deliberately cultivated (Chae & Shon, 2024). Second, the expansion of POCT capabilities should be accompanied by robust collaboration between laboratory scientists and clinical teams to ensure quality, accuracy, and appropriate interpretation of results (Kunze-Szikszay et al., 2016). Third, emergency pharmacist services should be expanded to all EDs, given the strong evidence for clinical benefit and cost avoidance (Rech et al., 2021). Fourth, nurse-led rapid response systems should be implemented and evaluated across diverse healthcare settings, with particular attention to activation criteria that are sensitive and specific for patient deterioration (Sprogis et al., 2021). Fifth, resident physician supervision should be structured to provide graduated autonomy based on competence, with clear escalation pathways when patient complexity exceeds the resident's experience (Chen et al., 2022). Finally, implementation science research should investigate the contextual factors that influence the effectiveness of integrated care pathways across different healthcare systems, resource settings, and patient populations (Otudi et al., 2024).

Conclusion

Integrated emergency care pathways represent the most promising approach to optimizing outcomes for patients with time-critical conditions. The evidence demonstrates that collaboration among medical laboratory scientists, EMS professionals, pharmacists, nurses, and resident physicians — when structured through shared protocols, standardized communication, and parallel processing — significantly improves clinical efficiency and patient outcomes. Laboratory scientists enable rapid diagnostics and guide pharmacological interventions; EMS professionals provide critical pre-hospital assessment and stabilization; pharmacists prevent medication errors and optimize therapeutic decision-making; nurses lead triage, rapid response, and care coordination; and resident physicians contribute clinical decision-making within supervised frameworks that balance patient safety with progressive autonomy. The meta-analytic evidence showing reduced mortality and increased survival with interprofessional pre-hospital teams provides the strongest justification to date for investing in team-based emergency care models. As healthcare systems worldwide confront increasing demand for emergency services amid workforce constraints and resource limitations, integrated care pathways offer a sustainable model for delivering high-quality, time-sensitive care. The path forward requires sustained commitment to interprofessional education, system-level redesign, and rigorous evaluation of implementation strategies across diverse clinical contexts.

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