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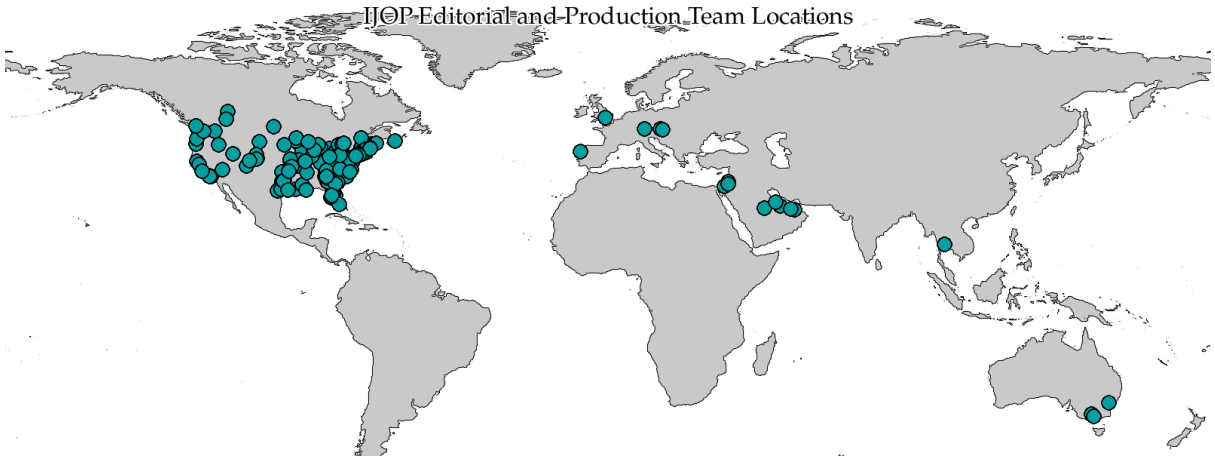
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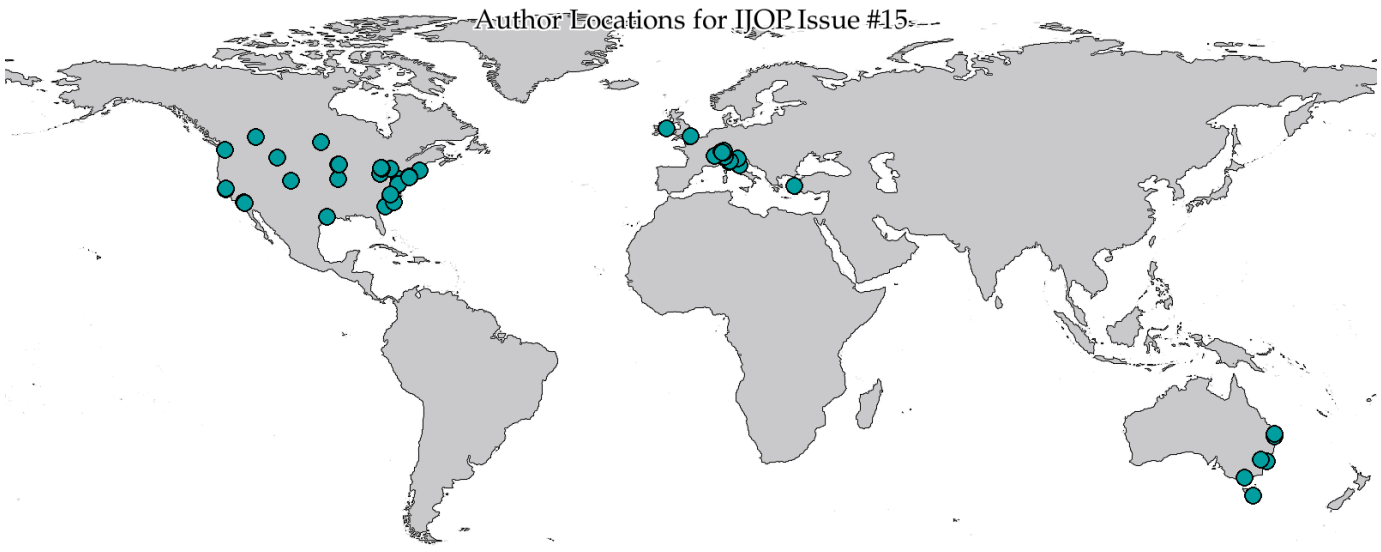
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EDITORIALS

WHEN HEALTHCARE BECOMES A TARGET: THE IMPACT OF HYBRID WARFARE ON PREHOSPITAL EMERGENCY CARE

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ABSTRACT

Hybrid warfare increasingly targets civilian healthcare infrastructure through cyber operations, infrastructure sabotage, disinformation, and energy disruption. Paramedics operate at the frontline of these system-level threats, positioned at the intersection of emergency healthcare delivery, public safety, and societal resilience. This editorial examines how hybrid warfare directly and indirectly affects paramedic practice and prehospital emergency care systems.

Drawing on recent international examples, the paper highlights how secondary system failures, including disrupted communications, loss of digital documentation, impaired rostering, supply chain interruption, and reduced hospital throughput, fundamentally alter paramedic decision-making and operational safety in the field. Growing dependence on integrated digital platforms, combined with reduced analogue redundancy and a workforce trained primarily in technology-enabled environments, increases vulnerability during prolonged disruption.

The editorial argues that recognizing hybrid warfare as a core concern for paramedicine is essential for patient safety, professional preparedness, and resilient prehospital emergency care systems.

INTRODUCTION

Paramedics operate at the intersection of healthcare delivery, public safety, and societal resilience (Williams et al., 2021). In an era increasingly shaped by hybrid warfare, this intersection has become both exposed and vulnerable. Hybrid warfare is commonly understood as the coordinated use of conventional and unconventional means, including cyber operations, infrastructure sabotage, terrorism, disinformation, and criminal activity, designed to exploit societal vulnerabilities while remaining below the threshold of declared armed conflict (Hoffman, 2009). These threats are no longer theoretical. They directly affect prehospital emergency care systems and the ability of paramedics to deliver safe, timely, and effective care, with parallel consequences for hospital emergency medicine systems and overall health system resilience (Granholm et al., 2022).

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Although the vulnerability of healthcare systems to cyber and infrastructure disruption is increasingly recognized, the operational implications for prehospital emergency care remain less clearly described. Much of the existing literature focuses on hospital-based systems, while the effects on prehospital decision-making, workflow adaptation, and patient safety have received comparatively limited attention.

HYBRID WARFARE AND HEALTHCARE SYSTEMS

Attacks of this nature have the potential to cripple entire emergency medical and health service systems, with cascading effects across the full spectrum of care, from frontline emergency response to patients receiving ongoing, chronic, or elective treatment. Importantly, hybrid attacks do not require the complete collapse of emergency medical services to cause harm. Even when dispatch centers, ambulance response, or radio systems remain partially functional, secondary system failures may significantly impair service delivery (Goebel et al., 2019). Rostering systems, digital communications, supply chains, patient records, and hospital throughput can all be disrupted, creating a broad operational footprint that directly affects paramedic decision-making in the field. These disruptions may also result in delayed response times, reduced situational awareness, and increased cognitive workload for clinicians operating in dynamic and uncertain environments.

Civilian healthcare systems have already been targeted within the framework of hybrid warfare. A prominent example is the attempted cyberattack on Boston Children's Hospital in the United States, attributed by U.S. authorities to state-sponsored actors (Raymond, 2022). Although the attack was disrupted before direct patient harm occurred, it demonstrated that healthcare institutions are considered legitimate targets in modern hybrid conflict.

The WannaCry ransomware attack in 2017 provides a concrete illustration of how cyber operations can disrupt emergency medical systems at scale (Smart, 2018). The attack caused widespread digital system failures across the United Kingdom's National Health Service, forcing hospitals to revert to manual workflows, cancel services, and divert emergency ambulances. For paramedics, this translated into longer transport times, uncertainty regarding hospital capacity, disrupted handovers, and altered destination decisions, all occurring under conditions of increased cognitive and operational stress (National Audit Office, 2017; Moore et al., 2023). Subsequent analyses of the incident highlighted the importance of system redundancy, fallback communication pathways, and the ability to maintain safe clinical practice in the absence of digital support systems (Smart, 2018; National Audit Office, 2017). These indirect effects on prehospital care are rarely captured in traditional outcome measures but represent a significant patient safety risk.

More recent events demonstrate that the impact of cyberattacks on healthcare extends well beyond the immediate loss of clinical systems. The large-scale cyberattack against the Irish Health Service Executive in 2021 resulted in extensive secondary disruption across the health system. Although emergency dispatch and ambulance response technology were not directly disabled, national healthcare email systems were shut down, staff rostering and crewing updates became unavailable, and supply chains for medical equipment were interrupted. Clinicians were forced to rely on telephone communica-

tion and paper-based processes, patient records could not be accessed, and outpatient appointments and elective surgical procedures were cancelled (Moore et al., 2023). The consequences of the attack were prolonged, with operational and clinical effects persisting long after the initial incident. This illustrates how hybrid threats can produce widespread degradation of healthcare delivery even when frontline emergency response appears superficially intact. Similar patterns have been observed in more recent cyber incidents affecting healthcare infrastructure, reinforcing concerns that increasing digital dependence may outpace the development of system resilience. Hybrid threats may originate from both state and non-state actors (Hoffman, 2009). State actors may employ coordinated cyber operations and infrastructure disruption as part of broader strategic objectives, while non-state actors, including criminal networks, may contribute through ransomware or targeted attacks. This convergence complicates attribution and increases the unpredictability of healthcare system disruption.

IMPLICATIONS FOR PREHOSPITAL EMERGENCY CARE

From a paramedic perspective, digital system failures fundamentally alter prehospital practice. Modern ambulance services are increasingly dependent on integrated technological platforms, including mobile data terminal dispatch systems, digital radio networks, satellite navigation and vehicle tracking, electronic patient care reporting, telemetry transmission of electrocardiograms, and real-time communication with receiving facilities. The loss or degradation of these systems increases the risk of error, delay, and cognitive overload, even when immediate mortality effects are not easily measurable (Kahl et al., 2026). These operational consequences remain underexplored in paramedic-focused research. Disruption or manipulation of dispatch systems, including false or spoofed emergency calls, may also lead to misallocation of resources and further strain on emergency response capacity (Goebel et al., 2019). These risks are summarized in Table 1.

Domain	Threat	Operational Consequence	Impact on Prehospital Care	Mitigation
Digital systems	System failure	Loss of patient data	Increased uncertainty in clinical decision-making	Paper documentation, offline systems
Dispatch	False or spoofed calls	Resource misallocation	Delayed Response	Call verification protocols
Energy	Power outage	Equipment failure	Increased demand	Backup power planning
Transport	GPS disruption	Navigation errors	Prolonged transport	Paper maps

Table 1. Hybrid threats and implications for prehospital emergency care.

A critical but often overlooked vulnerability lies in the erosion of system redundancy. Historically, transitions to new technologies were accompanied by the retention of legacy systems as operational backups. Over time, many of these redundancies have been reduced or removed in pursuit of efficiency, potentially limiting system resilience when digital infrastructure is disrupted. This vulnerability is further compounded by workforce demographics. A growing proportion of the paramedic workforce has trained and practiced exclusively within technology-enabled environments, with limited exposure to analogue navigation, paper-based documentation, or non-digital communication systems. In the context of large-scale or prolonged cyber incidents, this skills gap may significantly impair system adaptability and patient safety.

Hybrid warfare also encompasses attacks on critical energy infrastructure, where large-scale power outages can rapidly cascade into healthcare emergencies (Granholm et al., 2023a). These events may occur in combination with cyber or communication disruptions, further compounding their impact. Paramedics are often the first healthcare professionals to encounter the downstream consequences, including patients dependent on electrically powered home medical devices, failure of oxygen concentrators and ventilators, compromised communication networks, and surges in emergency call volume during prolonged outages. When cyber disruption, power loss, and physical threats occur simultaneously, a defining feature of hybrid warfare, the strain on prehospital emergency care is magnified.

These threats affect paramedic practice across its expanding subspecialties. Community paramedics, who increasingly care for medically fragile patients in homes and long-term care settings, are particularly exposed during cyber incidents and energy disruptions. Loss of power or monitoring systems in the home environment may result in rapid patient deterioration, increasing demand for emergency response services. Loss of power, digital documentation, or remote monitoring systems may directly compromise patients dependent on home ventilators, infusion pumps, or oxygen therapy, placing paramedics in ethically complex situations where clinical decision-making intersects with social vulnerability and infrastructure failure.

Critical care paramedics face a different but equally significant vulnerability. Their practice relies heavily on advanced monitoring, infusion technologies, ventilatory support, and seamless coordination with receiving facilities (Granholm et al., 2023b). Cyberattacks, communication outages, or hospital system failures can disrupt transport decision-making, interfacility coordination, and real-time clinical oversight, increasing risk during high-acuity transfers. In hybrid warfare scenarios, where redundancy cannot be assumed, critical care paramedics must be prepared to deliver advanced life support under conditions of technological degradation and prolonged system uncertainty. These system-level impacts across different prehospital care contexts are summarized in Table 2.

System level	Vulnerability	Consequence	Effect on EMS
Community care	Device dependency	Patient deterioration	Increased EMS demand
Hospital interface	Capacity uncertainty	Delayed handover	Extended transport
Workforce systems	Rostering disruption	Staffing issues	Reduced capacity
Infrastructure	Power/communication loss	System degradation	Reduced resilience

Table 2. System-level vulnerabilities and downstream effects.

PREPAREDNESS AND SYSTEM RESILIENCE

Despite these realities, education and research addressing hybrid warfare, cyber threats, and infrastructure vulnerability remain largely absent from paramedic education and continuing professional development (Labrague et al., 2018). Training rarely includes structured preparation for operating under prolonged system degradation or in the absence of digital support, despite the likelihood that such conditions may occur. Paramedics are routinely trained for trauma, major incidents, and disaster response, yet rarely for intentional, sustained, and system-level attacks on healthcare infrastructure itself

(Alqahtani et al., 2025). Training programs seldom include structured preparation for operating without digital dispatch, electronic documentation, navigation systems, or networked communications, despite the likelihood that such capabilities may be degraded or unavailable during hybrid attacks. Addressing these vulnerabilities requires coordinated efforts across multiple levels of the healthcare system. At an operational level, this includes preparing clinicians to function in low-technology environments and under conditions of degraded communication. At a system level, maintaining redundancy, strengthening cybersecurity, and developing contingency plans for infrastructure failure are essential. At an organizational level, regional coordination and shared planning may improve overall system resilience.

Further research informed by prehospital and emergency medical services expertise is needed to examine how hybrid threats affect workflows, patient outcomes, ethical decision-making, and workforce well-being. Equally important is the integration of this knowledge into education and simulation-based training, with an emphasis on low-technology care, degraded communications, prolonged system failure, and interagency collaboration (Kahl et al., 2026).

Preparing prehospital emergency care systems for hybrid warfare is not an abstract geopolitical concern; it is a patient safety imperative. As emergency medical services become increasingly dependent on digital systems, energy infrastructure, and networked coordination, their vulnerability grows. Paramedics must be equipped not only to respond to clinical emergencies, but also to function effectively when the systems that underpin modern emergency care fail. Recognizing hybrid warfare as a core concern for paramedic practice is a necessary step toward resilient, safe, and sustainable prehospital emergency care.

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RESEARCH REPORTS

PREHOSPITAL PROTOCOLS FOR TRANSCUTANEOUS PACING IN THE UNITED STATES: A CROSS-SECTIONAL DESCRIPTIVE ANALYSIS

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ABSTRACT

Objectives: Transcutaneous pacing (TCP) has a Class IIb recommendation from the American Heart Association (AHA) for the treatment of hemodynamically unstable bradycardia. Recent studies highlight a high rate of treatment failure and known difficulties verifying electrical capture ("false electrical capture") and mechanical capture. This study aimed to characterize the current recommendations within US prehospital TCP protocols.

Methods: A convenience sample of 260 prehospital protocols were selected from publicly available resources. Two trained abstractors were assigned to each; pre-specified categorical variables and free-text responses were recorded. The latter were coded using content analysis. Responses were analyzed using descriptive statistics and reported as frequencies and proportions.

Results: 228 protocols completed paired abstraction, 177/228 (78%) were accessible and mentioned TCP. The most frequent indication was symptomatic bradycardia 172/177 (97%). Electrical capture was mentioned in 116/177 (66%) with false electrical capture discussed in only 8/177 (5%). Pulse palpation was the primary method for capture confirmation 123/177 (69%). Indications discordant with AHA guidelines included cardiac arrest 23/177 (13%) and seizures 18/177 (10%). Overall, 70/177 (40%) protocols were assessed to completely match, 65/177 (37%) partially match, and 41/177 (23%) did not match AHA guidelines for TCP.

Conclusions: Prehospital TCP protocol indications varied, with 77% partially or completely matching AHA guidelines for TCP. Nevertheless, guideline-discordant recommendations remained. False electrical capture was rarely mentioned. Further research should systematically assess TCP implementation including methods to assess and confirm capture, and whether guideline adherence in prehospital protocols improves outcomes and reduces TCP failure.

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INTRODUCTION

Transcutaneous pacing (TCP) is a non-invasive cardiac pacing modality primarily used to treat hemodynamically unstable bradycardia. The 2018 ACC/AHA/HRS Guideline on the Evaluation and Management of Patients with Bradycardia and Cardiac Conduction Delay (2018 AHA Guideline) assigns a Class IIb recommendation to TCP supported by limited data for unstable bradycardia refractory to medical therapies as a bridge to transvenous pacing (Kusomoto et al. 2018). However, as noted in recent research, the treatment frequently fails; and in roughly 20% of patients, the patient may deteriorate into cardiac arrest following TCP (Smida et al. 2024). A multi-center observational effort published this year demonstrated that in 224/299 cases of transcutaneous pacing, 74.9% [69.6, 79.7] had no electrical capture observed from cardiac monitor files (Smida et al. 2026). A recent retrospective cohort study with an embedded case series found that of 23 cases receiving TCP, 19 (83%) had no evidence of electrical capture, with frequent artifact that appeared to be QRS-like, potentially arising from the device itself. This so-called "false electrical capture" has been noted by a TCP device manufacturer and appears to have misled the paramedics in these cases as all 19 patients had a documented palpable pulse during pacing (Kimbrell et al. 2024; Stryker Inc. 2018).

Possible solutions to address this significant concern have been proposed and include optimizing pad positioning, education on assessing electrical capture, and attention to mechanical capture methods (Moayedi et al. 2022, Cohen et al. 2022, Ettin & Cook, 1999, Holger et al. 2003, Tam, 2003).

Given the developing body of research on prehospital TCP, it is important to consider the contribution of practice patterns, guidelines, and evidentiary support present in prehospital protocols guiding prehospital care in the United States. As such, our aim is to evaluate prehospital TCP recommendations in a cross-sectional sample of EMS protocols, including the prevalence of false electrical capture, recommendations regarding electrical and mechanical capture verification, and adherence to existing guideline-based indications. We anticipate encountering appropriate indications for TCP, pulse palpation as a central method for confirmation of efficacy, and a limited discussion of false electrical capture. The expectation is indications will align with current guidelines.

METHODS

Study Design

We performed a cross-sectional descriptive study of TCP protocols using a convenience sample of available prehospital protocols in the US. The study was deemed non-human subjects research by an Institutional Review Board (STUDY-24-01043). We used the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) cross sectional checklist to guide this research (von Elm, et al. 2007).

Setting

This study was conducted using publicly available prehospital TCP protocols in the United States. Prehospital protocols provide a standardized quality of care in each operating area, with standing order protocols authorizing independent treatment and medication administration by credentialed prehospital clinicians without direct medical oversight

(Alonso-Serra et al. 1998, Cash et al. 2020, Cunningham et al. 2010). Prehospital protocols can span different geographic and regulatory levels: some may be state-wide or even encompass multiple states, while others are specific to individual agencies.

Data Sources and Collection

An initial eligibility list of all publicly accessible prehospital protocols was curated from emsprotocols.org and the mobile application Paramedic Protocol Provider® (PPP; AcidRemap, LLC, Lafayette, CA). We collected protocol titles from both sources and removed duplicates, with a final list of 585 protocols eligible for selection. We manually included all available statewide protocols (n=25) in alignment with prior literature and then included additional protocols via randomized selection. Following abstractor attrition, a total of 260 protocols were assigned (Figure 1). Additional information can be found below and in the supplement.

Ten abstractors with healthcare experience were recruited and trained. A pilot phase required the first author to review ten protocol abstractions from each abstractor for quality control. Abstractors first assessed if a protocol was accessible and if so, they searched within each protocol to find terms related to transcutaneous pacing, such as "transcutaneous," "pacing," and "bradycardia". Reasons for inaccessible protocols included those unable to be located or downloaded or those with password protection. If accessible, protocols were excluded if keywords were not found or if the protocol was not at the advanced life support level (e.g. first aid or basic life support only) (Figure 1).

The data abstraction form contained structured (pre-specified) variables and free-text variables. For free-text variables, abstractors were instructed to directly copy and paste all relevant text from the protocol, as well as to describe non-textual (e.g. pictorial) features regarding TCP indications, mentions of false electrical capture, and procedural recommendations. This method was chosen as false electrical capture can be described in a variety of ways, limiting simple methods such as text searches.

Each protocol was assigned to two abstractors. Informed by our preliminary work, assigning two abstractors allowed each protocol to receive two independent reviews, reducing the influence of individual abstractor interpretation or error and increasing data integrity. Discrepancies were reviewed by a senior author. Additional information regarding data collection is available in the supplement.

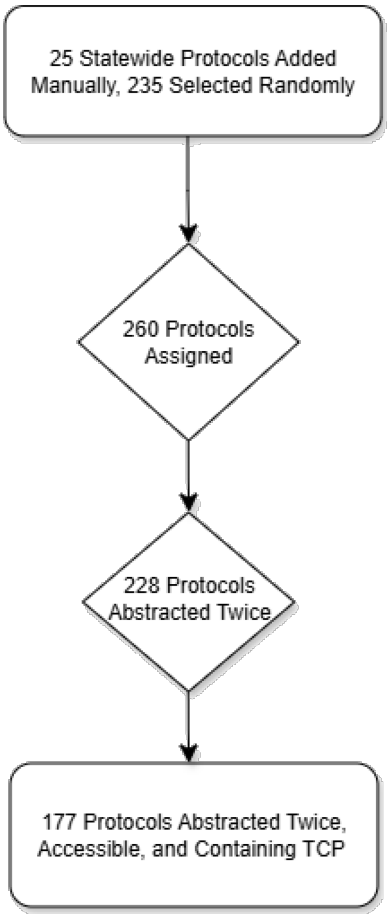


Figure 1. Diagram showing the pathway to final sample size.

Variable Definitions and Measurement

For variables with a free-text field, we used quantitative content analysis, a methodology ideal for free-text data (Kostick et al. 2015). Two coders, J.A.K. and J.T.W. used a deductive-inductive approach to identify keywords and phrases from the free text variables. If discrepancies were

identified between coders, authors J.M.K. and J.A.K. reviewed source data (e.g. protocol screenshots) to reconcile the discrepancy via consensus. To assess intercoder reliability (ICR) of the content analysis, a subset of 20 randomly selected protocols were re-coded by author J.A.K., allowing calculation of Krippendorff's Alpha, a measure of ICR (Krippendorff, 2018; Marzi et al. 2024). Detailed information is available in the supplement.

Comparison to a Reference Standard

To compare protocols to a reference standard, we selected the 2018 AHA Guideline, the most recent AHA guideline for bradycardia and cardiac conduction delay (Kusumoto et al. 2018). This guideline recommends the use of TCP for hemodynamically unstable bradycardia refractory to pharmacological therapy, using pharmacological therapy prior to TCP, and does not recommend TCP for unaccepted indications found in these data such as seizures or cardiac arrest (Sherbino et al. 2006). To characterize compliance with this reference standard for unstable bradycardia, we categorized protocols into one of three options - completely matched, partially matched, and does not match the 2018 AHA Guideline. If the listed indications and order of pharmacological therapy were in line with the guideline then it completely matched. If the listed indications were present with no listing of seizures or cardiac arrest but the order of therapy was not specified, or recommended TCP prior to pharmacological therapy, then it partially matched. The remainder were recorded as not matching.

Statistical Methods

Descriptive statistics were used to report frequencies and proportions for each pre-specified variable, as well as for counts of key words and phrases coded during content analysis.

RESULTS

Of the 260 protocols assigned for abstraction, 228 (88%) met criteria for pairwise abstraction, and 177/228 (78%) were accessible, mentioned TCP, and were fully abstracted. A US map of agency location for these 177 protocols is provided (see Figure 2).

Indications for TCP included symptomatic bradycardia in 172/177 (97%) protocols, altered mental status and hypotension, each in 124/177 (70%), inadequate perfusion in 120/177 (68%), and high-degree AV block in 69/177 (39%).

Electrical capture was mentioned in 116/177 (66%) of protocols in the sample. Of these, 68/116 (59%) did not describe characteristics of electrical capture, 39/116 (34%) described a wide QRS, and 28/116 (24%) described characteristics of the T-wave. False electrical capture was mentioned in 8/177 protocols (5%). Pulse palpation was the most common method to confirm mechanical capture in 123/177 (70%) protocols and ultrasound was only mentioned in 1 (0.5%).

Non-guideline-based indications for TCP included cardiac arrest in 23/177 (13%) protocols and seizures in 18/177 (10%). Anterior-posterior pad placement was recommended as primary configuration in 63/177 (36%), anterior-lateral or anterior-posterior in 23/177 (13%) and pad placement was not specified in 69/177 (39%). Only 4 protocols (2%) mentioned a procedure for the transfer of patient care for a patient receiving TCP from a prehospital to ED device. Results are available in Table 1 below.

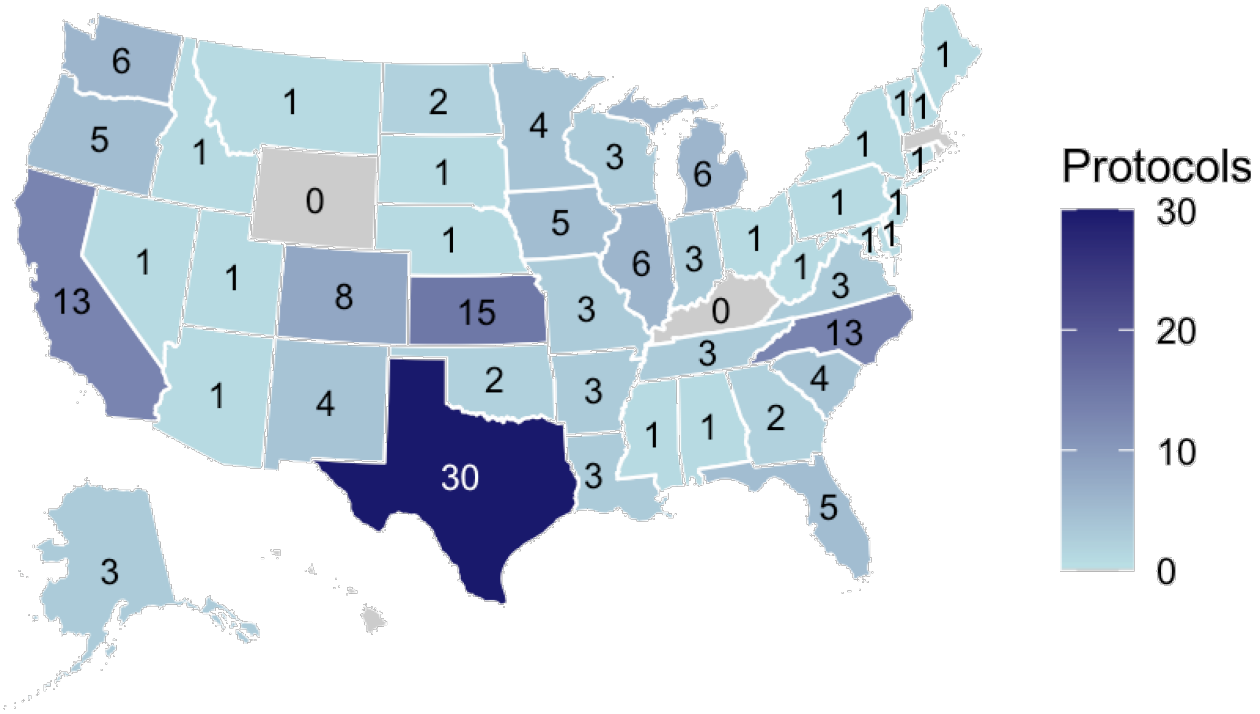


Figure 2. Protocols abstrated per state. A visual representation of the geography of protocols included in the analysis. Darker states have more abstracted protocols represented in the data set. States with zero (0) abstracted protocols are shown in gray (DC, HI, KY, MA, RI, WY). There were three (3) multi-state/regional protocols also abstracted that are not depicted on this map.

Of 177 included protocols, 70/177 (40%) completely matched the 2018 AHA Guideline, mentioning hemodynamic instability, recommending TCP after pharmacological therapy, and not recommending use in cardiac arrest or seizures, 65/177 (37%) partially matched the 2018 AHA Guideline (no pharmacological therapy prior to TCP), and 41/177 (23%) of protocols included an indication that does not match the 2018 AHA Guideline as they recommended TCP for either cardiac arrest or seizures.

Intercoder reliability among the authors evaluating free text responses was assessed for 20 random protocols. Krippendorff's Alpha values for the coded responses ranged from disagreement to perfect agreement, with 26/40 (68%) exhibiting satisfactory agreement ($\alpha > 0.80$). Additional details are available in the supplement.

DISCUSSION

We identified variation in prehospital TCP protocols with regards to listed indications, recommended pad position, descriptions of electrical capture, mentions of false electrical capture, and recommendations for mechanical capture verification. These data provide a foundation for understanding how TCP is protocolized within prehospital practice.

We found few mentions of false electrical capture and reliance on pulse palpation (found in over 60% of protocols) for mechanical capture verification. Smida et al. in their recent observational work, also identified that most of their cases that did not have electrical capture stated that they had mechanical capture in the medical record. These data support the recent call of the 2025 AHA CPR & ECC Guidelines for research supporting best practices to distinguish true capture from false electrical capture and identify reliable

Indications for TCP (n=177)	
Symptomatic bradycardia	172 (97.2%)
Altered mental status	124 (70.1%)
Hypotension	124 (70.1%)
Inadequate perfusion	120 (67.8%)
High-degree AV block	69 (39%)
Cardiac Arrest (asystole, PEA)	23 (13%)
Seizure	18 (10%)
Suspected toxicity and overdose	12 (7%)
Tachycardia	4 (2%)
Absent radial pulses	4 (4%)
Internal pacemaker failure	2 (1%)
Electrolyte disturbance	2 (1%)

TCP Confirmation Method (n=177)	
Pulse palpation	123 (69%)
Signs of increased perfusion	45 (25%)
Blood pressure	41 (23%)
Pulse oximetry	13 (7%)
End-tidal capnography	11 (6%)
Auscultation	2 (1%)
Ultrasound	1 (1%)
Other	5 (3%)
None mentioned	49 (28%)

Concordance with 2018 AHA Guideline (n=177)	
Completely matches (indications, instability, TCP after medication, and no non-supported indications)	70 (40%)
Partially matches, without pharmacological therapy before TCP	65 (37%)
Does not match (non-supported indications)	41 (24%)

Recommended Pad Positioning (n=177)	
Anterior-posterior only	63 (36%)
Anterior-lateral or anterior-posterior	23 (13%)
Manufacturer recommendations	13 (7%)
Anterior-lateral only	9 (5%)
Not mentioned	69 (39%)

Sedation and Analgesia (n=177)	
Recommended	131 (74%)
Required	31 (18%)
Not mentioned	15 (9%)

Sedative and Analgesic Medications (n=162)	
Benzodiazepines	134 (76%)
Opiate/opioids	62 (35%)
Anesthetics/Hypnotics	55 (31%)
Not mentioned	31 (18%)

Any Mention of False Electrical Capture (n=8)	
Yes	8/177 (5%)
Picture provided in protocol	5/8 (63%)
Lack of broad T-waves	3/8 (38%)
Pacer spike depicted without matching SpO2 pleth wave	3/8 (38%)
Discrepancies between pacer rate and pulse oximetry derived rate	2/8 (25%)
EKG artifact	2/8 (25%)
Electrical capture without mechanical capture	2/8 (25%)
Partial or intermittent capture depicted	2/8 (25%)
Other false electrical capture mention	2/8 (25%)
Fusion complexes or complexes in absolute refractory period	1/8 (13%)

Table 1. The proportions of key characteristics within prehospital TCP protocols. Responses are not mutually exclusive.

methods for confirming initial and sustained capture with prehospital TCP (Wigginton, et al. 2025).

We identified that only 1 in 20 protocols mention false electrical capture. While this may also reflect the novelty of the concept, it is an important link in understanding prehospital TCP that should be addressed in prehospital care protocols. False electrical capture refers specifically to QRS-like artifact or pacer dissociation deceiving providers into maintaining the TCP intervention, with further confusion due to skeletal muscle contractions from TCP current influencing pulse palpation (Kimbrell et al. 2024). Importantly, a common manufacturer of TCP devices recognizes that pacer artifacts can deceive the user, and provides visual examples (Stryker, Inc., 2018). Their recommendation is to use a multi-modal approach, relying on pulse palpation and clinical examination for hemodynamic improvement. Though not unreasonable, there is some evidence suggesting the utility of point of care ultrasound (POCUS) (Cohen et al. 2022, Ettin & Cook, 1999, Holger et al. 2003, Tam, 2003). This is supported by a recent case report where POCUS was used to identify pseudo pulseless electrical activity, utilizing the device to adjudicate mechanical capture (Czerwiec et al. 2025). Such a hemodynamically driven approach matches the

historical clinical trials which often lacked an associated ECG, instead starting at high currents and clinical exam, maximizing the chance of capture (Kreinbrook and Kimbrell, 2024). Given the poor performance of pulse palpation in cardiac arrest, the burden of proof might rest on this procedure, with POCUS or arterial line waveform as a reference standard (Cohen et al. 2022; Tibballs and Weeranatna, 2019).

Of concern, when compared to the 2018 AHA Guidelines as a standard, roughly 20% of protocols listed cardiac arrest or seizures as an indication for TCP. Though such protocols might be suggesting that seizure-like activity from EMS-witnessed arrest is an indication for TCP, there is no available evidence, to our knowledge, supporting this indication (Sherbino et al. 2006). In contrast, we found a roughly equal proportion which completely matched the 2018 AHA Guidelines as partially matched. Within our methodology, the difference pertained to the exact order of pharmacological versus electrical therapy. Currently, guidelines recommend pharmacological therapy first (Kusomoto et al. 2018). There is currently only one pilot randomized controlled trial which compared prehospital dopamine against TCP, limiting the available evidence in this space (Morrison et al. 2008). During review we found that many protocols recommended use of a TCP-first strategy if clinical instability was present without IV access or if a high-degree AV block was present, both reasonable interpretations based on pathophysiologic rationale. Nevertheless, more rigorous research is needed to understand if there are specific risks and benefits of the practice, especially as a previous pilot trial highlighted the rarity of the procedure, a barrier to clinical trials (Morrison et al. 2008).

To our knowledge, this is the first study to investigate prehospital TCP protocols and the first to investigate concordance of prehospital protocols with evidence-based guidelines. Several studies have examined prehospital protocol variability in other topics such as the use of the term "excited delirium," anaphylaxis, prehospital pain management, termination of resuscitation, elder abuse identification, differences in pediatric seizure management, prehospital hypoglycemia, post-arrest care, and prehospital ultrasound. These studies used variable methodologies, with some using a convenience sample of available statewide protocols (n=30-35), another using a convenience sample of protocols available on emsprotocols.org and identified via web search (n=104), another using a combination of cases from emsprotocols.org and those from the 50 most populous cities in the United States (n=185), and the largest using PPP to identify current practices in prehospital ultrasound (Fritz et al. 2024, Gunderson, et al. 2025, Li et al. 2023, Li et al. 2024, Namboodri et al. 2018, Ramgopal et al. 2021, Rostykus et al. 2016, Spigner et al. 2021, Warren & Toy, 2025).

Future studies of protocol variation should use rigorous methodology to ensure measurement quality; we found that protocols evaluated can offer contradictory instructions (e.g., conflicts between recommendations to initiate or cease TCP in one section of the protocol and recommendations to trial increased vasopressor therapy without TCP in another). In addition, some recommendations were specific in some treatment algorithms, and others noted more broadly "perform TCP". Further, researchers' preconceived opinions about clinical topics may influence interpretation.

We found high rates of variability in prehospital TCP protocols with roughly 20% continuing to recommend TCP in cardiac arrest or for seizures, both discordant with current evidence. There were also infrequent recommendations for anterior-posterior

pad positioning, mentions of false electrical capture, and frequent recommendations for pulse palpation as a primary method for confirming mechanical capture. Future research should investigate whether prehospital protocol adherence with evidence-based guidelines is associated with patient-centered outcomes and further develop the scant evidence base surrounding TCP as a bridge to TVP devices.

LIMITATIONS

Several potential sources of bias were considered during the study design. First, prior studies of EMS protocols have repeatedly mentioned the lack of a central, standardized instrument to perform EMS protocol abstraction. We originally piloted a single abstractor designed and failed to reach sufficient inter-rater reliability. Though partly due to the difficulty of the topic, we found that protocols were often discordant and required granular review to ensure validity. As such, we revised the data extraction form to include fewer prespecified variables, expanded the methodology to include quantitative content analysis of free text-responses, and ensured that every protocol was reviewed twice with discrepancies resolved via senior author and/or consensus. Second, despite these attempts, content analysis of publicly available protocols within a short timeframe may be subject to measurement bias, as protocols could vary over time and the most up-to-date protocol version may not be updated on the publicly accessible sources. This is mitigated, in part, by the short two-month timeframe—in line with prior research detailing an ideal collection timeframe—and our methodology, as the abstractor downloaded each protocol at the time of review. Third, the potential for selection bias remains, as EMS agencies choosing to publish their protocols publicly may differ systematically from those who do not. Fourth, we recognize that although we incorporated some random selection to reduce selection bias, this study has utilized a convenience sample due to the manual addition of statewide protocols, non-pairing of others, and the early termination of study abstraction. Fifth, the original simple randomization resulted in a representative sample from the database which overrepresents certain states. This may influence results as some states may have statewide protocols that promulgate overall standards of care in the state, and frequently represented states may give outsize influence to individual agencies. One example of the former is in California: the Emergency Medical Services Authority has removed pediatric intubation from the paramedic scope of practice and thereby all protocols within the state. In other states such removal may not occur writ large, but still takes place in select agencies.

CONCLUSIONS

The most common indications for prehospital TCP protocols in the US are symptomatic bradycardia, altered mental status, hypotension, and inadequate perfusion. We identified minimal discussion of false electrical capture, detection, and associated risk. There was significant variability in pad position, recommendations for sedation, descriptions of false electrical capture, and mechanical capture confirmation methods.

Adding to the urgency of this work, the most recent 2025 AHA Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care (2025 AHA CPR & ECC Guidelines) summarize the importance of addressing "...the need for improved methods to distinguish true electrical capture from false capture. Future research is needed to determine optimal pad placement and develop reliable methods for confirming initial

and sustained capture, such as the practicality and preferred location of pulse palpation, hemodynamic findings, pulse oximetry characteristics, continuous ETCO2 monitoring, and ultrasound" (Wigginton et al. 2025).

Further attention to development of the evidence for prehospital TCP is needed; reliably determining true versus false electrical capture, and methods to determine sustained capture, followed by dissemination and implementation within guidelines and practice. Several protocols advised TCP for indications that do not match the 2018 AHA Guideline for bradycardia and that are not supported by evidence.

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SUPPLEMENTAL MATERIAL

Original Data Collection, Instrument Development, and Training

Our initial data collection instrument was developed and refined by consensus among senior authors. All abstractors were recruited, understood the project and underwent training prior to beginning abstraction. These initial attempts at data collection revealed concerns with data consistency. For one, we attempted to use a single abstractor system with each abstractor (researcher) entering data from their assigned protocols. Two, the original abstraction form had few free-text questions and focused on prespecified responses. However, following iterative training and a review of overall performance on several duplicated protocols, there was more variation than the authors were comfortable with and results were not reassuring that protocols were being abstracted similarly. We recognize the reason is not clear, and could have included deficient training, lack of a guide to follow, or simply an adjustment period. To address the issues with data quality, we revised our methodology and assigned two abstractors to independently review each protocol. We also updated our data collection form and developed an abstraction guide incorporating feedback from our trained researchers. Variables to be collected as free text were decided to be collected as such to prompt inclusion of more direct quotes and reduce abstractor interpretation into pre-specified responses. The variables were not mutually exclusive. Before re-launch, abstractors again received over an hour of training by author J.S. and this time completed a sample of ten protocol abstractions that were reviewed for completeness. Our abstraction form and guide are included as supplementary data for transparency.

Pre-specified variables included the protocol's state of origin, requirement for pre-TCP medical oversight consultation, recommendation for pad positioning, recommendation of analgesia or sedative, mention and description of electrical capture, and methods for confirming successful mechanical capture. Separate free-text variables collected listed indications, descriptions of false electrical capture, procedures for TCP failure, and recommendations for transitioning TCP care at the conclusion of EMS treatment. Screenshots of relevant protocol sections were uploaded and appended to the end of the abstraction form, ensuring version control and source data for intercoder reliability.

Protocol Selection and Assignment

Based on our experience with our preliminary data collection, we predicted that 250 protocols would be an ascertainable goal. We wanted to select most protocols randomly, and also ensure all statewide protocols were reviewed. We sought inspiration from methods established for emergency medicine chart review, using initial pilot protocol abstraction with blinded IRR (Gilbert et al., 1996; Kaji et al., 2014), this prompted our new strategy using two abstractors with a senior author providing a tiebreaker when needed to ensure data integrity.

Following the initial randomization of all protocols, any statewide protocols not included in the randomization were manually added to the top. An equal number of randomly selected protocols were excluded from the bottom to accommodate the manually added protocols keeping the total at 250 protocols for 10 abstractors. To assign 10 abstractors to 250 protocols, five blocks of 50 protocols were created. These five original blocks were

then each duplicated, for a total of 10 blocks. A unique abstractor was assigned to each of the 10 blocks, for a total of two abstractors assigned to each protocol.

Although deadlines were shared with abstractors, we allowed additional time if requested. Despite follow up and personal outreach, some abstractors were unable to complete all assigned protocols. Protocols not attempted by any one abstractor were re-distributed to abstractors with additional bandwidth in a fashion to maximize the number of paired protocol abstractions (i.e. if a protocol had one abstraction completed, this would be assigned for a second abstraction before a protocol that had zero abstractions). In some cases, new protocols were assigned, and a total number of assigned protocols was 260. Following abstractor attrition, the total number of paired abstractions were 228. As mentioned in the manuscript, discrepancies between paired protocols were adjudicated by two authors not involved in the original abstraction.

Interrater Reliability for Coded Free Text Variables

Free text responses to the TCP Indications and the TCP Failure questions from our abstraction instrument (included as supplementary material) were defined and coded by two authors. Any discrepancies were reviewed by a third author (J.A.K. or J.M.K.) who reviewed the source material to resolve the discrepancy. To assess interrater reliability, Krippendorff's Alpha inter-rater reliability coefficient was calculated using 20 randomly selected protocols for the 40 response codes produced for the two questions above. An α value greater than or equal to 0.80 is considered reliable for drawing conclusions. Krippendorff's Alpha values between 0.69 and 0.79 are considered moderate agreement, <0.67 poor agreement, 0 is no agreement, and <0 systematic disagreement. (Krippendorff, 2018; Marzi et al., 2024). The coded responses are from raw responses and were later rolled up to the themes presented in the tables below.

Coded Response	Krippendorff's Alpha	Subjective Interpretation
As per AHA Guidelines	1	Perfect
Bradycardia, Symptomatic, Rate Unspecified	0.86	Satisfactory
Bradycardia, Symptomatic, Rate Specified	0.889	Satisfactory
Bradycardia, No Mention of Symptomatic or Asymptomatic Presentation	0	None
Inadequate Perfusion	0.768	Tentative
High Degree A/V Block (AVB)	0.9	Satisfactory
Any AVB	0	None
Asystole, Onset Unspecified	1	Perfect
Asystole, Observed or Immediate Onset	1	Perfect
Atropine Refractory	0.889	Satisfactory
Suspected Toxicity	1	Perfect
Bradycardia Unresponsive to Medial Therapy	0.649	Poor
Altered Mental Status Including Lethargy and Somnolence	1	Perfect
Ischemic Chest Pain	1	Perfect
Hypotension	0.86	Satisfactory
Other	1	Perfect
Congestive Heart Failure, Acute Heart Failure, Pulmonary Edema, Shortness of Breath, Dyspnea	0.797	Tentative
Diaphoresis, Pallor, Abnormal Skin Signs	0.86	Satisfactory
Pulseless Electrical Activity	1	Perfect
Overdrive Pacing	1	Perfect
Syncope and Near Syncope	0.458	Poor
STEMI or ECG Evidence of Ischemia or Infarct	1	Perfect
Seizures	0.649	Poor
Sick Sinus Syndrome, Junctional Escape, Ventricular Ectopy, Idioventricular Rhythms	-0.0833	Systematic Disagreement
Premature Ventricular Contractions	-0.0833	Systematic Disagreement
Heart Transplant	0.649	Poor
Internal Pacemaker Failure	1	Perfect
Electrolyte Disturbances	1	Perfect
Absent Radial Pulses	1	Perfect
Pending, Imminent, or Peri-Arrest	0	None

Table 2. Krippendorff's alpha inter-rater reliability coefficient. Indications for adult transcutaneous pacing (n=177).

Coded Response	Krippendorff's Alpha	Subjective Interpretation
None mentioned	1	Perfect
Use Atropine	0.86	Satisfactory
Increase Pacing Energy	1	Perfect
CPR or Resume ACLS	0.79	Tentative
Fluid Challenge	-0.0882	Systematic Disagreement
Medical Intervention Other Than Atropine	1	Perfect
Discontinue Pacing	0.58	Poor
Contact Medical Control	1	Perfect
Other	0.829	Satisfactory
Increase Pacing Rate	1	Perfect

Table 3. Krippendorff's alpha inter-rater reliability coefficient. What to do if pacing fails (n=98).

Subjective Rating	Alpha	Interpretation of Krippendorff's Alpha Values
Perfect	= 1	Indicates perfect agreement among raters. It is the scenario where all raters have provided the exact same ratings for each item evaluated.
Satisfactory	≥ 0.80	This value is generally considered a satisfactory level of agreement, indicating a reliable rating. In many research contexts, a Krippendorff's Alpha equal to or above 0.80 is acceptable for drawing triangulated conclusions based on the rated data.
Tentative	0.67 - 0.79	This range is often considered the lower bound for tentative conclusions. A Krippendorff's Alpha in this range suggests moderate agreement; thus, outcomes should be interpreted with concern, questioning the roots of such diverging ratings.
Poor	< 0.67	This is indicative of poor agreement among raters. Data with a Krippendorff's Alpha below this threshold are often deemed unreliable for drawing triangulated conclusions. It suggests that the raters are not applying the coding scheme consistently or that the scheme itself may be flawed.
None	= 0	Indicates no agreement among raters other than what would be expected by chance. It is similar to a random rating pattern.
Systematic Disagreement	< 0	A negative value of Krippendorff's Alpha indicates Alpha < 0 systematic disagreement among raters. This situation might arise in cases where raters are systematically inclined in opposite rating directions.

Table 4. Definitions of subjective interpretation (Marzi, et al., 2024).

Medical Control Contact Required to Begin Pacing	n	%
No	174	98.3%
Yes	3	1.7%

Table 5. Medical control contact required to begin pacing (n=177).

Mention and Characteristics of Electrical Capture	n	%
Described as having a wide QRS	39	22.0%
Described as having a T-wave	28	15.8%
Other	18	10.2%
Mentioned but not described	68	38.4%
Not mentioned	61	34.5%

Table 6. Mention and characteristics of electrical capture (n=177).

Location of Pulse Palpation for Confirmation of TCP Efficacy	n	%
Femoral	30	24.4%
Radial	17	13.8%
Carotid	7	5.7%
Other	1	0.8%
None mentioned	82	66.7%

Table 7. Location of pulse palpation for confirmation of TCP efficacy (n=123).

Steps to Follow if TCP Fails	n	%
Stop TCP	42	42.9%
Contact medical oversight	20	20.4%
CPR	18	18.4%
Increase TCP current	16	16.3%
Increase TCP rate	7	7.1%
Atropine	6	6.1%
Other medication	6	6.1%

Table 8. Steps to follow if TCP fails (n=98).

Mention and Description of a Procedure for Transfer of Care	n	%
Yes	4	2.3%
Transfer with change in pacer settings	2	1.1%
Transfer without change in pacer settings	1	0.6%
Other transition description	1	0.6%

Table 9. Mention and description of a procedure for transfer of care (n=177).

Prehospital Transcutaneous Pacing Survey Abstraction Form

Abstractor Name *

Please Select

Select a Protocol *

Please Select

Source of protocol *

- ( ) https://emsprotocols.org/
- ( ) Regular PPP App (no extra download)
- ( ) PPP Locality-Specific Separate Download App

Were you able to review this protocol? *

- [ ] Yes
- [x] No

Please type another option here

Indication(s) for ADULT transcutaneous pacing: *

Paste protocol indications for TCP

Is online medical control contact required to *begin* pacing? *

- ( ) Yes
- ( ) No

Recommended pad position for transcutaneous pacing: *

- [ ] Antero-Lateral
- [ ] Anterior-Posterior
- [ ] Per manufacturer / AHA instructions
- [ ] Not mentioned

Is sedation or pain management recommended or required specifically for TCP? *

- ( ) Recommended (e.g. consider)
- ( ) Required (e.g. administer)
- ( ) Not mentioned

If medications were mentioned for sedation or pain management specifically for TCP?

- [ ] Benzodiazepines (e.g. diazepam, lorazepam, midazolam, etc.)
- [ ] Opiate/Opioids (e.g. fentanyl, hydromorphone, morphine, etc.)
- [ ] Anesthetic/hypnotic (e.g. etomidate, ketamine)
- [ ] None mentioned specifically for TCP

Is electrical capture (e.g. ECG or visual confirmation of pacing) mentioned? *

- (•) Yes
- ( ) No

In the description of electrical capture, were any of these findings mentioned? *

- [ ] ST-segment
- [ ] Wide QRS
- [ ] T wave
- [ ] None mentioned
- [x] Other

Please type another option here

What methods within the pacing protocol were specifically mentioned for confirming pacing efficacy? *

- [ ] Pulse palpation
- [ ] SpO2
- [ ] End-tidal CO2
- [ ] Blood pressure
- [ ] Mental status
- [ ] Skin color, temperature, or condition
- [ ] Ultrasound
- [ ] None mentioned
- [x] Other not listed

Please type another option here

If confirmation of mechanical capture by pulse palpation is recommended, where should you check?

- [ ] Carotid
- [ ] Femoral
- [ ] Radial
- [ ] Not mentioned

Is false electrical capture mentioned? *

- (●) Yes
- ( ) No

Description of false electrical capture: *

Paste description of false electrical capture

Does the protocol describe what to do if capture cannot be obtained or pacing fails? *

- ( ) Not mentioned
- (●) Yes, click here and paste

Please type another option here

Are there instructions for transitioning a paced patient from EMS to receiving hospital care? *

- ( ) Not mentioned
- (●) Yes, click here and paste

Please type another option here

Upload screenshot of relevant protocol areas (each page you took information from): *

Browse Files

Drag and drop files here

Do you want this entry to be reviewed? *

- ( ) Yes
- ( ) No

Is there anything outstanding or concerning or notable specifically about this protocol that you want to mention: *

Submit

Transcutaneous Pacing Protocol Survey Coding Guide

1. Select your name
2. Select the protocol
   A. Confirm protocol ID and name match
3. Source of protocol
   A. emsprotocols.net: you can access this protocol via the web and were sent there from a link on emsprotocols.net
   B. PPP App: you did not download an additional application. The protocol was available to load within the original PPP app with just the + button.
   C. Locality-specific: A separate app download is required. You were sent to the Google Play or App Store to get a county or agency specific application.
4. Were you able to review this protocol?
   A. Yes if it is available for download and you can access the relevant protocols, skills sheets, and data within the group.
   B. No - you can download the separate locality-specific app, however a password is required to view the protocols. You can download the protocol but it doesn't have anything more than a facesheet. You can't get it to download, or it downloads empty. Any other reason that you cannot fully read the protocol - please select No. You will be taken to the end of the survey, please make a note describing the inaccessibility.
   C. Please note: if you are prompted for a password, please try this:
   Click cancel, and re-attempt opening the protocol you want again. It is possible the password is for sensitive areas of the protocol and not for protocols related to TCP.
   If you're still unable to open the protocols, mark the protocol as inaccessible due to the password, don't try to guess.
   D. The goal of this project is publicly accessible protocols only. If you know the password, or this is an agency you have data for outside of this process, *please do not use it*. This would not be easily replicated by others.
5. Indications for ADULT transcutaneous pacing.
   A. Please take care not to include pediatric pacing indications.
   B. Search procedure:
      a. Use the search function to search for: **pacing, transcutaneous, TCP**.
      b. Include items found in the skills or procedure sheet or supplement for transcutaneous pacing as well as treatment protocol (e.g. Bradycardia, Heart Problems, Heart Block, etc.).
      c. If there is a conflict between a skills sheet, supplement, or a treatment protocol, write only the indications in the treatment protocol.
6. Is Online Medical Control (OLMC) required to BEGIN transcutaneous pacing?
   A. If OLMC contact is REQUIRED to *initiate* pacing, then **yes**.
   B. If OLMC is an option for additional treatments and not required to initiate pacing, select no.
7. Recommended pad position for transcutaneous pacing:
   A. If the treatment protocol suggests one and then the other if the first fails, **select the first**.
   B. If "you may use either A/L or A/P" is noted, select both.

C. If the treatment protocol and skills sheet or supplement disagree, you should select all recommended.

8. Is sedation or pain management recommended or required specifically for TCP?
   A. Language for recommended includes: "consider," "if necessary," and "recommend".
   B. Language for required includes: "administer," or other similar directive that makes it clear that pain management and/or sedation is mandatory.
   C. The **goal of this question** is to determine if TCP is **written in the protocol** specifically as an intervention requiring pain management and/or sedation; not clinical judgement.
   D. If the treatment or skills sheet specifically mentions the pain management or sedation, then answer accordingly.
   E. If the treatment or skills sheet states administer pain management or sedation per pain management protocol, then the answer is yes, as this is recommended specifically for TCP.
   F. If during your search for "pacing," or "transcutaneous" you see a pain management protocol that specifically mentions transcutaneous pacing, that counts as yes - and follow above.
   G. If you do not see a pain management or sedation recommendation anywhere, or, there is only a general pain or sedation protocol, do not make this inference yourself, and select none mentioned specifically for TCP.
9. If medications were mentioned for sedation or pain management specifically for TCP?
   A. Following guidelines for question 9 above, complete medication class here. If there is a medication that does not fit, please include it in the box at the end of the protocol.
10. Is electrical capture (e.g. ECG or visual confirmation of pacing) mentioned?
   A. a. Does the entire download, in either the treatment protocol or pacing skill page or supplement mention to look for visual confirmation of pacing, or use the words electronic or capture together? Examples include, "ensure you see a visual change in the QRS," or "ensure pacer spikes and visual deflections are noted".
   B. b. If particular guidance for electrical capture is incorrect, such as "pacing spikes confirm electrical capture," still select yes.
11. In the description of electrical capture, were any of these findings mentioned?
   A. If electrical capture is described using any "**ST-segment**," "**Wide QRS**," or "**T-wave**" please select these.
   B. If electrical capture is described via another method, e.g. look for "paced complex," please select **other** and enter it.
   C. If only "electrical capture" is mentioned without further explanation or description, then select "**not mentioned**".
12. What methods within the pacing protocol were specifically mentioned for confirming pacing efficacy?
   A. If the protocol mentions how to confirm pacing is working, please select all that apply. If there is a conflict between treatment protocol and skill sheet or supplement, select the skill sheet items.

   B. If only "vital signs" are mentioned, select **Other not listed** and type in vital signs.
   C. If none are mentioned, select none, if a method not included is mentioned, select other.
   D. If pulse palpation is mentioned as a confirmation mechanism, this will open a second question to identify if **specific pulse sites** are identified. If none are mentioned, select none mentioned. Sometimes they are hyper-specific (check right carotid). In this case we only have "carotid" so check that.
13. Is false electrical capture mentioned?
   A. If this topic is mentioned anywhere throughout, select yes. This should be **verbatim**.
   B. If another similar discussion is noted within, please copy and paste in the **comment box** at the end of the Jotform and **flag the case for review**. We DO NOT expect you to be 100% sure on this variable as many descriptions sound similar to false capture related.
14. Does the protocol describe what to do if capture cannot be obtained or pacing fails?
   A. If transcutaneous pacing fails, or capture cannot be obtained, is there a suggestion of what to do next?
   B. This may include change pad position (e.g. A/L to A/P), return to medications, immediately disconnect pacer, etc.
   C. If there is something unique, copy and paste in the comment box created by clicking yes and **flag for review**.
15. Are there instructions for transitioning a paced patient from EMS to receiving hospital care?
   A. Is there information anywhere within the protocol noting a process for transitioning care of a paced patient from EMS care to receiving facility. This does not need to be an emergency department only.
   B. This might be found while searching for pacing or TCP and might not be only for TCP.
16. Do you want this entry to be reviewed?
   A. If there are concerns about an inability to abstract or **you are unsure, please select yes**. Use the comment box at the end of the Jotform to include any concerns you may have.
17. Is there anything outstanding or concerning or notable specifically about this protocol that you want to mention:
   A. Use this comment box to include any items that are unusual, impressive, confounding or otherwise notable (can be related to protocol as a whole or questions above).
   B. Use this comment box to include any concerns that you may have.



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RESEARCH REPORTS

URBAN PARAMEDICS' PERSPECTIVES ON WORKPLACE LEARNING: A THEMATIC ANALYSIS

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ABSTRACT

Background: In the most desperate and urgent situations, the public relies on the skills and expertise of paramedicine professionals. Due to the high-stress nature of responding to medical emergencies, paramedicine has a psychological cost, particularly when educational programs have a short duration and leave candidates feeling inadequately trained (Hazzard, 2016).

Purpose: We determined that further research was required to focus on the educational pipeline and to ensure that paramedicine candidates are prepared for the contextual challenges of the workplace. We highlight gaps in the education process followed in preparing paramedics for service. The overall objective of this research was to develop an understanding of how candidates learn to become paramedics, draw meaning from the work, and sustain performance in an occupation characterized by high stress and/or risk.

Methods: We conducted semi-structured interviews (n=18) with paramedics to develop a greater appreciation of the key aspects of learning in their workplace(s). Braun and Clarke's (2006; 2009) thematic analysis provided the framework to deconstruct the interview transcripts, code and develop themes, and put forth thick and rich descriptions of the learning situations described, to better understand how professional practice was developed. Our study is informed by theories of workplace learning, an umbrella term that involves understanding how people learn to solve workplace problems.

Results: We found three types of learning that paramedicine candidates apply both before and during the performance of their duties. We found that paramedics learned through a variety of situations with varying levels of outside direction, self-initiation, and reflection. We end by offering recommendations for improvements to scholars, professional paramedicine programs, and practitioners.

Conclusion: While current paramedicine training programs are effective at teaching the necessary medical skills to paramedic candidates, we found that paramedicine professionals engage in significant experiential learning to supplement their required training in order to sustain effective job performance.

INTRODUCTION

When the public hears sirens and sees the flashing lights of an emergency vehicle, they anticipate a quick and caring response. The anecdotal perception of paramedics is that they are stoic sentinels, ever watchful and present until called (Hazzard, 2016). When things go wrong, the public expects to be taken care of

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by paramedics as they rush to respond to an emergency. Yet, compared to similar jobs in healthcare, the training process for paramedicine is relatively short. We define paramedics as the various public safety personnel who respond to medical emergencies and participate in medical transport. We define paramedicine as the domain of emergency and primary care practice in a pre-hospital context (Williams et al., 2021). Our fundamental research question is: What essential skills do paramedics learn beyond their formal education and training programs?

Few occupations repeatedly put their workers in harm's way. While the military may be the most obvious example, paramedics should also be included (Oliphant, 2016). The work of first responders typically involves prolonged/routine exposure to physical and psychological stressors, increasing the risk of severe injury or even death (Anderson et al., 2020; Hazzard, 2016). It is these traumatic stressors that distinguish the work of first responders from almost all other occupations (Anderson et al., 2020). A large body of research has found that consistent exposure to traumatic stressors increases the potential for first responders to experience burnout and post-traumatic stress disorder (Benedek et al., 2007; Eastwood, 2018; Haugen et al., 2021; Wallace, 2009). Throughout their careers, successful paramedics learn the necessary skills to manage exposure to these traumatic stressors.

Learning has been conceptualized in a variety of different ways. It is perhaps most commonly understood that learning occurs in an environment that offers education, training, or both (Merriam & Baumgartner, 2020). To guide this study, we are interested in exploring literature related to learning in the workplace, specifically within the pre-hospital context. Fenwick (2008) articulates that workplace learning is an umbrella term that involves understanding how people learn to solve workplace problems. Hager (2004) and Leslie et al. (1998) categorize workplace learning as occurring either through formal learning situations (mediated) or through informal learning situations (unmediated). Internal learning situations have been proposed as an additional category to describe the internal process of integrating experiential learning (Eraut, 2004, 2007; Jarvis, 2006; Merriam & Baumgartner, 2020). We have decided to use the terminology proposed by Moon (2004): mediated, unmediated, and experiential learning. While others have articulated different classifications for learning in the workplace, we feel that this terminology is appropriately descriptive of the various learning opportunities accessed by paramedics.

Mediated learning describes learning directed or taught by another person. Unmediated learning describes situations in which the learner is responsible for guiding their learning. This includes self-directed online training courses, reading manuals, and accessing optional professional development materials. Experiential learning encompasses the learning that occurs when external experiences cause the learner to integrate new information into their existing knowledge. The defining characteristic of experiential learning is that it occurs unintentionally. Although researchers have identified the significant occurrence of experiential learning in the workplace, it has traditionally been ignored and unaccredited by educational systems, as well as by the workplace in general (Eraut, 2004, 2007).

Broadly, scholarship on learning of any kind in the pre-hospital context is scant. Moreover, the work that does exist rarely features the voices of paramedics themselves. Current research in the field focuses on how ambiguity and uncertainty might impact

learning and clinical practice in emergency situations (Goldman et al., 2009; Hussain et al., 2021; Taber, 2008; Taber et al., 2008). In Canada, for example, research in the pre-hospital context has not yet examined the educational experience of paramedics. Drennan et al. (2014) conducted a randomized controlled trial to examine patient outcomes following a community paramedicine intervention. Bigham et al. (2014) used a seven-point Likert scale to measure workplace violence exposure of paramedics. Another notable study utilized grounded theory to examine a community paramedicine program and its influence on patient care through observation and interviews with both patients and families but failed to include the voices of the paramedics involved (Dainty et al., 2018). Thus, there remains a considerable gap in the literature as it relates to learning in the pre-hospital context. The purpose of this study, which focuses on the experiential learning of paramedics, is to meaningfully address this omission through the use of qualitative interviews exploring the lived experience (van Manen, 1997) of paramedicine professionals.

METHODS

Qualitative approaches to research are incredibly diverse, complex, and nuanced. Braun and Clarke's (2006) thematic analysis (TA) was selected as a widely used foundational qualitative analytic method for both essentialist and constructivist paradigms within psychology. This method was chosen to allow the perspectives of paramedics to be the guiding voice of the results. TA provides a deep analytic philosophy and clearly defined procedures while prioritizing reflexivity and theoretical engagement. We are using TA for an interpretative phenomenological analysis of narrative discourse. Epistemologically, we frame it as an experiential method examining the lived experiences of paramedic personnel. TA provides a flexible research tool that offers a rich and detailed account of our data that remains methodologically sound. The inductive approach of TA ensures that the themes identified during the analysis are strongly linked to the data. Axiologically, this research was conducted with the belief that more paramedic education would improve outcomes and should encapsulate a period of experiential learning. Therefore, it was important to explore the perspectives of experienced paramedics about the relationship between their initial education versus education obtained after licensure and their practice in the field. This method includes the ontological assumption that lived experience is an interpretive process that is situated within the lives of paramedics (Mertens, 2023). We applied Braun and Clarke's (2006) TA to the transcribed open-ended question interview data.

Reflexivity and Positionality

Reflexivity and positionality are closely intertwined and important concepts that enable readers to assess the credibility of qualitative research. Based on the work of Braun and Clarke (2006, 2019), we tried to ensure reflexivity in our TA by openly examining and acknowledging how each of our perspectives, values, assumptions, and biases might influence the research process. Positionality in qualitative research refers to the researcher's social identity, worldview, and standpoint when conducting research. It situates a researcher in relation to their participants and reflects the position that the researcher has chosen to adopt within a given research study. Reviewing the findings with consideration of our positionality, while being cognizant of the identity of the participants, served to minimize predisposition or bias.

Sampling

Participants in this study were identified as being (a) active-duty paramedic personnel, (b) having current licensure, and (c) having voluntarily agreed to participate. Several known paramedics were contacted as participants in the study. Additional participants were then acquired through snowball sampling (Parker et al., 2019).

In qualitative research, it has been argued that a sufficiently large sample exists when theoretical data saturation is reached. We have chosen to follow Braun and Clarke (2016), who state, "sample size…is something qualitative researchers often revisit during data collection, in a live and critically-reflexive, evaluative way." Paramedics tend to be a closed community; however, connections with members of the paramedic service allowed those individuals to act as keyholders, opening the door (Parker et al., 2019).

Participants

Eighteen participants were ultimately recruited, five identified as female and 13 identified as male (see Table 1). Individuals who were not yet active-duty paramedics were excluded because they could not be asked about their current experiences and/or perceptions with learning and performance, since they do not have the lived experience of the occupational context. For this project, we were interested primarily in the lived experience of current active-duty paramedicine personnel.

Participant #	Sex	Age	Level of Training	Years of Experience
P1	M	34	PCP	10
P2	M	41	ACP	11
P3	F	24	PCP	4.5
P4	M	37	ACP	17
P5	M	32	ACP	10
P6	M	40	ACP (TEMS)	12
P7	F	42	ACP	22
P8	M	39	ICP (PCP)	12
P9	F	38	ACP	12
P10	F	38	Flight Medic	8
P11	M	46	ACP	9
P12	M	38	PCP	7
P13	M	43	Instructor (ACP)	16
P14	M	44	Flight Medic	23
P15	M	36	PCP	5
P16	M	47	District Chief	19
P17	M	37	Assistant Chief	19
P18	F	35	Flight Nurse	10
AVERAGE	n/a	38.4	n/a	12.6

Note: ACP - Advanced Care Paramedic, ICP - Intermediate Care Paramedic, PCP - Primary Care Paramedic, TEMS – Tactical Emergency Medical Support.

Table 1. Participant demographics.

Ethical Considerations

Institutional Review Board ethical approval was obtained from the University's human research ethics board (HE09631), and a signed written consent was obtained from participants indicating their agreement to participate in the study.

Risk/Benefit Analysis

There was the potential for cognitive and emotional stress if the participants were reflecting on a particularly difficult learning experience or case-related performance in their occupation. As always, the participants' experience and sensitivity were prioritized. Participants were not obligated to answer any questions and could choose to withdraw from the interview at any point. The potential benefits to the participants were that they could become more mindful of their own learning and performance strategies and incorporate them further into their daily practice.

As this study involved learning about how paramedics manage themselves in situations of high stress and high pressure, the participants were free to refer to on-the-job

incidents and experiences, but they were asked not to be specific about the situations, thereby ensuring that they did not breach privacy legislation. The stories the participants shared were specific to their own experiences and learning, not to the patients involved.

Confidentiality

All participants were identified by an assigned ID number to maintain anonymity. The data collected from participants was only available to the researchers and was kept strictly confidential. Recorded media containing sensitive information is stored in a locked filing cabinet on a password-protected and encrypted hard drive. Data is reported in aggregate form.

Data Collection

Given the significance ascribed to the lived experience recalled by the participants, it is particularly important for the researchers to engage the participants in dialogue to bring meaning to those experiences so that the researchers can represent them in a written narrative. Semi-structured interviews drew out the participants lived experience with learning and sustaining performance. Data was collected through an interactive means, utilizing interviews that were open-ended. Once the interviews were completed, the digitally recorded interview data were transcribed verbatim to conduct the TA.

Data Analysis

Through the analysis, the research team discovered the emergence of patterns of meaning and issues of potential interest in the data by following Braun and Clarke's (2006) "6-phase guide to performing thematic analysis." TA is a recursive process where constant review amongst the entire data set is needed throughout the phases, rather than simply coding line by line. The research team initially followed Braun and Clarke's semantic approach, where "the themes are identified within the explicit or surface meanings of the data, and the analyst is not looking for anything beyond what a participant has said or what has been written" by taking notes and marking ideas for coding. This evolved into their latent approach, which "goes beyond the semantic content of the data, and starts to identify or examine the underlying ideas, assumptions, and conceptualizations." Using this approach, we began reading into the subtext and assumptions underlying the data. This is an important part of the analysis within an interpretive qualitative methodology.

Phase one of the TA involved reading the transcripts to become familiar with the data while simultaneously listening to the audio recordings to understand emphasis and tone. During this process, the researchers took notes on anything mentioned by the participants in relation to the learning process of paramedics, including everything they had to learn to be effective practitioners in all aspects of their careers. The notes generated in phase one identified initial codes.

Phase two is where the interpretive analysis of the data occurred. Using the initial codes generated in phase one, we began organizing interesting aspects of the lived experiences of paramedics into meaningful groups. These groups serve to create broader units of analysis, a precursor to the final themes. Repeated patterns were used to form the basis of the potential themes. This process continued until we were confident that all data extracts had been identified.

Phase three allowed us to refocus the analysis on broader level themes. We collated each potential theme, including all specific quotes relating to learning in paramedicine, into separate documents for easier analysis and to ensure anonymity. During this collation, we kept some of the surrounding data to avoid the common criticism of coding that context may be lost. Each potential theme was categorized into one or multiple of the three learning types, based on the descriptions of how the participants learned about each potential theme.

Phase four involved developing candidate themes. A candidate thematic map was created by exploring the connections between the dataset and the themes. Ultimately, the 17 themes were written out, and the data was examined again, this time looking for connections between the themes identified in phases one to three. Additionally, the map was coded using shapes to indicate the learning type (mediated, unmediated, and experiential) associated with each theme. Finally, the elements of the thematic map were cross-checked against the data by comparing the collated documents created in phase three to the thematic map. This process ensured that every connection on the thematic map could be justified using direct quotes and that no direct connections described in the data were missing from the thematic map.

Phase five involved refining the themes and ensuring they were clearly defined (Table 2). While the final themes had already been determined in phase four, phase five included writing specific definitions for each theme in the thematic map to ensure they accurately described the scope and content of each theme. We selected specific quotes from the dataset that best represented each theme. With the themes refined, we began to write our detailed analysis and identify the narrative description within each theme. We also considered how each theme fit into the broader overall narrative while ensuring that there was not excessive overlap between the themes.

Phase six involved describing and discussing the findings in this article once we had fully worked out a set of themes. The quotes selected in phase five were embedded within the analytic narrative to compellingly illustrate the findings. This analytic narrative goes beyond a description of the data and discusses the themes in relation to the research question and the three learning types while ensuring it is internally coherent and consistent.

It is anticipated that this analysis will contribute to the literature, as it challenges perceived wisdom about the comprehensiveness of mediated learning, supports the need to supplement that learning with additional unmediated learning opportunities, and recommends the inclusion of targeted experiential learning in paramedic training programs, similar to that in other medical fields.

RESULTS

The main finding from our interpretations of the interview data was a discrepancy between the learning required for effective job performance and the content of the mediated learning. Many essential components of paramedic education are learned solely through unmediated and experiential learning that are not covered in the training. Paramedics seek to learn these components because they are underprepared after completing the mediated training process.

Data Point	Description
Didactic Medical Training	Formally delivered training consisting primarily of classroom style teaching and studying through traditional methods.
Practical Training	Training done in which trainees practice applicable skills and knowledge through a simulated situation using either actors, simulation manikins, or technology.
Mindset / Mental Preparation	Refers to increasing, maintaining, and/or decreasing levels of mental arousal before, during, and/or after work and/or a specific call. Can include but is not limited to daily routine, exercise, meditation, equipment checks, tactical breathing, and compartmentalization.
Personal Health	Refers to activities performed by the paramedic designed to maintain their own health. Can include but is not limited to sleep, nutrition, exercise, socialization, decompression time, family, and techniques for managing shift work.
Time Management	Refers to planning use of time both inside and outside the work context to attain as many work and personal goals as possible while maintaining work-life balance.
Self-Defense	Formal training that paramedics can use to protect themselves while on duty. Can be either physical defense techniques or verbal de-escalation techniques.
Technology / Social Media	Includes all formal and informal use of technology related to training for and performance of paramedicine. Can include but is not limited to all social media platforms, cell phone usage, podcasts, videos, electronic medical records, and simulation manikins.
Self-Directed Learning	Refers to paramedics seeking out additional information related to their job performance (i.e. any included data point categories) using technology, academic resources, and practical simulation practice. Self-directed learning is specified as learning that is not funded or acknowledged by the training programs or paramedic service in any official capacity.
Situational Awareness	Refers to initial scene assessment for safety as well as continuous monitoring of the scene and conditions that may become dangerous.
Debriefing / Communication	Refers to verbal debriefing of events and communication between paramedics, with dispatchers, and with people in other professions.
Teamwork / Coworkers	Refers to working with other paramedics through successful teamwork strategies, managing conflicts, and working with difficult coworkers.
Leadership / Mentorship	Refers to training in leadership/mentorship practices, the development of leadership styles, preceptorship experiences, and training in adult education theories.
On-the-job Learning	Refers to anything learned specifically through time working that is not otherwise categorized and cannot effectively be learned other than through experience. Includes the development of habits and personal styles of approaching patient care.
Problem-Solving	Refers to the ability to adapt to changing scenarios and situations that differ from common or practiced situations. Includes skills such as delegation and resource management.
Service Protocol	Refers to training on the protocols specific to a paramedic service. Can be protocols regarding patient care or other logistical components of paramedicine such as transfer to a hospital.
Ethics	Refers to how paramedics make decisions that are not encompassed by service protocols. Includes triage decisions, morality, and personal biases.
Interprofessionalism	Refers to training and working with allied professionals who are not paramedics. Can include but is not limited to dispatchers, police, firefighters, nurses, and physicians.

Table 2. Theme descriptions.

Mediated Learning

Our TA revealed a total of 17 themes in which learning is essential to paramedic job performance. Interestingly, of those 17 themes, only four are included in the mediated learning process, and three of those four were still being supplemented by experiential learning. The four themes of mediated learning include didactic medical training, practical training, situational awareness, and technology.

The didactic medical training relied heavily on self-directed learning from the students due to the high volume of material covered in a short timeframe. It was emphasized that "you're only in class for about six months, so there's a lot of expectation for you to self-study and to do work at home" (P3). The practical training component was described as highly valuable by most participants. It is through this theme that situational awareness and technology are covered. Situational awareness is emphasized by checking for scene safety at the beginning of the practical training scenario; however, it becomes a redundant phrase used in simulation rather than an ongoing focus throughout the entire sce-

nario and in practice. "So, every single scenario that you would practice, that algorithm that you would go through, you would start by verbalizing and saying and checking for scene safety. It becomes a check mark, and then you move on" (P4). Technology has been incorporated into the mediated training process. Those four themes, depicted in Figure 1 with the top right corner cut, correspond to what was anecdotally stated to be about 10% of the paramedic job description. One participant noted that the training process is "hyper-focused on that 10% of that work we do. It's hyper-focused on the medicine" (P4).

Unmediated Learning

The same four themes as mediated learning are included in unmediated training processes, as well as two additional themes. Didactic medical training, delivered either in person or through an online platform, is used to teach the specific service protocol to already certified paramedics. "Today we are using an online forum, and so if a new procedure comes out, I would get onto the internal online forum and review the material that has been placed there by our training academy" (P7). There is occasional didactic continuing education that discusses maintenance of personal health habits for paramedics, but it is not included because participants suggested that the training was ineffective and that their learning within the category did not occur in the unmediated training

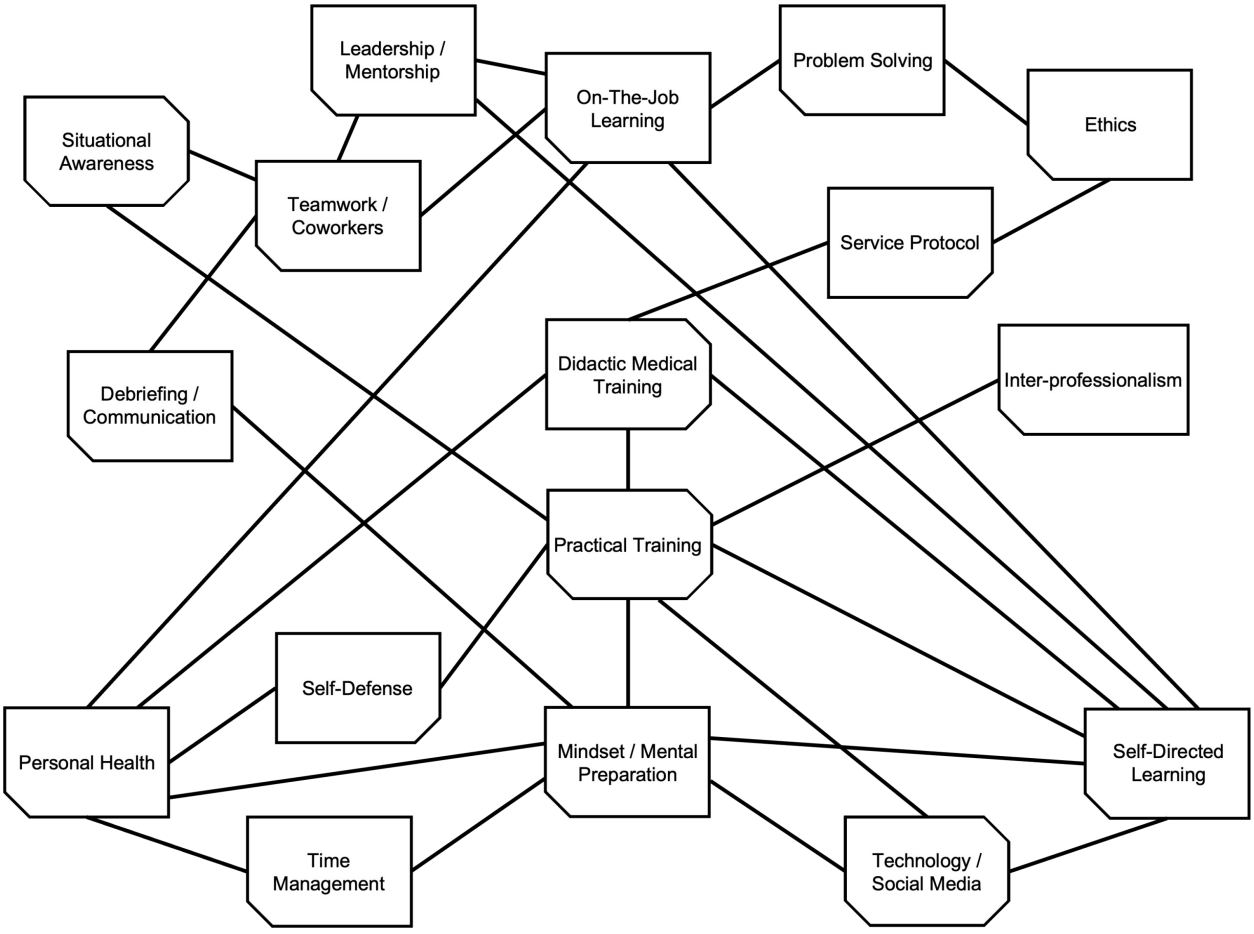


Figure 1. Thematic map of 17 final themes categorized into mediated, unmediated, and experiential learning.

Note: The top right corner cut indicates mediated learning, the bottom right corner cut indicates unmediated learning, and the bottom left corner cut indicates experiential learning.

setting. "They'll put, like, posters up or memos out about getting, like, good sleeps and stuff like that, but no, no formal training" (P9). Practical training is often used in continuing education and, therefore, includes some situational awareness and technology. If the practical training is done in conjunction with other professionals, such as firefighters or police, it helps develop interprofessionalism even if it is not explicitly taught. This area was identified as a weak point in the training program: "We need to start practicing how we play … we have an integrated response … When we do our training though, EMS does their training, and fire does their training in a separate room" (P17). Some participants also described a self-defense class and verbal judo training that were offered as part of continuing education, but that they were not adequate for use in real situations. "We practiced some sort of self-defense maneuvers that I couldn't even replicate them or tell you what they are right now" (P1). These six unmediated themes are depicted with the bottom right corner cut in Figure 1.

Experiential Learning

Three overlapping themes and the remaining 11 undiscussed themes are all components of paramedicine that are typically acquired through experiential learning. These 14 themes represent the components of paramedic work that are either excluded from or inadequately included in the mediated training process and are depicted with the bottom left corner cut in Figure 1. Due to the definition of experiential learning, all categories in this learning style are linked to on-the-job learning or self-directed learning, but only the strongest connections are depicted in Figure 1.

Since practical training was considered so valuable to the learning process, some paramedics do additional practical training outside of mediated and unmediated learning environments. Continued practical training was described as limited, and the importance was strongly emphasized in the following explanation: "You taught me how to do a cricothyrotomy six years ago when I became an ACP. It's never been revisited since… you're talking about cutting somebody open and throwing a tube down the throat because you can't vent them and they can't breathe… Those types of things I like to go review them on my own… unfortunately, we don't get the opportunities to do as much hands-on practice as I'd like" (P2).

Mindset/mental preparation is initially learned in an unmediated way during practical training, but further developed through experiential learning, often using technology/social media as a source for information. Managing one's own personal health is essential for peak job performance. Many participants talked about struggling with their personal health at the onset of their career until they were able to learn what they could do to maintain their health while working through trial and error. "I've managed to find a good sleeping schedule that works for me… but that took probably six months to figure out what worked for me" (P3). Time management is a huge component of personal health because, when done properly, it allows adequate time for sleep, nutrition, physical activity, and work-life balance. Time management is also useful in mental preparation by allowing time to check over equipment at the beginning of a shift in order to feel fully prepared.

Problem-solving was described as the majority aspect of the job, and is learned through practice in real situations. "Problem-solving is beyond a doubt the number one thing all

of us do" (P4). Problem-solving relies on paramedics' ability to make ethical decisions. Ethics is influenced by what is outlined in service protocols, but not all decisions fall within those protocols, and decisions often have to be made quickly in order to solve a problem. Awareness of personal biases is essential in effectively treating patients ethically, as demonstrated in a story shared by a respondent: "I watched two clients come in that I had picked up hundreds of times each in the ambulance… And I instantly had this, a bit of a reflection on myself, as to about, I don't want to say racism, but it was pre-judgment and a reflection on that I had never treated them like human beings. So, for me, that was profoundly affecting on future practice" (P17).

Leadership/mentorship is largely influenced by both positive and negative experiences while working on developing an initial style. "I literally model how I do things in a combination based on how not to do things, on how my first partner did things, and a lot of the things that I learned from the other successive mentors that I had along the way" (P16). The knowledge is then extended through self-directed research on leadership techniques. "Primarily, I source books and podcasts and things like that as a self-study of leadership" (P4). Working effectively with other paramedics, labelled teamwork/coworkers, is also learned through experiences guided by mentors. Another important component of teamwork is debriefing/communication, which can also have an effect on mindset. Continued situational awareness relies on teamwork so that members can warn each other about changes in scene safety. Interprofessionalism is generally learned through experience interacting with other professionals while working.

All 17 themes, their connections, and the learning types revealed through the TA are summarized in Figure 1. This patchwork for paramedic education is a concern and was acknowledged by almost every participant interviewed during this study.

DISCUSSION

Unlike many professions, paramedic training, by the nature of the career, necessitates early proficiency in all clinical skills and medical knowledge. Lives would be put at risk if paramedics were sent into the field without first completing the necessary mediated medical training. Our data, however, shows that upon entering the profession, following PCP and employer academy training, paramedics are still unprepared for the realities of the job. Much of the learning that is perceived as more valuable and applicable to everyday work is experiential, and paramedics themselves are searching for information to fill the gaps.

In the current training model, students who enter paramedic training receive basic medical and practical training focused on the delivery of emergency medical interventions, get accepted into an employer academy to learn specific protocols, equipment, and service logistics, and then enter the field, expected to work as a team. Prospective students who are attempting to become a trained and licensed primary care paramedic generally undergo 7-18 months of formal training, depending on jurisdiction and the educational institution delivering the qualification. Nevertheless, consistent among the educational streams is a focus on the formal delivery of clinical content, typically didactic classroom instruction and practical training, with accompanying high and low fidelity simulations. Those students who successfully graduate can then write the certification/licensure exam. Successful graduates are considered licensed and employable across most juris-

dictions. Separate licensing requirements are often specific to the regional or municipal requirements and usually involve additional formal training to become familiar with service-specific protocols, procedures, and equipment.

Limitations

Although the findings from this paper provide a contribution to the field, some limitations need to be addressed. While interviews offer a rich and in-depth assessment of workplace learning, limitations exist, including potential response bias and the inherent confines of qualitative data. Since we interviewed a small sample size of volunteer participants, it is possible that self-selection and non-response bias may have occurred. Our study provided valuable insight into the unmediated and experiential learning of paramedics, but further studies may benefit from a broader sample size. Additionally, due to the nature of qualitative research, direct comparison between our findings and other similar studies may present challenges. Moreover, since our sample includes participants from a combined fire paramedic service in a single municipality, results may not be generalizable to municipalities with split services.

Future Directions

As we progress towards more ratified training, such as granting university degree status to paramedical education, it is crucial to consider the inclusion of currently unmediated and experiential learning outcomes in the program to ensure a broad base of education and training. Further research should focus on integrating various practical training opportunities and unmediated on-the-job experience within the mediated education pathways. Further investigation into best practices among established degree-granting paramedic programs is warranted. Analyzing their approaches can provide valuable insights for refining and enhancing paramedic education globally. Ultimately, if the aim is to sustain an enduring career as a paramedic, mediated education should prioritize elements that align with the benefits of unmediated training and experiential learning. Our findings indicate that blending mediated education with hands-on experiences offers a viable pathway forward. There should be a deliberate effort to integrate ancillary skills, beyond core medical training, into practical training and continuing education for paramedics. This holistic approach ensures that paramedics are equipped with a diverse skill set to address the complex needs of patients and communities effectively. At the end of the day, if sustaining a career as a paramedic is the overall goal, lifelong learning needs to be emphasized throughout the mediated learning in parallel with complementary unmediated learning and crafted experiential learning.

There are several benefits associated with this research. The first is that the findings will add to the literature on workplace learning and well-being within occupations characterized by chaotic work and potential for burnout (Lauria et al., 2017; Wilson et al., 2016). Secondly, findings from the reflective interviews will help to provide a more nuanced picture of the experience of how learning and sustaining performance occur with paramedics. Finally, the trade-off between adequate preparation and moving novice paramedics into service expediently is also a political consideration for the regulators of the profession. The much-referenced statistic from David and Harrington (2011), indicating that the average career length of a paramedic is a scant 6.5 years, adds pressure to move paramedic candidates into practice quickly to replenish the workforce. There is, however,

a trade-off between moving candidates quickly through their training and providing optimal care during a crisis. We believe that the more comprehensive program suggested by this research will better prepare candidates for practice while reducing the emotional stress felt in the early part of the career through an extensive apprenticeship, leading to longer careers and better service.

CONCLUSION

Overall, our research suggests that while the current paramedic training programs successfully teach the medical skills necessary to provide patient care, many other aspects of successful paramedic practice are lacking, including problem-solving, personal health maintenance, collaboration, and continuing education, etc., as noted by our participants (see Table 2). These findings raise the concern that while newly trained paramedics are capable of providing effective medical treatment, they are underprepared for the full scope of practice in the high-stress environment. The missing educational components leave the profession with a training program that is not conducive to sustained practice, likely contributing to the high rates of burnout and rapid turnover.

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RESEARCH REPORTS

EXPERIENCED AGENCIES, FASTER CHUTE TIMES: DETERMINANTS OF EMS RESPONSE IN THE UNITED STATES

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ABSTRACT

Why do emergency medical units respond more rapidly to some dispatched calls than others? This study examines over 355 million emergency medical services (EMS) activations recorded in the National Emergency Medical Services Information System (NEMSIS) database between 2018 and 2023. The results show that teams operating in the top 5% of agencies by call volume—representing the most experienced systems—initiate response more quickly and post consistently shorter chute times.

Experienced responders more quickly recognize the nature of the call, develop confidence in both the likely course of events and their own ability to manage it, and initiate mobilization with minimal hesitation. As these behaviors are repeated, they become embedded in routines, coordination, and shared expectations. In this way, experienced responders shape agency-level culture from the ground up, contributing to persistent differences in performance across agencies, captured in agency-level fixed effects.

INTRODUCTION

What explains the variation in the amount of time it takes emergency medical responders to begin responding once dispatched? This question is examined using NEMSIS data comprising over 355 million 911 activations routed to EMS in the United States between 2018-2023. This study shows that teams operating within the highest call volume agencies—those in the top 5% of total volume—more quickly initiate their response, resulting in substantially shorter EMS chute times. Through repeated exposure, responders learn to anticipate call demands, coordinate more effectively, and initiate mobilization with fewer delays—patterns that become visible in the timestamp data as faster and more consistent chute times.

In practice, first responders must rapidly interpret limited dispatch information (e.g., age and call type) to decide how urgently to mobilize. These split-second judgments determine whether crews depart immediately or delay briefly (for instance, to finish washing their hands in the bathroom) before responding. To what extent do patient factors and dispatch call type help pre-

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dict the speed of response? After all, a call for a child in full arrest might yield a slightly different behavior pattern than for abdominal pain.

SECONDS MATTER

For true emergencies, every second matters. For example, consider a patient in cardiac arrest. Given that "shockable" arrests presenting with Ventricular Tachycardia or Ventricular Fibrillation only "stay shockable" for a limited time before progressing to asystole or Pulseless Electrical Activity arrest (which are not shockable rhythms and where the odds of survival are much lower), being on time to deliver a shock can mean life or death for a patient in cardiac arrest. One study found that for every additional minute it takes for an ambulance to respond, the odds of a patient presenting with a shockable rhythm decrease by 8% per minute. (Renkiewicz, et al., 2014). In another study, the odds of surviving a cardiac arrest increase 24% if ambulances respond 1 minute faster than the mean (O'Keeffe et al., 2011).

Other studies emphasize the importance of response speed after critical MVAs (Motor Vehicle Accidents), where delays can be fatal due to rapid hemorrhage Helander et al., 2024). A growing body of research demonstrates how even short delays in care can impact patient outcomes. For instance, during cerebrovascular events (CVAs), a patient experiencing a typical ischemic stroke loses 1.9 million neurons every minute. Over that same minute, an estimated 14 billion synapses and 7.5 miles of myelinated fibers are also lost (Saver, 2006).

LITERATURE

A number of studies examine the length of time it takes for an ambulance to respond. This variable is referred to in several different ways, including squad chute time, call-response time, activation time, Ambulance Response Time, response time, and EMS Chute Initiation Time (Adeyemi et al., 2022, Medrano et al., 2022). Explanations for why EMS practitioners respond to certain calls more quickly than others are broadly divided in the literature into patient-level and system-level factors. (Abbas et al., 2022, Do et al., 2013, Nehme et al., 2016).

Patient-level factors include the information regularly dispatched to a responding unit: "Medic 1, I show you responding to 123 Main Street for a 27-year-old female, unresponsive." With this information, both dispatchers and first responders share information on the nature of the call, the age of the patient, and the gender of the patient. The dataset does not contain the dispatched address as doing so would compromise patient privacy; in addition, national changes in how and the extent to which gender is coded in each year necessitated dropping gender as a variable from the analysis.

Literature in this field indicates there are also systemic factors that can help explain variation in EMS chute times, like season, time of day, geographic region and urbanicity score. For example, a recent multivariate analysis of response times in China demonstrates how the pace of unit mobilization changes across the seasons (Chen et al., 2024). Temporal patterns in emergency call data reveal a consistent nationwide diurnal rhythm in call volume. For example, Helander et al. find that, regardless of dispatched call type, nationwide call volume consistently peaks around 15:00 local time (2024). Exceptions to this pattern include cases of: overdoses, which peak later, around 19:00, stabbings and

shootings, which peak around 20:00, and assaults (peaking around 20:30, local time). Previous research has also found that the pace of 911 response is intimately linked to overall call volume at the agency level. Some studies have teased out how average hospital delay times in the previous hour as well as the workload of the squad in the previous hour impacts the pace of response (Nehme, et al., 2016). Finally, literature from around the world has deployed location-based analyses to test a number of hypotheses. Some studies examine how the geographic density of emergency stations in an area influences response time. Others use geography and income together to help tease out effects. For example, Hsia et al. found that the average income of a zip code helped predict the speed of an ambulance's response to a full arrest. Ambulances respond more slowly to 911 emergencies in poor areas, especially when compared with their counterparts working in wealthy communities (2018, see also Chen et al. 2024 and Earnest et al., 2011). While prior work has examined both patient and system-level constraints, less attention has been paid to how first responders accumulate knowledge about EMS gained through repeated exposure to different kinds of emergency calls, and how this learning translates into faster and more consistent response times. This study builds on this gap by examining whether agency-level experience—measured through call volume—serves as a primary determinant of EMS chute times.

A SYSTEM UNDER STRESS

More broadly, this analysis is motivated by a desire to better understand what systems do when placed under incredible strain. The emergency response system was designed so those experiencing true life-threatening emergencies could receive pre-hospital care and quick transit to the hospital. Instead, many service areas often find themselves inundated with calls that are not true emergencies. Indeed, many calls occur as a direct outcome of what is widely noted as widespread systemic failures of the health care system. Unable to pay for your medications and now feel sick? Don't have a ride to the pharmacy to pick up the medications prescribed to you in the emergency department last week? Tired of waiting in pain and discomfort over 3 months for a primary care visit, only to be directed to a series of specialists that are scheduling another 3 months out? Enough is enough, their family says. Call an ambulance.

First responders and emergency room employees operate under significant personnel and resource constraints; they work long hours and often do what should be the job of 2 or 3 others. On many occasions, all beds in the emergency room are full, often with a substantial number of people queuing to be triaged in the waiting room. For their part, pre-hospital first responders go from one call to another, often without time to start their report or adequately restock the ambulance before being paged to see if they are available to take the next.

To make matters worse, many of the people being seen are well known to the first responders and the hospital staff that greet them. A relatively limited number of people account for a substantial number of EMS calls. Studies examining the abuse of the 911 system by "frequent fliers" fill an important gap in our understanding of this problem (Gehrt 2025).

ABUSE OF THE 911 SYSTEM

While NEMSIS data do not collect "frequent flier" data directly, it is plausible that, taken together with the aforementioned stressors on the EMS system, first responders would move more slowly when dispatched to most frequent call types, due to call type burnout ("one of those calls again"). In much the same way that responders might groan when being dispatched to a frequent flier, one may hypothesize that high-frequency call types might yield a similar kind of sentiment, especially because over 40% of all EMS calls come from just three categories: Sick Person (20%), Respiratory Issues (11%), and Falls (10%), as Table 1 shows.

Next, the paper details all model variables and specifies hypotheses to be formally tested.

The dependent variable, Squad Response Time, is measured as the time elapsed between when a unit is assigned a call and the unit's departure, in seconds.

Dispatch Call Type	Frequency	Percent
Sick Person	41,153	20.1%
Respiratory	22,311	10.9%
Falls	20,633	10.1%
Chest Pain	14,455	7.1%
Unclear	12,389	6.0%
Traffic Incident	11,875	5.8%
Unconscious	10,852	5.3%
Abdominal Pain/Problems	7,678	3.7%
Seizure	7,449	3.6%
Psych	7,274	3.5%
Unknown/Person Down	6,536	3.2%
Traumatic Injury	5,511	2.7%
Stroke	5,172	2.5%
Hemorrhage/Laceration	4,600	2.2%
Overdose	4,467	2.2%
Heart Problems	3,238	1.6%
Diabetic	2,909	1.4%
Back Pain	2,554	1.2%
Cardiac Arrest	2,473	1.2%
Assault	2,445	1.2%
Allergic Reaction	1,537	0.7%
OBGYN	1,393	0.7%
Headache	1,219	0.6%
Stab/GSW	921	0.4%

Table 1. Distribution of top 25 EMS dispatch call types.

HYPOTHESES

Attributes of Responding Unit

H1: "Top 5% Experienced Agency": Agencies with greater call volume have more operational experience and are expected to demonstrate faster chute times.

An agency-level dataset was constructed using deidentified keys linked to each agency. Teams operating within agencies in the top 5% of call volume in the sample are classified as "most experienced" under a binary threshold model. While experience cannot be directly observed, agencies that handle more calls are exposed to a wider range of emergency scenarios, allowing them to develop and reinforce routines, coordination, and institutional knowledge. Call volume therefore provides a practical and observable proxy for accumulated operational experience.

Truck Disposition at Dispatch

H2: "In-Vehicle When Dispatched": To account for operational differences in unit status at the time of dispatch, a binary variable identifies cases in which first responders are already in the response vehicle when the call is received. All observations with zero-second chute times are coded as 1 for this variable. This control distinguishes true mobilization performance from cases in which no mobilization phase is required and accounts for the possibility that high-volume agencies may be more likely to have units already in motion.

Call Type Characteristics

H3: "Dispatched Call Type": Higher-acuity dispatch types (e.g. Full Arrest, Choking, and Stabbing/GSW) will be associated with shorter chute times relative to lower-acuity calls (e.g., Back Pain). Each dispatch call type is included as an independent predictor of chute time. "Abdominal Pain/Problems" is set as the reference category.

H4: "Call Type Fatigue": Response times will be longer for the most common call types (Respiratory, Falls, and Sick Person) than for other call types, reflecting potential fatigue with these call types.

Characteristics Relayed to EMS

H5: "Patient Age": Response times will increase with dispatch-reported patient age.

Timing of Dispatched Response

H6: "COVID Period": Response times will be longer during the period set equal to 1 for all dates inclusive of March 11, 2020 and May 1, 2023, marking the beginning and end of CDC-announced COVID-era restrictions.

H7: "Night Response": Response times will be longer during overnight hours. Coded as 1 for calls occurring between midnight and 07:30, and 0 otherwise.

H8: "Weekend Response": Response times will be longer on weekends than weekdays. Coded 1 for calls taking place on Saturday and Sunday and 0 otherwise.

Other Control Variables

H9: "Region of EMS Response": NEMSIS deidentifies location data to preserve patient privacy. However, each call is coded for region (South, East, West, Great Lakes, or Western Plains) and urbanicity (Wilderness, Rural, Suburban or Urban). Dummy variables are included for Western, Southern, Western Plains, and Great Lakes regions, with the East set as the reference category.

H10: "Urbanicity": Dummy variables are included for Suburban, Rural, and Wilderness areas with Urban set as the reference category.

Region and location variables act as important controls given the geographic distribution of EMS calls and resources.

What stands out immediately after exploration of Figure 1 is that most of the calls in the United States take place in urban areas with high-call volume environments, where resources are more likely to be constrained and demand high. This concentration of calls in urban environments suggests that many agencies operate under conditions of sustained demand, requiring a multivariate model to control for the independent effect of urbanicity on squad response time. To evaluate these hypotheses, two complementary modeling approaches are used using data described below.

DATA AND SAMPLING

First responders generate Patient Care reports (PCRs) with detailed information about each patient interaction. Stations submit these reports to the National EMS Information

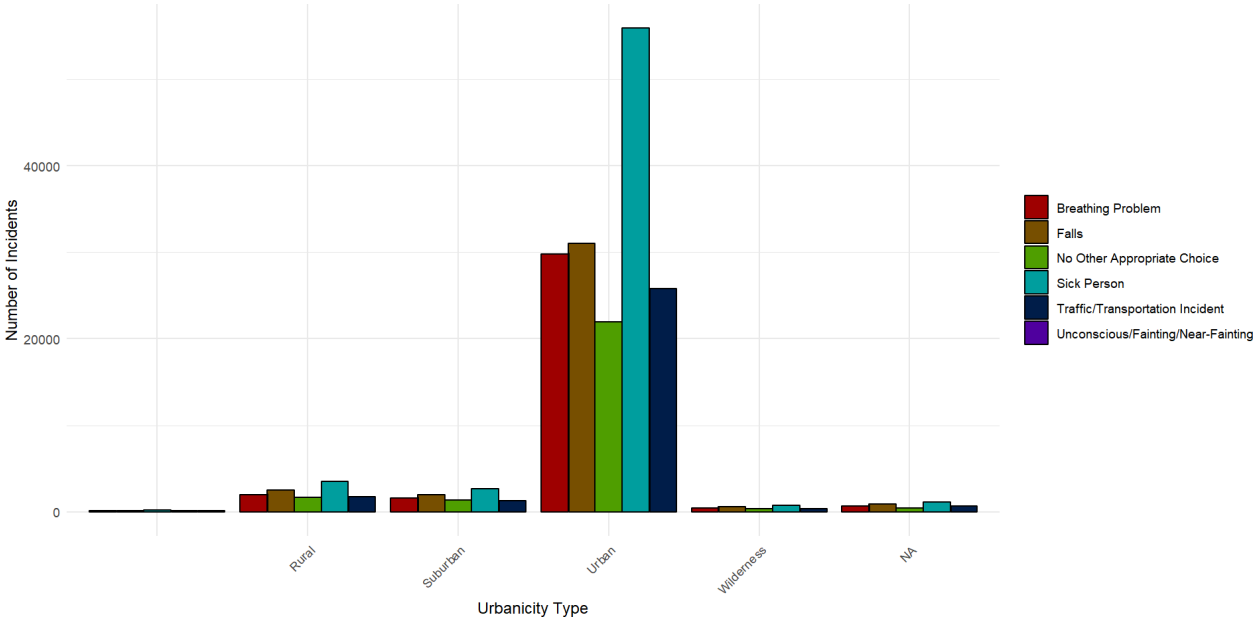


Figure 1. Top five dispatched call types by urbanicity score

System (National Association of State EMS Officials, 2024). Each 911 call in the database includes timestamps (specific to the second) that indicate the local time that the trunk system alerted local EMS dispatchers, the time the call was dispatched to a specific responding unit, and the time that first responders marked themselves en route toward the dispatched location.

The NEMSIS repository contains hundreds of millions of 911 ambulance patient care reports (PCRs), organized by year into approximately 40 relational tables. Each table contains hundreds of interrelated variables. Given the sheer complexity and raw size of the dataset, conventional approaches to random sampling that involve first reading the dataset into memory are unwieldy. To construct a representative analytic sample from the full dataset, reservoir sampling was implemented. As records were read sequentially in batches, candidate observations were probabilistically retained or replaced within a fixed-size reservoir, ensuring that each observation in the full dataset had an equal probability of selection without requiring full in-memory storage.

To begin, 100,000 records per year were selected from the 354.8 million rows over the years 2018-2023, and then a master file was created that appended all years to one another. Next, a second sample of 100,000 observations was taken from each year and appended to the combined dataset. Table 2 describes the workflow that led to the final analytic sample and Table 3 presents descriptive statistics for the main variables used in the analysis.

MODEL ESTIMATION

The distribution of the dependent variable, Squad Response Time, is strongly right skewed with a long upper tail, consistent with the asymmetric nature of operational time data. Given this skewness and the presence of extreme values, robust modeling approaches were used, and observations exceeding 10 minutes were excluded to limit the influence of atypical cases that likely reflected non-routine operational conditions and coding errors rather than typical response behavior.

NEMSIS Dataset (≈354 million records)
↓
Reservoir Sample (≈600,000 records)
↓
Valid Response Times (0 < time ≤ 600 seconds) (N ≈ 205,000 records)
↓
Final Analytic Sample (striking covariate missing values)
(N ≈ 185k (Model 1), N ≈ 183.5k (Model 2)

Table 2. Data construction workflow.

RANDOM LINEAR MODEL AND FIXED EFFECTS OLS MODELS

The logic described in Pek et al.'s study guided model selection (2018). First, a baseline multivariate model using a robust linear approach was estimated using RLM in R (Model 1). Electing to use robust models helps us rein in those extreme observations (e.g., the handful of extreme outliers where chute times are measured in hours or even days rather than seconds) that would otherwise normally substantially influence or skew the results. Second, use of a fixed effects model helps account for expected substantial variation in the dependent variable best explained by agency-level fixed effects, using FEOLS in R (Model 2).

Variable	Mean/%(SD) [Median]
Main Variables	
Squad Response Time (sec)	66.11 (78.81) [50]
Patient Age	55.86 (22.92) [58]
Experienced Agency	56.9%
In Vehicle When Dispatched	11.7%
COVID Period	54.2%
Night Response	18.2%
Weekend Response	27.3%
Urbanicity	
Urban	85.1%
Suburban	5.2%
Rural	6.2%
Wilderness	1.4%
Missing	2.0%
Region	
South	38.8%
East	22.7%
West	19.6%
Great Lakes	11.5%
Western Plains	7.3%

Table 3. Descriptive statistics.

DISCUSSION

Highly Experienced Agencies have the fastest EMS Chute Times

The most significant finding of this research project is that, even when controlling for urbanicity and other factors, **experience is the strongest predictor of the speed of EMS response**. Importantly, these effects persist even after controlling for agency-level fixed effects, indicating that the relationship is not solely driven by differences across agencies.

In a simple bivariate model, agency experience is strongly associated with faster chute times. A one-unit increase in agency experience rank (0–1 scale) is associated with a 135-second reduction in chute time ($p < 0.001$), with experience alone explaining approximately 7.5% of the variation in response times.

In the multivariate model, a one-unit increase in agency experience rank (0–1 scale) is associated with an 87-second reduction in chute time, while a one standard deviation increase corresponds to approximately a 15–16 second reduction in response time.

These results suggest that what is being captured is not simply exposure to a higher volume of calls, but the accumulation of experiential learning in the field. Through repeated exposure, responders learn to anticipate call demands, coordinate more effectively, and

$$\begin{aligned}\text{ResponseTime}_i = \beta_0 + \beta_1 \text{Top5PctAgency}_i + \beta_2 \text{InVehicle}_i \\ + \beta_3 \text{CallTypeFatigue}_i + \sum_k \beta_k \text{CallType}_{ik} + \beta_4 \text{Age}_i \\ + \beta_5 \text{COVID}_i + \beta_6 \text{Night}_i + \beta_7 \text{Weekend}_i \\ + \sum_r \gamma_r \text{Region}_{ir} + \sum_u \delta_u \text{Urbanicity}_{iu} + \varepsilon_i\end{aligned}$$

Model 1. Robust linear model.

$$\begin{aligned}\text{ResponseTime}_i = \beta_0 + \beta_1 \text{InVehicle}_i \\ + \beta_2 \text{CallTypeFatigue}_i + \sum_k \beta_k \text{CallType}_{ik} + \beta_3 \text{Age}_i \\ + \beta_4 \text{COVID}_i + \beta_5 \text{Night}_i + \beta_6 \text{Weekend}_i \\ + \sum_r \gamma_r \text{Region}_{ir} + \sum_u \delta_u \text{Urbanicity}_{iu} \\ + \alpha_{\text{agency}(i)} + \varepsilon_i\end{aligned}$$

Model 2. OLS with agency-level fixed effects.

initiate mobilization with fewer delays. We posit that these learned behaviors are not directly observed but are revealed in the timestamp data through faster and more consistent chute times, as illustrated in Figure 2.

Figure 2 illustrates the relationship between agency call volume and mean chute time. Each point represents an agency in the dataset. The relationship is nonlinear, with the largest reductions in chute time occurring at lower levels of volume with increasing returns giving way to diminishing returns at higher levels. There is also evidence of a tightening in the distribution of chute times at higher levels of agency volume, with fewer extreme values.

Figure 2 demonstrates that high-volume agencies aren't just faster, they are more consistent in their performance. Taken together, the figure provides visual evidence that accumulated exposure to emergency calls is associated with both faster and more predictable response times.

However, at the most extreme end of total call volume and agency experience, any additional exposure does not significantly impact response speed. Figure 3 presents a binned version of the relationship between agency call volume and mean chute time, helping to

Hypothesis	Variable	Model 1 Robust Linear Model	Model 2 OLS Fixed Effects
H1 Attributes of Responding Unit	Agency experience	-97.68*** (0.76)	—
H2 Truck Disposition at Dispatch	In Vehicle When Dispatched	-70.38***	-86.37***
H3 Call Type as Dispatched	Cardiac Arrest	-4.06*** (1.14)	-6.79*** (1.43)
H4 Call Type Fatigue	Falls	0.79 (0.67)	-1.06 (0.84)
	Respiratory	0.63 (0.66)	-1.666* (0.826)
	Sick Person	0.85 (0.62)	0.66 (0.78)
H5	Patient Age	0.032*** (0.005)	0.008 (0.007)
H6 Timing of Dispatched Response	COVID period	-1.12*** (0.23)	-0.27 (0.31)
H7	Night Response	17.87*** (0.29)	23.22*** (0.36)
H8	Weekend response	0.44 (0.25)	0.03 (0.31)
H9 Region: East is Reference Category	Western US	-16.25*** (0.35)	-2.62 (1.52)
	Southern US	3.61*** (0.30)	-3.73** (1.38)
	Western Plains US	-1.93*** (0.48)	—
	Great Lakes US	-5.13*** (0.40)	—
H10 Dispatched Location Type: Urban is reference category	Suburban area	10.57*** (0.50)	4.83** (1.85)
	Rural area	14.77*** (0.48)	13.14*** (1.69)
	Wilderness area	19.99*** (0.96)	17.30*** (3.46)
		(0.35)	(0.53)
	BIC	2,127,039	—
	Agency fixed effects	No	Yes (5,518 agencies)
	Observations	185,015	183,592
	RMSE	45.58	57.10
	R^2 / Adj. R^2	—	0.432
*Notes. Standard errors in parentheses. * p < 0.05, ** p < 0.01, *** p < 0.001. Maximum Variance inflation factors (VIFs) = 1.31, indicating no evidence of multicollinearity. For complete model estimation results, reference Appendix 1.*			

Table 4. Determinants of EMS chute time (seconds).

clarify the underlying pattern observed in Figure 2. Mean chute time declines sharply at lower levels of call volume, indicating that early increases in exposure yield substantial gains in mobilization speed. As call volume increases further, this relationship flattens, suggesting diminishing returns to additional experience.

This pattern is consistent with a learning curve: initial exposure to emergency response generates rapid improvements, while additional experience yields smaller, incremental gains. At the highest levels of call volume, the slight plateau suggests that operational constraints may limit further improvements in mobilization speed. Together, Figures 2 and 3 indicate that experience improves response performance, but that the marginal benefit of additional exposure decreases as agencies become highly experienced.

To further clarify this pattern, Figure 3 shows that mean chute times decline sharply at lower levels of volume and then flatten. Figure 4 turns to agency-level fixed effects to capture persistent differences in mobilization performance.

Figure 4 displays the estimated agency-level fixed effects, capturing persistent deviations in chute time across agencies after controlling for observed characteristics. The wide distribution of these effects—ranging from agencies that mobilize substantially faster than

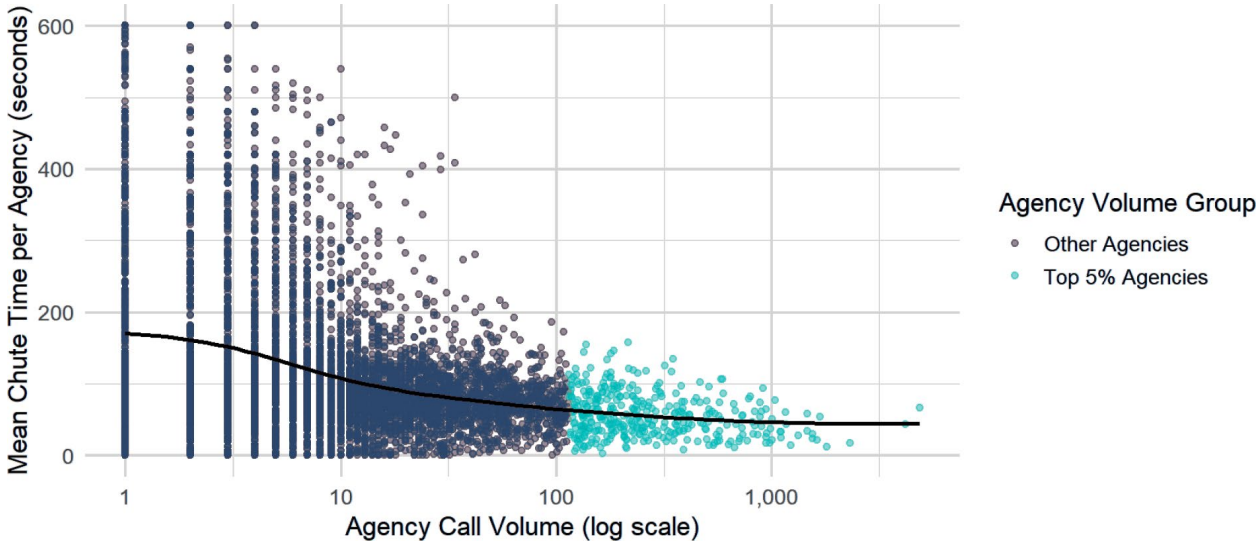


Figure 2. Agency volume vs. chute time.

Note: Each point represents an agency.

average to those that are consistently slower—reveals large and systematic differences in operational performance.

These differences are not explained by call characteristics, geography, or timing, but instead reflect underlying organizational factors such as routines, coordination practices, and institutional norms. In this sense, the fixed effects capture each agency's "operational signature"—a stable pattern of behavior that governs how quickly units mobilize. The magnitude of these differences suggests that organizational factors play a central role in determining EMS response speed. While experience contributes to improved performance, Figure 4 demonstrates that agencies differ in systematic ways beyond observable characteristics, reinforcing the interpretation that learned behaviors become embedded in agency-level culture over time.

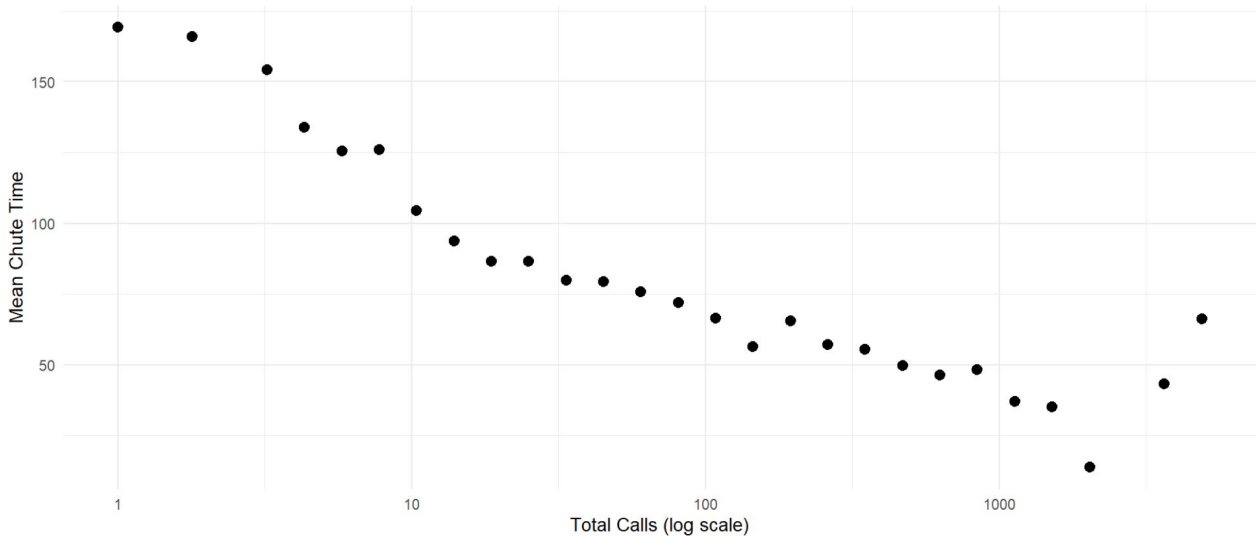


Figure 3. Binned relationship between volume and chute time.

Note: Points represent average chute time within bins of agency call volume (log scale).

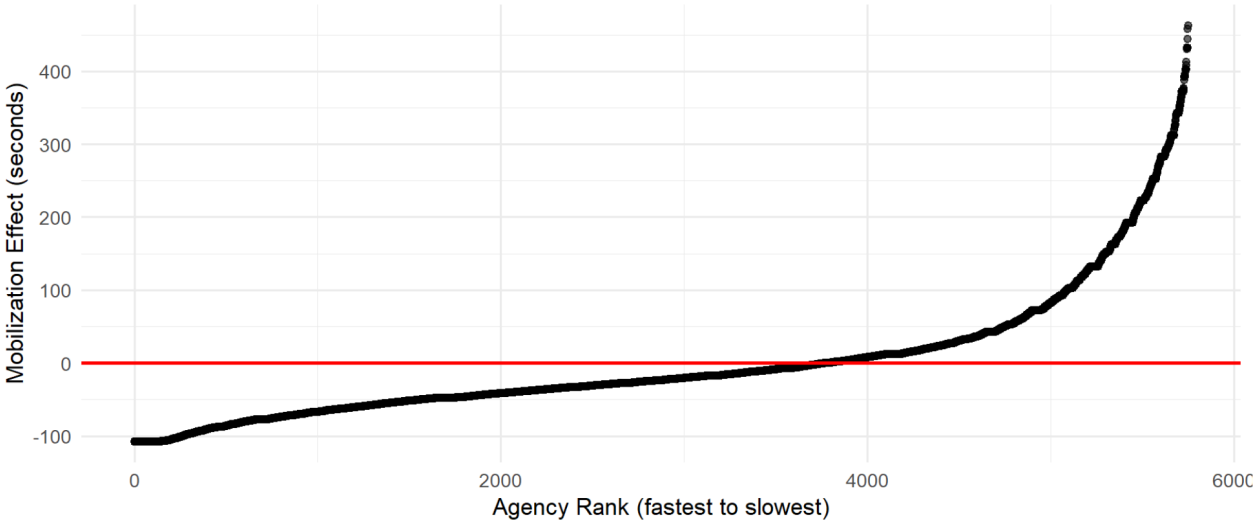


Figure 4. Agency-level fixed effects on chute time.

Note: Each point represents an agency's estimated deviation from the average mobilization time

To account for operational differences in unit status, an indicator is included for cases in which the responding unit was already in motion at the time of dispatch. An assumption was made that chute times that were exactly zero seconds in length represented in-vehicle status. This helps parse between call types in which the unit is at the station versus those already on the road. As expected, these observations are associated with substantially shorter chute times (approximately 70 seconds), reflecting a fundamentally different operational state rather than faster mobilization. Including this control improves overall model fit and helps more accurately assess other parameter estimates.

One assumes that high-volume agencies might be faster simply because they are more likely to be in the vehicle, clearing from the past call, than low volume agencies. Contrary to expectations, high-volume, high-experience agencies are actually substantially less likely to be in motion at the time of dispatch compared with everyone else, suggesting that their faster chute times are not driven by a greater reliance on immediate response, but instead are truly reflective of more efficient mobilization processes (Table 5).

Agency Experience	Unit in Motion at Dispatch = yes
Other Agencies	15.7%
Top 5% Most Experienced Agencies	8.7%

Table 5. Unit status at dispatch by agency experience level.

AGENCY-LEVEL FIXED EFFECTS

Beyond experience, agency-level fixed effects capture stable, agency-specific patterns of behavior that explain a substantial portion of the variation in the dependent variable. Approximately 27.9% of the global variation in EMS 911 chute times can be attributed to agency-level fixed effects. In a nutshell: organizations exhibit stable, characteristic patterns of behavior. Agencies operate differently and have their own distinct operational signatures, and these differences systematically explain a large proportion of response-time variation. Crucially, once agency-level fixed effects are included in the

model, many variables that appeared to have substantial independent effects across multiple model specifications no longer remain significant.

This model also finds that, when first responders are dispatched to a fall, respiratory call, or "sick person," Call Type Fatigue does not set in, nor does the presence of these call types have an impact on EMS chute times (in either direction). Likewise, the model finds no robust or statistically significant evidence for the impact of age on response times, nor does the COVID period appear to affect the speed of response. Additionally, there is no measurable difference between weekend responses and responses that take place during weekday hours. Compared with the Eastern US, while the South technically posts longer chute times, the differences are negligible (approximately 3 seconds). In short, regional variation does not meaningfully explain variation once agency-level differences are accounted for.

Urban areas exhibit faster chute times (approximately 4–20 seconds, on average) compared with their suburban, rural, and wilderness counterparts. These differences are statistically significant, robust across model specifications, and persist after the inclusion of agency-level fixed effects. EMS units also mobilize more quickly during daytime hours than during overnight periods, with delays of approximately 17–23 seconds observed at night.

Some evidence suggests that responders mobilize more quickly for certain high-acuity calls. In particular, cardiac arrest calls are associated with modest but statistically significant reductions in chute time (approximately 5–7 seconds). However, most other dispatch call types do not independently predict chute time once other factors are controlled for.

LIMITATIONS

This study has several important limitations. First, while efforts were made to restrict the analysis to 911 responses by specifically excluding routine and transport and administrative calls from the dataset, it remains possible that some non-emergency, prescheduled, or administratively oriented runs remain in the dataset. As such, some heterogeneity in call context may persist despite best efforts.

Second, experience is measured at the agency level rather than the level of the responding unit, using call volume as a proxy for experience. Further disaggregation to the unit level would provide a more precise measure but is not currently feasible given the scale and computational demands of the dataset.

Third, while agency-level fixed effects capture persistent differences across organizations, they do not identify the reason why, or help understand the specific causal mechanisms underlying these differences. Further research incorporating qualitative or operational data would be necessary to better understand how organizational practices, protocols, and constraints contribute to variation in response times.

An additional limitation of this study concerns the lack of detailed dispatch context within the NEMSIS dataset. The data do not distinguish between different types of call origins or operational workflows, such as whether a call was initiated through the 911 system or represented a pre-scheduled or administratively assigned event. As a result, the dataset cannot fully capture situations in which crews may report "en route" simul-

taneously, particularly for pre-scheduled movements or stacked assignments. These reporting patterns may produce artificially short recorded chute times that are more reflective of documentation practices rather than true mobilization behavior.

More broadly, "en route" timestamps may reflect differences in reporting practices across agencies, including local conventions or dispatcher-specific decision rules governing when units are marked as responding. These systematic reporting differences or individual decision-rules (i.e. "I've always just coded it that way…") may introduce measurement error that is not fully captured by observed variables and may instead be absorbed within agency-level fixed effects. While a control variable was introduced to account for cases in which units are already in motion at the time of dispatch, some degree of misclassification may remain due to the absence of a directly observed measure of unit status.

POLICY IMPLICATIONS

These findings highlight an important limitation in current EMS data systems: the inability to truly distinguish between units that are already in motion at dispatch and those that initiate mobilization from a stationary position. To partially address this, chute times equal to zero were assumed to represent units already in motion at the time of dispatch. However, explicitly recording unit status (e.g., in-vehicle vs. stationary) at dispatch would substantially improve measurement precision in future research. Because these operational states produce fundamentally different "chute time" profiles, future data collection efforts should explicitly record unit status at the moment of dispatch.

A simple modification—such as adding a structured field indicating whether a unit is "in vehicle and mobile," "at station," "in hospital," or "other" at the time of dispatch—would substantially improve the interpretability of EMS response time data. Improving timestamp granularity in this way would enhance both research validity and system-level performance monitoring, enabling more precise identification of operational inefficiencies and best practices across agencies.

CONCLUSION

In conclusion, this analysis demonstrates that EMS chute times are shaped far less by individual call characteristics—such as patient age or dispatched call type—than by the expertise that accrues as a result of repeated exposure to a vast array of unique and diverse 911 calls.

These findings point to a fundamental insight: response speed reflects not only the nature of the call, but the accumulated learning, anticipatory capacity, and confidence in execution of the responders themselves. As these capabilities develop over time, they become embedded in routines, coordination, and shared expectations, producing persistent differences in performance across agencies. Improving EMS response times, therefore, requires understanding how emergency response is practiced on the ground—insights best learned from those working in the field every day.

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APPENDIX. Determinants of EMS Chute Time (seconds): Full Model

Variable	Model 1 – Robust Linear Model	Model 2 – Fixed Effects
Allergic Reaction	-3.33* (1.39)	-1.48 (1.75)
Animal Bite	0.07 (2.92)	-2.81 (3.70)
Assault	-1.32 (1.17)	*-0.21 (1.46)*
Back Pain	3.26** (1.14)	*1.61 (1.43)*
Burns/Explosion	2.50 (3.27)	*-5.20 (4.16)*
Cardiac Arrest	-4.06*** (1.14)	*-6.79*** (1.43)*
Chest Pain	-0.97 (0.70)	*-1.61 (0.88)*
Choking	-1.23 (2.28)	*-3.57 (2.85)*
Diabetic	1.08 (1.09)	*-1.17 (1.37)*
Falls	0.79 (0.67)	*-1.06 (0.84)*
Fire	0.60 (3.38)	*6.09 (4.32)*
Headache	2.86 (1.54)	*2.32 (1.93)*
Heart Problems	3.43** (1.05)	*-0.89 (1.33)*
Heat/Cold Exposure	-5.58* (2.83)	*-9.85** (3.55)*
Hemorrhage/Laceration	-0.46 (0.93)	*-0.41 (1.16)*
Medical Alarm	4.40* (1.88)	*-0.65 (2.41)*
OBGYN	-1.41 (1.47)	*0.41 (1.82)*
Overdose	-2.09* (0.94)	*-2.81* (1.17)*
Pandemic	-7.35*** (1.99)	*0.70 (2.50)*
Psych	-3.82*** (0.82)	*2.71** (1.02)*
Respiratory	0.63 (0.66)	*-1.67* (0.83)*
Seizure	-2.27** (0.81)	*-3.95*** (1.02)*
Sick Person	0.85 (0.62)	*0.66 (0.78)*
Stabbing/GSW	-8.58*** (1.71)	*-0.40 (2.14)*
Standby	3.64 (2.53)	*-2.29 (3.22)*
Stroke	-0.74 (0.90)	*-4.01*** (1.13)*
Traffic Incident	0.34 (0.74)	*-2.61** (0.93)*
Traumatic Injury	-2.37** (0.88)	*-1.70 (1.11)*
Unclear	-0.99 (0.72)	*1.00 (0.96)*
Unconscious	-1.32 (0.74)	*-3.34*** (0.93)*
Unknown/Person Down	-2.36** (0.84)	*-1.97 (1.07)*
Well Check	-0.39 (2.27)	*-5.52 (2.92)*
Patient Age	0.032*** (0.005)	*0.008 (0.007)*
COVID period	-1.12*** (0.23)	*-0.27 (0.31)*
Night response	17.87*** (0.29)	*23.22*** (0.36)*
Weekend response	0.44 (0.25)	*0.03 (0.31)*
West region	-16.25*** (0.35)	*-2.62 (1.52)*
South region	3.61*** (0.30)	*-3.73** (1.38)*
Western Plains	-1.93*** (0.48)	—
Great Lakes	-5.13*** (0.40)	—
Suburban area	10.57*** (0.50)	*4.83** (1.85)*
Rural area	14.77*** (0.48)	*13.14*** (1.69)*
Wilderness area	19.99*** (0.96)	*17.30*** (3.46)*
Agency experience	-97.68*** (0.76)	—
In Vehicle When Dispatched	-70.38***	*-86.37****
AIC	2,126,573	—
BIC	2,127,039	—
Agency fixed effects	No	*Yes (5,518 agencies)*
Variance Explained by Fixed Effects	—	*27.9%*
Observations	185,015	*183,592*
RMSE	45.58	*57.10*
R^2 / Adj. R^2	—	*0.432*

Notes: Standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Variance inflation factors (VIFs) were examined. The maximum VIF was 1.31, indicating no evidence of multicollinearity. Reference categories were set to avoid multicollinearity: "East" was the reference category set for "region". "Urban" was the reference category for "urbanicity", and "Abdominal Pain/Problems" was the reference category selected for "Dispatched Call Type."

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RESEARCH REPORTS

ASSOCIATION BETWEEN STROKE CENTER AND COUNTY-LEVEL EMERGENCY MEDICAL SERVICES BYPASS POLICIES AND PROPORTION OF STROKE PATIENTS RECEIVING THROMBOLYTIC THERAPY

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ABSTRACT

Objective: Over the past two decades, numerous policy efforts have been made to improve management in acute stroke, including stroke center policy and EMS bypass policy. The effect of these policies on clinical outcomes such as thrombolysis are yet not understood on a national scale. Our objective is to identify the association between thrombolysis and stroke center policy, and furthermore, the synergistic effect of stroke center policy and EMS bypass policy on thrombolysis rates.

Methods: We conducted a retrospective observational study using a 20% national sample of Medicare beneficiaries diagnosed with ischemic stroke from 2007 to 2014. We estimated the difference-in-differences (DID) to determine the stroke center policy effect on thrombolysis rates, and to determine the stroke center and EMS bypass policy effect together on thrombolysis rates.

Results: Overall, counties that implemented a stroke center policy had a significant increase in thrombolysis compared to counties who did not have a stroke center policy (RR = 1.42, 95% CI [1.12, 1.80], p = 0.004) in the pre-policy period. There was no significant association in stroke policy counties with increasing thrombolysis rate in only the post-policy period compared to no stroke center policy counties. There was an increase in thrombolysis rate overall and in the post policy period among counties that implemented both an EMS bypass and stroke center policy compared to counties that did not implement any policy (RR = 1.48, 95% CI [1.19, 1.84], $p < 0.001$).

Conclusions: Counties with both stroke center policy and EMS bypass policy had significantly higher thrombolysis rates after policy implementation. This is likely the first analysis of the effect of stroke policies on thrombolysis using the largest ever national stroke database.

INTRODUCTION

Background

In recent decades, improvements in the management of acute stroke have led to numerous policy implementations. In 2000,

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the Brain Attack Coalition recommendations led to the establishment of comprehensive stroke centers that deliver specialized care including appropriate personnel, advanced neuroimaging capabilities, and appropriate intensive care infrastructure (Alberts et al., 2000). Subsequently, the Joint Commission began certifying primary stroke centers (PSCs) in 2003 (Uchino et al., 2015), and by 2022, 44% of United States emergency departments (EDs) were associated with stroke centers (Boggs et al., 2022). However, the clinical effect of these policies on the care of stroke patients is not yet fully understood on a national scale.

Importance

Some existing literature suggests that PSCs are associated with high thrombolysis utilization. For example, Mullen et al. (2013) identified high rates of intravenous thrombolysis at PSCs as compared to non-PSCs. Similarly, Meng et al. (2022) noted higher probabilities of intravenous thrombolysis use among patients treated at stroke centers. Man et al. (2017) found hospitals certified as PSCs between 2009 and 2013 had improved mortality rates compared to existing PSCs. Furthermore, new and existing PSCs have demonstrated improved mortality when compared to non-PSC hospitals (Man et al., 2017).

Multiple studies indicate pre-hospital factors greatly contribute to delays in the administration of intravenous tissue plasminogen activator (Amalia, 2023; Sharobeam et al., 2021) (a well-established yet highly time-sensitive treatment therapy (National Institute of Neurological Disorders and Stroke rt-PA Stroke Study Group, 1995)). Given that "time is brain" in acute stroke management, dedicated efforts enhance stroke care (in addition to stroke center policy) such as pre-hospital bypass policies in which emergency medical service (EMS) providers bypass the nearest hospital to instead go directly to the nearest certified stroke center were established. As such, the American Heart Association and American Stroke Association suggested establishing interactions within stroke systems of care, such as pre-hospital providers triaging patients to the highest level of care stroke center when multiple are available (Higashida et al., 2013). In addition to clinical outcomes of stroke center policy, the impact of interactions with EMS bypass policy and stroke center policy on clinical outcomes of stroke patients on a national scale is nascent.

Goals of This Investigation

In this study, we examine the independent effect of stroke center policy on thrombolysis (specifically tPA) utilization in stroke patients on a national scale. Furthermore, we describe the synergistic effect of EMS bypass policy and stroke center policy on proportion of thrombolysis utilization. We hypothesize that the presence of a stroke center policy and county-level pre-hospital bypass policy are independently associated with an increase in county-level thrombolysis usage, in addition to the synergistic effect of the two.

METHODS

Study Design and Setting

We conducted a retrospective observational study using a 20% national random sample of Medicare beneficiaries diagnosed with ischemic stroke using Medicare fee-for-service claims from 2007 to 2014. We accessed the following Medicare files for patient-level data: 1) Outpatient files for ED, 2) Carrier files for EMS claims, 3) Medicare Provider Analysis

and Review (MedPAR) files for aggregated inpatient claims, and 4) Master Beneficiary Summary File (MBSF) files for demographic data.

To construct hospital-level data and characteristics, we accessed the Provider of Services (POS) Current File. This quarterly updated database contains geographic and resource information for Centers for Medicare and Medicaid Services (CMS)-certified hospitals, including hospital characteristics. We added stroke center certification data from the certifying organizations (Joint Commission, Det Norske Veritas [DNV], Healthcare Facilities Accreditation Program [HFAP], and independent state-level organizations). These organizations would not provide historical data; therefore, we obtained the information using a non-profit resource (Internet Archive's Wayback Machine, web.archive.org) as well as direct contact with individuals at the American Heart Association and state-level certifying bodies.

To obtain and verify effective policy, we distributed a questionnaire to the EMS officials to obtain the effective policy dates, reviewed online protocols published on the state websites, and the dates mentioned in previous publications, and analyzed state law and compilations by the Centers for Disease Control and Prevention. Stroke center policy and EMS bypass policy were defined by the Westlaw Database definitions (Dunkley et al., 2024). Stroke center policy was defined as policy that expressly required or authorized hospitals or other health care facilities to hold themselves out as providing stroke care at a specified level. With regards to EMS bypass policy, this was defined broadly as any policy that authorizes or requires EMS providers to bypass the nearest local hospital and instead transport to the closest certified stroke facility. Most states had state-level policy, but a few had county-level policies and, therefore, the analysis was done at the county level. If policy was at the state level, it was assumed that the policy applied at the county level. An example of a state policy included in the supplemental materials, the Commonwealth of Massachusetts Circular Letter from June 2005, describes regulations regarding primary stroke services.

Selection of Participants

Our study population includes patients aged 66 years or older who received their initial care in the ED and were subsequently admitted through the ED with a primary diagnosis of acute ischemic stroke (International Classification of Diseases, Ninth Revision, Clinical Modification, ICD-9-CM: 433.x1, 434.x1, 436). We focused on the patient's first hospitalization for stroke observed in the study dataset. We restricted the cohort to patients with at least 12 months of continuous Medicare Part A or Part B enrollment before inpatient admission, to allow sufficient time to identify pre-existing medical comorbidities. Patients with Medicare Advantage plans were excluded to ensure we observed complete claims. The CMS, the Research Data Assistance Center (ResDAC), and the University Institutional Review Board approved the study (IRB 48353).

To evaluate the impact of stroke center and single-tier EMS bypass policies, which allow EMS providers to bypass the nearest hospital and go directly to a PSC, we restricted the population to those who used EMS to arrive at the hospital. Participants were identified using the Healthcare Common Procedure Coding System (HCPCS) codes in inpatient and carrier claims (HCPSC codes A0426-A0434). We excluded private transportation to the hospital and inter-hospital transfers. In Medicare databases, ED visits and subse-

quent hospitalizations are not linked by construct. Therefore, we linked inpatient records and prior ED visit(s) leading up to admission. Associated ED visits were captured if: 1) the MedPAR ED charge amount (variable ER_AMT was > $0 or 2) emergency services (Revenue Center Codes 045x) were reported in outpatient claims two days before the MedPAR inpatient admission date.

Measurements

Our team defined the pre-policy period as two years before the policy went into effect. This was deemed an adequate timeframe to capture a pre-policy period and pilot implementation with the gradual infrastructure and logistical changes that need to occur before an official policy implementation date. The post-policy period was defined as the year of policy going into effect and onward. An actual washout period was not excluded during policy implementation to assess the real world, continuous impact of implementation efforts. We identified policy counties (cases) with the policy in effect at any time from 2007-2014 and no policy counties (controls) without any policy in effect during 2007-2014. We also categorized counties with policies taking effect after 2016 as control counties and excluded counties that enacted policies before 2007. Finally, Rhode Island counties were excluded because it was the only state to implement a stroke policy in the year 2009, and there was no thrombolysis data available during the pre-policy period.

The county-level stroke center policy and the single-tier EMS bypass policy were both measured as ever vs. never. Time-based policy effect status was measured each year between 2007 and 2014. The primary independent variables in the analysis are: 1) stroke center policy, a binary variable indicating whether the patient resides in a county with a stroke center policy; 2) post-policy, a binary variable indicating whether the observation is from the pre- or post-policy period; and 3) the interaction term stroke center policy * post-policy. The secondary independent variables in the analysis are: 1) EMS bypass policy and stroke center policy, which includes a 4-level category that denotes whether counties had neither policy, one of the policies, or both; and 2) the interaction term EMS bypass policy * stroke center policy.

The Charlson Comorbidity Index (CCI) was used to assess patient comorbidity from one year before stroke hospitalization. We obtained patient-level demographic and clinical characteristics and categorized age, sex, and race/ethnicity variables. Patients were categorized into groups by age (66-75 years, 76-85 years, or 86 years), sex (female or male), and race/ethnicity (Asian, Black, Hispanic, Native American, White, Other, or Unknown). Race and ethnicity information was obtained from the Social Security Administration records and further refined by algorithms generated through the Research Triangle Institute (RTI). We constructed urban and rural classifications using residence zip codes from the MBSF files and census data. Using 2010 Census classifications, we defined zip codes with more than 50% of the population living in a rural area as "rural" and others as "urban."

We conducted descriptive analyses of all variables using summary statistics, counts, and percentages for categorical variables and mean and standard deviation for continuous variables (see Table 1).

	Total (N = 189,345) % (N)	Stroke Center Policy (n = 32,719) % (n)	No Stroke Center Policy (n = 156,626) % (n)
Age (N = 169,276)			
66 to 75	31.86 (53930)	34.28 (9946)	31.36 (43984)
76 to 85	40.39 (68367)	39.87 (11568)	40.49 (56799)
> 85	27.75 (46979)	25.85 (7500)	28.15 (39479)
Gender			
Female	57.32 (108537)	57.61 (18850)	57.26 (89687)
Male	42.68 (80808)	42.39 (13869)	42.74 (66939)
Race/Ethnicity			
Asian	1.24 (2355)	0.99 (325)	1.30 (2030)
Black	12.07 (22852)	12.56 (4108)	11.97 (18744)
Hispanic	2.45 (4641)	1.08 (355)	2.74 (4286)
Native American	0.50 (944)	1.51 (493)	0.29 (451)
White	82.31 (155844)	82.84 (27104)	82.20 (128740)
Other	1.20 (2278)	0.85 (278)	1.28 (2000)
Unknown	0.23 (431)	0.17 (56)	0.24 (375)
Charlson Comorbidity Index (CCI)			
1	10.56 (20004)	10.95 (3583)	10.48 (16421)
2+	89.44 (169341)	89.05 (29136)	89.52 (140205)
Inhabitance			
Urban	82.40 (156013)	77.74 (25437)	83.37 (130576)
Rural	15.98 (30256)	20.53 (6716)	15.03 (23540)
Unknown	1.62 (3076)	1.73 (566)	1.60 (2510)
Thrombolysis Usage	5.24 (9921)	5.24 (1713)	5.24 (8208)

Table 1. Patient demographics and clinical characteristics by stroke center policy status.

Outcomes and Analysis

We estimated the difference-in-differences (DID) to determine the stroke center policy effect on proportion of thrombolysis utilization. We calculated Zou's relative risk regression using Poisson GLM with a log link and generalized estimating equations with independent working correlation and robust standard errors (Zou & Donner, 2013). The outcome was proportion of IV tPA a county-level variable, where the numerator represented the number of patients receiving thrombolysis. The offset/denominator was all stroke patients. Independent variables included county-level policy and the post-policy indicator. The difference-in-difference term of interest is the interaction coefficient (stroke center policy * post).

In the DID model, the policy group (cases) was defined as those with an effective stroke policy (and no EMS policy) enacted during our study period, while the no policy group (controls) were those without an effective policy in place. We then conducted a per year pairing of policy and no policy counties by assigning a pseudo-policy year to the no policy counties that was the same as the policy counties (Zou & Donner, 2013). We repeated this process for each implementation year pairing policy counties with all no policy counties. For example, suppose that counties A and B implemented a policy in 2012, counties E and F implemented a policy in 2013, and counties C and D did not implement a policy during the observation period. In this example, counties C and D would serve as controls for all the counties who implemented a policy in 2012 and for all the counties who implemented a policy in 2013. To assess the effect of both EMS bypass policy and

stroke center policy on thrombolysis, we conducted a DID analysis that included counties that had both policies implemented to counties that did not have any policy between 2007 and 2014.

To ensure internal validity for the DID models and prevent biased estimation of the causal effect, we confirmed the parallel trends assumption using linear regression models by comparing pre-policy outcome trends between policy and no policy counties. We evaluated estimates at a significance level of $p < 0.05$. The analytic models were conducted in R 4.1.1 while all other analyses used SAS 9.4.

RESULTS

Our study included 284,452 hospitalized ischemic stroke patients from within the ED, which represented 4,745 hospitals from 3,142 counties in 50 states (including District of Columbia). There were 561 counties who implemented a stroke center policy and 432 counties that implemented an EMS bypass policy during the study period; there were 393 counties that implemented both (Figure 1).

There were 32,719 (17.28%) patients residing in a stroke center policy county and 156,626 (82.72%) in a no policy stroke center county (Table 1). There were 1,713 (5.24%) patients that received thrombolysis in a policy county and 8,208 (5.24%) that received thrombolysis in a no stroke center policy county. In our study, most patients were female (57.32%),

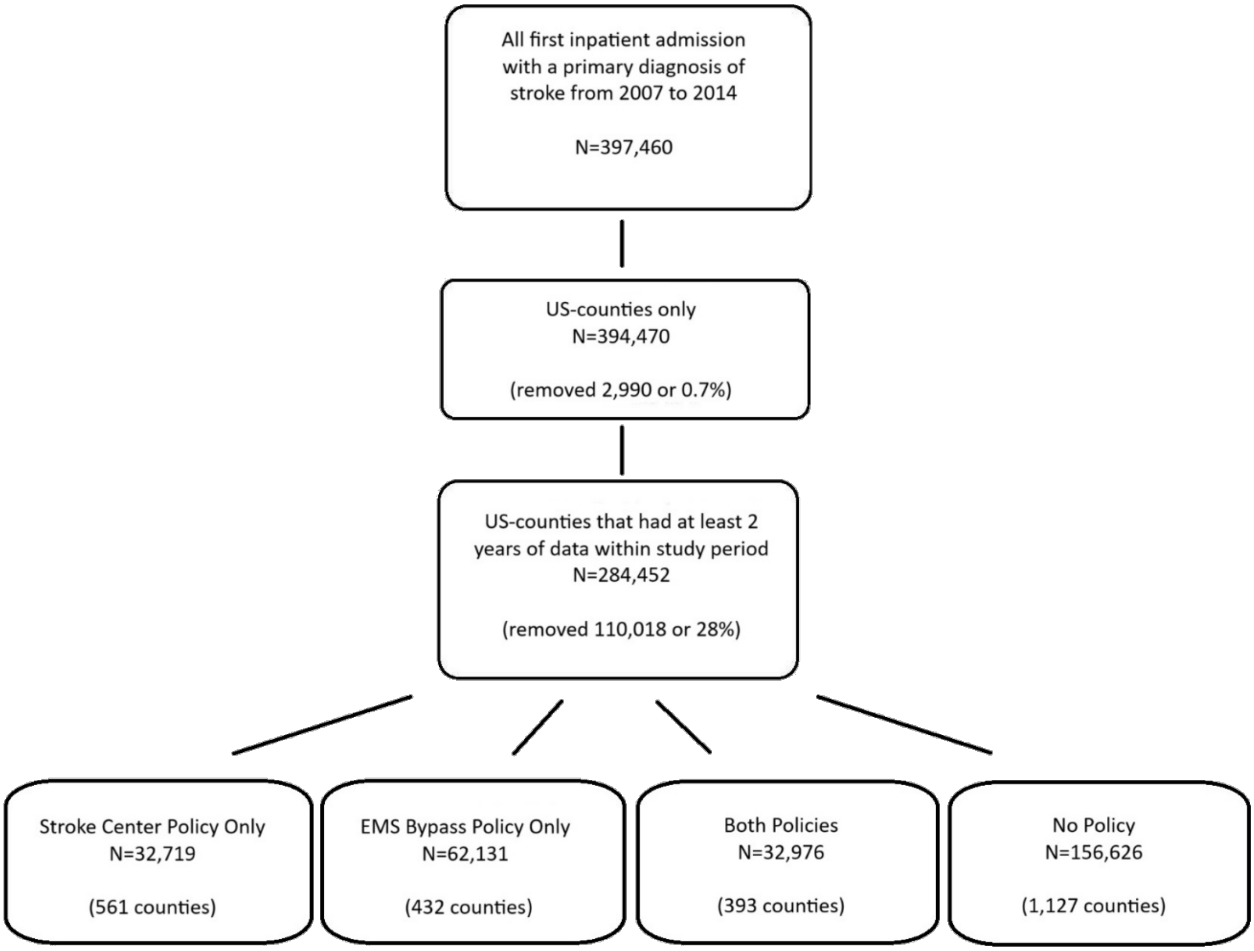


Figure 1. Study cohort.

White (82.31%), and between the ages of 76 and 85 (40.39%). Most patients also lived in an urban environment (82.40%) and had a Charlson Comorbidity Index (CCI) score of 2 or more (89.44%). When comparing policy and no policy counties, many patient demographics and clinical characteristics were similar. However, policy counties had less patients living in an urban setting compared to no policy counties (77.74% vs 83.37%, respectively).

Using inferential testing, we confirmed that the parallel trends assumption was met during the two-year pre-policy period ($p = 0.27$). In the primary difference-in-differences (DiD) analysis, counties that implemented a stroke center policy experienced a significant increase in thrombolysis during the two years preceding policy implementation ($RR = 1.42$, 95% CI [1.12, 1.80], $p = 0.004$). Thrombolysis utilization continued to rise across all counties during the post-implementation period ($RR = 1.17$, 95% CI [1.09, 1.25], $p < 0.001$). However, there was no significant difference in the rate of increase in thrombolysis use between stroke policy and non-policy counties during the post-policy period ($RR = 1.04$, 95% CI [0.76, 1.41], $p = 0.83$) (Table 2).
For clarity, the post-policy period interaction term estimates whether counties that adopted stroke center policy experienced greater change in thrombolysis rates after policy implementation compared to counties without a policy–to assess the added effect of the policy itself beyond pre-existing trends.

	Relative Risk of Thrombolysis Use (95% CI)	*p*-value
Stroke-Policy (ref=No Stroke Policy)	1.42 [1.12, 1.80]	0.004
Post-Policy (ref=Pre Policy)	1.17 [1.09, 1.25]	< 0.001
Stroke-Policy*Post-Policy	1.04 [0.76, 1.41]	0.826

Table 2. Modified poisson regression by stroke policy status and policy pre/post implementation.

For our secondary analysis, we observed trends between counties that had a stroke center and EMS bypass policy and compared them to those with no policy. There were 94,850 (37.72%) patients residing in a stroke center and EMS bypass policy county, while 156,626 (62.28%) patients resided in a no stroke center and EMS bypass policy county (Table 3). There were 4,918 (5.19%) patients that received thrombolysis in a policy county and 8,208 (5.24%) that received thrombolysis in a no policy stroke center county. Most patients were female (57.15%), White (80.46%), and between the ages of 76 and 85 (40.25%). Most patients also lived in an urban environment (83.00%) and had a Charlson Comorbidity Index (CCI) score of 2 or more (89.26%). When comparing policy and no policy counties, patient demographics and clinical characteristics were similar.

We observed an increase in thrombolysis utilization during the post-implementation period in counties that implemented both an EMS bypass policy and a stroke center policy, compared to counties without any policy implementation ($RR = 1.35$, 95% CI [1.00, 1.81], $p = 0.040$). Thrombolysis use also increased in the two years prior to policy implementation in these counties relative to those with no policy ($RR = 1.48$, 95% CI [1.19, 1.84], $p < 0.001$), and continued to rise in the post-policy period across all counties ($RR = 1.33$, 95% CI [1.23, 1.44], $p < 0.001$) (Table 4; Figure 2).

LIMITATIONS

Our data has several limitations. First, many of the counties in our database had zero proportion of thrombolysis, suggesting potential gaps in the dataset. Given thrombol-

	Total (N = 251,476) % (N)	Stroke Center + EMS Bypass Policy (n = 94,850) % (n)	No Policy (n = 156,626) % (n)
Age (N = 224,640)			
66 to 75	32.05 (72004)	33.21 (28020)	31.36 (43984)
76 to 85	40.25 (90423)	39.85 (33624)	40.49 (56799)
> 85	27.69 (62213)	26.94 (22734)	28.15 (39479)
Gender			
Female	57.15 (143725)	56.97 (54038)	57.26 (86987)
Male	42.85 (107751)	43.03 (40812)	42.74 (66939)
Race/Ethnicity			
Asian	1.98 (4979)	3.11 (2949)	1.30 (2030)
Black	12.63 (31766)	13.73 (13022)	11.97 (18744)
Hispanic	2.74 (6894)	2.75 (2608)	2.74 (4286)
Native American	0.48 (1205)	0.79 (754)	0.29 (451)
White	80.46 (202331)	77.59 (73591)	82.20 (128740)
Other	1.50 (3775)	1.87 (1775)	1.28 (2000)
Unknown	0.21 (526)	0.16 (151)	0.24 (375)
Charlson Comorbidity Index (CCI)			
1	10.74 (26997)	11.15 (10576)	10.48 (16421)
2+	89.26 (224479)	88.85 (84274)	89.52 (140205)
Inhabitance			
Urban	83.00 (208731)	82.40 (78155)	83.37 (130576)
Rural	15.20 (38233)	15.49 (14693)	15.03 (23540)
Unknown	1.79 (4512)	2.11 (2002)	1.60 (2510)
Thrombolysis Usage	5.22 (13126)	5.19 (4918)	5.24 (8208)

Table 3. Patient demographics and clinical characteristics by stroke center and EMS bypass policy status.

	Relative Risk of Thrombolysis Use (95% CI)	*p*-value
Stroke/EMS-Policy (ref=-No Stroke OR EMS Policy)	1.48 [1.19, 1.84]	< 0.001
Post-Policy (ref=Pre Policy)	1.33 [1.23, 1.44]	< 0.001
Stroke/EMS-Policy*Post-Policy	1.35 [1.00, 1.81]	0.04

Table 4. Modified poisson regression by stroke/EMS policy status and pre/post policy implementation.

ysis in general is quite low, small changes may exaggerate the effect of intervention. Furthermore, the quality of policy data is highly variable, and collected from multimodal sources. Survey data relies on response rate and is also subject to response bias. Bypass policy data in general differs in nature, execution, and enforcement nationally. Some counties had state-level policies dictating care, while others were county-level only. Additionally, our stroke data are limited. We were unable to adjust for many patient-level factors relevant to the administration of thrombolytic including stroke severity, comorbidities, and meeting of exclusion criteria, as the analysis was done on a county level. We also acknowledge the significant multifactorial approach to administration of thrombolytic that we cannot account for, including physician and staff resources, financial resources, drug availability, etc. Finally, the data set spans from 2007 to 2014, which may be less applicable to today's systems given the dynamic nature of stroke care over time. The data set is only a 20% random sampling, which, despite a resultant cohort of nearly 250,000 patients, still limits our relative sample size on a national level, and is only of Medicare patients, which limits the generalizability. Nonetheless, the breadth of data

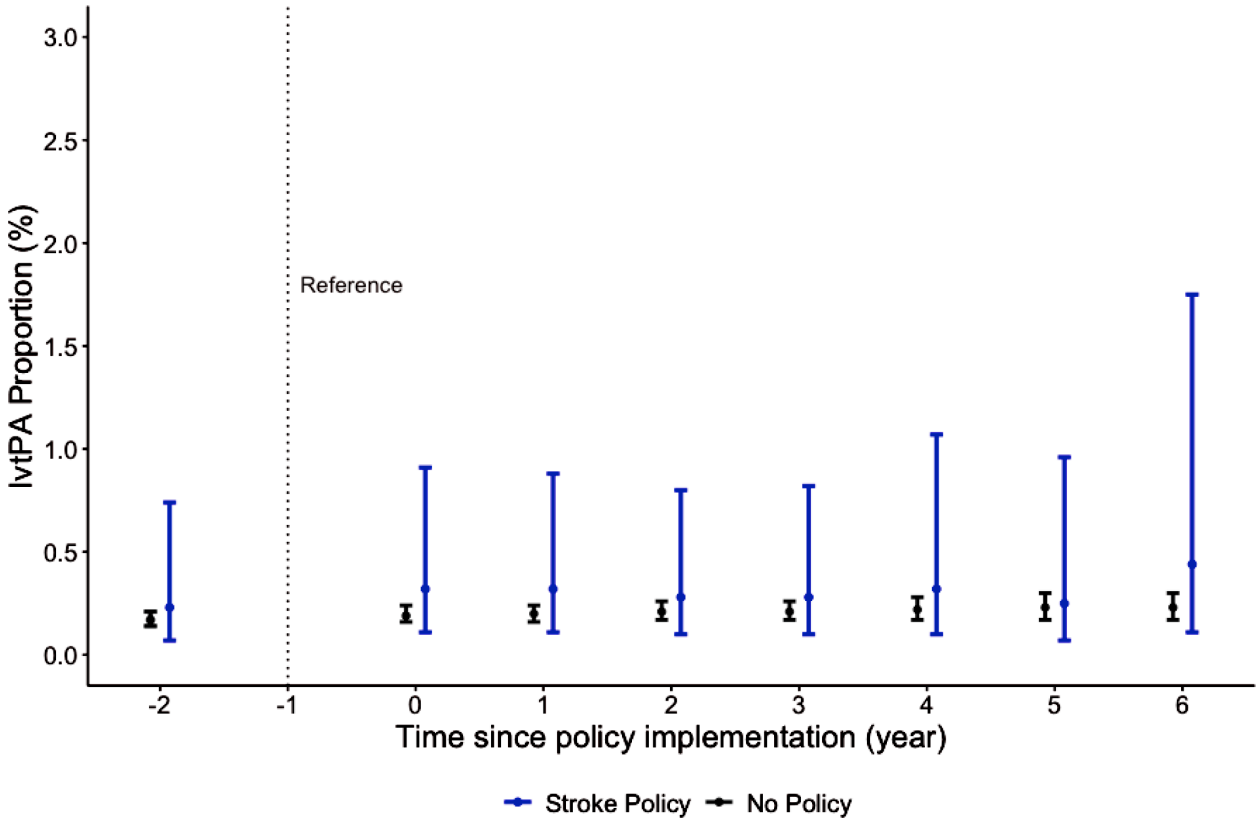


Figure 2. Proportion of IV tPA utilization by time since policy implementation (pre and post policy) by stroke policy status. Time 0 refers to the year that policy was implemented.

provides valuable insight into the possible synergistic effect of policies and subsequent clinical outcomes.

DISCUSSION

Our dataset, derived from the largest national stroke database of Medicare enrollees, is the first to assess the effects of stroke policy across the nation. Our findings suggest a significant increase in thrombolysis utilization in counties with stroke center policy. Specifically in the post-policy era, there were no independent associations with stroke center policy and increase in thrombolysis usage. Counties with both stroke center policy and EMS bypass policy had a significant increase in thrombolysis use, which was maintained in post-policy era.

Although the administration of thrombolytic is incredibly multifactorial, our data suggest that targeted policies encouraging EMS transport to designated stroke centers rather than local EDs increase the likelihood of a patient receiving thrombolysis. Furthermore, stroke centers, in general, have higher rates of thrombolytic use when compared to non-stroke centers, deriving directly from the certification process (Shkirkova et al., 2020), thus, targeted transfer of patients to these centers also likely improves thrombolysis utilization.

We identified that the post-policy era had an independent association with increase in proportion of thrombolysis use, irrespective of policy status (meaning both counties with and without stroke center policies had increases in thrombolysis utilization over time).

Our hypothesis is that even despite formal stroke center policy, there may have been a spill-over effect of the general national stroke center policy conversation and national emphasis on thrombolysis as a desired outcome in non-policy counties. This is in-line with existing literature suggesting an overall increase in thrombolytic administration over time, likely due to additional data regarding efficacy of thrombolytic, clinician comfort, and increasing hospital resources.

Although stroke center policy independently was not associated with an increase in thrombolysis in the post-policy era, when combined with EMS bypass policy, we identified a significant association, which suggests a synergistic effect when stroke center policy is combined with EMS bypass policy. A system-wide approach involving not only stroke center resources but also a focus on pre-hospital policy, education, and resources can clearly have a significant impact on patient-centered stroke outcomes.

We also found an increase in proportion of thrombolysis usage in policy counties prior to policy implementation. As policy making is not an immediate intervention (it requires extensive education, lobbying, and training before implementation), we are likely to see the effects of gradual onboarding prior to the exact policy date. Furthermore, many of our policy dates are estimates given lack of official data.

In general, our study period thrombolysis utilization was quite low. A variety of factors limit the use of thrombolytic, including poor public awareness of stroke systems, insufficient facility funding, and physician fear of legal liability (Bambauer et al., 2006), and the overall national thrombolytic administration rate remains extremely low (Kleindorfer et al., 2008). However, by precisely determining the most effective bypass policies at the appropriate level with systems of care, we can continue to optimize care for stroke patients.

Numerous strategies to improve thrombolysis utilization, including multilevel stroke education, pre-hospital acute stroke triage protocols, mobile stroke units, increased pre-hospital priority level for stroke, telestroke, and even less restrictive exclusion thrombolytic treatment criteria, have been met with varying improvements in thrombolysis rates (McDermott et al., 2019). Put into this context, our work suggests stroke center policy combined with county-level EMS bypass policy has the greatest potential to improve regional stroke care. Identification of county needs and barriers to thrombolytic administration may yield to a precision approach in improving stroke care. In stroke systems in which hospital resources vary widely, or pre-hospital care variations or delays are predominant, a stroke center and EMS bypass policy may be appropriate, whereas other stroke systems may have barriers in which this may not be effective.

This is the first analysis of the effect of stroke policy on thrombolysis using the largest ever national stroke database. Although national stroke policies have existed for decades and have widely been understood to improve access to stroke care, direct investigations on clinical outcomes of these policies such as thrombolysis have not been extensively studied, necessitating our work and driving its importance. Our findings highlight important trends and opportunities for further investigation, laying the groundwork for future studies that can include larger as well as more localized databases to continue to assess and monitor improvements in stroke care. Finally, we used data in the pre-thrombectomy period, allowing us to investigate a foundational association between initial stroke care and fundamental clinical outcomes of thrombolysis, which would not be as

feasible with contemporary data. Assessing this initial impact may be crucial to guide further policy implementation in the dynamic field of stroke care. Future studies will need to investigate the association of policy with thrombectomy rates, novel thrombolytics, and new advances in stroke management.

CONCLUSION

Stroke center policy alone was not independently associated with increased thrombolysis in the post-policy period. However, stroke center policy combined with single-tier EMS county bypass policies is associated with increased usage of thrombolysis when compared to non-policy counties, which is a pattern that is sustained over time. Continued work is needed at various levels to continue to monitor the effect of stroke policy and novel stroke management therapies.

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RESEARCH REPORTS

ACCEPTANCE AND PERCEPTIONS OF MOTHERS AND PROVIDERS ON PARAMEDIC-LED MIDWIFERY SERVICES IN MATERNAL CARE DESERTS

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ABSTRACT

Background: Maternal care deserts, characterized by limited or no access to essential maternity services, contribute to high maternal and infant morbidity and mortality rates. While emergency medical service and community paramedicine have expanded preventive and perinatal services in other countries, U.S.-based research on integrating paramedics into maternal health delivery remains limited, particularly in underserved areas.

Purpose: The purpose of this study was to explore the level of acceptance, perceived benefits, and challenges of paramedics providing midwifery-type services in maternal care deserts in the Commonwealth of Virginia. Specifically, we investigated the perspectives of expecting mothers and paramedics regarding the perceived acceptability of expanding paramedics' roles to address the growing maternal care crisis in underserved areas.

Methods: We used a qualitative phenomenological design and recruited participants through digital outreach and complete semi-structured interviews that lasted 30-60 minutes via Zoom. Interviews were recorded with consent and transcribed. The primary investigator analyzed data using thematic analysis with manual coding and codebook development.

Results: The study included 23 participants (12 paramedics, 11 mothers) from maternal care deserts in Virginia. Five themes emerged: acceptance, perceptions of paramedic-led midwifery (PLM), barriers, benefits, and implementation needs.

Conclusion: Paramedic-led midwifery is a community-supported approach to improving care in maternal care deserts. Findings underscore the need for enhanced training, policy change, and collaboration. With intentional implementation, paramedic-led midwifery holds promise as a model to advance maternal health equity in underserved U.S. regions.

INTRODUCTION

Maternal care deserts (MCDs), regions where maternity care services such as obstetricians, midwives, and birthing centers are scarce or nonexistent, pose a substantial challenge to maternal and infant health in the United States. MCD areas disproportionately affect low-income, rural, and racially marginalized populations. According to the March of Dimes (n.d.), 6.9 million women of childbearing age live in counties with limited or no

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maternity care, and 2.2 million reside in complete care deserts in the United States. These shortages correlate with significantly elevated rates of maternal and infant morbidity and mortality (Wallace et al., 2021).

Historically, midwives have served as the cornerstone of maternal health care, especially in communities lacking formal medical infrastructure. Yet their role was systematically undermined in the 20th century through restrictive legislation and racialized campaigns that marginalized Black and immigrant midwives (Goode, 2015; Vedam et al., 2018). Although there has been a resurgence of midwifery-led care due to its demonstrated benefits, including reduced cesarean rates, lower intervention use, and increased maternal satisfaction, there remains a severe shortage of providers to meet growing demands (Combellick et al., 2023; Homer et al., 2014).

Paramedics, in contrast, represent a more widely available workforce, with over 289,000 credentialed providers nationwide, compared to approximately 14,000 midwives (Cash et al., 2022; American College of Nurse-Midwives, n.d.). Paramedic integration into maternal care is supported by evidence demonstrating their ability to manage high-risk deliveries, provide life-saving care during out-of-hospital births, and support home-based interventions (McLelland et al., 2016; Strózik et al., 2023). In global contexts, particularly low- and middle-income countries, community-based care delivered by paramedical professionals has led to measurable improvements in maternal and neonatal outcomes (Gupta et al., 2023). Specific evidence on expanded scope in the United States is lacking, but similar programs in other high-income countries such as the United Kingdom, Australia, and Canada have shown promise in improving overall system performance and patient outcomes (Brigham et al., 2013).

Emerging health policy acknowledges the need for innovative care models to address maternal health disparities. The Biden-Harris Administration's 2022 blueprint for maternal health highlights the importance of expanding and diversifying the perinatal workforce, explicitly encouraging non-traditional solutions for underserved regions (The United States Government, 2024). Concurrently, community paramedicine programs have proven effective in addressing chronic and acute health conditions in disadvantaged populations when adequate training, oversight, and governance are in place (Lunn et al., 2024; Shannon et al., 2022). The Virginia Department of Health (2025) has acknowledged the potential need for expanded care through community paramedicine roles and developed guidelines for any agency wishing to adopt such programs. Signaling an understanding for expanded roles for EMS services in the Commonwealth. Despite policies supporting change and a current paramedic model that provides community-focused care, research on paramedics' role and ability to fill the gaps in maternal health care remains limited, particularly regarding long-term, non-emergent support aligned with a midwifery model.

Understanding the social, emotional, and clinical acceptability of this model requires examining the lived experiences of potential patients and providers. Studies emphasize the importance of cultural competency, trust, and continuity of care when implementing new health care roles in communities with existing disparities (Hansen et al., 2023; Jomeen et al., 2020). Without stakeholder buy-in, particularly from mothers and frontline paramedics, even well-intentioned care expansions can falter. Therefore, this research sought to fill a critical gap in understanding the acceptability of paramedic-led mid-

wifery (PLM), defined as paramedics acting in a scope more aligned with midwifery for out-of-hospital births in MCDs.

The purpose of this qualitative, phenomenological study was to describe the perceptions, experiences, and acceptance levels of mothers and paramedics regarding expanded roles in maternal care. The purpose was accomplished by addressing two research questions. First, what is the level of acceptance among expecting mothers regarding paramedics providing midwifery services in maternal care deserts (MCDs)? Second, what are the perceived benefits and challenges of paramedics providing midwifery services in areas lacking maternal care?

The research used semi-structured interviews conducted with paramedics and mothers living or working in maternal care deserts. The objectives of this research were to: (a) assess maternal acceptance of receiving perinatal care from paramedics; (b) evaluate perceptions of paramedic readiness to provide such care; (c) identify anticipated benefits and concerns from both provider and patient perspectives; and (d) offer actionable insights to support policy development, training, and implementation.

With maternal mortality rates in the United States reaching 32.9 deaths per 100,000 live births and nearly 80% of these deaths deemed preventable, innovative care models and enhanced training are imperative (CDC, 2022; CDC, 2022b). Paramedics already possess foundational training in many of the emergency scenarios that contribute to maternal deaths, such as hemorrhage and hypertensive crises. Expanding paramedics' scope through targeted maternal health education and coordinated care efforts could transform outcomes in underserved areas. This study aimed to guide future research and inform policy on bridging maternal health disparities by harnessing an existing yet underutilized workforce.

METHODS

This study employed a qualitative phenomenological design to explore the acceptance, perceived benefits, and challenges associated with paramedics providing midwifery-type services in MCDs in the United States. The aim was to gather in-depth insights into the lived experiences and perceptions of paramedics and mothers residing in underserved areas with limited access to maternity care. A purposive sampling strategy was used to recruit 23 total participants with 20 participants meeting eligibility criteria and fully completing the study. The 23 participants included two key groups: certified, actively practicing paramedics in MCDs and mothers who were currently pregnant or had given birth within the past six months while residing in designated MCDs. The study employed a pragmatic approach to sample size, which was determined by the time constraints of the data collection period. Data collection was bounded by a ten-week recruitment window. Participants were accepted only if they met all inclusion criteria. The inclusion of two stakeholder groups also made it possible to achieve data source triangulation which allowed comparison and integration of perceptions across paramedic and maternal participants. Additionally, multiple analyst triangulation was conducted between the researchers to strengthen trustworthiness of the results.

Inclusion criteria for paramedics required that participants be at least 18 years of age, certified at the state or national level, and actively working or volunteering in MCDs. Mothers were eligible if they were 18 years or older, pregnant or postpartum within six

months, and had lived and delivered in one of the identified MCDs. Participants were recruited through digital flyers, social media posts, and emails to EMS agencies, birth centers, and doula service providers. This method provided broad reach but does invite some bias through recruitment as only those with access to the recruiting information would be able to participate, potentially leaving out participants without access to internet services or ability to obtain birth services from doulas or midwives who received the study information.

Data Collection and Analysis

Data were collected through individual semi-structured interviews conducted via Zoom or, if necessary, in person at approved locations. Interviews lasted between 30 and 60 minutes and were audio- and video-recorded with participant consent. Prior to the interview, participants were provided with digital consent forms outlining the study's purpose, procedures, and confidentiality measures. Verbal consent for participation and written consent for recording was obtained. All participants were required to verbally confirm their eligibility based on the inclusion criteria for their group before interviews began. An interview guide tailored separately for paramedics and mothers was used to explore perceptions of training, readiness, benefits, barriers, and community acceptance of paramedic-led midwifery services. Throughout the interviews, member checking was conducted to ensure the accuracy of the findings. A thematic analysis approach was used, with initial coding conducted manually by the principal investigator. After the first several interviews were coded, a preliminary codebook was developed that organized emerging codes into defined categories. The codebook included code identification, theme, subtheme, definition, and corresponding quotes from the interviews. As additional transcripts were analyzed by the primary researcher, new codes were added when novel concepts emerged, overlapping codes were refined, and previous codes were revisited to ensure consistent application of defined themes and sub themes. This was used as a basis for the final codebook allowing for systematic categorization of recurring ideas and concepts. To enhance analytic rigor, the secondary researcher independently reviewed the codebook and subset of coded transcripts to ensure alignment between coded data and thematic interpretations. Discrepancies were discussed and the codebook was refined accordingly. This process continued until thematic saturation was achieved and no new codes emerged. The study received approval from the necessary institutional review boards and is under the Exempt Protocol #2024-208 for A.T. Still University. All study activities were designed to minimize risk and ensure confidentiality and safety of participants.

Although themes included discussion of potential logistical and structural barriers, the study was designed to explore perceived acceptability as opposed to evaluating objective feasibility. No formal assessment of workforce capacity, reimbursement options, scope-of-practice constraints, or health system infrastructure was conducted. The following results and conclusions from this research are therefore limited to informed perceptions from participants.

Reflexivity Statement

The first author brings doctoral-level training in health sciences and professional work in paramedicine. This orientation informed the conceptualization of the study. Awareness

of potential predispositions towards workforce expansions as a solution to care deserts prompted deliberate reflexive practice through the study. This was achieved through reflexive reviews to examine how professional identity, advocacy, experience, and assumptions about access barriers could shape interview dynamics and thematic interpretation. The reviews were conducted by the second author, who is a research methodologist with broad background in health sciences research and no specific experience in paramedicine. To further ensure findings were reflective of participant perspectives rather than normative commitments, peer debriefing was conducted throughout the study design and analysis.

Demographics

This qualitative study included a total of 23 participants (12 paramedics and 11 mothers) across MCDs in Virginia following exclusion of three participants due to eligibility or technical issues causing the interviews to be incomplete. Prior to data analysis, three participants were excluded due to persistent internet connectivity issues that prevented the completion of major portions of their interviews. While the remaining data yielded rich thematic insights, the exclusion of these participants represents a minor loss of data that could potentially impact the overall results or narrow the scope of the findings.

The paramedic group consisted of 12 participants ranging in age from 23 to 37 years, with a mean age of approximately 27.4 years. Two identified as female and 10 as male. All paramedics reported providing care in U.S. state counties classified as MCDs per the March of Dimes (n.d.), with Charles City, Virginia being the most represented location (n = 2). Paramedics reported sample-specific demographics, including years as a medic, additional maternal care training, care provided in other MCDs, and familiarity with a midwife. Paramedic participants had between 1 and 8 years of field experience, with an average of 2.75 years. Of the 12 paramedics, only three paramedics reported receiving additional maternal health training beyond standard certification requirements. All participants in the paramedic category reported familiarity with midwifery roles. Demographics for each paramedic can be found in Table 2 (in Appendix) and additional breakdown of study participant distribution can be found in Figure 1.

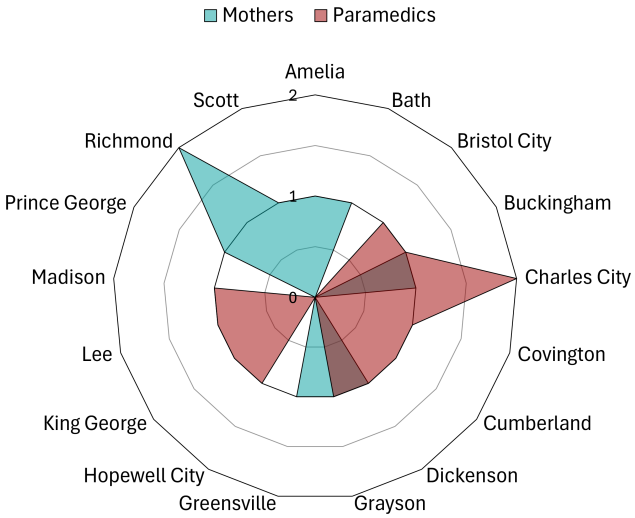


Figure 1. Distribution of study participants across counties in Virginia. Note: Mothers (teal) and paramedics (red) were recruited from multiple maternal care deserts with overlap in locations such as Buckingham and Charles City.

The maternal group included 11 participants, all of whom identified as female and were between the ages of 26 and 35, with a mean age of 28.7 years. All mothers resided in MCDs, with Richmond being the most represented location (n = 2). Specific demographics collected for the maternal group were pregnancy status; number of children; if they saw a provider regularly during pregnancy; what type of provider they saw; if they were

familiar with paramedics; if they had used 911 during their pregnancy; if they experienced birth complications; and their distance in miles or minutes from the nearest maternal care provider. Out of the 11 maternal participants, none were currently pregnant, but all had given birth within the previous six months. Seven mothers saw a provider on a regular basis while four did not. Five of those women saw midwives, one saw a doctor, and one sought care from multiple types of providers. Each participant from the maternal group noted they were familiar with paramedics, and nine used emergency medical services during their pregnancy. Four of the eleven mothers mentioned they had some sort of complication during their most recent birth. Maternal travel time to the nearest provider ranged from 10 to 110 minutes, with the average travel time estimated at 47 minutes. These metrics illustrate the reality of maternal care access challenges in MCDs. Demographics for each mother can be found in Table 3 (in Appendix) with additional breakdown of maternal study participant distribution can be found in Figure 1.

RESULTS

Five major themes were identified across participant groups: (1) Acceptance, (2) Perceptions of PLM, (3) Barriers, (4) Benefits, and (5) Perceived Needs for Implementation. Within several of the themes, various subthemes were identified, each supported with quotes and organized in thematic tables to provide direct insight into participant perspectives found in Tables 4 through 7 (in Appendix). Additional exemplar quotes can be found in Table 1.

Theme 1: Acceptance of Paramedic-Led Midwifery

Three subthemes emerged: community acceptance, competence and training, and demographic/cultural factors. Participants valued PLM for addressing maternal care gaps, but acceptance depended on trust in clinical skills and sensitivity to cultural and language differences. Each stakeholder group showed a high level of perceived acceptance for programs to enhance maternal care in their region and both groups agreed that cultural awareness would be critical for acceptance.

> *"I believe the community will respond perfectly if they're being equipped with the right information… they'll be much appreciative." (Paramedic 3)*
>
> *"It's like they're bridging a gap between me and where the health facility is." (Mother 4)*
>
> *"Maybe something like I talked about cultural differences. Some don't have that cultural understanding, so they might not be able to understand the mother." (Mother 13)*
>
> *"Yeah, I've had issues of stereotype, ethnic minority discrimination being talked down on or excused of duty because they feel you're not competent enough." (Paramedic 3)*

Theme 2: Perceptions of Paramedic Roles in Maternal Care

Two subthemes were identified: perceptions of paramedics providing PLM and perceptions of mothers receiving PLM. Paramedics described maternal care as a fulfilling extension of their role, while mothers noted value in expanded maternal care support. Almost all paramedics had positive perceptions towards their current or future ability to provide maternal care. In contrast, mothers were more wary in the ability of paramedics to provide enhanced maternal services and noted issues with trust. Additionally, moth-

ers noted that their perceptions would be shaped by the training and services provided from paramedic providers.

"We play a crucial role especially in places that weren't really prepared for delivery." (Paramedic 7)

"They respond very well... we have a lot of resources, and we are capable and well trained. So they trust us a lot." (Paramedic 12)

"Their quick response was lifesaving…" (Mother 7)

"I would be moderately comfortable because I don't really, really trust them." (Mother 6)

Theme 3: Barriers to Implementation

Five subthemes emerged: financial/resource constraints, training gaps, logistical challenges, cultural/communication issues, and systemic/policy barriers. Both groups cited cost, limited training, logistical hurdles, and restrictive policies as major obstacles to PLM adoption. There was variation in what was considered a financial barrier with mothers noting affordability of services as a major barrier while paramedics indicated that their own compensation is a barrier to providing, and afford training for, enhanced services.

"One of the barriers are high cost of these trainings and also limited opportunities...I think some paramedic, I think some paramedic in some cases paramedic needs some certain kinds of license and training to be able to perform some certain aspect of midwife care." (Paramedic 12)

"Some patients cannot afford ambulance services, and these delay their cause for help." (Mother 5)

"We do not have many paramedics with in-depth maternal care knowledge, and that is a problem." (Paramedic 6)

"I would say the challenge or the limitation would be to the scope of practice. Like I said at first, they are not expertise in that period. They only have an elementary knowledge about it. So the scope of practice is a major constraints because they limit their ability to provide certain aspect of care to the pregnant mother." (Mother 9)

Theme 4: Benefits of Paramedic-Led Midwifery

Two subthemes were prevalent: improved access and enhanced patient experience. PLM was seen as a potential way to bridge distances to care for and provide emotional reassurance during vulnerable times. Additionally, both groups noted emotional and educational benefits for mothers if PLM were to include proactive care models.

"Paramedics can deliver prenatal checkups in their remote areas." (Mother 6)

"Paramedics can be part of a maternal health education, fitting expectant models and being proactive" (Paramedic 8)

"They should go to different places in the desert and try advising and providing maternal care to people who are not around the hospital area." (Mother 5)

"They provide emotional support to mom, make sure that they don't feel scared... we try to tell them everything is going to be okay." (Paramedic 9)

"They really supported me emotionally and their transport was appropriate." (Mother 7)

Theme 5: Perceived Needs for Sustainable Implementation

Participants emphasized training, collaboration, policy reform, and outreach. They stressed that adequate preparation, interprofessional partnerships, and public awareness are essential for lasting acceptance. Mothers also noted an increased need for collaboration across the maternal care continuum for enhanced acceptance of such models. Paramedics focused on the need for specialized training as it relates to maternal care.

“Specialized training will give patients more confidence.” (Paramedic 2)

“They need support from the community… without training and resources they won’t implement it effectively.” (Mother 1)

"I feel that there should be that collaboration between midwives and other, maybe even the nurses" (Mother 13)

	Key Codes	Exemplar Quotes
Acceptance	• Demographic / Cultural • Competence & Training	"If you create an environment where you accommodate everyone, it's going to be smooth... I need that rapport." (Mother 13)
		"We are trained to manage the delivery... ensuring that mothers and babies are safe and providing initial newborn care." (Paramedic 8)
Perceptions of PLM	• Paramedics Providing PLM • Mothers Receiving PLM	"It opens up more purpose for us in EMS... not just trauma and transport." (Paramedic 6)
		"Yeah, it could have helped me a lot because I actually have wound and trauma... I wish I called." (Mother 14)
Barriers to PLM	• Cultural • Logistical / Operational • Policy	"Paramedics sometimes have this attitude like they discriminate... because of my color that discriminates me." (Mother 6)
		"I've had issues of stereotype, ethnic minority discrimination and all of that..." (Paramedic 3)
		" Initiatives like community paramedicine or mobile integrated health... would help go a long way." (Paramedic 13)
Benefits of PLM	• Care Access • Patient Experience	"They could help in enhanced patient experience... provide a more personalized and supportive experience during pregnancy and postpartum." (Mother 10)
		"Paramedics are quite beneficial for mothers who might have to move quite some distance... they would help to stabilize everything that needs to be in place." (Paramedic 6)
Perceived Needs	• Needs for Implementing PLM	"I think a little more support from the community and government." (Paramedic 12)
		"There should be a community program... maybe a service sometimes free of charge, like a community service for people." (Mother 9)

Table 1. Additional exemplar quotes from various participants.

DISCUSSION

Maternal care deserts (MCDs) continue to pose a critical threat to maternal and infant health in the United States, disproportionately affecting rural and underserved communities. In these areas, the absence of obstetricians, midwives, and birthing centers contributes to preventable deaths and poor health outcomes. While midwifery and doula care have long been proposed as partial solutions, there remains a gap in emergency and longitudinal maternal services (The United States Government, 2024) that this study explored using PLM as an innovative response to fill that gap.

The themes revealed in this study suggest a strong community openness alongside systemic barriers to PLM adoption. While prior literature has emphasized the value of

midwifery, this study uniquely explores how EMS providers, who are already embedded in communities, perceive the potential implementation of enhanced training in maternal care. The findings suggest that with proper training, policy support, and interdisciplinary collaboration, providers and mothers are open to PLM models and feel they could become a viable, culturally responsive solution to one of the most pressing public health disparities in the United States. This study found that participants broadly supported expanding the paramedic role to include midwifery-aligned services, particularly in contexts where traditional maternal care is limited or nonexistent. Community acceptance appeared closely tied to perceptions of clinical competence and prior trust in EMS.

These findings align with Combellick et al. (2023), who emphasized the relational strengths of midwifery-led care, and Gupta et al. (2023), whose systematic review showed significant improvements in maternal outcomes when paramedical professionals delivered community-based perinatal care. The study also confirms previous research by McLelland et al. (2016) and Strózik et al. (2023), which showed the effectiveness of EMS in supporting out-of-hospital births. However, this study extends the literature by focusing specifically on U.S.-based MCDs in Virginia and incorporating perspectives from paramedics and mothers. Findings from Hansen et al. (2023) and Crear-Perry et al. (2021) are especially relevant, reinforcing the need for culturally responsive care and stakeholder inclusion in maternal health planning.

Barriers, Opportunities, and Policy Pathways for PLM Implementation

While PLM was perceived by both interview groups to hold significant promise, participants identified several barriers to its adoption, including financial constraints, inconsistent training, logistical challenges, cultural and communication gaps, and restrictive policies. Paramedics cited low pay and inadequate resources as critical obstacles, while mothers expressed skepticism about provider preparedness beyond emergency management. Both groups emphasized the need for culturally competent care, echoing systemic issues documented by Greenaway (2019) and Heys et al. (2022) regarding perceived EMS readiness and regulatory inconsistencies across states. Within the narratives provided for the study, perspectives diverged on professional and emotional drivers as they related to the perceived practicability of this potential service enhancement. Paramedics tended to emphasize competence-recognition loop where their perceived success of an implemented PLM program was contingent upon rigorous specialized training, professional appreciation, and the assurance of skills to patients. Paramedics also emphasized that regulatory entities would need to provide set guidelines and training requirements or certifications before a PLM style service could be offered. They also focused on the need for the government to ensure any such program was covered by future initiatives that would allow reimbursement for "treatment in place" (Castillo et al., 2026). In contrast, mothers prioritized a more relational-experiential, valuing convenience, comfort, and integrated care model with midwives to increase viability of implementing PLM models in Virginia. Significant tensions emerged around systemic barriers with both groups identifying cultural disconnects, language barriers, and racial discrimination as critical inhibitors to trust. Furthermore, while paramedics advocated professional incentives and international training to solidify their role, mothers expressed a more cautious view of paramedics' scope of practice, suggesting that while their current emergency skills were invaluable for crisis situations, they must remain integrated with traditional midwifery and obstetrics to ensure comprehensive maternal care.

Despite these challenges, participants highlighted clear opportunities, particularly in remote and underserved communities where timely access, emotional support, and early intervention could improve maternal outcomes. These perspectives align with international evidence on the benefits of paramedic involvement in maternal care (Gupta et al., 2023; McLelland et al., 2016) and reinforce the role of paramedics as trusted, embedded community caregivers. Furthermore, while evidence on U.S. based programs is lacking, studies focused on Zanzibar indicated Mobile Integrated Health (MIH) models were highly successful for maternal care (Battle et al., 2015), a positive outlook for the feasibility of similar programs if adopted in the United States. In contrast, the implementation of a specialized PLM model faces systemic challenges that mirror the broader barriers identified in the adoption of other Mobile Integrated Health initiatives. Specifically, financial- and policy-based obstacles such as those highlighted by O'Conner et al. (2024) citing the lack of national licensure standards and dedicated reimbursement structures often causes insurers to view similar community-based interventions as "additional costs" as opposed to mitigation or "replacement costs."

To translate the opportunities noted in the study into practice, standardized maternal health training should be integrated into EMS education. State agencies should review and expand EMS scope-of-practice regulations for maternal health in MCDs, while federal agencies such as HRSA could target MCDs for PLM pilot programs using geographic mapping tools. Funding models like the Teaching Health Center GME program (Bureau of Health Workforce, n.d.) and Maternity Care Target Area initiatives (Topmiller et al., 2023) could be adapted to support training and service delivery. Finally, public awareness campaigns developed in partnership with midwives and doulas can build trust and normalize paramedic-led maternal care in communities where traditional services are scarce.

Limitations and Recommendations for Future Research

Limitations of this study include its geographic focus on Virginia, a small and gender-skewed sample, recruited primarily from digital platforms. This strategy had the potential to introduce selection bias, potentially underrepresenting individuals who lack reliable internet connection or internet available technology. While the findings indicated a conditional openness to the concept of PLM, this study captured perceived acceptability and conceptual promise rather than operational feasibility. The lack of data from additional stakeholder groups such as midwives, obstetric providers, and policy makers prevents a holistic understanding of whole system barriers to implementation. Additionally, limitations are noted in the availability of reference to similar programs either in Virginia or across the United States.

While PLM introduces an innovative service delivery model for bridging care gaps, it currently functions as a nascent clinical proposition that requires further formalization of its regulatory and governance parameters. Research into exploratory perceptions has the opportunity to transition into implementation science, utilizing multi-site or national designs to assess clinical safety, reimbursement pathways for sustained programs, and regulatory hurdles. Incorporating additional stakeholder voices and defining clinical standards will be essential. Simulation-based training models, legal analysis of scope expansions, and cost-effectiveness assessments would also strengthen the evidence base. This research underscores the potential of EMS providers to function as emergency

responders and longitudinal maternal care partners, particularly in areas facing severe healthcare shortages. By capturing the voices of mothers and paramedics, this study provides critical context for designing PLM studies and models that move beyond acceptability into feasibility and cultural responsiveness.

CONCLUSION

Paramedic-led midwifery (PLM) represents a bold but practical opportunity to address maternal care gaps in the United States. This study has shown a positive perception and potential acceptance of such a program from mothers and paramedics who supported expanded roles for EMS providers. This work opens the doors for future feasibility research on a broader scale as well as work informing policy and best practices. However, both groups identified the need for more contextualized medical training, community-informed initiatives and policies, and a deeper focus on culturally sensitive care. With policy alignment, interdisciplinary training, and infrastructure support, PLM could become a transformative solution to one of the nation's most urgent public health disparities. As the maternal health crisis deepens, innovative models like PLM represent not only a stopgap, but a sustainable path forward for equity, access, and survival.

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APPENDIX

ID	Age	Sex	Years as a Medic	Working Location	Maternal Training	Provided Care in Other MCD	Familiar with Midwives
P1	23	F	3	Buckingham	No	No	Yes
P2	25	M	1	Charles City	No	Yes	Yes
P3	37	M	5	Charles City	No	No	Yes
P4	26	M	2	Hopewell City	No	No	Yes
P5	27	M	1	Madison	Yes	Yes	Yes
P6	26	M	1	Bristol City	No	No	Yes
P7	29	M	4	Dickenson	No	No	Yes
P8	28	M	3	King George	No	No	Yes
P9	25	F	2	Grayson	Yes	No	Yes
P10	26	M	1	Lee	Yes	No	Yes
P11	32	M	8	Cumberland	No	No	Yes
P12	25	M	2	Covington	No	No	Yes
Note: F = Female. M=Male. Age reported in years. Years as a medic reported in years rounded to the nearest full year.							

Table 2. Paramedic demographic data.

ID	Age	Sex	Residence Location	Pregnancy Status	Number of Children	Saw Provider Regularly	Type of Provider	Used 911	Birth Complications	Distance to Provider
M1	26	F	Prince George	PP	2	Yes	Doctor	Yes	Yes	76 Min.
M2	30	F	Scott	PP	3	No	None	Yes	Yes	20 Min.
M3	32	F	Greensville	PP	4	No	None	Yes	No	N/A
M4	28	F	Amelia	PP	1	No	None	Yes	Yes	60 Min.
M5	26	F	Charles City	PP	1	Yes	Midwife	Yes	No	110 Min.
M6	35	F	Grayson	PP	3	No	Midwife	Yes	No	20 Min.
M7	26	F	Richmond	PP	2	Yes	Midwife	Yes	No	60 Min.
M8	26	F	Richmond	PP	3	Yes	Midwife	Yes	No	45 Min.
M9	28	F	Buckingham	PP	1	Yes	Multiple	Yes	Yes	20 Min.
M10	28	F	Bath	PP	1	Yes	Midwife	Yes	No	45 Min.
M11	31	F	Dickenson	PP	2	Yes	Midwife	Yes	No	10 Min.
Note: P = Postpartum 6 months or less. Min. = minutes. Ages reported in years.										

Table 3. Mother demographic data.

Sub Theme	Description	Direct Quotes
Community Acceptance	Refers to the extent to which the community is open to and supportive of new health-care roles or services, particularly those that address unmet needs.	"I believe that the community will respond perfectly if they're being equipped with the right information about the paramedics they'll be very happy and much appreciative." (P7)
		"They would be accepting of such enhanced care." (P6)
		"I believe the community are responding positively to us (P10)
		"Some might accept it very well and some might not. Some may not be open because they don't really believe in the medical profession [due to] past experiences." (P13)
		"They gave me this assurance everything is going to be okay. They made me have peace of mind. I really appreciate the fact that I had to use them."(M9)
		"I believe the fact that I can access them anywhere, even they can come to my home. It's like they're bridging a gap." (M13)
Competence and Training	Involves the perceived skill level, education, and preparedness of providers to deliver quality care as it relates to PLM, which can influence trust and acceptance.	"They respond very well. We have a lot of resources and we are capable and well trained." (P12)
		"The training I received has been of great help to me as a paramedic, and I believe that a well-trained paramedic will definitely make a good mark out there in the field." (P6)
		"We are trained to manage the delivery ensuring that mothers and babies are actually safe and providing initial newborn care." (P8)
		"With the knowledge I gathered, I've been able to actively and effectively [work] in maternal care." (P10)
		"I feel paramedics can be trained especially for those who have passion. They will have the skill." (P9)
		"I would say they are able to support because they've acquired the skills, they've been trained to take care of babies and mothers during and after childbirth." (M6)
		"They are trained to help in birth and understand complications... their training would've helped me a lot—I wish I called." (M14)
		"I've passed through those trainings. I think the trainings are effective and helpful to the medical profession." (P10)
		"I pay attention to my former education, kind of nursing and midwifery degree trying to advance prenatal care and emergency skills." (P8)
Demographic/Cultural Factors Affecting Acceptance	Includes cultural beliefs, language, past experiences, and social identities that shape how individuals respond to care models or healthcare providers.	"Maybe something like I talked about cultural differences. Some don't have that cultural understanding, so they might not be able to understand the mother." (M13)
		"Paramedics sometimes have this attitudes like they discriminate. They have this discriminating because of my color that discriminates me. So sometimes I don't feel really comfortable with them taking care of me." (M6)
		"I identify as an immigrant. We experience obscuring cases of language barrier it becomes a challenge trying to communicate and pass vital information." (P3)
		"Connecting a midwife that has the same cultural orientation would be helpful." (P6)
		"Even among paramedics, there are those that are more open to being trained as midwives. It boils down to individual preference." (P6)
		"Yeah, I've had issues of stereotype, ethnic minority discrimination being talked down on or excused of duty because they feel you're not competent enough." (P3)

Table 4. Themes of acceptance.

Sub Theme	Description	Direct Quotes
Paramedics Providing PLM	Reflects how providers perceive their own role, capabilities, and level of preparedness when offering expanded services in maternal or specialty care.	"I think as a maternal care provider, paramedic, I think we are much prepared" (P12)
		"We are trained to manage the delivery during ensuring that mothers and babies are actually safe" (P8)
		"We offer emotional support... guide them through before birth and after birth... give advice and sometimes resources that would help taking care of the baby." (P6)
		"Paramedics are quite beneficial for mothers who might have to move quite some distance." (P6)
		"I think paramedics are very vital organs of medical care because care begins with them, continues with them, and also continues after them." (P3)
		"I'm much familiar with prenatal care... especially complicated issues... I think I'm really good at that." (P12)
		"We play a crucial role especially in places that weren't really prepared for delivery." (P8)
Mothers Receiving PLM	Captures patient experiences and impressions of receiving care from non-traditional providers, including levels of comfort, trust, and emotional support.	"Their quick response was a bit lifesaving to me and I found it's so nice dealing with them." (M3)
		"I would be moderately comfortable because I don't really, really trust them." (M6)
		"I felt comfortable because they have been trained... to take care of babies and mothers during and after childbirth." (M6)
		"It was advantageous on my side because they really supported me emotionally and their transport was also appropriate." (M7)
		"People like me who are at high risk... paramedics with nurses can deliver prenatal checkups, BP monitoring, and educate those in remote areas." (M5)

Table 5. Participant perception of paramedic-led midwifery and preparedness to provide maternal care.

Sub Theme	Description	Direct Quotes
Financial and Resources	Encompasses economic limitations such as low funding, limited reimbursement, and high out-of-pocket costs that affect service delivery and accessibility.	"I talked about finance, not being able to get some paychecks enough to cater for yourself in your family could cause some mental reiteration trying to think and either affect service delivery." (P3)
		"Some patients cannot afford ambulance services and these delay their cause for help." (M5)
		"The finances left at disposals are mostly not enough for us to actually survive." (P10)
		"Financial instability is also a big issue... allowances or the primary pay should be increased greatly." (P5)
Training and Education	Refers to gaps in professional education, access to specialized training, or continuing education opportunities needed for expanded scopes of care.	"We do not have many paramedics who have this in-depth knowledge of maternal care, and that is actually a problem." (P6)
		"A barrier... some paramedics might not be accurately equipped with the necessary information." (P5)
		"With the proper support and training, I'd be proud to do this kind of work." (P8)
		"One of the barriers are high cost of these trainings and also limited opportunities...I think some paramedic, I think some paramedic in some cases paramedic needs some certain kinds of license and training to be able to perform some certain aspect of midwife care." (P12)
		"They should have special courses to handle these disasters." (M5)
		"I think that paramedics should have more training, they should acquire more skills on how to take care of pregnant women and the babies." (M10)
		"Paramedics sometimes do have limited training. They sometimes have limited training, so they do not really have that skill that midwives do have." (M7)
Logistics and Operational	Includes challenges related to scheduling, geographic distance, staffing, equipment, and infrastructure that hinder efficient service delivery.	"We don't have much accessibility to some certain facilities and the shifting that is being set does not really favor us." (P10)
		"Limited resources... not enough equipment... more hands are needed every day." (P6)
		"Being able to meet up with different patients at a time, should I call it time constraints, being able to balance it, it's a problem." (M9)
Cultural and Communication	Pertains to language differences, cultural misunderstandings, and interpersonal dynamics that affect communication and quality of care.	"Maybe at some point language barrier." (M3)
		"Well, if there was more training on language, it would help a lot of people." (M3)
		"Maybe something like I talked about cultural differences. Probably you find some don't have that cultural background or that cultural understanding, so they might be having that difference whereby they may not be able to understand by the mother." (M13)
		"....the cultural orientation of individual paramedics. That should be put into consideration because it constitutes a big barrier because paramedics come from different backgrounds, different ways of handing things." (P6)
		"Paramedics sometimes have this attitude like they discriminate. They have this discriminating because of my color that discriminates me. So sometimes I don't feel really comfortable with them taking care of me." (M6)
		"I've had issues of stereotype, ethnic minority discrimination and all of that especially, or when you have a paramedic who identifies as a person of color working in a predominantly wide facility, sometimes there are cases of stereotype being talked down on and sometimes being excused of duty because the field, they're not competent enough." (P3)
		"We experience obscuring cases of language barrier. Trying to communicate and pass vital information." (P3)
		"Some patients have contradiction to routine medications and prefer halal medications. The community must recommend and provide." (P3)

Table 6. Barriers to paramedic-led midwifery.

Sub Theme	Description	Direct Quotes
Systemic and Policy	Involves institutional, regulatory, or structural barriers such as scope of practice limitations, policy restrictions, or lack of integration into existing systems.	“The scope of practice is a major constraints because they limit their ability to provide certain aspect of care to the pregnant model." (M9)
		"Yes. I feel that there should be that collaboration between midwives and other, maybe even the nurses and other mobile units... they can give the services here and be able to attach to everyone regardless of the condition that you have." (M13)
		"There are international policies that prevent other paramedics from other countries from coming in to work here." (P3)
		"There are regulatory bodies that should set up stuff [refering to enhanced policies and telemedicine} so it could be beneficial to all." (P10)
		"Initiatives like community paramedicine or mobile integrated health would help go a long way." (P13)
		"Maybe on other work overload, maybe they could increase the number of people doing that work." (M3)

Table 6 (continued). Barriers to paramedic-led midwifery.

Sub Theme	Description	Direct Quotes
Improved Access in Remote Areas	Describes how expanded services can help reach underserved or geographically isolated populations, improving timely access to care.	"Paramedics are quite beneficial for mothers who might have to move quite some distance... they would help to stabilize everything that needs to be in place." (P6)
		"I think that paramedics with nurses can deliver prenatal checkups... in their remote areas." (M5)
		"They should go to different places in the [maternal] desert and try advising and providing maternal care to people who are not around the hospital area." (M5)
		"They're offering rapid response being able to provide their immediate care in emergencies" (M9)
		"I think they're just like life savers probably if you have to take a drive of maybe 45 to an hour" (M14)
		"Paramedics bring maybe by the integration into the society...if they can be able to give door to door services...they also solve that problem overcrowding some hospitals" (M14)
		"I feel the paramedic can actually improve the outcomes of mothers and babies by providing early intervention and support" (M10)
		"It's like they're bridging a gap between me and where the health facility is" (M13)
Enhanced Patient Experienced	Refers to the positive emotional, educational, or relational aspects of care that contribute to patient satisfaction and well-being.	"I received postpartum care that has to do with the emotional support" (M10)
		"They gave me this form of assurance that I could give birth to my baby successfully" (M10)
		"They gave me a comfortable environment. They made me feel at home" (M9)
		"They offered some pre-hospital medical treatment... and they reduced some of my complications." (M3)
		"They are supporting. Their quick response was a bit lifesaving to me." (M3)
		"They provide emotional support to mom, make sure that they don't feel scared... we try to tell them everything is going to be okay." (P9)
		"...it helps to ensure that people in the community have healthy living...when paramedics take care of these things it becomes quite easier for the people to navigate through the whole experience." (P6)
		"The advice she gave to me and the help, it was really beneficial." (M6)
Perceived needs for sustained acceptance of PLM	Captures recommendations for long-term success, such as additional training, stakeholder collaboration, public awareness, and resource support.	"They should do collaborations with other healthcare professionals... and there should be awareness programs... not everybody in the community knows about it." (M9)
		"I feel specialized training one of the things that would allow people to accept this kind of service around in their communities. .So it will give patients more confidence that they are dealing with the right person..." (P6)
		"I think a little bit more funding and more support from the community and the government." (P12)
		"Monthly webinar sessions or virtual sessions and incentives should be made available to entice the paramedic in order to be part of such meetings." (P10)
		"They need support from the community. If they don't have enough training, those skills or enough resources in that workforce they won't be able to implement it effectively." (M13)
		"I feel that there should be that collaboration between midwives and other, maybe even the nurses" (M13)
		"There should be a community program... maybe a service sometimes free of charge, like a community service for people." (M9)
		"I think paramedics should be part of maternal health education... promote early precare and reduce anxiety by teaching and reassuring pregnant women." (P8)
		"More improvement for paramedics to go for international conferences and trainings. Partnering with other healthcare professionals." (P3)
		"The scope of practice is a major constraint because they limit their ability to provide certain aspect of care" (M10)

Table 7. Benefits of and perceived needs for implementation of paramedic-led midwifery.

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RESEARCH REPORTS

COMPARATIVE DIAGNOSTIC ACCURACY OF LARGE LANGUAGE MODELS FOR STEMI CLASSIFICATION: AN EXPLORATORY STUDY USING DE-IDENTIFIED EMERGENCY DEPARTMENT CASES

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ABSTRACT

Background: Early and accurate identification of ST-Elevation Myocardial Infarction (STEMI) in the prehospital setting would reduce morbidity and mortality (Rao et al. 2025). Artificial Intelligence (AI) tools may assist emergency medical personnel by providing rapid electrocardiogram (ECG) interpretation and differential diagnosis (Chen et al. 2022; Nallamothu et al., 2015).

Objective: To evaluate the diagnostic accuracy of ChatGPT-4.0, Gemini 2.5 Pro, and a hybrid model combining ECG-GPT + ChatGPT-4.0 in classifying STEMI versus non-STEMI cases based on ECG and clinical data inputs.

Methods: Fifty-six consecutive de-identified cases (28 STEMI, 28 non-STEMI) from Staten Island University Hospital EMR (1/2025-6/2025) were analyzed. Each case included demographics, vital signs, chief complaints, and a representative 12-lead ECG. The three AI models were independently asked to classify each case as STEMI or not STEMI.

Results: For the STEMI cohort (n=28), detection rates were: ChatGPT-4.0 21.4%, Gemini 2.5 Pro 67.9%, and ECG-GPT + ChatGPT hybrid 71.4%. For the non-STEMI cohort (n=28), correct classification rates were: ChatGPT-4.0 92.9%, Gemini 2.5 Pro 28.6%, and ECG-GPT + ChatGPT hybrid: 96.4%. The ECG-GPT + ChatGPT hybrid model demonstrated the highest diagnostic accuracy at 83.9%.

Conclusion: While ChatGPT-4.0 showed high specificity, it lacked sensitivity for STEMI detection. Gemini 2.5 Pro improved sensitivity but yielded higher false positives. The hybrid ECG-GPT + ChatGPT model outperformed both standalone models, suggesting that multimodal AI integration may enhance triage accuracy for prehospital care. Despite the small population size and limitations associated with this, these results propose a viable means to hypothesize that AI may have potential in assisting responders with early STEMI identification. Future improvements in model precision could support the implementation of AI-based triage systems in emergency response settings, reducing time to treatment and improving outcomes by aiding direct cardiac catheterization lab transfers without unnecessary delays (Garvey et al., 2012; Squire et al., 2014).

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INTRODUCTION

Timely identification and treatment of ST-Elevation Myocardial Infarctions (STEMIs) are imperative in improving cardiac patient outcomes (Nallamothu et al., 2015; Rao et al., 2025). In this study, we explore the integration of artificial intelligence (AI) into prehospital triage protocols to enhance early STEMI detection and expedite contact-to-balloon time (Nallamothu et al., 2015). Recognizing the limitations faced by paramedics and emergency medical technicians in the field and physicians in the emergency room, we propose AI as a decision-support tool to assess prehospital ECGs and clinical data.

Importantly, not all AI systems are equivalent in clinical use. Purpose-built medical AI devices, including software as a medical device, are typically developed for a defined intended use, trained and validated on clinical datasets, evaluated with prespecified performance metrics, and deployed within regulated quality, safety, and risk-management frameworks. By contrast, consumer-facing large language models (LLMs) such as ChatGPT and Gemini are general-purpose conversational systems. They are not designed, cleared, or validated as standalone diagnostic devices for STEMI interpretation, and their outputs may be influenced by prompt structure, model updates, incomplete clinical context, and probabilistic language generation. Therefore, this study does not evaluate ChatGPT or Gemini as deployable medical devices. Rather, it examines whether general-purpose multimodal LLMs can perform a constrained experimental classification task and whether pairing an ECG-focused model with a language model improves performance compared with consumer LLMs alone.

Despite its recognized benefits, accurate ECG interpretation by emergency medical technicians (EMTs) in prehospital settings remains challenging. Conventional devices require meticulous electrode placement and skilled interpretation—often compromised by the complexities of prehospital environments (Gregory et al., 2019). Rule-based algorithms used in systems like those in Hong Kong deliver high sensitivity (~94.6%) but only fair specificity (~87.9%), leading to notable false-positive rates and potential over-triage (Lai et al., 2024).

The current state of prehospital STEMI diagnosis varies across EMS systems. In paramedic-led interpretation models, diagnostic performance may be limited by STEMI mimics and variation in training. One study done at Pennsylvania State University found that paramedics recognized STEMI with imperfect sensitivity and specificity when faced with ECG mimics such as left ventricular hypertrophy, bundle branch block, paced rhythms, and supraventricular tachycardia (Mencl et al., 2013). In systems using computerized ECG interpretation, performance can be highly specific but not always sufficiently sensitive, and incorrect computer interpretations may influence paramedic decision-making. The UK RESPECT feasibility study showed that computer interpretation messages affected paramedic STEMI decisions, improving accuracy when correct but worsening accuracy when incorrect (Pillberry et al., 2016). In systems using ECG transmission, physician overread may improve positive predictive value, although studies show variable impact on false-positive activations and workflow time. Therefore, the potential role of AI is not to replace existing EMS protocols, but to serve as adjunctive decision support in systems where rapid interpretation must occur before definitive cardiology review.

AI and deep learning algorithms have the potential to enhance prehospital ECG interpretation (Chen et al., 2022). These methods can automate analysis, reduce human error, and potentially reduce diagnostic delays. For instance, models leveraging convolutional neural networks (CNNs) and long short-term memory (LSTM) architectures have demonstrated impressive real-world performance: an AI model deployed in ambulances in Central Taiwan, using a mini-portable 12-lead ECG device achieved accuracy of 99.2%, sensitivity (recall) of 94.1%, specificity of 99.4%, and an impressively low response time (37 s versus >113 s for physicians). Moreover, this system helped initiate PPCI in ten identified STEMI patients, with a median contact-to-door time of 18.5 minutes (IQR: 16–20.8) (Chen et al., 2022).

To address these gaps, our investigation evaluated three AI-driven approaches—ChatGPT-4.0, Gemini 2.5 Pro, and a hybrid model combining ECG-GPT with ChatGPT—for their ability to discriminate STEMI versus non-STEMI cases based on prehospital ECG findings, vital signs, and chief complaints. Using a balanced dataset of 28 confirmed STEMI and 28 confirmed non-STEMI cases, we measured each model's accuracy, sensitivity, and specificity in order to (1) assess the standalone performance of language-based models on ECG interpretation tasks, (2) determine whether multimodal integration (ECG plus clinical data) enhances diagnostic performance, and (3) explore the feasibility of deploying AI-based triage tools to accelerate in-field identification of STEMI.

METHODS

Study Design and Data Source

This was a retrospective diagnostic accuracy study using de-identified patient data extracted from the electronic medical records (EMR) of Staten Island University Hospital (Northwell Health). Cases included patients transported to the emergency department (ED) with a variety of acute complaints in 2025. Although this study was motivated by prehospital triage, the dataset consisted of retrospective ED-arrival cases rather than prospectively collected ambulance ECGs; therefore, results should be interpreted as an exploratory simulation of early triage decision support rather than validation in an operational EMS system. The study population comprised two cohorts: patients with confirmed ST-Elevation Myocardial Infarction (STEMI) and patients without STEMI. All data were fully de-identified prior to analysis in accordance with institutional review protocols.

Case Selection

A total of 56 cases were randomly selected from the EMR system, consisting of 28 patients with confirmed STEMI (22 male, 6 female) and 28 patients without STEMI. STEMI confirmation was based on final cardiology and interventional reports, while non-STEMI cases were confirmed by discharge diagnoses and absence of acute coronary intervention. Cases were stratified by age to ensure even distribution across both cohorts. Chief presenting complaints in the STEMI cohort included chest pain, abdominal pain, syncope, weakness, or dyspnea, consistent with known STEMI presentations. Non-STEMI cases represented a mixture of chest pain and alternative complaints such as dizziness, confusion, seizures, abdominal pain, or viral syndromes.

Data Preparation

For each patient, the following clinical variables were extracted:

- Demographics: Age, sex;
- Physiological data: Systolic and diastolic blood pressure, heart rate, respiratory rate, and oxygen saturation;
- Presenting complaint: Chief symptom(s) at ED arrival;
- Electrocardiogram (ECG): Representative 12-lead image at presentation.

All data was compiled into a standardized case vignette format. Each vignette was stripped of identifying information to maintain anonymity.

AI Model Evaluation

Three AI models were evaluated:

- ChatGPT-4.0 (OpenAI, 2024)—a general-purpose large language model
- Gemini 2.5 Pro (Google DeepMind, 2025)—an advanced multimodal language model
- ECG-GPT + ChatGPT model – a two-step system combining an ECG-specific model (ECG-GPT, fine-tuned on electrocardiographic data) with ChatGPT for clinical reasoning integration. No prompt was required for ECG-GPT; just an image was attached. The output is a reading of the ECG, which was paired with the prompt (as seen in Appendix) and input into ChatGPT.

Each model was independently provided with the same case vignette, including vital signs, age, chief complaint, and ECG image. Models were instructed to classify each case dichotomously as "STEMI" or "not STEMI." No intermediate or probabilistic outputs were recorded.

Outcome Measures

The primary outcome was diagnostic accuracy of each model, defined as the proportion of correctly classified cases compared to the gold-standard diagnosis (STEMI vs. not STEMI) confirmed in the EMR. Secondary outcomes included:

- Sensitivity: proportion of true STEMI cases correctly identified;
- Specificity: proportion of true non-STEMI cases correctly excluded.

Statistical Analysis

Results were tabulated separately for the STEMI (n = 28) and non-STEMI (n = 28) cohorts. Sensitivity, specificity, and accuracy were calculated with 95% confidence intervals (Wilson method). Accuracy was computed as the proportion of correctly classified cases across all 56 patients. All analyses were descriptive, given the exploratory nature of the study.

RESULTS

Study Population

A total of 56 patient cases were included in the analysis, comprising 28 confirmed ST-elevation myocardial infarction (STEMI) cases and 28 confirmed not STEMI cases. Among the STEMI group, 22 (78.6%) patients were male and 6 (21.4%) were female, with ages

ranging from 38 to 89 years. The most common presenting complaint in STEMI patients was chest pain, reported in 21 of 28 cases (75%), followed by abdominal pain, syncope, weakness, or dyspnea. The non-STEMI cohort included 19 (67.9%) males and 9 (32.1%) females, with ages ranging from 34 to 85 years. Presenting complaints included chest pain, dizziness, seizures, abdominal pain, and flulike symptoms. Baseline vital signs demonstrated broad variability in both cohorts, reflecting the heterogeneity of clinical presentations in the ED setting. No image quality issues arose from ECG submission, and all model responses were binary due to the submitted prompt. No ambiguous responses were output from any of the three LLMs.

Model Performance on STEMI Cases

The ability of each AI model to correctly classify STEMI cases varied considerably (Table 1):

- ChatGPT-4.0 correctly identified only 6 of 28 STEMI cases (21.4% sensitivity;
- Gemini 2.5 Pro correctly identified 19 of 28 STEMI cases (67.9% sensitivity);
- ECG-GPT + ChatGPT hybrid model correctly identified 20 of 28 STEMI cases (71.4% sensitivity).

While ChatGPT-4.0 frequently failed to recognize STEMI despite suggestive clinical and ECG findings, Gemini 2.5 Pro and the hybrid model demonstrated substantially greater sensitivity.

Model	Sensitivity (STEMI, 95% CI)	Specificity (not STEMI 95% CI)	Accuracy (95% CI)
ChatGPT-4.0	21.4% (10.2–39.5)	92.9% (77.4–98.0)	57.1% (44.1–69.2)
Gemini 2.5 Pro	67.9% (49.3–82.1)	28.6% (15.3–47.1)	48.2% (35.7–61.0)
Hybrid ECG-GPT + ChatGPT	71.4% (52.9–84.7)	96.4% (82.3–99.4)	83.9% (72.2–91.3)

Table 1. Diagnostic performance of AI models in identifying STEMI.

Model Performance on Non-STEMI Cases

Performance on the 28 non-STEMI cases showed a contrasting pattern:

- ChatGPT-4.0 correctly classified 26 of 28 non-STEMI cases (92.9% specificity);
- Gemini 2.5 Pro correctly classified only 8 of 28 non-STEMI cases (28.6% specificity), with frequent false-positive STEMI classifications;
- ECG-GPT + ChatGPT hybrid model correctly classified 27 of 28 non-STEMI cases (96.4% specificity).

Thus, while Gemini 2.5 Pro increased sensitivity, it did so at the cost of markedly reduced specificity. In contrast, the hybrid model preserved both high specificity and improved sensitivity.

Overall Accuracy

When combining both cohorts (n = 56), overall diagnostic accuracy was:

- ChatGPT-4.0: 57.1% (32/56 correct);
- Gemini 2.5 Pro: 48.2% (27/56 correct);
- ECG-GPT + ChatGPT hybrid: 83.9% (47/56 correct).

Confidence intervals are presented in Table 1. The hybrid model's performance intervals did not overlap substantially with those of ChatGPT-4.0 or Gemini 2.5 Pro, supporting its

superior diagnostic balance. Performance metrics are illustrated in Figure 2, and the case selection process is summarized in Figure 1.

Key Observations

- ChatGPT-4.0 demonstrated strong specificity but extremely poor sensitivity, under recognizing STEMI cases;
- Gemini 2.5 Pro demonstrated improved sensitivity but produced frequent false positives, lowering specificity;
- Hybrid ECG-GPT + ChatGPT achieved the best balance, with both high sensitivity and specificity and the highest overall accuracy.

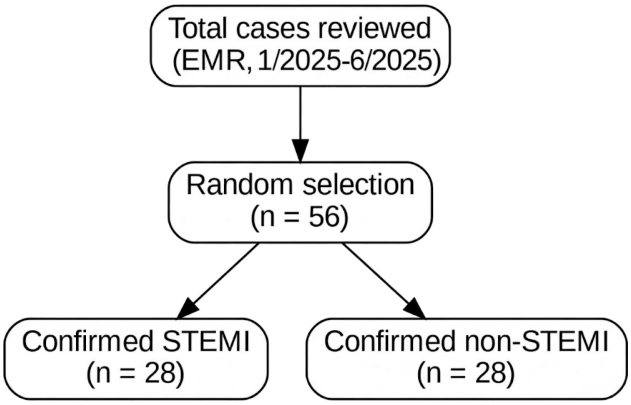


Figure 1. Case selection flow diagram.

Note. Flow diagram illustrating case inclusion. From electronic medical records (1/2025-6/2025), 56 cases were randomly selected, comprising 28 confirmed STEMI and 28 confirmed not STEMI patients.

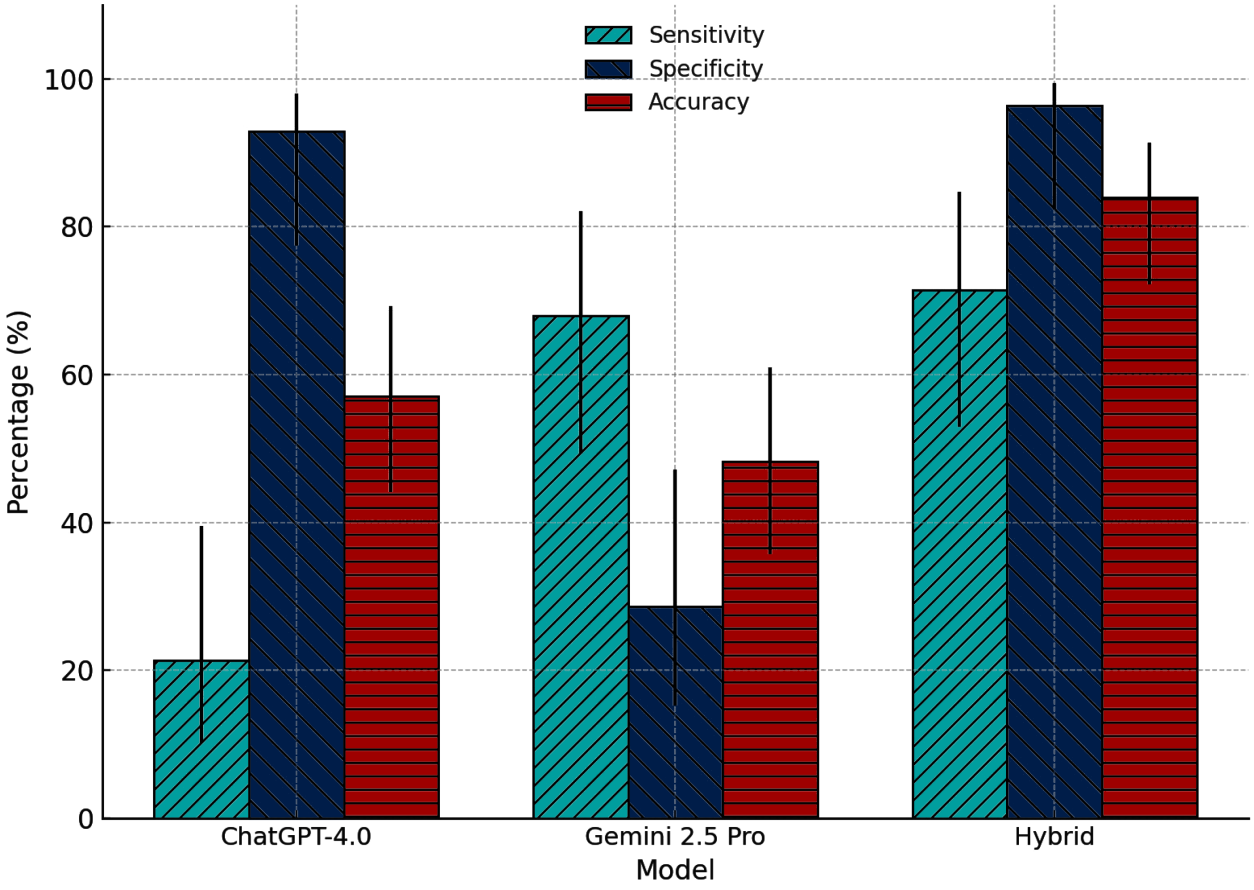


Figure 2. Performance of AI models in STEMI classification.

Note. Bar chart showing sensitivity, specificity, and overall accuracy (with 95% confidence intervals) for ChatGPT-4.0, Gemini 2.5 Pro, and the hybrid ECG-GPT + ChatGPT model. Distinct hatching patterns and colors indicate the three performance metrics.

DISCUSSION

Principal Findings

In this study, we evaluated the diagnostic performance of three artificial intelligence (AI) models, ChatGPT-4.0, Gemini 2.5 Pro, and a hybrid ECG-GPT + ChatGPT system, in classifying ST-elevation myocardial infarction (STEMI) versus non-STEMI presentations using deidentified emergency department cases. The hybrid model achieved the highest overall diagnostic accuracy (83.9%), outperforming both general-purpose language models. While ChatGPT-4.0 exhibited high specificity (92.9%) in ruling out not STEMI, it showed poor sensitivity (21.4%), highlighting a limitation in recognizing true STEMI cases. In contrast, Gemini 2.5 Pro improved sensitivity (67.9%) but at the cost of a steep decline in specificity (28.6%), producing frequent false positives. Confidence intervals further highlight this advantage: the hybrid model achieved 83.9% accuracy (72.2–91.3), compared with 57.1% (44.1– 69.2) for ChatGPT-4.0 and 48.2% (35.7–61.0) for Gemini 2.5 Pro, demonstrating a clear performance margin in this exploratory sample.

Comparison With Prior Studies

Our findings align with prior work demonstrating the promise of AI in prehospital and ED cardiac triage. Earlier studies reported that an AI-driven mini-12-lead ECG device deployed in ambulances in Taiwan achieved 94.1% sensitivity, 99.4% specificity, and a 99.2% overall accuracy, while also reducing time to physician notification from 113 seconds to 37 seconds (Chen et al., 2022). Similarly, large-scale validation studies of deep learning ECG classifiers have reported very accurate results, performing on par with human cardiologists in controlled settings (Hannun et al., 2019). However, most existing models have been domain-specific (CNN or LSTM-based ECG interpreters) and do not completely incorporate clinical context such as vital signs or patient-reported symptoms.

Our study is distinct in comparing general-purpose LLMs, which are readily available to EMTs and medical personnel, with a specialized hybrid approach that integrates ECG-focused AI. The poor sensitivity of ChatGPT-4.0 illustrates the limitations of LLMs when applied directly to clinical classification tasks without domain-specific training. Conversely, Gemini 2.5 Pro's higher sensitivity but poor specificity suggests that LLMs may overfit to the presence of suggestive symptoms (e.g., chest pain), generating false alarms. The hybrid approach, by contrast, suggests a promising pathway: combining domain-trained models with general reasoning models to capture both structured ECG patterns and unstructured clinical context.

Clinical Implications

The ability to rapidly and accurately identify STEMI in prehospital and ED settings is important, as early reperfusion therapy directly correlates with reduced morbidity and mortality (Rao et al., 2025; Nallamothu et al., 2015). False negatives (missed STEMIs) can delay reperfusion and worsen outcomes, while false positives can overwhelm catheterization laboratories with unnecessary activations (Garvey et al., 2012; Larson et al., 2007; Squire et al., 2014). Our results suggest that an integrated hybrid AI system may enhance frontline responders' diagnostic capabilities while minimizing unnecessary over triage. Such systems could be embedded into ambulance monitors or emergency department

workflows to support rapid triage and expedite "door-to-balloon" times (Squire et al., 2014).

Strengths and Limitations

A strength of this study is the inclusion of both ECG images and clinical variables, reflecting real-world ED presentations rather than isolated waveform data. Cases were also balanced by age distribution, minimizing demographic skew. However, several limitations must be acknowledged. First, the sample size was modest (n=56), limiting generalizability. Second, the dataset was retrospective and restricted to a single health system, which may not completely capture variability in ECG presentations or patient populations. Third, AI models were tested in a static classification framework, without iterative refinement or probabilistic confidence outputs, which may underestimate their potential performance in real deployment. Finally, we did not benchmark against human paramedic or physician interpretations, which would provide useful context for relative performance.

Future Directions

Future research should evaluate hybrid AI models in larger, prospective, and multicenter datasets, ideally incorporating real-time ambulance and ED workflows. Integration of additional multimodal inputs—such as laboratory biomarkers, prior ECGs, and risk scores—may further enhance accuracy. Moreover, comparative studies against human experts are essential to establish clinical utility and safety. Importantly, research should also examine usability and workflow integration, ensuring that AI systems support rather than overwhelm frontline responders.

CONCLUSION

This study highlights both the potential and limitations of current AI models for STEMI detection. While general-purpose LLMs alone were insufficient, a hybrid ECG-GPT + ChatGPT model achieved superior diagnostic accuracy, balancing sensitivity and specificity. This suggests that multimodal AI integration may offer a powerful tool for prehospital and ED triage. These results are hypothesis-generating and calling for prospective, multicenter, adequately powered validation—with human comparators and validated reporting standards such as TRIPOD-AI (Collins et al., 2024).

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APPENDIX

Verbatim LLM Prompt

You are reviewing a de-identified emergency department presentation for research purposes only. You will be provided with patient age, sex, vital signs, chief complaint, and a 12-lead ECG image. Classify the case as either STEMI or not STEMI based on the ECG and clinical information.

Do not provide treatment recommendations.

Do not request additional information.

Choose only one final classification: STEMI or not STEMI.

Case:

- Age: [age]
- Sex: [sex]
- Chief complaint: [chief complaint]
- Blood pressure: [BP]
- Heart rate: [HR]
- Respiratory rate: [RR]
- Oxygen saturation: [SpO2]
- ECG image: [uploaded ECG image]

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RESEARCH REPORTS

DIAGNOSIS FEEDBACK: A PROSPECTIVE SURVEY ON PARAMEDIC PERSPECTIVES AND CLINICAL IMPACT

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ABSTRACT

Introduction: Paramedics rarely receive formal feedback on patient outcomes following handover, despite evidence that such information may support learning, confidence, and reflective practice.

Objective: To evaluate whether emergency department (ED) diagnosis feedback influences paramedics' perceived sense of closure, confidence managing similar cases, reflective practice, and perceived diagnostic skill.

Methods: This prospective, predominantly quantitative survey was conducted among paramedics in a mid-sized urban setting, between April and December 2018. Paramedics who requested their patient's final ED diagnosis (n = 317) were provided with diagnosis feedback and invited to complete online surveys at one week and three months. Quantitative data were analyzed descriptively, and optional free-text responses were reviewed to identify recurring themes.

Results: Of the 317 paramedics who received diagnosis feedback, 46.4% completed the one-week survey and 32.2% completed the three-month survey. At one week, 86% reported a sense of closure about the call, and over 80% agreed that feedback increased their confidence for similar cases and prompted clinical reflection. At three months, 91% reported improved differential diagnostic skills, and 96% stated they would use feedback regularly if available. A minority reported added stress or anxiety when their field impression differed from the ED diagnosis. Qualitative comments reinforced these results, describing feedback as a helpful educational tool that provided confidence and closure.

Conclusion: Paramedics perceived ED diagnosis feedback as a valuable educational tool that may support reflective practice, confidence managing similar cases, and perceived diagnostic skill. These findings suggest that structured diagnosis feedback may serve as a meaningful component of paramedic professional development.

INTRODUCTION

Paramedics are frontline emergency medical services (EMS) clinicians who make high-stakes decisions in fast-paced, out-of-hospital environments (Rowland & Brydges, 2023). In Canada alone, more than 30,000 licensed paramedics respond

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to emergencies each year, often delivering time-critical interventions that improve morbidity and mortality in conditions such as cardiac arrest and sepsis (Kotnarin et al., 2023; Lee et al., 2020; Rowland & Brydges, 2023; Varney et al., 2022). Paramedics rarely receive feedback on their performance or how closely their prehospital clinical impressions match the eventual in-hospital diagnosis, despite their crucial role in patient care (Cash et al., 2017; Kästner et al., 2025; Missel et al., 2023; Wilson et al., 2022, 2024). As the profession evolves, national paramedicine guidelines call for a culture of ongoing learning and routine evidence-based practice, backed by coordination between hospitals and EMS (Tavares et al., 2022). To address this gap, structured feedback mechanisms are increasingly recognized as essential for continuous quality improvement and are becoming integral to EMS professional development and training standards (Gunderson et al., 2021).

Growing evidence demonstrates that paramedics both value and would benefit from patient diagnosis feedback (Kaduce et al., 2024; Schneider et al., 2026; Wilson et al., 2024). In a survey of 428 EMS personnel, 95.4% stated they would welcome patient diagnosis feedback, and 94.7% perceived it as helpful for their clinical work (Kästner et al., 2025). Moreover, over 80% believed it would increase their clinical confidence, self-evaluation, and experience to respond to future calls. Formal feedback systems, in particular, provide paramedics visibility into patient outcomes and have been shown to foster meaningful personal and professional growth (Brandling et al., 2019; Budworth et al., 2023). Yet routine delivery of such feedback often falls short due to privacy regulations and separate hospital and EMS data systems, among other systemic challenges (Klausen et al., 2023; Melaika et al., 2022; Snowsill et al., 2023). As a result, to gain closure and learn from cases, paramedics often pursue patient outcomes informally, whether by later inquiring at the treating hospital or discussing cases with peers (Kästner et al., 2025; Missel et al., 2023). These informal pathways often depend on individual initiative and have been cited as barriers to patient care improvement and enhanced decision-making (Brunton et al., 2019; Eaton-Williams et al., 2020b; Keimer et al., 2023; Schneider et al., 2024; Wilson et al., 2023). Despite growing recognition of its importance, few studies have explored how paramedics perceive structured diagnosis feedback over time or how such feedback may influence ongoing clinical development.

This study piloted a simple, structured feedback process and assessed paramedics' interest in receiving patient diagnosis information, with follow-up at one week and three months. The objective was to evaluate how receiving emergency department (ED) diagnosis feedback influences paramedics' perceived closure, confidence, reflective practice, and clinical assessment at one week and three months.

METHODS

Study Design

This prospective study with an integrated qualitative component was conducted between April and December 2018. Paramedics completed a paper-based baseline survey before an ED patient handover and were subsequently invited to complete two web-based follow-up surveys at one week and three months. Quantitative data were collected using structured, closed-ended items, and qualitative data were obtained through optional free-text fields. Participation was voluntary, and all responses were de-identified prior to analysis.

Study Setting

The study was conducted in an urban center in Ontario, Canada (population approximately 415,000 during the study period), at two adult tertiary-care emergency departments with a combined annual census of 106,000 patients. All participating paramedics were employed by a single paramedic service, the region's sole land EMS agency, which responded to over 60,000 calls annually and employed 331 paramedics in 2018. This agency includes both primary care paramedics (PCPs) and advanced care paramedics (ACPs). PCPs are trained to deliver essential prehospital care, focusing on stabilization and initial treatment, while ACPs have additional training that builds off the PCP scope, allowing for more complex procedures and pharmacologic management in the field. Paramedics were introduced to the study during a staff education session, where they received written study information and had the opportunity to ask questions.

Participants

Eligible participants were active-duty paramedics involved in the direct care, transport, and handover of adult patients to one of the participating EDs during study hours. Paramedics were approached in the ED patient offload area prior to triage and before patient handover whenever feasible, using a convenience sampling strategy. Recruitment was conducted by PCPs employed by the same EMS agency who held peer-level roles and did not have supervisory authority over participants. Paramedics were eligible to enroll for each qualifying patient encounter during recruitment periods. The total number of eligible patient encounters was not systematically recorded. Inclusion criteria required employment with the participating EMS agency, involvement in the direct transport of an adult patient to a participating ED, and the ability to provide written informed consent before triage. Paramedics were excluded if they transported a Canadian Triage Acuity Scale Level 1 patient, transported to the pediatric ED, transported under an alternative destination or bypass protocol (e.g., obstetrics bypass, ST-elevation myocardial infarction bypass, stroke bypass, etc.), or transferred patients between facilities for a known diagnosis and disposition (e.g., direct transfers to a floor, transfers from urgent care, etc.). Paramedics were also excluded if they reported receiving diagnostic information prior to completing the survey. Paramedics who had previously provided written consent during the training session were re-confirmed for participation at recruitment. Ethics approval was obtained from an institutional research ethics board (REB). The sharing of outcome information with paramedics for quality improvement and educational purposes was permitted under provincial privacy legislation; individual patient consent was waived by the REB, as the study involved analysis of hospital outcome data shared with paramedics in de-identified form and did not involve direct patient contact.

Interventions

The study procedure consisted of a structured diagnostic feedback process supported by three sequential surveys. After an eligible patient encounter, consenting paramedics completed the baseline paper survey (Survey #1), which asked them to document their suspected patient diagnosis. Within approximately one week of the encounter, the research team retrieved the final ED diagnosis and disposition from hospital records. A de-identified diagnostic summary was sent to the paramedic via email in accordance with institutional privacy policies. This feedback email contained a link to a one-week

follow-up survey, which assessed immediate reflections on the diagnostic feedback. At three months, paramedics were emailed a link to the final follow-up survey, regardless of whether they had completed the one-week survey. Figure 1 illustrates the recruitment and follow-up process.

Participant flow is shown from consent (n = 317) to completion of the one-week (n = 147) and three-month (n = 102) follow-up surveys. A total of 170 and 215 participants did not complete the one-week and three-month surveys, respectively.

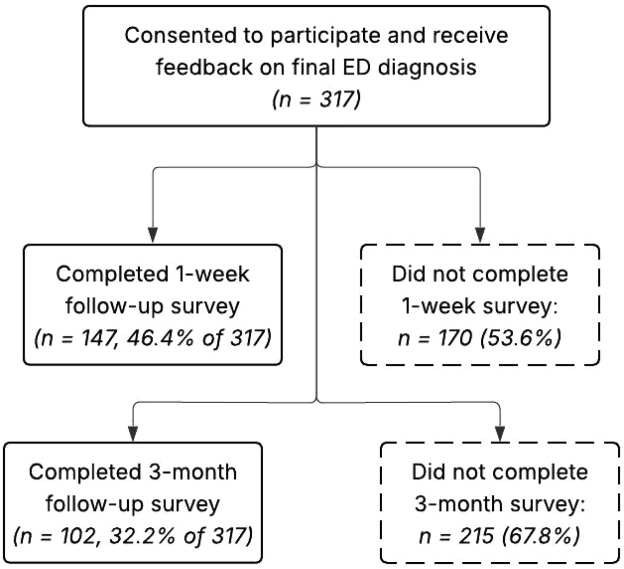


Figure 1. Flow diagram illustrating participant recruitment and follow-up survey completion.

Outcome Measures

The one-week survey evaluated the paramedics' sense of closure, confidence managing similar cases, and reflections on call management. The three-month survey assessed perceived longer-term effects on differential diagnostic skills, perceived educational value, willingness to routinely receive such feedback, and emotional responses to diagnostic discrepancies. Demographic information (PCP/ACP; years of experience) was collected in the three-month survey. All structured items used a five-point Likert scale ranging from "strongly agree" to "strongly disagree." The final survey included an optional free-text field for additional comments regarding the feedback process. Survey items were developed by the multidisciplinary research team based on existing literature examining EMS feedback systems and personal knowledge of the local systems. The survey instrument was developed specifically for this study and had not undergone prior formal validation.

Data Collection

Paper baseline surveys were collected immediately after completion and assigned unique study identifiers. Follow-up surveys were distributed electronically using SurveyMonkey®. Ambulance call report numbers were recorded to allow linkage between surveys and ED outcomes, and identifiers were removed from the analytic dataset during data preparation. All data were stored on secure, password-protected institutional servers, with personal identifiers maintained separately from analytic files.

Data Analysis

Quantitative data were analyzed descriptively using IBM SPSS Statistics 19.0 (IBM Corp., Armonk, New York, USA). Frequencies and percentages were calculated for all closed-ended responses using the total number of responses for each survey as denominators. Missing data were rare and not imputed. Likert-scale items were collapsed into agree, neutral, and disagree categories for reporting. Free-text responses were analyzed using descriptive content analysis. One investigator identified recurring themes, which

were subsequently reviewed and refined through discussion with two additional investigators to achieve consensus.

RESULTS

A total of 317 paramedics consented to participate in the study and receive ED patient diagnosis feedback. Of these, 46.4% (147/317) completed the one-week follow-up survey, and 32.2% (102/317) completed the three-month survey. Because follow-up survey responses were analyzed in de-identified form and could not be linked across time points, longitudinal comparisons between the one-week and three-month surveys were not feasible.

At the one-week follow-up (n = 147), most respondents agreed that receiving patient diagnosis feedback helped them feel closure about the call (85.7%, 126/147) and increased their confidence in managing similar calls in the future (81.6%, 120/147). Feedback prompted reflection on call management for 79.6% (117/147), although 7.4% (11/147) disagreed. Neutral responses across items ranged from 11.6% to 15.6%, and disagreement was uncommon (two or fewer respondents per item). At the three-month follow-up (n = 102), most participants reported improved skills in forming differential diagnoses (91.2%, 93/102), agreed they would use diagnosis feedback as a learning tool if routinely available (96.1%, 98/102), and regarded it as a valuable educational resource in paramedicine (97.0%, 99/102). Neutral responses ranged from 2.0% to 7.8%. Regarding emotional impact, 10.8% (11/102) reported increased stress or anxiety when the ED diagnosis differed from their field impression, while 62.7% (64/102) disagreed and 25.5% (26/102) were neutral. Survey responses are summarized in Table 1.

Survey Item	Agree or Strongly Agree *n* (%)	Neither Agree nor Disagree *n* (%)	Disagree or Strongly Disagree *n* (%)	Did Not Answer *n* (%)
1-week follow-up (n = 147)				
Learning about my patient's outcome has helped me feel closure about the call.	126 (85.7%)	17 (11.6%)	2 (1.4%)	2 (1.4%)
After receiving information about my patient's diagnosis, I believe I will have an increased level of confidence when managing a similar case in the future.	120 (81.6%)	23 (15.6%)	1 (0.7%)	3 (1.4%)
Receiving information regarding my patient's diagnosis has caused me to reflect on the way the call was handled.	117 (79.6%)	19 (12.9%)	11 (7.4%)	0 (0)
3-month follow-up (n = 102)				
Learning about my patient's outcomes has been beneficial to me as a clinician, as it has helped me improve my differential diagnostic skills.	93 (91.2%)	8 (7.8%)	1 (1.0%)	0 (0)
If information regarding patient diagnosis was made available to me on a regular basis, I would utilize it as a learning tool.	98 (96.1%)	2 (2.0%)	1 (1.0%)	1 (1.0%)
Receiving information regarding patient diagnosis is useful as an educational tool in the field of Paramedicine.	99 (97.0%)	3 (2.9%)	0 (0)	0 (0)
The possibility of learning there might be a difference between my impression of a patient's problem and the Emergency Department's diagnosis has caused an increase in my occupational stress/anxiety.	11 (10.8%)	26 (25.5%)	64 (62.7%)	1 (1.0%)

Table 1. Survey item responses at one-week and three-month follow-up.

Demographic data were available for the 102 participants who completed the three-month survey. Among them, 74.5% (76/102) held PCP certification, and 25.5% (26/102) were ACPs. Participants represented a wide range of experience levels: 33.3% (34/102) had 5 or fewer years of experience, 21.6% (22/102) had 6-10 years, 16.7% (17/102) had 11-15 years, 6.9% (7/102) had 16-20 years, and 20.6% (21/102) had more than 20 years of experience.

Twenty-two of the 102 respondents (21.6%) provided open-ended comments. Recurring themes included enhanced confidence and closure, educational value and skill development, and support for continued implementation of diagnostic feedback.

DISCUSSION

Interpretation

This study found that structured diagnostic feedback was consistently perceived as helpful for understanding patient outcomes, encouraging reflective practice, and increasing confidence in managing similar cases, with these perceived effects persisting at three months. Qualitative comments supported these observations and emphasized feedback as a useful tool for personal and professional development. Only a minority of participants reported stress or anxiety when their initial impression differed from the ED diagnosis, suggesting that diagnostic feedback was generally viewed as constructive.

Despite data being collected in 2018, the core issues discussed in this study, including paramedic access to diagnostic outcome feedback and its perceived educational value, remain relevant to contemporary EMS practice. By integrating both quantitative and qualitative data, this study offers a more nuanced understanding of how paramedics experience diagnostic feedback within a single EMS system. The inclusion of a three-month follow-up also provided insight into how perceptions of feedback may evolve over time.

Previous Studies

Findings align with international literature demonstrating strong paramedic interest in receiving outcome feedback. Prior work in Canada, the United States, and the United Kingdom has shown that structured feedback systems are well received and may enhance decision-making confidence and perceived clinical performance (Brandling et al., 2019; McGuire et al., 2025; Pollard et al., 2015; Snowsill et al., 2023; Sommers et al., 2019). For example, a U.S. peer review and outcome feedback system providing EMS clinicians with case summaries and areas for improvement was associated with enhancements in patient assessment and treatment decisions (McGuire et al., 2025). Similarly, condition-specific pathways, such as stroke and cardiac care systems, have demonstrated educational value (Lally et al., 2020; Morrison et al., 2017; Oostema et al., 2019; Siriwardena et al., 2014; Steiner et al., 2023). The Canadian Strategic Management of Acute Reperfusion and Therapies in Acute Myocardial Infarction program, which uses an electronic audit-and-feedback loop for myocardial infarction cases, has been associated with improved awareness of ECG-to-reperfusion times (Morrison et al., 2017). In the U.K., the Paramedic Acute Stroke Treatment Assessment project reported improved stroke recognition and smoother handovers following the introduction of immediate feedback during pilot implementation (Lally et al., 2020).

The manner in which feedback is delivered appears central to its effectiveness. Paramedic feedback perceived as criticism can undermine confidence and provoke negative emotional reactions such as frustration or blame (Brunton et al., 2019; Eaton-Williams et al., 2020b; Morrison et al., 2017; Wilson et al., 2024). By contrast, systems designed to provide supportive, requested feedback are associated with improved morale and stronger educational outcomes (Budworth et al., 2023; Cash et al., 2017; McGuire et al., 2021; Snowsill et al., 2023). These findings align with the generally positive reception reported in this study.

System-level barriers remain a major challenge for widespread feedback implementation. EMS and hospital systems often function in silos with limited data integration (Eaton-Williams et al., 2020a; Klausen et al., 2023). Electronic health records could bridge the gap, yet current interfaces are not integrated enough to enable effective data exchange (Porter et al., 2020). Privacy regulations and their interpretation may further restrict data sharing across organizations (Keimer et al., 2023; Melaika et al., 2022). In Europe, the General Data Protection Regulation is often cited as a barrier; in the U.S., uncertainty about the Health Insurance Portability and Accountability Act can lead some hospitals to limit disclosure (Gunderson et al., 2021; Melaika et al., 2022). Some EMS agencies now appoint privacy officers to negotiate data access (Gunderson et al., 2021). Operational realities compound these issues, as the nature of mobile work in EMS, combined with time pressures and competing clinical priorities, can make it difficult for both paramedics and hospital staff to consistently engage in feedback processes (Lally et al., 2020; McGuire et al., 2025; Schneider et al., 2026; Wilson et al., 2022). These barriers highlight the need for coordinated, sustained feedback mechanisms within EMS systems.

While paramedics in this study reported increased confidence from diagnostic feedback, subjective confidence does not always align with objective clinical competence. Simulation-based research in paramedicine has shown weak, and at times negative, associations between self-reported confidence and measured performance in technical and teamwork tasks, suggesting that perceived ability may not reliably reflect actual skill (Turan et al., 2026; Yang et al., 2022). These findings highlight the importance of incorporating objective performance measures when evaluating educational interventions.

Clinical Implications

Structured diagnostic feedback may support ongoing professional development across levels of paramedic experience. Innovative approaches, such as linking outcome feedback to microlearning and continuing education credit, may offer promising models for implementation (Kaduce et al., 2024). Low-resource approaches, including digital diagnosis summaries or QR-linked outcome reports, may serve as feasible starting points for EMS services seeking to introduce feedback at a system level (Klausen et al., 2023; Schneider et al., 2026). Policy-level coordination between hospitals and EMS organizations, along with clearer data-sharing frameworks, may help address long-standing barriers. These considerations align with broader efforts to modernize paramedic practice in Canada (Tavares et al., 2022).

Research Implications

Future studies could explore whether repeated feedback influences clinical practice over time. This could include using objective performance measures in addition to self-report.

Comparative studies evaluating different feedback formats, including timing, tone, mode of delivery, or integration with education platforms, could help identify optimal strategies for EMS systems. Engaging hospital leadership and frontline clinicians in future work may support more feasible and sustainable solutions to organizational barriers.

LIMITATIONS

This study has several limitations. First, data were collected from a single EMS region, which may limit the generalizability to settings with different organizational structures or existing feedback systems. Second, recruitment was conducted using a convenience sampling strategy, and the total number of eligible patient encounters was not recorded; because participation was encounter-based, opportunities to enroll may have varied between paramedics based on shift schedules and recruitment timing, which may limit the representativeness of the enrolled sample. Moreover, paramedics who declined to receive feedback were not studied; therefore, results largely reflect the views of individuals already inclined to engage with feedback systems and may underrepresent more skeptical views. Some paramedics informally reported declining feedback when they felt confident in their clinical impression (e.g., clear fractures or asthma exacerbations), though this was not formally assessed. Reasons for attrition between survey stages were not collected. The survey instrument was developed specifically for this study and had not undergone prior validation, which should be considered when interpreting the findings. Additionally, given the limited number of open-ended comments (n = 22), the qualitative component was limited in scope and findings are intended to provide contextual insight. Finally, the study relied on self-reported perceptions rather than objective performance data, which may introduce response bias.

CONCLUSION

In this study, paramedics reported that receiving ED diagnosis feedback supported their clinical development, encouraged reflective practice, and increased confidence in managing similar cases. Feedback was generally perceived as constructive, with only a minority reporting stress or anxiety related to diagnostic discrepancies. Timely delivery and supportive framing may enhance learning while minimizing unintended negative effects. Strengthening communication channels between hospitals and EMS agencies could further support sustainable feedback systems. Structured diagnostic feedback represents a practical approach to fostering professional growth and promoting collaboration between prehospital and hospital care teams.

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RESEARCH REPORTS

APPLYING THE MODIFIED LOS ANGELES PREHOSPITAL STROKE SCREEN TO A RETROSPECTIVE COHORT OF CHILDREN

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ABSTRACT

Introduction: Childhood acute ischemic stroke is rare but increasingly recognized, with a variety of causes including thromboembolism, arteriopathy, prothrombotic states, systemic illness, and trauma. Childhood stroke is frequently under-recognized, causing delays in seeking care and delays in diagnosis. Prehospital stroke scales have been widely validated in adults. The Modified Los Angeles Prehospital Stroke Screen (mLAPSS) is one tool used in the prehospital setting but not validated in children. Our goal was to determine in a retrospective cohort whether children with acute stroke had a positive mLAPSS score.

Methods: We performed a retrospective case series of patients less than 18 years old with a final diagnosis of acute ischemic stroke admitted to our pediatric hospital between 2014 and 2024. Demographics, presenting symptoms, mode of hospital arrival, hospital results and interventions, and final diagnosis were recorded. We attempted to determine mLAPSS criteria from earliest patient contact available, whether prehospital or emergency department records.

Results: Seventy patients with 82 stroke episodes were evaluated during the study period. Of those with past medical history, the most common were a cardiac defect or sickle cell disease. Median time from symptom onset to presentation was one day. Half of the patients presented by private vehicle. The most common symptom was a new focal weakness, but the majority of patients had more than one symptom. Documentation of grip strength and arm drift was uncommon. Only one patient had clear documentation of all three components of the mLAPSS. The etiology of stroke was uncertain in 27%, hypercoagulable in 23%, moyamoya or sickle cell disease in 23%, systemic disease in 15%, and cardiac disease in 12%.

Conclusion: While focal weakness, headache, and seizures were routinely documented in children with a final diagnosis of AIS, specific criteria of the mLAPSS, especially arm drift and grip strength, were rarely documented on initial examination.

INTRODUCTION

Childhood acute ischemic stroke (AIS) is increasingly being recognized and studied in the literature. The stroke rate in children is 1.72-13 per 100,000 people (deVeber et al., 2017; Hollist et al., 2021; Lehman et al., 2018). The incidence is highest in children less than five years of age, with the most common being less than one year of age (Ferriero et al., 2019). Childhood AIS is more

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common in boys than girls and more common in Black and Asian children (Ferriero et al., 2019). The risk factors for pediatric AIS are cardiac disease-causing thromboembolism, arteriopathies including sickle cell disease and moyamoya disease, prothrombotic states, traumatic vascular injury, and inflammatory etiologies such as systemic lupus erythematosus (deVeber et al., 2017; Ferriero et al., 2019; Sobu et al., 2019).

The most common presenting symptom of AIS in children is hemiplegia, which is regularly associated with facial weakness and speech issues (Arends et al., 2024; Baldovsky & Okada, 2020; Camacho-Sampaio et al., 2024; Hidalgo et al., 2018; Hollist et al., 2021; Mackay et al., 2011; Veber et al., 2017; Yock-Corrales et al., 2018). Children are more likely to have lower GCS and seizures than adults (Baldovsky & Okada, 2020). This includes 61% of children presenting with diffuse symptoms such as headache, vomiting, and decreased level of consciousness, and 29% of patients presenting with seizures (Baldovsky & Okada, 2020; deVeber et al., 2017).

Childhood AIS is frequently under-recognized by family and practitioners. 76% of patients presented after 6 hours of symptoms (Hartman, 2009). Less than half of patients' families considered stroke or called for an ambulance (Mackay et al., 2016). The time to diagnosis by health care practitioners is frequently prolonged, with the median time to radiographic confirmation being 15-24 hours (Braun et al., 2006; Ferriero et al., 2019; Rafay et al., 2009). Pediatric AIS can have devastating long-term symptoms, with 20-50% of children moderately to severely impaired, thus making advances in treatment and decreasing time to treatment paramount (Hollist et al., 2021; Mackay et al., 2017).

Early identification of adult stroke is recognized as a key component of treatment, with national benchmarks and educational campaigns for not only health care practitioners but the public alike on the importance of quickly recognizing stroke symptoms. In the prehospital setting, this includes utilizing emergency medical services (EMS) specific scoring systems to appropriately triage patients to stroke centers. One such tool is the Rapid Arterial Occlusion Evaluation (RACE) scale which evaluates facial palsy, arm motor impairment, leg motor impairment, head and gaze deviation, and hemiparesis. A RACE scale value of greater or equal to five showed a sensitivity of 0.85, a specificity of 0.68, a positive predictive value of 0.42, and a negative predictive value of 0.94 for detecting a large vessel occlusion. Another tool is the Modified Los Angeles Prehospital Stroke Screen (mLAPSS), which is used widely in our local prehospital systems. The mLAPSS has a sensitivity of 91% and sensitivity of 97% in adults but has not been studied specifically in children (Kidwell et al., 2000).

To expedite diagnosis and potential treatment, early recognition of stroke symptoms in children is equally important. Treatment for these patients begins in the prehospital setting with the ability to accurately triage these patients to stroke centers. The Pediatric RACE scale was specifically adapted from the adult RACE scale for use in children and evaluated 50 children in a 2024 study (Turón-Viñas et al., 2024). There was good interrater reliability, but small numbers with only 18 confirmed strokes. Given the widespread use of mLAPSS in our regional EMS system, we wanted to discover if this score could be applied to children. Before studying this prospectively, our group elected to evaluate a group of pediatric patients diagnosed with AIS and retrospectively evaluate how commonly the components of the mLAPSS were obtained on initial assessment.

Our primary goal was to determine if pediatric patients with an ultimate diagnosis of AIS or TIA had an arrival or prehospital mLAPSS score concerning for acute stroke. Secondary goals were to describe the presenting symptoms of these patients and ultimate stroke etiology.

METHODS

We performed a retrospective case series of all patients less than 18 years of age with a final diagnosis of acute ischemic stroke admitted to our hospital from 2014 to 2024. Our setting is a pediatric tertiary care center serving a population of approximately 1.3 million children. The hospital has 24-hour pediatric neurology and neurosurgery services.

Using a standardized data collection sheet and two data collectors not blinded to the study outcome, data were obtained from the EMS report, the ED record, and the hospital record. The following were collected: demographics, presenting symptoms, length of symptoms, method of arriving at the hospital, medical history, imaging and lab results, interventions, and final diagnosis. We attempted to determine mLAPSS from the earliest patient contact available, either from prehospital records, or if unavailable, from emergency department records. The presenting symptoms we recorded included focal weakness, altered mental status, headache, speech difficulty, dizziness or lightheadedness, visual change, and new or recurrent seizure. We determined etiology based on the final diagnosis of the inpatient discharge summary. If hypercoagulable testing was still pending, then follow-up visits were reviewed and final diagnosis determined by outpatient neurologist was recorded.

The mLAPSS examination criteria involves facial asymmetry, grip strength and arm strength (see Table 1), and the mLAPSS considered positive if all of the following criteria are met: 1) no history of seizures or epilepsy; 2) age 40 years or older; 3) at baseline, patient is not wheelchair bound or bedridden; 4) blood glucose between 60 and 400 mg/dL; and 5) obvious asymmetry-unilateral weakness with any of the forementioned motor exams.

	Normal	Right	Left
Facial Smile/Grimace	☐	☐ Droop	☐ Droop
Grip	☐	☐ Weak Grip ☐ No Grip	☐ Weak Grip ☐ No Grip
Arm Strength	☐	☐ Drifts Down ☐ Falls Rapidly	☐ Drifts Down ☐ Falls Rapidly

Table 1. Modified Los Angeles Prehospital Stroke Screen.

Descriptive statistics were used; nonparametric data was presented in medians and interquartile ranges. Patients were excluded if a stroke was determined to have occurred in the hospital or if deemed primarily traumatic or hemorrhagic. This study was approved by our hospital's institutional review board (IRB). Being a retrospective chart review, informed consent was waived by the IRB.

RESULTS

There were 70 patients with a final diagnosis of non-traumatic, non-hemorrhagic AIS or TIA during the study period. Due to recurrent stroke episodes, there were 82 total AIS or TIA episodes. Twenty-eight patients were female; 42 patients were male. The median age was 8 years (IQR 4-13 years). Of those with known past medical history, the most common was a cardiac defect in 14 patients and 6 patients with sickle cell disease. Three

patients had known moyamoya disease. Two patients had active leukemia on chemotherapy.

Median time from symptom onset to presentation was one day (IQR 2 hours to 2.75 days). In one patient there was insufficient documentation for how long the symptoms had occurred; in one patient the symptoms had been intermittent for 3 weeks, and one patient had a limp for 6 months. Approximately half of the patients came to the ED by private vehicle and not by ambulance (see Table 2). In the patients that arrived at the ED via ambulance, only 55% had EMS records available to review within the hospital's electronic medical record.

	n
Arrival to hospital	
By private vehicle	42 (51%)
By ambulance	18 (22%)
Uncertain	22 (27%)
Number of Presenting Symptoms	
Only 1 symptom	29 (35%)
2 symptoms	33 (40%)
3 symptoms	14 (18%)
>3 symptoms	6 (7%)
Types of Symptoms*	
New focal weakness	53 (65%)
Confusion	25 (30%)
Headache	24 (29%)
Speech deficit	22 (27%)
New or recurrent seizure	18 (22%)
Dizziness / lightheaded	12 (15%)
Vision change	9 (11%)
**Note. The total percentages add up to more than 100% because most patients had more than 1 symptom.*	

Table 2. Arrival and symptoms.

There were 30 patients who presented with only one symptom, the most common being a new focal weakness. The rest of the patients had more than one presenting symptom (see Table 2). While the majority of patients had weakness documented, specific mention of facial asymmetry or droop varied. Documentation of grip strength and arm drift was uncommon. Forty-one patients had facial symmetry documented, with 20 patients with a facial droop and 21 patients with normal symmetry. Only 9 patients specifically had grip strength documented, with 7 patients having a weak grip and 2 patients with a normal grip. Eleven patients had arm drift documented, including 4 patients with arm drift and 7 with no arm drift. Only one patient in our cohort had clear initial documentation of all three components of the mLAPSS.

In 11 of the encounters, we were unable to find an initial glucose test recorded. For the rest of the encounters, the earliest glucose recorded was a range of 67-345 mg/dL with a median of 100 (IQR 87-118).

A non-contrast, head computed tomography (CT) was the first diagnostic study in 63 patients, of which 60 went on to have confirmatory magnetic resonance imaging (MRI). Nineteen patients had MRI as the initial imaging test. Sixty-seven patients had either CT angiogram or MRI angiogram as part of continued stroke workup. The causes of stroke episodes included hypercoagulable in 23%, systemic disease in 15%, moyamoya in 13%, cardiac in 12%, sickle cell disease in 10%, and uncertain in 27%. Five patients had recurrent AIS episodes during the study period, including 2 patients with sickle cell disease with 6 and 2 strokes, respectively; one patient with MELAS syndrome (mitochondrial encephalopathy, lactic acidosis, stroke-like episodes) with 5 strokes; one patient with arrhythmogenic cardiomyopathy with 2 strokes; and one patient with adenosine deaminase deficiency with 2 strokes.

For initial treatment, 36 patients were placed on aspirin and 22 patients were placed on heparin or low molecular weight heparin. Six patients were sent for attempted thrombectomy with neurointerventional radiology. One patient had a carotid stent placed for a carotid dissection. Two patients required emergent craniectomy for increased intracranial pressure. Both cases were for large cerebral venous thromboses.

DISCUSSION

While focal weakness, headache, and seizures were routinely documented in children whose final diagnosis was AIS, specific motor criteria of arm drift and grip strength were rarely described in initial documentation. Similar to previous studies, new focal weakness was the most common presenting symptom. The frequency of focal weakness is a characteristic seen in both adult and pediatric strokes. Diffuse symptoms of confusion, headache, and seizure were common in children, which is less observed in adults.

This study has significant limitations including that, being retrospective, documentation of neurologic exam was not standardized and showed a high degree of variability in what was and was not written. It is possible that many of these patients specifically had grip strength and facial asymmetry evaluated, but this was not documented.

Multiple prior studies have shown a significant delay in time to diagnosis of childhood AIS (Braun et al., 2006; Hartman et al., 2009; Rafay et al., 2009). There is an opportunity to shine a light on the need for improvement in the awareness of AIS as a differential diagnosis in any patient with concerning symptoms and need for urgent diagnostics.

The average time to presentation was significant at one day. Only half of patients' family members believed the symptoms were serious enough to warrant calling for an ambulance. More education should be implemented for the public regarding recognition of early stroke symptoms at any age, not just in adults. Public education campaigns such as BE-FAST (Balance loss, Eyesight changes, Face droop, Arm weakness, Speech difficulty, Time to call 911 immediately) are focused on adult cohorts, but there is an opportunity to include that strokes can happen in children and are time-dependent.

Pediatric AIS is a game of diminishing returns. Delays in seeking care, delays in routing to the correct center, delays in consideration of stroke, and delays in diagnostics can all lead to critical missed opportunities to intervene. In the care of adult stroke, each metric is carefully monitored: time to provider evaluation, time to CT, time to CT reading, time to thrombolytics, and time to transfer or neurointerventional radiology. Delays at any step can lead to the inability to administer potential treatment for a life-altering event. Future studies should focus on developing a pediatric prehospital screening tool that accurately includes the most common symptoms and risk factors.

CONCLUSIONS

While focal weakness, headache, and seizures were routinely documented in children with a final diagnosis of acute ischemic stroke, specific criteria of the mLAPSS, especially arm drift and grip strength, were rarely documented on initial examination. Future studies should focus on determining and validating a specific pediatric prehospital stroke scale. Stroke campaigns should include pediatric specific teaching to improve public awareness of this diagnosis.

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RESEARCH REPORTS

A TIME-DRIVEN, ACTIVITY-BASED COSTING ANALYSIS OF ALTERNATIVE ED TRANSPORT OPTIONS: TREATMENT-IN-PLACE AND TRANSPORT TO ALTERNATIVE DESTINATION

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ABSTRACT

Background: Reducing acute care utilization (i.e., Emergency Department (ED) visits and hospitalizations) is critical to reducing total costs of care. Offering alternatives to ED transport for many lower acuity Emergency Medical Services (EMS) calls is a promising pathway toward reducing acute care use. We used a Time-Driven Activity-Based Costing (TDABC) method to analyze the costs of implementing two Alternative Care Pathways (ACPs) for EMS treatment that seek to reduce ED transport: treatment-in-place and transport to an alternative destination in a midwestern ambulance service.

Methods: Publicly available costs per unit of time were determined for needed equipment and personnel resources, including a fully staffed and equipped ambulance, an emergency physician, an ED nurse, and an emergency dispatcher. Process maps were developed to estimate resource times for four treatment outcomes: usual care (transport to the ED), treat-in-place, transport to an alternative destination, and an unsuccessful ACP attempt with transport to the ED. Costs were estimated for each treatment outcome.

Results: The least expensive pathway was treat-in-place, costing $1,559 per intervention, followed by transport to an alternative destination ($2,151), and usual care ($3,677). Thus, each successful completion of treat-in-place could offset the costs associated with 6.5 attempted but failed ACP interventions (that culminated in ED transport). Each successful transport to an alternative destination offset 4.7 attempted but unsuccessful ACP interventions.

Conclusions: ACP implementation can result in substantial cost savings, though results will need to be validated in other settings.

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COST ANALYSIS OF ALTERNATIVE ED TRANSPORT OPTIONS

Emergency department (ED) visits and hospitalizations are major drivers of total healthcare costs and incur substantial burden on patients and healthcare systems. Many lower acuity ED visits and hospitalizations can be avoided if patient care needs may be effectively met through alternative care pathways (North et al., 2023). However, multiple barriers to ED avoidance exist. Alternative treatment options have not been historically incorporated into emergency medical services (EMS) workflows, particularly in settings where care fragmentation precludes collaboration and partnership between EMS and other care providers. Additionally, ambulance services in the US have historically been reimbursed only when they transport a patient to an ED (Rubin, 2021). This reimbursement structure creates a financial incentive for EMS agencies to transport patients to the ED, even when lower acuity care options might be appropriate and effective (Harrison, 2017). As a result, EDs often serve as the default destination for a wide range of medical concerns, including conditions that can be safely, effectively, and even preferentially managed in non-emergency settings. This practice contributes to ED overcrowding and drives up costs for patients, health systems, and society at large (McKenna et al., 2019).

To address this inefficiency, some EMS systems are adopting innovative care models that allow paramedics to either treat patients at the scene (treat-in-place) or transport them to an alternative care site (transport to an alternative destination) (Neeki et al., 2016). Examples of alternative destinations include primary care clinics, urgent care centers, community-based mental health facilities, and alcohol and drug treatment centers. Treat-in-place models may involve paramedics or community paramedics working in collaboration with physicians or advanced practice providers, often using telehealth, to assess and manage patients on-site without transport. These alternatives, which often fall under the umbrella of mobile integrated health (MIH), aim to provide appropriate care in a more efficient and patient-centered manner, while reducing unnecessary ED utilization, preventing hospitalizations, and reducing total costs of care (Mechem et al., 2020). Indeed, several studies have shown that MIH alternative care pathway (ACP) programs can successfully reduce ED and hospital utilization (Thurman et al., 2021; Lurie et al., 2023; Adibhatla et al., 2024; Boland et al., 2023; Leyenaar et al., 2021). With greater interest in total cost of care models, it is important to assess the financial impacts of different ED substitutional efforts such as treat-in-place and transport to an alternative destination.

However, for alternative care pathway (ACP) programs such as treat-in-place and transport to alternative destination interventions to scale and succeed, health systems and EMS agencies must co-develop integrated and financially sustainable pathways that address not only the clinical appropriateness of ED alternatives but also the logistical, financial, and regulatory challenges that currently impede real-time decision-making and access to care. This study uses time-driven activity-based costing (TDABC) to estimate the actual resource costs of implementing treat-in-place and transport to alternative destination interventions within a large, advanced life support ambulance service in the upper Midwest. (Kaplan & Anderson, 2004; Kaplan & Porter, 2011). By analyzing the time and resource demands of treat-in-place and transport to alternative destination interventions, this study provides a transparent cost framework to inform decision-making by EMS leaders, health systems, and policymakers seeking to redesign emergency response systems for value-based care (Heaton et al., 2019). The project objective was to determine if adoption of EMS-based alternative care pathways, including treatment-in-place and

transport to an alternative destination, can provide a cost-efficient approach to reducing acute care utilization and total cost of care.

METHODS

Setting

Mayo Clinic Ambulance service provides advanced and critical patient care and transport via ground transport (74 ambulances) and air ambulance (4 helicopters and 1 airplane) to a service area spanning 6,894 square miles of urban, suburban, and rural areas across southeast and north central Minnesota and northwest Wisconsin. The counties served have a total population of 1,473,366 based on the 2020 American Community Survey (United States Census Bureau, 2022). Mayo Clinic Ambulance service responds to approximately 100,000 requests for service annually, including 75,000 calls through the 911 system. Although first responders from police and/or fire departments also respond to a subset of 911 calls in this catchment area, their associated costs were excluded from analysis because they are not impacted by ACP implementation.

Medical direction to Mayo Clinic Ambulance is provided by physicians affiliated with Mayo Clinic, an integrated health care delivery system serving local, regional, national, and international patients with a clinical and administrative hub in Rochester, Minnesota. Mayo Clinic Rochester is a tertiary referral center that includes an ED (equipped with telehealth capabilities), two hospital campuses, ambulatory specialty referral practices, and comprehensive primary care practices that specifically care for residents of Olmsted County and the surrounding areas. Olmsted Medical Center is the only other health system in the county and includes ambulatory clinics, an ED, and hospital. Mayo Clinic Health System (MCHS) is an integrated network of community-based clinics, hospitals, and health care facilities that provide both primary and specialty care to the residents of the other communities (outside of Olmsted County) served by Mayo Clinic Ambulance service. There is a standalone Veterans Health Administration outpatient facility in Rochester as well as one urgent care center not affiliated (Centers for Medicare & Medicaid Services, 2025) with either health system. Mayo Clinic Ambulance is the sole EMS provider in its service areas.

The ACP programs were initially implemented in two primary service areas under the Centers for Medicare & Medicaid Services (CMS) pilot Emergency Triage, Treatment and Transport (ET3) program: Rochester and Mankato, Minnesota. In Mankato, MCHS operates a hospital with an ED, as well as urgent care, ambulatory specialty, and primary care clinics. Implementation of ACP programs in Rochester began January 1, 2021, and in Mankato on February 1, 2022, with telehealth support provided by emergency medicine physicians at Mayo Clinic Rochester. Data for this study were collected between January 1, 2021, and December 31, 2021.

Ethics Review

This retrospective study was deemed exempt by the Mayo Clinic Institutional Review Board.

Alternative Care Pathway Programs

Mayo Clinic Ambulance ACP programs included two treatment options, treat-in-place and transport to an alternative destination, and four potential treatment outcomes: successful treat-in-place, successful transport to an alternative destination, attempted ACP but unable to complete, and usual care (i.e., ACP not attempted). The service had telehealth access to Mayo Clinic emergency medicine physicians 24 hours a day, 7 days a week. The Nationally Registered Paramedics (NRP) and Emergency Medical Technicians (EMTs) registered by the National Registry of EMTs were empowered to offer telehealth services to any patient 18 years and older with decision-making capacity or with a medical decision-maker present based on their clinical expertise. The decision to proceed with an ACP was made collaboratively by the on-scene EMS personnel, the Mayo Clinic emergency medicine physician, and the patient and/or caregiver.

Alternative destinations included two primary care clinics, three urgent care clinics, a 16-bed crisis behavioral health hospital, and a 22-bed health care facility with acute detoxification services. Only the crisis behavioral health hospital and acute detoxification service provided support 24 hours a day, 7 days a week.

Analysis

TDABC, as described by Kaplan and Porter (Kaplan & Porter, 2011), was used to quantify the hospital and ambulance service's costs for providing all care services to the patient. TDABC combines process mapping and activity-based costing to capture the full scope of personnel time and other resource utilization involved in delivering these interventions. Data were analyzed using Microsoft Excel. We followed the STROBE guidelines (Strengthening the Reporting of Observational Studies in Epidemiology) to report study findings (von Elm et al., 2007).

We estimated activity times from a combination of observations, interviews, and data time stamps generated by the Mayo Clinic Ambulance dispatch system. Total direct costs were calculated by multiplying each resource's (personnel and equipment) capacity cost rate (described below) by the minutes that the resource was used during the intervention. Costs were summed across all resource types to obtain the cost over the full response cycle (Salary.com, 2023).

Costs used in the TDABC analysis were gathered from publicly available websites, articles, and databases. The website Salary.com (Salary.com, 2023) provides distributions of salaries for positions based on a specified location. For this analysis, we reviewed data including benefits from Salary.com for the hub location (Rochester, Minnesota) and used the median salary (cost/hour) for each position in TDABC calculations during the year of program implementation: emergency dispatcher (Salary.com, 2023), $30; emergency department nurse (Salary.com, 2023), $72; and emergency department physician (Salary.com, 2023), $195.

The cost of an ambulance includes its operating expense, equipment, depreciation, and personnel staffing. Ambulance costs were calculated using published annual budgetary expenditures and ambulance run numbers for a midwestern city (Woodbury, Minnesota) (City of Woodbury, 2022). The average cost per transport was $703, including all budgeted costs divided by the total number of ambulance transports (defined as calls

in which a patient was taken from the scene to a destination, as distinct from total ambulance runs which include all responses). Woodbury, Minnesota budgetary data were used because comparable publicly available itemized ambulance budget data were not available for Mayo Clinic Ambulance at the time of this analysis; this represents a limitation, as noted below. Using Mayo Clinic Ambulance data, a typical call takes an ambulance out of service for 67 minutes, leading to a per-minute cost of $11. Although miles traveled per call varies, an estimated average transport distance of 10 miles was used to simplify calculations. Personnel per-minute costs reflect time-on-task for paramedics (time on call) and, for ED physicians and nurses, time per shift regardless of caseload, consistent with standard TDABC methodology.

Care costs for EDs were based on national averages of ED encounters regarded by the UnitedHealth Group to be treatable at a lower cost care location, such as a primary or urgent care center (UnitedHealth Group, 2019). These encounters included 10 common conditions that are often treated in the ED but can be treated equally well in primary or urgent care settings: bronchitis, cough, dizziness, flu, headache, low back pain, nausea, sore throat, strep throat, and upper respiratory infections. Urgent care costs were based on published UnitedHealthcare data for average costs when patients were treated at a UnitedHealthcare owned and contracted service provider (UnitedHealthcare, 2023): ED treatment after transport (UnitedHealth Group, 2019), $2,032; urgent care treatment after transport (UnitedHealthcare, 2023), $180.

RESULTS

Resource Time and Costs

The Mayo Clinic ACP programs had potential treatment outcomes for all emergency 911 calls: 1) respond to the scene and transport the patient to the ED without implementing a substitution program (usual care), 2) implement treat-in-place, 3) implement transport to alternative destination, and 4) attempt to implement an ACP but find it necessary to transport the patient to the ED. The fourth outcome, attempted but unsuccessful ACP with ultimate ED transport, accounted for the added cost of the telehealth consultation plus the standard transport costs; this pathway was included in cost modeling to enable calculation of how many failed attempts could be offset by each successful ACP.

Multiple types of practitioners participated in at least one of the four treatment outcomes. Emergency medical dispatchers received 911 calls, dispatched appropriate ambulance service resources, and tracked these resources throughout the response. NRPs and EMTs traveled to the scene in ambulances, assessed the patient, provided treatment, conducted telehealth interactions at their discretion, and treated the patient in place or transported the patient to the ED or to an alternative treatment site. Ambulance costs were calculated based on a 2-paramedic crew because all Mayo Clinic ambulances have at least one NRP, and ambulances are dispatched equivalently whether they are staffed by two paramedics or by one paramedic and one EMT. A registered nurse working in the Admissions and Transfer Center received all requests for interventions and coordinated connections with the on-duty ED telehealth physician, who then connected via an audiovisual telehealth link to the paramedic in the field. Patients who were transported to the ED were evaluated and treated by ED staff including physicians, advanced practice providers (nurse practitioners or physician assistants), and nurses.

Time spent on patient care tasks was estimated in minutes for each personnel type. These cost and time estimates were then compiled into a swimlane process map for each of the four treatment outcomes, with urgent care designated as the destination for the transport to alternative destination pathway option (Figures 1 and 2).

Using the process maps, costs were estimated for each of the four treatment outcomes (Table 1). A successful treat-in-place activation cost 28% of the traditional response and transport ambulance intervention. A patient transported to a primary or urgent care center cost 50% compared to a traditional response with ED transport. If the patient was transported to the ED after an attempted ACP intervention, the incremental cost for implementing treat-in-place or transport to an alternative destination was 17%. Cost savings from treat-in-place were equivalent to the additional costs of 6.5 attempted but failed ACP interventions or 4.3 standard ED transports, while transport to alternative destination savings were equivalent to 4.7 attempted but failed ACP interventions or 3.0 ED transports.

	Respond and Transport to ED	Treatment-in-Place	Transport to Urgent care	Transport to ED
Dispatch and arrive at scene	$132	$132	$132	$132
Conduct intervention	N/A	$467	$467	$467
Ambulance transport	$605	$165	$605	$605
Treat in ED	$2,032	N/A	N/A	$2,032
Treat in urgent care	N/A	N/A	$180	N/A
Total	$2,769	$ 764	$1,384	$3,236

Table 1. Cost associated with each treatment intervention.

DISCUSSION

We examined the costs associated with two alternative care pathway strategies: treatment in place (treat-in-place) and transporting patients to an alternative destination. The results demonstrate that cost savings from treat-in-place offset the additional costs of 6.5 attempted but failed ACP interventions or 4.3 standard ED transports, while transport to an alternative destination offset the cost of 4.7 attempted but failed ACP interventions or 3.0 ED transports. Importantly, while both ACP models show net savings, these savings accrue differently across stakeholders.

These findings build on a growing body of literature examining prehospital alternatives to default ED transport for low-acuity patients (Gingold et al., 2022). Community paramedicine and MIH programs have demonstrated that expanding the role of EMS to include on-scene assessment, triage, and care coordination can reduce avoidable ED visits and hospital admissions (Thurman et al., 2021; Lurie et al., 2023; Adibhatla et al., 2024; Boland et al., 2023; Leyenaar et al., 2021). These programs often integrate EMS with primary care, behavioral health, or social services to address patient needs more holistically and potentially prevent unnecessary use of high-cost emergency care. For example, interventions targeting frequent 911 users through in-home evaluations and longitudinal follow-up have shown reductions in both ED utilization and total medical spending (Korczak et al., 2019). However, scalability and impact of these programs have been limited by misaligned reimbursement models, inconsistent telehealth integration, lack of

interoperability between EMS and outpatient health systems, and variable support from regional healthcare partners. Beyond clinical integration, EMS clinicians should also be integrated into the social services ecosystem, equipped with awareness of available community resources and able to connect patients with non-healthcare supports such as housing assistance, food security programs, and transportation services—to more comprehensively address the social determinants of health that often underlie 911 utilization.

However, most prior work has focused almost exclusively on quantifying utilization outcomes such as ED use and hospital readmissions without examining the underlying cost structures that drive those changes. Even when costs were considered, analyses have been reimbursement rather than cost-based and payer-specific, often focused on Medicare savings or return-on-investment for a single stakeholder (Munjal et al., 2019; Blodgett et al., 2021). Our analysis therefore adds a novel and important dimension by applying a TDABC framework to directly measure the real costs of ED substitution strategies, namely, treat-in-place and transport to alternative destination. This approach enabled a more granular understanding of the tradeoffs at the system level, revealing that cost savings from treat-in-place and transport to alternative destination interventions can offset multiple standard ED transports, but that the distribution of savings and costs varies significantly across stakeholders (e.g., ambulance services, hospitals, and patients).

For ambulance services, the cost burden often includes dispatch, on-scene care, coordination with clinicians (such as via telehealth), transport (if applicable), and post-call activities like documentation and restocking. Importantly, ambulance services often do not typically bear the cost of physician consultations or downstream ED care. Therefore, if reimbursement is not aligned with the increased time and complexity involved in treat-in-place or transport to an alternative destination, there may be disincentives to participation in ACPs. This highlights the need for cost-sharing models or new reimbursement structures to make ACP financially viable when cost savings are asymmetrically distributed between the prehospital and in-hospital care. Additionally, costs may differ substantially in settings where ED services are provided through contracted, for-profit arrangements rather than integrated health systems. In these contexts, the financial incentive structure may further complicate ACP adoption, as contracted EDs may have less flexibility to absorb reduced volume and may lack the organizational alignment needed to support care coordination with EMS. Health systems benefit from ACPs not only through cost savings but also by preserving ED and hospital capacity for higher-acuity patients. During periods of high demand or in the setting of ED overcrowding and boarding, alternative transport and treat-in-place strategies allow systems to redirect low-acuity cases away from crowded EDs, supporting more efficient resource use.

In addition to conserving finite resources, the ACP programs have subtly reframed the role of prehospital practitioners by increased treat-in-place and use of alternative destinations. When skilled paramedics and EMTs solely transport patients to the ED, they are often working below their capabilities and not using their extensive training and experience in providing medical care (Torres & McCoy, 2022). ACP programs therefore mobilize the capabilities of prehospital practitioners, allowing them to use their medical judgment to triage patients according to the need for ED-level care, to identify appropriate treat-in-place and/or transport to alternative destination options, and to counsel patients and caregivers about health status. Other MIH programs, such as community

paramedicine, can become a means for patients to access a more flexible system for providing unscheduled health care.

Patients stand to benefit from the reduced financial burden and improved care experience when treated through an ACP. Treating patients at home or redirecting them to primary care avoids the high costs associated with ED visits, though these costs may not be paid directly by patients depending on their insurance status. Critically, the role of the patient's primary care provider (PCP) is an important and underexplored dimension of ACP integration. Some patients who access 911 services have an established PCP, and effective ACP programs must coordinate with PCPs to ensure appropriate follow-up, continuity of medication management, and longitudinal care planning after an ACP encounter. Without this coordination, the gains of an ED diversion may be offset by fragmented downstream care. Future ACP program designs should explicitly address how EMS can communicate encounter details to PCPs and facilitate timely follow-up appointments, particularly for patients with complex chronic conditions. Beyond cost-saving, successful ACP programs can support continuity of care and improve the patient's care experience. Notably, in the absence of public education about these options, some patients may be hesitant to accept non-ED care after calling 911. This would require EMS crews to provide real-time education under time pressure when an ACP does not match the patient's expectations for EMS care. The patient and caregiver experiences within the treat-in-place and transport to alternative destination models should be evaluated in future work, focusing on perceptions of met and unmet needs, responsiveness of the health care system to concerns, ability to receive care in the required timeframe, and impact on continuity of care.

Importantly, our ACP program and its evaluation are payer agnostic, demonstrating cost savings despite providing non-reimbursed care. The ET3 Model, implemented in 2021 as a voluntary five-year CMS payment model, offered the potential for ACP program reimbursement for Medicare beneficiaries, and was an important advancement toward efficient and sustainable pre-hospital care. Unfortunately, it ended in 2023, two years ahead of schedule, due to fewer than anticipated interventions and lack of data on cost-savings (Centers for Medicare & Medicaid Services, 2025; JEMS Staff, 2023). Our data underscore the potential efficiencies and cost-savings from ACP programs, providing much needed evidence in support of ET3 and other alternative payment models to reduce low value acute care use while meeting patient care needs in a financially sustainable way for all stakeholders.

ACP models face technological, organizational culture, and broader societal barriers beyond financial efficiency. Implementing ACP models requires EMS agencies to move beyond traditional transport-based workflows and instead adopt a more integrated, patient-centered approach to unscheduled care. This shift demands new clinical protocols, staff training, and technology infrastructure—such as telehealth capabilities, consistent access to internet (a major challenge in rural areas), point-of-care diagnostics, and treatment supplies—to make on-scene decision-making and care delivery viable. Operationally, these models also often require longer scene times, collaboration with physicians or advanced practice providers, and coordination with alternative care sites for follow-up. Yet, EMS agencies have historically emphasized the importance of minimizing time on scene and expediting calls to prepare for the next emergency, (Ito et al., 2022) necessitating a culture shift and realignment of EMS quality measures. Notably, our data show

that successful interventions resulting in treat-in-place required less total time on task than transporting patients to the ED.

One of the biggest barriers to effective ACP programs is the lack of streamlined reliable processes that allow EMS to meet patients' clinical needs safely and effectively within the narrow timeframes required once 911 is activated. While EMS systems are well equipped for rapid response, they are not traditionally designed to navigate the complexities of care navigation, resource coordination, and longitudinal follow-up needed to replace a subset of ED visits (Piasecki et al., 2023). Without real-time access to alternative care sites, appointment availability, telemedicine or other physician support, or shared patient health records, EMS personnel may default to ED transport—even when it may not be clinically necessary.

LIMITATIONS

Our study was conducted within an integrated delivery system where EMS, EDs, and primary care operate under a single organization. This may limit generalizability, especially considering the heterogeneity of EMS system designs. Furthermore, costs for specific resources discussed can vary regionally and across healthcare systems, as does the availability and accessibility of alternative treatment destinations and care pathways. Our study focused on costs rather than reimbursement, which will be a critical factor in real-world adoption. Costs related to program startup, training, and infrastructure (e.g., telehealth connectivity) were also not included, as they were part of usual care processes in our healthcare system prior to ACP implementation. The setting is representative of the U.S. upper Midwest but does not generalize to large urban or highly rural areas, and has a limited number of health systems, which may affect applicability to broader populations. Additionally, Mayo Clinic Ambulance differs from many U.S. EMS systems in the absence of fragmented agency structures, the lack of overlapping fire department EMS responsibility, and the presence of an integrated telehealth system, and that these features may limit direct generalizability to other settings. It should also be noted that additional real-world outcomes exist beyond these four modeled scenarios, including patient refusal of care and calls where no care is required; these were not included in the cost modeling as they do not involve ACP-related resource utilization.

CONCLUSIONS

This study demonstrates the economic viability of treating select 911 patients outside the ED via alternative care pathways such as treat-in-place and transport to an alternative destination. These approaches offer cost savings across the health system while potentially improving patient outcomes and experience. By focusing on actual resource utilization rather than charges or reimbursements, our study helps fill a critical gap in the literature and provides a stronger foundation for policymakers and health system leaders considering scalable alternatives to traditional ED-centric models of acute care. It also underscores the importance of aligning financial incentives across the continuum of care to support the viability of prehospital substitution models. Future research should focus on broader implementation in diverse systems, patient education strategies, and the development of sustainable funding models. Additionally, further study is needed to understand long-term outcomes and the effect of these interventions on ED capacity, staff satisfaction, and continuity of care.

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RESEARCH REPORTS

TRACTION SPLINT USAGE IN PREHOSPITAL EMERGENCY MEDICAL SERVICES: A CROSS-SECTIONAL ANALYSIS OF PERSONNEL KNOWLEDGE, APPLICATION FREQUENCY, AND ERGONOMIC CHALLENGES IN THE FIELD

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ABSTRACT

Introduction: Femur fractures are potentially life-threatening injuries requiring effective prehospital immobilization. Traction splints (TS) are standard equipment for this purpose, yet their infrequent use raises concerns about skill decay. This study aimed to assess the self-reported knowledge, frequency of use, and practical difficulties encountered by Turkish 112 Emergency Medical Services (EMS) personnel when applying traction splints, while acknowledging the limitations of self-reported data.

Methods: A cross-sectional study was conducted with 263 prehospital healthcare personnel across Izmir, Turkey. Data were collected via a structured survey covering demographic characteristics, traction splint (TS) training, self-reported knowledge, usage frequency, and ergonomic challenges. Categorical variables were analyzed using the Chi-Square test.

Results: Over half of the participants (52.9%, n=139) reported never having used a TS in their career. A significant difference was found between professional groups and self reported knowledge levels ($p < .001$). Over 50% of physicians and paramedics rated their knowledge as "Very good," while most emergency medical technicians (EMTs) described theirs as "Moderate." The most frequently reported challenge during application was "patient positioning/access difficulty" (52.5%, n=138). Only 10.6% (n=28) of participants found the device "very suitable" ergonomically.

Conclusion: The traction splint is a low frequency piece of equipment, carrying a high risk of skill decay. The findings highlight significant ergonomic limitations in field use and disparities in perceived competency among professional groups. To ensure effective application when needed, targeted simulation based training---especially for EMTs---and the design of ergonomic equipment adapted to real world field conditions are strongly recommended.

INTRODUCTION

The primary objectives of prehospital emergency care are to reduce morbidity, preserve vital functions, and prevent secondary injuries. Extremity traumas, if not managed correctly, can lead to serious complications. The femur, being the longest and strongest bone in the body, requires a high-energy mechanism to fracture. Such fractures carry life-threatening risks, including

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hypovolemic shock due to significant blood loss, fat embolism syndrome, and compromise of neurovascular integrity. The epidemiological profile of these injuries can vary significantly by region; for example, mechanisms may range from high-velocity traffic accidents in urban settings to falls or skiing-related trauma in specific geographic areas. In the Turkish context, traffic accidents represent a leading cause of such high-energy traumas.

Traction splints (TS) have been a standard component of ambulance equipment for decades for the field management of femoral shaft fractures. They aim to realign bone fragments, relieve pain by reducing muscle spasm, and limit soft tissue damage (National Association of Emergency Medical Technicians [NAEMT], 2020). While traditional views and international protocols such as Prehospital Trauma Life Support (PHTLS) recommend their use for isolated femur fractures, research over the past two decades has opened debate on their absolute necessity and safety profile (NAEMT, 2020; Philipsen et al., 2022). Recent statements from professional bodies like the National Association of EMS Physicians (NAEMSP) have further called the routine use of TS into question, adding to the clinical dilemma.

There is no consensus in the literature regarding the efficacy of TS use. Some studies report significant reductions in pain scores and analgesic requirements compared with simple splinting (Bumpass et al., 2015; Irajpour et al., 2012). In contrast, other researchers question the place of TS in modern trauma management, labelling it an "EMS relic," and cite concerns about time-consuming application, potential delays in the "golden hour" for multi-trauma patients, and specific contraindications (Agrawal et al., 2009; Bledsoe & Barnes, 2004).

The primary motivation for this study stemmed from the researcher's own educational experiences. While teaching traction splint application to students, significant practical issues were observed, including excessive application time, parts of the splint extending beyond the stretcher, and difficulties in positioning the device inside the ambulance. These observations raised the question of what frontline personnel truly think about this device. Therefore, this study aims to systematically collect feedback from field providers to identify the shortcomings of the current design and to lay the groundwork for developing a simpler, more user-friendly traction splint based on their insights.

In the context of Turkey's trauma epidemiology and diverse geographical conditions, the effective use of this equipment depends not only on theoretical knowledge but also on the practical skills of personnel and the ergonomic suitability of the device. However, as noted in recent reviews, low frequency of use increases the risk of "skill decay" among healthcare providers (Acker et al., 2021; Davis et al., 2023). This gap between training and field application is a core educational and operational challenge.

This study was guided by the following objectives and hypotheses:

- To assess the frequency of TS use among Turkish prehospital providers.
- To compare self-reported TS knowledge across professional groups (physicians, paramedics, EMTs).
- H_1: Professional group is associated with self-reported knowledge level.
- H_0: There is no such association.

- To identify the primary ergonomic and practical barriers to TS application in the field.

Through these aims, this study contributes local data to the international debate on the role of TS in modern paramedicine.

METHODS

Study Design and Setting

This is a descriptive, cross-sectional study conducted among active healthcare personnel working at 112 Emergency Medical Services stations throughout Izmir. The 112 service is the legally mandated public ambulance service providing emergency care and transportation throughout Turkey.

Participants

The study population comprised all 112 EMS personnel in Izmir, with a convenience sample of 263 participants included. Participants were eligible if they were actively working in the 112 system during the data collection period and consented to take part. No exclusion criteria were applied. Participants were categorized by professional title: physician, paramedic, emergency medical technician (EMT), and other healthcare personnel.

Data Collection

Data were collected using a structured survey form, titled "Questionnaire on the Use of Traction Splints among 112 Ambulance Staff." The questionnaire was developed based on a literature review and was pilot tested for clarity and face validity with 10 EMS professionals who were not included in the final sample. Feedback from the pilot led to minor wording adjustments. The internal consistency of the survey items related to knowledge and barriers was acceptable (Cronbach's $\alpha = 0.78$). The final questionnaire was distributed electronically via professional networks and completed anonymously. It consisted of three main sections:

1. Demographic information: Station location, professional title, and total service duration in the EMS system (0–2, 3–5, 6–10, and >10 years).
2. Training and knowledge level: TS training status (theoretical/practical), self reported knowledge level regarding indications and contraindications ("Very good," "Moderate," "Inadequate"), and perceived adequacy of the training received. For the analysis, "Very good" was operationally defined as the ability to list all key indications and contraindications without assistance.

Usage Frequency, Ergonomics, and Challenges

Frequency of TS use over the participant's career and in the last year, time since last use, type of splint used (e.g., Sager, Thomas, CT6), main difficulties encountered during application (e.g., patient positioning, time pressure), and opinions on equipment ergonomics. Participants were also asked for recommendations on the frequency of refresher training.

Statistical Analysis

Statistical analysis was performed using SPSS version 21. Descriptive data are presented as number (n) and percentage (%). The Chi-Square test was used to examine relationships between categorical variables, particularly differences between professional groups regarding knowledge level and usage habits. For significant Chi-Square results, effect sizes were calculated using Cramer's V. To account for multiple comparisons when analyzing subgroups, a Bonferroni correction was applied, adjusting the significance threshold to $p < .01$. A p-value < .01 was therefore considered statistically significant for group-wise comparisons.

Ethical Considerations

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments. Ethical approval was obtained from the Non-Interventional Research Ethics Committee of Izmir University of Economics (Approval Number: E-97429853-050.04- 120822). Completion of the survey was taken as implied consent.

RESULTS

A total of 263 healthcare personnel actively working at 112 Emergency Medical Services stations participated in the study. Data regarding demographic characteristics, knowledge levels, application frequencies, and ergonomic challenges are presented below.

Demographic Characteristics

The professional distribution showed that paramedics constituted 46.4% (n=122) and EMTs 37.3% (n=98) of the group. In terms of service duration, the profile was experienced, with 46.0% (n=121) having worked for 10 years or more. Detailed demographic data are shown in Table 1.

Groups	n	%
Profession		
Paramedic	122	46.4
EMT	98	37.3
Physician	31	11.8
Other*	9	3.4
Service Years		
0–2 years	44	16.7
3–5 years	37	14.1
6–10 years	59	22.4
>10 years	121	46.0

Note. "Other" includes healthcare personnel with titles such as nurse or health officer.

Table 1. Demographic characteristics of participants (n=263).

Training Status and Knowledge Level

The majority of participants (n=202, 76.8%) had received both theoretical and practical TS training. A statistically significant difference was found between professional groups and self reported knowledge levels ($p < .001$). Over half of physicians and paramedics rated their knowledge as "Very good," whereas the majority of EMTs (51.0%) described it as "Moderate." These findings are summarized in Table 2.

Usage Frequency and Equipment Preference

One of the most striking findings was the low rate of TS use in field practice. Overall, 52.9% (n=139) of participants stated they had never used this equipment throughout their career. The CT6

Profession	Very Good n (%)	Moderate n (%)	Inadequate n (%)	p-value
Paramedic	64 (52.5)	48 (39.3)	4 (3.3)	< .001
Physician	16 (51.6)	12 (38.7)	3 (9.7)	
EMT	33 (33.7)	50 (51.0)	11 (11.2)	

Table 2. Comparison of self reported knowledge level by professional group.

model was the most commonly used splint type, at 70.0% (n=184). Usage frequency and equipment preferences are detailed in Table 3.

Options	n	%
Usage Frequency		
Never used	139	52.9
1–3 times/year	97	36.9
4–6 times/year	21	8.0
7 times/year	4	1.5
Splint Type Used		
CT6	184	70.0
Thomas	40	15.2
Other	9	3.4

Table 3. Traction splint usage frequency and equipment preferences.

Field Challenges and Ergonomics

"Patient positioning/access difficulty" was the most frequently reported challenge (52.5%, n=138), followed by "Time pressure" (17.9%, n=47). Only 10.6% (n=28) of participants found the device "very suitable" ergonomically. The "Other reasons" category (8.4%, n=22) included open-ended responses such as "device is too heavy to carry," "difficult to clean," and "lack of clear protocols." These qualitative insights are summarized in Table 4 and Table 5.

Difficulty Encountered	n	%
Patient positioning/ access difficulty	138	52.5
Time pressure	47	17.9
Lack of knowledge/ experience	26	9.9
Other reasons	22	8.4
Lack of equipment	9	3.4

Table 4. Main difficulties encountered during application.

Other Reason	n	%
Device is too heavy to carry	8	36.4
Difficult to clean/ maintain	6	27.3
Lack of clear protocols	5	22.7
Patient discomfort	3	13.6
Total	22	100

Table 5. Specified "other reasons" for difficulty (n=22).

DISCUSSION

This study reveals that the traction splint is used very infrequently in prehospital practice in Turkey. It identifies differences in perceived knowledge levels among professional groups and highlights ergonomic constraints as the primary barrier to application.

Low Usage Frequency and Skill Decay

The finding that over half of the participants had never used a TS aligns with international literature (Abarbanell, 2001; Campagne et al., 2020; Nackenson et al., 2017). This infrequency poses a significant risk of skill decay, a phenomenon well-documented in low-frequency, high-acuity procedures (Davis et al., 2023). The reported "lack of knowledge/experience" as a challenge underscores that theoretical training is not reinforced by practical experience, potentially eroding provider confidence. In the Turkish system, where no national real-time EMS database (comparable to NEMSIS in the US) exists to track intervention-specific outcomes, reliance on self-reporting and periodic training becomes even more critical.

The Dilemma of Clinical Necessity, Pain Management, and Time

"Time pressure" was a cited barrier, supporting arguments that TS application may prolong on-scene time (Bledsoe & Barnes, 2004). This creates a field dilemma between swift transport and the benefits of fracture stabilization (Bumpass et al., 2015; Irajpour et al., 2012). Furthermore, local protocols in many Turkish EMS regions do not explicitly mandate TS use in multi-trauma scenarios, which may contribute to both the low usage frequency and the perception of time pressure. The skill decay observed is therefore likely a product of both low opportunity and protocol-driven hesitation.

Ergonomics and the Impact of Field Conditions

The most salient finding is that "patient positioning/access difficulty" is the foremost barrier. Traditional TS designs often require full leg extension and ample working space, conditions frequently unmet in real-world scenarios (Auerbach et al., 1984; DeFroda et al., 2016). This ergonomic mismatch is a primary deterrent. The "other reasons" provided by participants, such as the device being too heavy or difficult to clean, point to further human-centered design flaws that are rarely discussed in the clinical literature but are paramount for field providers.

Professional Competencies and Training Needs

The disparity in self-reported knowledge, with EMTs feeling less competent, points to a specific need for targeted education. To mitigate the identified skill decay, EMS systems should consider implementing low-cost, high-frequency simulation-based training. For example, a "deliberate practice" model using simple, home-made mannequins in 15-minute station drills every six months could maintain psychomotor skills without requiring real-life opportunities. This is particularly relevant for EMTs, who represent a large segment of the workforce and have less initial training than paramedics.

Generalizability and System-Level Context

While these findings are specific to Turkey, they are likely relevant to EMS systems of similar maturity where TS is a standard but rarely used device. In systems with broader paramedic scopes of practice or more mature trauma systems, the barriers might shift from basic knowledge (as seen with EMTs) to system-level time pressures or protocol restrictions. The ergonomic challenges, however, are universal and independent of clinical training level.

LIMITATIONS

This study has several limitations. The use of self-reported data may introduce recall or social desirability bias, and the study did not assess actual clinical competence through objective testing. The cross-sectional design captures only a snapshot in time. The sample may not be fully representative of all Turkish 112 personnel. Furthermore, the study did not collect objective data on call types (e.g., traffic vs. fall), urban vs. rural station locations, or specific transport times, which could influence TS use. The absence of a national EMS database in Turkey to link patient outcomes with specific prehospital interventions prevented a more robust, objective analysis of TS application and its clinical impact.

CONCLUSION

The traction splint remains a part of EMS inventories but is characterized by infrequent use, which jeopardizes skill retention. Application is significantly hindered by ergonomic challenges. To address these issues, we recommend: (1) the development of next-generation traction splints with improved ergonomics; (2) the implementation of mandatory, periodic, simulation-based training programs, particularly for EMTs; and (3) the revision of clinical protocols to provide clear guidance on TS use in multi-trauma scenarios.

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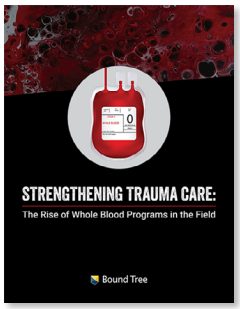
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CHARACTERISTICS OF RESPONSES FROM AN AUSTRALIAN EMERGENCY MEDICAL SERVICE THAT RESULTED IN NON-CONVEYANCE: A RETROSPECTIVE CROSS-SECTIONAL STUDY

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ABSTRACT

Rates of non-conveyance (referred to as a patient refusal or non-transport in areas outside of Australia), defined as paramedic discharge of a patient in the community rather than transporting them to hospital, are increasing. These episodes of care require complex decision-making from paramedics to ensure patients' needs are appropriately addressed in a timely manner. Knowledge of non-conveyance case characteristics may be useful to direct the focus of research that aims to inform and design effective, patient-centric models of ambulance healthcare delivery.

A retrospective, observational cross-sectional study describing characteristics of non-conveyance cases occurring within an Australian ambulance service setting between 1 January 2019 and 31 December 2020.

Of 1,533,453 adults attended and assessed, *n*=193,970 (12.6%) were not conveyed to the hospital. Dispatch initially prioritized 43.7% of non-conveyed cases as requiring an emergency (lights and sirens) response. Older people, aged 65 years and above, accounted for 44% of all non-conveyed patients. Pain was the most frequently recorded diagnosis, and less than 1% of all patients not conveyed were recorded as being referred to an alternative form of healthcare service.

This study provides insight into characteristics of ambulance cases in an Australian jurisdictional ambulance service setting which resulted in non-conveyance during the impacts of the COVID-19 epidemic. These findings can be used to focus future investigations that aim to understand how evolving models of ambulance healthcare delivery can safely meet the needs of patients requesting ambulance services and enhance operational efficiency.

INTRODUCTION

Individuals assessed by paramedics after requesting ambulance attendance are typically transferred to an Emergency Department (ED). However, rates of non-conveyance, the discharge of a patient in to the community following paramedic assessment rather than transporting them to hospital, are increasing (Australian Institute of Health and Welfare [AIHW], 2025; King, 2024).

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Disposition options for non-conveyed patients include on-site paramedic care, self-care advice, and/or referral to community-based healthcare services or social supports (Blodget et al., 2021; Delardes et al., 2025; Lunn, et al., 2024). By facilitating non-conveyance decisions, paramedics are able redirect patients to services more tailored to patients' needs and preferences, simultaneously enhancing person-centered care and alleviating emergency health service pressures (King et al., 2023; Jani et al., 2021). However, inappropriate decisions or misdiagnosis that result in delays to patients receiving necessary investigations and care increase risk of patient mortality and morbidity (Yeung et al., 2019; Ebben et al., 2017; Höglund et al., 2022).

Differentiating which patients may benefit the most, and who are at greatest risk, from non-conveyance is complex and multifactorial (Delardes et al., 2024; Morrison et al., 2025; Höglund et al., 2019). Rising demand for ambulance services has been attributed to the growing burden of mental illness, an ageing population, people suffering chronic health issues, and barriers to accessing community-based primary and urgent healthcare services (Andrew et al., 2019; Leyenaar et al., 2021; O'Cathain et al., 2019; Long et al., 2021; McManamny et al., 2022; Booker et al., 2017). However, paramedic education remains focused on time-critical emergency presentations; a clear need has been identified for extended education and training in lower acuity conditions and non-conveyance decisions (Carnicelli et al., 2024). Furthermore, ambulance dispatch systems are designed to enable rapid decisions regarding the urgency of response and level of clinical skill required, they are not designed to differentiate complex clinical or psychosocial presentations (Andrew et al., 2019). This may result in unnecessary ambulance dispatch and conveyance of patients whose needs may be better served in the community or out-patient settings (Delardes et al., 2024).

Health services are working on strategies to reduce preventable hospital admissions. Ambulance services are adopting secondary triage systems, virtual clinical care, alternative response units of healthcare delivery, and increasing access to community referral pathways for paramedics (Eastwood et al., 2016; Shannon et al., 2022; Nehme et al., 2024). Many of these approaches are an outcome of innovations required to maintain the delivery of healthcare services during the COVID-19 pandemic.

However, despite the increasing frequency of non-conveyance, there remains few openly-available empirical descriptions of the characteristics of such cases in Australian ambulance health service settings. Addressing this knowledge gap is a necessary step to guide further exploratory research identified as a priority for Australian and New Zealand paramedicine (Pap et al., 2024; Andrew et al., 2019; Oosterworld et al., 2018; Ball et al., 2016). Descriptions of how the cases are prioritized by dispatch systems, the epidemiological and clinical attributes of those not conveyed, and what interventions and referral decisions are made by the attending paramedics. This would be useful to inform and focus the design of evolving models of care and the educational needs of expanded paramedic roles to make safe, quality decisions aligning with person-centered care (Pap et al., 2024).

AIMS

The primary aim of this study was to systematically describe the operational, demographic, and clinical characteristics of an Australian ambulance service's attendances

to adults that resulted in non-conveyance. By characterizing the frequency, dispatch prioritization and clinical profile of non-conveyed cases, the study seeks to inform the development of safe, person-centered and operationally efficient models of ambulance healthcare delivery.

OBJECTIVES

Previous research has indicated wide variation in non-conveyance rates across international settings, dispatch priority systems over-triage lower acuity cases, paramedics require additional, focused, education on lower-acuity presentations, and despite increasing availability, referral pathways are infrequently accessed (Ebben et al., 2017; Ball et al., 2026; Carnicelli et al., 2024; Delardes et al., 2024). To better understand these concerns in an Australian AHS setting, this descriptive study has three main objectives:

1. To quantify the frequency of adult non-conveyance within the ambulance service over the study period.
2. To describe the initial dispatch priority assigned to cases that ultimately resulted in non-conveyance.
3. To profile the epidemiological and clinical characteristics of adult non-conveyed patients (age and gender, pre-existing conditions, working diagnosis, paramedic-initiated interventions, and referral decisions).

METHODS

Design

A retrospective, observational cross-sectional approach was used to explore characteristics of non-conveyance cases occurring within a single Australian AHS setting over a 2-year period.

Research Setting

This study is based on the New South Wales (NSW) Ambulance service response to requests for ambulance attendance via the national emergency number (000). NSW Ambulance is one of the largest Australian AHS that provides emergency response, rescue and retrieval services to those people of NSW with emergency and medical health needs (New South Wales Ambulance, 2025). The service is the sole provider of emergency ambulance response in the state, serving a population of over eight million residents across an area of 801,600 km that includes metropolitan, regional, and sparsely populated rural regions (New South Wales Clinical Systems, 2026).

At the time of this study, 000 calls to ambulance undergo a medical priority dispatch system that determines case urgency and the nature of the responding unit(s). A standard response unit is an ambulance crewed by two registered paramedics who make clinical decisions semi-autonomously under guidance from pre-determined practice guidelines. This includes a level of autonomy, under certain conditions, to recommend the best disposition for a patient, including non-transport to the ED.

Data Collection

De-identified, aggregated data were collected from electronic databases, Computer Aided Dispatch (CAD), and electronic Medical Records (eMR) of ambulance responses

to adults (aged 18 years) that resulted in non-conveyance between 1 January 2019 to 31 December 2020. To describe case characteristics, variables included: count of patients attended, and patients not conveyed; priority dispatch designation; gender; age; pre-existing medical conditions; final clinical assessment, clinical interventions provided; and referral decision. This selection of variables was chosen to describe characteristics that enable the research aims and is guided by previous research into non-conveyed populations (Ebben et al., 2019; Vloet et al., 2018; Dinh et al., 2016).

Study Population

Records of surviving adult patients attended, assessed, and not conveyed to an ED by the attending ambulance clinician within NSW. Exclusion and inclusion criteria are listed in Table 1.

Inclusion	Exclusion
• Records of persons aged 18 years or above who received a response from NSW emergency ambulance; and • Attended by a paramedic of any clinical level; and • Not transported via ambulance to a hospital ED on that occasion.	• Persons who refused to be assessed by paramedics or who were unable to be located; or • Deceased persons at the time of paramedic assessment, or those in cardiac arrest who were not transported; or • Secondary transfers or routine (non-emergency) cases e.g., inter-hospital transfers.
• *(Persons may have been transported to alternative destinations such as GP, health clinic, or were transported on a separate response occasion to an ED by ambulance or private means).*	

Table 1. Data inclusion/exclusion criteria.

Data Analysis

Analyses were structured to meet the intended objectives; the frequency of non-conveyance, dispatch prioritization, epidemiologic and clinical characteristics of the study population, paramedic interventions count, and referral decisions count. No unique identifier was provided for each set of data therefore additional statistical analysis was not performed. Findings are reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cross-sectional studies.

Ethics

Approval to release this data was provided by the Executive Director, Epidemiology and Evidence of the NSW Ministry of Health, under clause 16(2) of the Health Administration Regulation 2020. Ethics approval was provided by the South-Eastern Sydney Local Health District Human Research Ethics Committee - 2019/ETH00116.

RESULTS

Frequency of Non-Conveyance

Between 1 January 2019 and 31 December 2020, NSW Ambulance responded to *n*=1,533,453 patients aged 18 years and above. Of these patients attended, and where eMRs were generated by paramedics, *n*=193,970 (12.6%) were not conveyed to an ED.

Dispatch Priority Code

A dispatch priority code 1 (lights and sirens) response was designated to *n*=84,757 (43.7%) of all non-conveyed cases. Table 2 provides the dispatch priority codes allocated

to cases resulting in non-conveyance and includes their corresponding response time targets.

Non-Conveyed Patient Epidemiological and Clinical Characteristics

Count and percentage for patient associated characteristics are summarized in Table 3.

Age

Older people, those aged 65 years and over, accounted for 44% of all non-conveyed patients.

Dispatch Priority Code	Count *n* (%)
1 - Immediate dispatch - Emergency lights and sirens (L&S)	84,757 (43.7)
2 - Immediate dispatch, no L&S	78,619 (40.5)
2A - Arrival within 30 minutes	17,940 (9.2)
2B - Arrival within 60 minutes	12,647 (6.5)
2C - Arrival within 90 minutes	7 (0.0)
Total:	193,970 (100)

Table 2. Non-conveyance by MPDS dispatch code priority designation.

Final Assessment

The combination of recorded responses under the options of 'No problem identified', 'Other', 'no assessment' and 'Unknown problem' accounted for 33.8% of all final assessments. Pain was the most frequently recorded specific diagnosis (13%).

Paramedic Initiated Intervention

Reassurance was the most frequently recorded intervention, followed by advice, assistance, and then analgesia (Table 3).
Patients may receive a combination of interventions form paramedics.

Referral Disposition

In *n*=192,008 (99%) of occasions paramedics documented that the patient was not referred to any other agency. Where a referral was made, this was most frequently to a General Practitioner (GP) as reported for *n*=1,428 (0.7%) of all cases. Patients who declined transport against advice, a NSW designated "P2" protocol, accounted for *n*=53,963 (27.8%) of cases, whereas it was the paramedic's recommendation that *n*=16,963 (8.6%) of the patients did not require transport.

	Count	Percentage of Non-Conveyed Cases
Gender		
Male	105,396	*54.3%*
Female	88,471	*45.6%*
Indeterminate	104	*0.1%*
Age (Years)		
18-25	*19,554*	*10.1%*
26-35	*23,532*	*12.1%*
36-45	*21,267*	*11.0%*
46-55	*22,010*	*11.3%*
56-65	*22,285*	*11.5%*
66-75	*26,628*	*13.7%*
76+	*58,965*	*30.4%*
Pre-existing medical conditions *(Top 10, there may be multiple per patient)*		
Hypertension	44,985	23.2%
No pre-existing condition recorded	36,233	18.7%
Diabetes (not specified)	25,967	13.4%
Hypercholesterolemia	21,876	11.3%
'Other' (not specified)	18,810	9.7%
Depression	17,322	8.9%
Anxiety	16,574	8.5%
Gastric Reflux	13,493	7%
Asthma	12,549	6.5%
Atrial fibrillation	11,056	5.7%

Table 3. Patient characteristics (Epidemiological, clinical, intervention and referral disposition).

DISCUSSION

Discharge of patients into the community is becoming an increasingly frequent outcome following ambulance attendance (Ebben et al., 2017). Ambulance service responses that result in non-conveyance to a hospital have significance in terms of patient safety, operational efficiency, design of ambulance health

service delivery models, and the educational needs of paramedics. Yet there remains little published literature describing the operational, demographic, and clinical characteristics of these cases. To add knowledge to this topic, this study describes the dispatch prioritization, epidemiological and clinical patient characteristics, paramedic-initiated interventions, and referral decisions for non-conveyed ambulance responses in an Australian service setting.

During the two-year study period NSW Ambulance responded to over 1.5 million individual patients aged 18 years and older, of which 12.6% were not conveyed to an ED. It is important to highlight that less than 1% of these non-conveyed patients were recorded as being referred to any alternative healthcare service. Older people, those aged 65 years and older, accounted for the greatest proportion (44%) of all non-conveyed patients; more than a third of the responses (33.8%) were not allocated any specific diagnosis by paramedics; and almost half (43.7%) of patients that were not conveyed to a hospital were initially prioritized as requiring an emergency lights and sirens response.

	Count	Percentage of Non-Conveyed Cases
Final Assessment *(Working diagnosis)*		
No problem identified	34,190	17.6%
Pain	25,200	13.0%
Other	12,188	6.3%
No Assessment	10,125	5.2%
Unknown problem	9,144	4.7%
Anxiety	9,143	4.7%
Laceration	6,769	3.5%
Abrasion/Graze	6,154	3.2%
Alcohol Intoxication	4,559	2.4%
Short of Breath	3,701	1.9%
Hypoglycemia	3,644	1.9%
Faint	3,458	1.8%
Bruising/Hematoma	3,037	1.6%
Mobility Problem	3,018	1.6%
Combination of other named conditions	134,330	30.7%
Interventions *(Top 10, there may be multiple interventions per patient)*		
Reassurance provided	145,229	74.9%
Advice to patient/carer: specify	22,625	11.7%
Assistance only	12,790	6.6%
Paracetamol	12,616	6.5%
(No management)	11,320	5.8%
Dressing - wound/burns cover	11,061	5.7%
PPE worn	7,692	4.0%
Ibuprofen	7,633	3.9%
Ondansetron	6,123	3.2%
Mental Health Procedure	5,412	2.8%
Referral decision		
No referral	192,008	99.0%
Doctor	1,428	0.7%
Other: specify	396	0.2%
Alternate pathways	100	0.0%
Other health professional	96	0.0%
Mental health	33	0.0%
Family	15	0.0%
Specialized medical service	2	0.0%
Other team	1	0.0%
Children services	1	0.0%
Assessment Team	1	0.0%

Table 3 (continued). Patient characteristics (Epidemiological, clinical, intervention and referral disposition).

Frequency

The proportion of responses resulting in non-conveyance in NSW was slightly higher than the mean average of other Australian jurisdictional services (11%) (AIHW., 2025). However, during a similar period in areas outside of Australian jurisdiction, rates of non-conveyance, were 13.8% in Stockholm, Sweden (Lederman et al., 2020), 40% to 68% in England (O'Cathain et al., 2018), and 26% in Aotearoa/New Zealand (Swain et al., 2012). Several factors may account for this variation, warranting further investigation as to why these Australian rates appear lower and should include whether patient safety and quality of care outcomes differ.

Dispatch Priority

The high percentage of non-conveyed cases determined to require 'lights and sirens', and immediate response indicates that the triage system is over-prioritizing less urgent cases. Wider research also suggests that ambulance prioritization systems often do not match the acuity of the actual incident with wide inaccuracies (Andrew et al., 2019; Ebben et al., 2019; Ball et al., 2018; Bohm & Kurland., 2018). This highlights the difficulty of predicting the urgency or suitability of health resources until the individual has been assessed by a health professional. As ambulance services are adopting alternative care models, further investigation is required to ensure the appropriate response unit and clinical capability of clinician is made available to the right patients (Cormack, 2024, p. 97) Consideration should also be given to the adverse impacts from unnecessary over-reliance on transporting to ED such as: hospital acquired infections, and ambulance offload-delays impacting both ramped patients and service response to the community (Yardley & Donaldson., 2025; Cook et al., 2024; Li et al., 2019).

Epidemiological and Clinical Characteristics

Age

Older people accounted for the largest proportion of patients not conveyed (44%). This finding mirrors those from similar research conducted in Sweden (48%) and Finland (59.8%) (Lederman et al., 2021; Paulin et al., 2021). Studies investigating patient outcomes indicate that older people are at the highest risk for deterioration and re-presentation following non-conveyance (Höglund et al., 2022; Speijers et al., 2025; Møller et al., 2025).

During the period of this study, older people made up 16% of the Australian population and this is predicted to rise to 18.1% over the next decade (AIHW., 2024). Therefore, to risk stratify paramedic clinical decision-making for people suffering complexities of ageing and frailty, entry-to-practice curriculum and in-service education may need to be reviewed for content (Krohn & Singler., 2025; Corman et al., 2025). Although often viewed as a 'safe' option to transport patients to ED, knowledge may also need to be reinforced regarding the potential adverse implications of unnecessary ED attendance for this population, such as hospital acquired infections and increased risk of delirium (Krohn & Singler., 2025; Fogg et al., 2025).

Final Assessment

'Pain' was the most common symptom, though its nature (chronic vs acute) or etiology was unclear. Further research is necessary to understand the specific types of pain AHS paramedics are being requested for. Previous research has indicated that people suffering chronic pain are dissatisfied and feel underserved by paramedics (Peacock et al., 2024). Paramedic-focused curriculum may require review to understand whether content sufficiently covers the multidimensional experience of patients physiological, emotional, and cognitive response to reduce perceived stigma and skepticism towards people suffering chronic pain including pelvic pain (Peacock et al., 2024; Dalhoud et al., 2024).

Over a third of final assessments lacked a specific diagnosis. Without further exploration, this may be the result of record keeping systems forcing responses, or as accurate

as paramedics could identify without the benefit of diagnostic tests or access to medical history.

Referral Decision

Less than 1% of non-conveyed patients were recorded as being referred to any alternative care pathway. This is much lower than reported across international settings. A study in Sweden reports 30% of non-conveyed patients were referred to primary care (Höglund et al., 2022), and in the Netherlands Ebben et al, report 46.7% of non-conveyed patients were referred to another service. However, differences in systems of care limit further comparisons for the scope of this study.

Australian paramedics are registered health professionals required to support patient autonomy through shared decision making, support referral to other service providers, and formulate appropriate patient care and treatment activities (Cormack., 2024; Paramedic Board of Australia [PBA]., 2021). Referral of a patient to another health service demonstrates person-centered care, understanding of clinical risk, and may assist patients in navigating the health system appropriately. The lack of referrals is concerning as this may reflect a limited understanding of paramedic obligations to make appropriate referrals to other service providers or simply highlights the lack of referral options particularly when care is unscheduled and outside normal operating hours (Delardes et al., 2024; Bloomer at al., 2024; Granlund et al., 2024). Of greater concern is that this may also reflect inaccurate or incomplete documentation. Studies reporting on barriers to referral also include concerns for misdiagnosis (Blodgett et al., 2021; Bloomer et al., 2024), and fear of litigation or sanctions by the employer (Vella et al., 2024). The low referral rate therefore seems counterintuitive, as discharging a patient to another service may mitigate risk and demonstrate a form of safeguarding (Oosterwold et al., 2018; O'Hara et al., 2015).

This finding highlights the value of this research to direct future investigation. This variation requires closer investigation as to factors that may be limiting referral, including the accuracy of paramedic documentation, and whether these factors have changed as the range of referral options have expanded since data were collected.

LIMITATIONS

Several limitations must be noted. This research reports on a single setting in Australia, which due to significant heterogeneity of ambulance systems and their local environment may lack generalizability for other settings. Data was collected during impacts of the COVID-19 pandemic; factors such as limited access to community healthcare, increased levels of anxiety, and reluctance to visit the ED may have influenced the nature of requests for an ambulance and non-conveyance decisions. Furthermore, since the data was collected, enhancements have been made to improve efficiency of ambulance healthcare delivery which includes Virtual Care services and increased availability of referral pathway options to paramedics.

Importantly, this paper provides data that may be used as a baseline to measure the impacts of these changes in the future. Patient specific data was collected from eMR records; this data was manually entered by paramedics and subject to variation, omissions, and errors, therefore reliability could not be assessed. No comparisons were made with

characteristics of patients conveyed to the ED, so it remains unknown if there are differences between these cohorts.

RECOMMENDATIONS

This study contributes to paramedicine research by identifying key characteristics of non-conveyed cases that warrant further exploration. Given variation in rates of non-conveyance within international settings, Australian paramedics may be insufficiently prepared to identify and safely manage presentations that would benefit from non-conveyance (Jani et al., 2021; Yeung et al., 2019; O'Hara et al., 2015). It is also necessary to understand how more recent innovations in dispatch processes and alternative response units, such as extended care paramedics and co-responder units, have influenced non-conveyance rates and patient orientated outcomes.

A deeper dive into the epidemiological characteristics of lower acuity presentations that result in non-conveyance will be useful to inform the development of professional capabilities for registered paramedics and capabilities for endorsement of advanced practice (PBA., 2021). Given the aging population and the proportion of older people not conveyed, particular focus may be required into how well paramedics understand the complexities of older patients and the risk-benefits of transfer to the hospital or other services.

Entry-to-practice curriculum may need to include more emphasis on complex chronic medical conditions that reflect the needs of the majority of presentations, while not limiting performance during high-acuity-low-occurrence presentations (Weber et al., 2025; McAnn et al., 2018). Future research will be also valuable to explore whether entry-to practice curriculum and associated accreditation standards support non-conveyance decision making, or whether this is an advanced skill.

CONCLUSION

This study provides valuable insights into characteristics of ambulance cases in NSW which resulted in non-conveyance during impacts of the COVID-19 pandemic. A significant proportion of cases that ambulance services attend are not conveyed to hospital. Almost half of these cases were responded to using emergency lights and sirens, older people represent the highest cohort of non-conveyed patients, pain was the most frequent complaint, and over 99% of patients were documented as being discharged from paramedic's care without ongoing referral. These findings can be used to focus future investigations that aim to understand how evolving models of ambulance healthcare delivery can safely meet the needs of patients requesting ambulance services and enhance operational efficiency.

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RESEARCH REPORTS

PERCEPTIONS AND EXPECTATIONS OF ACADEMIC KNOWLEDGE IN SWISS PARAMEDICINE (SWISS PEAK): A NATIONAL CROSS-SECTIONAL SURVEY OF EMS PROFESSIONALS

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ABSTRACT

Objectives: Paramedic education in Switzerland remains strictly vocational despite ongoing academic development internationally. This study examined Swiss emergency medical services (EMS) professionals' attitudes toward selected opportunity- and threat-related items concerning academic development and whether these attitudes varied by academic degree status and the perceived applicability of prior academic training to current practice.

Methods: A national cross-sectional online survey was conducted among Swiss EMS professionals. A de novo questionnaire assessed questionnaire-defined opportunity and threat dimensions related to academic development, covering selected perceived benefits and concerns. After psychometric refinement, Opportunity and Threat scale scores (0–100) were used to derive a Dominance Index (D = Opportunity - Threat) and four attitudinal profiles (High/Low Opportunity High/Low Threat). Group differences and associations with academic degree status and perceived applicability of prior academic training were examined using t-tests, χ^2-tests, correlations, and logistic regression.

Results: Among 590 respondents, mean Opportunity and Threat scores were 75.5 and 29.9, respectively, yielding a mean Dominance Index of +45.6. Overall, 79.3% were Opportunity-leaning, 10.0% Neutral, and 10.7% Threat-leaning; 74.1% fell into the High-Opportunity/Low-Threat profile. Respondents with an academic degree (16.6%) showed higher Opportunity and lower Threat scores than respondents without an academic degree, resulting in a higher Dominance Index (mean difference +12.7). Among respondents with an academic degree, 69.6% reported that their studies were applicable to current practice, but perceived applicability showed no clear association with attitudinal orientation (r = -0.16, 99% CI [-0.41, 0.12]).

Conclusion: In this national convenience sample, respondents endorsed the opportunity-related items captured by the questionnaire more strongly than the threat-related items. Differences by academic degree status were modest, and the perceived applicability of prior academic training showed no clear association with attitudinal orientation. These findings inform ongoing discussion of how academic development, paramedic education, and professional roles may evolve within Swiss EMS.

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INTRODUCTION

Health professions evolve through the development of discipline-specific knowledge, research capacity, and structured educational pathways. Academic development can play a central role in this process by enabling systematic evaluation of clinical practice, strengthening professional autonomy, and supporting evidence-informed care (Catu, 2021; Cordrey et al., 2024; Hofmann, 2022; O'Meara, 2011; Yalniz et al., 2024). Across multiple health professions, including nursing, midwifery, and allied health disciplines, the establishment of university-based education has been closely associated with professional consolidation and the expansion of research activity (Catu, 2021; Cignacco et al., 2024; Cordrey et al., 2024; Yalniz et al., 2024).

Paramedicine has undergone a comparable transformation in several countries. In Australia, New Zealand, Ireland, and the United Kingdom, degree-level entry to practice and dedicated research agendas have become established components of the profession (Bowles et al., 2024; Feerick et al., 2025; O'Meara et al., 2015; Pap et al., 2024). These developments reflect a broader shift from a predominantly technical and protocol-driven role toward a health care profession grounded in clinical reasoning, research literacy, and professional autonomy (Makrides et al., 2022b; Reed et al., 2019). At the European level, initiatives such as the European Paramedic Curriculum aim to harmonize educational standards through bachelor-level training frameworks (Dúason et al., 2021).

Switzerland represents a contrasting institutional context. Paramedic education is situated within the higher vocational sector, while vertically integrated academic career pathways in paramedicine remain largely absent and discipline-specific research infrastructure is limited (Brinkmann, 2024; Schmutz et al., 2022). This does not imply that Swiss paramedics are clinically underprepared; rather, it points to a structural distinction between vocational clinical qualification and academic development within the profession. Bibliometric analyses suggest that paramedicine remains underrepresented in the broader scientific literature, with research agendas historically shaped by medicine and nursing (Olaussen et al., 2021; Xu et al., 2021). In such settings, questions of academic development extend beyond educational structure and also concern professional visibility, knowledge production, and the position of EMS professionals within multiprofessional healthcare systems (Bueter & Jukola, 2025; Feyereisen et al., 2021; Makrides et al., 2022a, 2023; Nielsen et al., 2025).

The introduction of academic pathways within vocational professions may be viewed in terms of both opportunity and threat. Experiences from nursing and other health professions indicate that academic development may strengthen professional identity and research capacity, while also raising questions regarding role boundaries, workforce structure, and the relationship between academic credentials and clinical practice (Batt et al., 2019; Catu, 2021; Cignacco et al., 2024; Coetsee, 1999; Feerick et al., 2025; Gonon & Bonoli, 2025; Toffel, 2020). How such developments are interpreted by EMS professionals themselves is therefore relevant to ongoing debates about the future of the profession.

Within Swiss EMS, empirical evidence on attitudes toward academic development remains limited. Previous work has shown interest in research engagement among EMS professionals, but participation remains constrained and opportunities for structured academic progression remain rare (Brinkmann, 2024; Runacres et al., 2024; Vuilleumier

et al., 2021; Zünd et al., 2025). What remains unclear is how Swiss EMS professionals evaluate academic development in terms of possible opportunities and threats, including perceived implications for care quality, evidence-informed decision-making, professional visibility, career progression, team cohesion, job security, and the perceived need for additional qualifications.

The present study addresses this gap through the project Perceptions and Expectations of Academic Knowledge in Swiss Paramedicine (SWISS PEAK). The aim of this study was to examine Swiss EMS professionals' responses to questionnaire-defined opportunity and threat dimensions related to academic development, and to assess how these responses varied according to respondents' academic degree status and the perceived applicability of prior academic training. Given the absence of prior Swiss data on these specific attitudes, no directional hypotheses were prespecified. By providing the first nationwide overview of these perspectives, the study aims to inform ongoing discussions on the future development of paramedic education and research capacity in Switzerland.

METHODS

SWISS PEAK was a national, cross-sectional, web-based survey of EMS professionals in Switzerland and the Principality of Liechtenstein conducted between September 4 and September 25, 2025. The study is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (von Elm et al., 2007). The target population comprised EMS personnel currently employed at least 20% full-time equivalent, including paramedics, EMTs, trainees, telecommunicators, instructors, and individuals in managerial roles. Inclusion required current employment in a Swiss or Liechtenstein EMS service; exclusion criteria were non-consent or no current EMS employment. Participation was anonymous and voluntary. Recruitment was conducted via the Swiss Paramedic Association mailing list and promotional outreach at an EMS conference, resulting in a national convenience sample.

The three main Swiss language regions (German, French, and Italian) were represented. A Romansh version was not developed, given its approximate 0.5% share of the resident population, its likely lower prevalence among EMS professionals, and the fact that Romansh speakers generally also speak German or Italian (Federal Statistical Office, 2025).

Ethics

The study protocol was submitted to the Ethics Committee of Northwestern and Central Switzerland (EKNZ; Project ID AO_2025-00054), which confirmed that SWISS PEAK complied with ethical and scientific standards for human research under the Swiss Human Research Act (HRA, Art. 51 para. 2). Owing to its nationwide scope, EKNZ forwarded the dossier to all other Swiss cantonal ethics committees.

Questionnaire Development

The questionnaire was developed specifically for this study, as no validated Swiss instrument assessing attitudes toward academic development in EMS was available. Item generation was informed by literature on professionalization, academic development, and research engagement in paramedicine and related health professions (Bowles et al., 2024; Cignacco et al., 2024; Hofmann, 2022; Runacres et al., 2024; Toffel, 2020; Zünd et al.,

2025). Because no prior work had established the full range of perceived opportunities and threats related to academic development in Swiss EMS, questionnaire development was exploratory and based on theory- and expert-informed item generation rather than inductive qualitative derivation from the target population.

Draft items were reviewed within the multidisciplinary SWISS PEAK research team and by external EMS stakeholders for content relevance and clarity. Cognitive pretesting with EMS professionals from different language regions (n = 17) assessed comprehensibility and interpretation. The questionnaire was translated into German, French, and Italian by native speakers and reviewed for linguistic equivalence. The full instrument and detailed information on questionnaire development are provided in Appendix B.

Measures

Demographic and professional items assessed respondents' current role, highest academic qualification, and whether this qualification was applicable in their present EMS function. Attitudinal items were rated on a 0 to 100 visual analog scale (VAS; 0 = "strongly disagree," 100 = "strongly agree"). Responses were range checked, cleaned for invalid entries, and prepared for scale construction.

The attitudinal section was organized around two questionnaire-defined dimensions. Opportunity comprised items reflecting selected anticipated benefits of academic development, including improved care quality through research, strengthened data-informed decision-making, enhanced professional visibility, career development and workforce sustainability, and expanded educational pathways. Threat comprised items reflecting selected anticipated concerns, including potential impacts on team cohesion, job security, and the perceived necessity of additional qualifications. Opportunity initially comprised six items (Q11 and Q13-Q17), and Threat comprised three items (Q18-Q20). These dimensions were conceptual starting points for scale construction and psychometric evaluation and were not intended to represent an exhaustive account of all possible views on academic development.

The questionnaire also contained additional items addressing broader research attitudes and a free-text question on perceived advantages and risks of increased scientific engagement in EMS. These responses were outside the scope of the present study and will be examined separately.

Psychometric Analysis

Attitudinal scale construction followed standard psychometric procedures. Items in the Opportunity and Threat dimensions were screened using corrected item-total correlations and changes in Cronbach's alpha if deleted. Items with correlations below 0.30 were considered for exclusion if removal improved internal consistency, consistent with established psychometric guidelines (DeVellis, 1991). In the Opportunity dimension, Q11 showed a weak corrected item-total correlation (r = 0.19) and was removed. The removed item addressed whether research in EMS improves the quality of prehospital care. Although conceptually related to academic development, its weak association with the other Opportunity items suggested that it captured a broader attitude toward EMS research than the more specific scale content retained in the final model. The final Opportunity scale therefore comprised five items (Q13-Q17), and the Threat scale comprised

three items (Q18-Q20). Scale scores were calculated as the mean of the retained items, preserving the original 0 to 100 scale.

Internal consistency was assessed using Cronbach's alpha and McDonald's omega. Dimensionality was examined with exploratory and confirmatory factor analyses comparing a one-factor model with a two-factor correlated model to assess whether the included opportunity and threat items reflected a single construct or two related but distinct dimensions within the questionnaire. Confirmatory analyses used robust maximum likelihood estimation, and model fit was evaluated with the Comparative Fit Index (CFI) and the Root Mean Square Error of Approximation (RMSEA). Correlation matrices were inspected for numerical instability; no issues of singularity or non-positive definiteness were observed. Psychometric refinement was used to evaluate the coherence of the included items but does not imply that all relevant opportunity- or threat-related items were captured.

Dominance Index

To summarize each respondent's relative position within the Opportunity and Threat scales, a Dominance Index was calculated as an arithmetic contrast between the two scales (Dominance (D) = Opportunity - Threat). This contrast reflects the relative balance between endorsement of the included opportunity- and threat-related items. The index was used as a descriptive summary of the two questionnaire-derived scales rather than as a validated latent construct. Because the index used - mean scale scores, the unequal number of opportunity and threat items did not assign greater numerical weight to either scale.

As both underlying scales of Opportunity and Threat ranged from 0 to 100, the Dominance Index spanned -100 (fully Threat-leaning) to +100 (fully Opportunity-leaning), with 0 indicating equal endorsement of Opportunity and Threat. To avoid classifying trivial differences as meaningful, a ±10 interval around zero was prespecified as a neutral zone. Respondents with $D \geq +10$ were classified as Opportunity-leaning, those with $D \leq -10$ as Threat-leaning, and those with $-10 < D < +10$ as Neutral. Sensitivity analyses using narrower (±5) and wider (±15) Neutral intervals were conducted to evaluate robustness.

Attitudinal Profiles

To complement this single-score summary, a second measure retaining the full two-dimensional structure of the questionnaire was derived. This approach captures respondents who may endorse both Opportunity and Threat strongly, even when their net difference is similar. Opportunity and Threat are interpreted directly on their original 0 to 100 scales, and each respondent was classified as high or low on both scales using a cutoff of 60, reflecting a clear level of endorsement on the VAS. This yielded four profiles: High-Opportunity/Low-Threat, High-Opportunity/High-Threat, Low-Opportunity/High-Threat, and Low-Opportunity/Low-Threat.

Academic Degree Status

Respondents' highest academic qualification was recoded into a binary variable distinguishing respondents with and without an academic degree. Because no academic de-

grees specific to EMS currently exist in Switzerland, any academic qualification reported by participants originated from another field.

The primary coding followed a predefined definition in which academic degrees included bachelor's, master's, doctorate, or equivalent qualifications from universities or universities of applied sciences. Vocational qualifications, including Advanced Federal Diplomas of Higher Education and Federal Diplomas of Higher Education and related certificates, were coded as non-academic. A broader definition that additionally classified postgraduate CAS, DAS, or MAS programs as academic was used only for planned sensitivity analyses, which are documented in Appendix C.

Statistical Analysis

All analyses were conducted in R version 4.3.2 within RStudio (Posit team, 2025). Because academic development is a normatively and professionally sensitive topic and multiple contrasts were examined, 99% confidence intervals (CIs) are reported for all effect estimates to emphasize estimation precision and limit over-interpretation of small differences. P-values are reported for transparency but were not interpreted using fixed significance thresholds. Analyses were based on complete cases, with "prefer not to answer" coded as missing in analyses involving academic degree status or applicability.

Descriptive statistics were calculated for the refined Opportunity and Threat scales and for the Dominance Index. For categorical variables derived from the Dominance Index (Opportunity-leaning, Neutral, Threat-leaning) and from the four attitudinal profiles (High or Low Opportunity × High or Low Threat), proportions with 99% CIs were reported. The association between Opportunity and Threat was examined using Pearson correlation. Differences between respondents with and without an academic degree in Opportunity, Threat and the Dominance Index were tested using Welch's t-tests with Cohen's d as the effect size. Group differences in the distribution of Dominance classifications and profiles were evaluated using chi-square tests with Cramér's V.

Among respondents with an academic degree, the association between perceived applicability of their studies and the Dominance Index was examined using point-biserial correlation, and differences in the proportion classified as Opportunity-leaning were summarized as risk differences. Predictors were limited to academic degree status and, among respondents with an academic degree, perceived applicability of prior academic training, consistent with the study aim to examine attitudinal differences by academic exposure. Logistic regression models were fitted to estimate the odds of being Opportunity-leaning (Dominance Index ≥ +10). This outcome was a prespecified categorization of the Dominance Index and was used only as a descriptive binary summary of attitudinal orientation; it was not used to predict the underlying Opportunity or Threat scores. The primary model included the full sample and used a three-level combined predictor reflecting academic degree status and, where applicable, perceived applicability of that degree in current practice (no academic degree, academic degree not applicable in practice, academic degree applicable in practice). A second model within the academic subgroup tested whether applicability alone predicted Opportunity-leaning attitudes. Odds ratios (ORs) with 99% CIs were reported, and model adequacy was verified by checking model convergence and inspecting residual and influence diagnostics. Regression analyses were conducted on complete cases for all variables included in each model.

RESULTS

Participant Flow and Sample Characteristics

The survey link was viewed 758 times. Of these, 590 participants completed the questionnaire, corresponding to a completion rate of 77.8% (590/758). A total of 168 participants exited before completion: 22 exited before the consent page, 1 declined participation, and 145 exited after providing consent but before completing the questionnaire.

Relative to the accessible recruitment frame of the Swiss Paramedic Association mailing list (N = 1,900), the sample represents 31.1% of listed members. Based on an estimated workforce of 3,669 EMS professionals in Switzerland and Liechtenstein, the sample corresponds to 16.1% of the target population. Because no complete national registry of EMS professionals with standardized role and qualification information is available in Switzerland, formal benchmarking of sample composition and calculation of a true population response rate were not possible (Interverband Rettungswesen, 2024). However, respondents were drawn from all language regions and cantons and represented a broad range of EMS roles. Participant characteristics are summarized in Table 1.

Scale Reliability and Dimensionality

After item screening, the final Opportunity scale comprised five items (Q13-Q17) and the Threat scale comprised three items (Q18-Q20). Both scales showed strong internal consistency. Opportunity demonstrated $\alpha = 0.90$ and $\omega_total = 0.92$, and Threat $\alpha = 0.75$ and $\omega_total = 0.75$. Confirmatory factor analysis favored a correlated two-factor structure (Opportunity and Threat; CFI = 0.94, RMSEA = 0.11) over a single-factor model (CFI = 0.88, RMSEA = 0.16; $\Delta\chi^2(1) = 67.6$, $p < 0.001$). Comparative fit favored the correlated two-factor model, although absolute fit was mixed because RMSEA remained elevated. The two-factor structure was therefore interpreted cautiously as an empirical distinction between the questionnaire-defined Opportunity and Threat item sets. The factors were inversely correlated ($r = -0.55$, $p < 0.001$), indicating that the two scales captured related but distinct constructs.

Attitudinal Response Patterns

Respondents reported higher Opportunity than Threat scores on the questionnaire-defined scales (Opportunity: $M = 75.5$, $SD = 23.0$; Threat: $M = 29.9$, $SD = 23.1$). The Dominance Index (D = Opportunity - Threat) averaged 45.6 (99% CI [41.3, 49.9]), with 79.3% (99% CI [74.7, 83.3]) classified as Opportunity-leaning, 10.0% (99% CI [7.3, 13.6]) as Neutral, and 10.7% (99% CI [7.8, 14.4]) as Threat-leaning. Varying the Neutral tie zone did not materially affect this distribution; using ±5 or ±15 shifted the proportion classified as Neutral as expected, but Opportunity-leaning respondents remained the clear majority and subgroup comparisons were unchanged (Appendix C).

To examine responses across both scales, respondents were also profiled as high or low on Opportunity and Threat, yielding four quadrants (Figure 1). Most participants (74.1%) fell into the High-Opportunity/Low-Threat profile, 5.6% into High-Opportunity/High-Threat, 8.1% into Low-Opportunity/High-Threat, and 12.2% into Low-Opportunity/Low-Threat (Table 2).

Characteristic		Result
Age, mean (*SD*)		38 (9.6)
Gender, *n* (%)	Female	211 (35.8)
	Male	377 (63.9)
	No information / other	2 (0.3)
Years of experience, median (quartiles)		11 (5, 19)
Current role, *n* (%)	Registered Paramedic (Advanced Diploma)	328 (55.6)
	Management / Leadership	84 (14.2)
	Trainee Paramedic	80 (13.6)
	EMT (Swiss Federal Diploma)	30 (5.1)
	Vocational Trainer	23 (3.9)
	Emergency Medical Telecommunicators	16 (2.7)
	Instructor at a Higher Vocational School	11 (1.9)
	Other	18 (3.1)
Highest qualification, *n* (%)	Federal Diploma of Higher Education	80 (13.6)
	Advanced Federal Diploma of Higher Education	394 (66.8)
	Bachelor's Degree from a University of Applied Sciences	36 (6.1)
	Bachelor's Degree from a University	12 (2.0)
	Master's Degree from a University of Applied Sciences	20 (3.4)
	Master's Degree from a University	23 (3.9)
	Other	25 (4.3)
Academic degree, *n* (%)		98 (16.6)
Canton of work, *n* (%)	Aargau (AG)	29 (4.9)
	Appenzell Innerrhoden (AI)	2 (0.3)
	Appenzell Ausserrhoden (AR)	3 (0.5)
	Bern (BE)	50 (8.5)
	Basel-Landschaft (BL)	17 (2.9)
	Basel-Stadt (BS)	20 (3.4)
	Fribourg (FR)	16 (2.7)
	Geneva (GE)	62 (10.5)
	Glarus (GL)	1 (0.2)
	Graubünden (GR)	29 (4.9)
	Jura (JU)	8 (1.4)
	Lucerne (LU)	26 (4.4)
	Neuchâtel (NE)	32 (5.4)
	Nidwalden (NW)	3 (0.5)
	Obwalden (OW)	3 (0.5)
	St. Gallen (SG)	27 (4.6)
	Schaffhausen (SH)	4 (0.7)
	Solothurn (SO)	4 (0.7)
	Schwyz (SZ)	7 (1.2)
	Thurgau (TG)	15 (2.5)
	Ticino (TI)	40 (6.8)
	Uri (UR)	13 (2.2)
	Vaud (VD)	69 (11.7)
	Valais (VS)	34 (5.8)
	Zug (ZG)	6 (1.0)
	Zürich (ZH)	68 (11.5)
	Liechtenstein* (FL)	2 (0.3)
Survey language, *n* (%)	German	344 (58.3)
	French	206 (34.9)
	Italian	40 (6.8)

*Note. Totals may not sum to 100% due to rounding. *Liechtenstein appears under "Canton of work" for completeness, although it is a country rather than a canton. SD = standard deviation; quartiles = 25th-75th percentile.*

Table 1. Participant characteristics (n = 590).

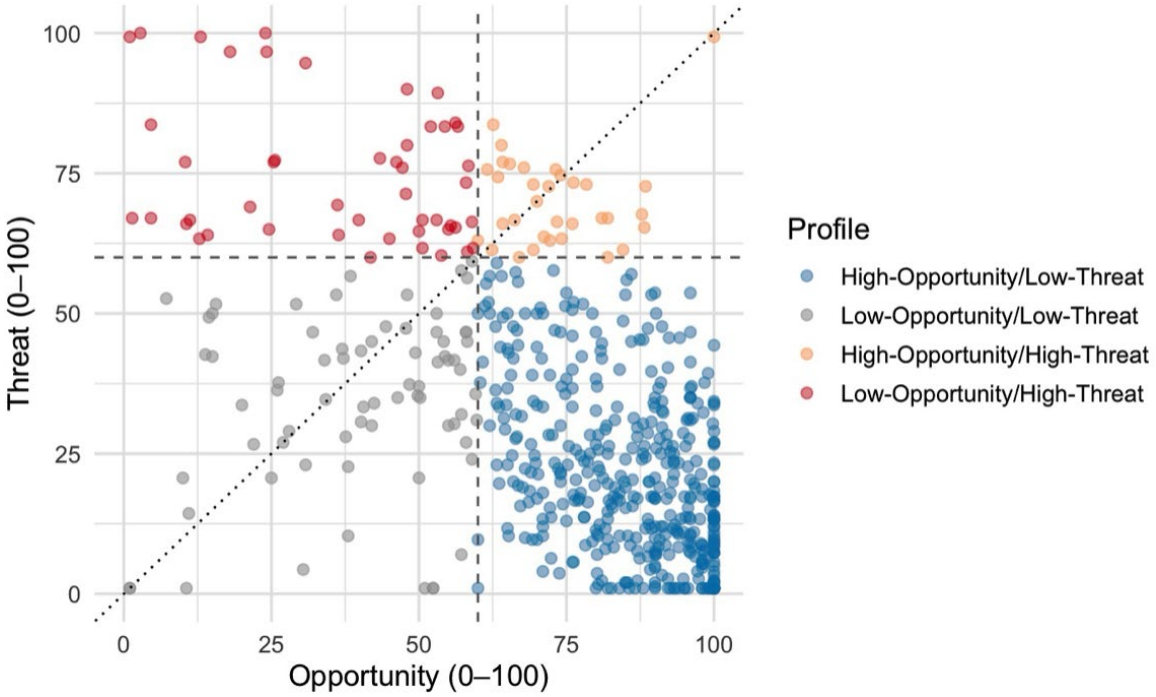


Figure 1A. Joint profiles of opportunity and threat scores - Individual attitudinal profiles.

Note. Scatterplot of Opportunity (x-axis) and Threat (y-axis) scores (0–100 VAS), color-coded by profile. Dashed lines mark the 60-point cutoff for "High" vs "Low" values; the dotted line (y = x) indicates parity between Opportunity and Threat. Each point represents one respondent (N = 590).

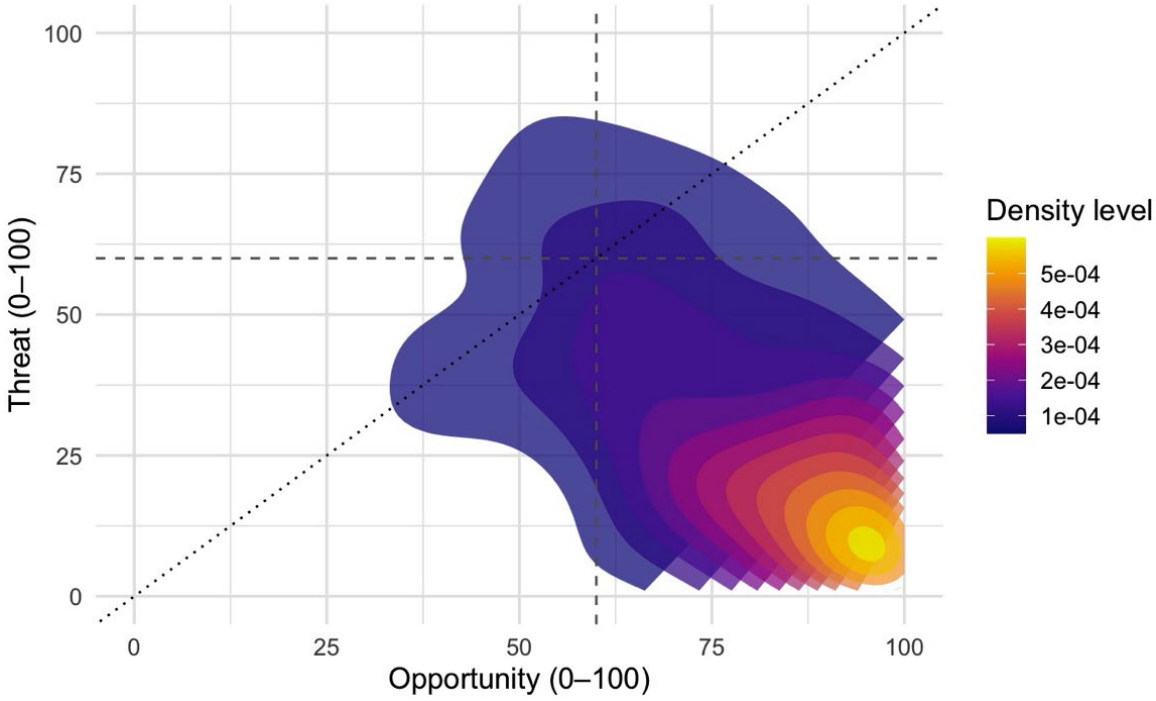


Figure 1B. Joint profiles of opportunity and threat scores - Density distribution.

Note. Kernel-density plot of the same data showing the distribution of Opportunity (x-axis) and Threat (y-axis) scores. Warmer colors represent higher response density, revealing a strong clustering in the high-Opportunity, low-Threat region consistent with the categorical profiles in Figure 1A.

Respondents with an academic degree represented 16.6% of the sample (n = 98). As shown in Table 3, they reported somewhat higher Opportunity scores (mean difference +5.1 points) and lower Threat scores (mean difference -7.6 points) than respondents without an academic degree, resulting in a higher Dominance Index (ΔD +12.7 points; d = 0.3). Consistent with the 99% CIs, differences in Threat and Dominance excluded zero, whereas the Opportunity difference did not, indicating greater uncertainty around the Opportunity difference. Figure 2 shows that respondents with an academic degree clustered at somewhat higher Opportunity and Dominance values and showed lower density of high Threat scores than their non-academic peers. Within-group correlations indicated that Opportunity and Threat were inversely related in both subgroups, more strongly among respondents without an academic degree (r = -0.6) than among respondents with an academic degree (r = -0.4).

Measure / Profile	*n*	Mean (*SD*) / %	99% CI
Descriptive statistics (mean (SD))			
Opportunity	590	75.5 (23.0)	73.1, 78.0
Threat	590	29.9 (23.1)	27.4, 32.4
Dominance (D = Opp - Threat)	590	45.6 (30.7)	41.3, 49.9
Dominance classifications (%)			
Opportunity-leaning (D ≥ +10)	468	79.3	74.7, 83.3
Neutral (10 < D < +10)	59	10.0	7.3, 13.6
Threat-leaning (D -10)	63	10.7	7.8, 14.4
Joint Opportunity x Threat profiles (%)			
High-Opportunity / Low-Threat	437	74.1	69.2, 78.4
High-Opportunity / High-Threat	33	5.6	3.6, 8.6
Low-Opportunity / High-Threat	48	8.1	5.7, 11.5
Low-Opportunity / Low-Threat	72	12.2	9.2, 16.1

Note. SD = standard deviation; CI = 99% confidence interval. n indicates the number of respondents included in each estimate. Continuous measures (Opportunity, Threat, Dominance) are shown as mean (SD) with 99% CIs; categorical measures are shown as percentages with 99% CIs. The Dominance Index is defined as Opportunity minus Threat, with positive values indicating greater relative endorsement of Opportunity than Threat. Joint profiles classify respondents based on their combined Opportunity and Threat positions across the two scales.

Table 2. Opportunity, threat, dominance, and joint opportunity x threat profiles among Swiss EMS professionals (n = 590).

Dominance classifications showed the same pattern. Among respondents with an academic degree, 86.7% (85/98) were Opportunity-leaning and 5.1% (5/98) Threat-leaning, compared with 77.8% (383/492) and 11.8% (58/492), respectively, among respondents without an academic degree. Respondents with an academic degree were more often in the High-Opportunity/Low-Threat profile (80.6% vs. 72.8%) and less often in the Low-Opportunity/High-Threat profile (2.0% vs. 9.4%). The remaining profiles (High-Opportunity/High-Threat and Low-Opportunity/Low-Threat) were similarly distributed between groups, and the overall association between academic degree status and profile membership was small ($\chi^2(3) = 6.63$, p = 0.085; Cramér's V = 0.08). Broader definitions of academic degree status and alternative Dominance thresholds (±5, ±15) produced substantively unchanged distributions and effect estimates, as detailed in Appendix C.

Variable	With Academic Degree, Mean (*SD*)	Without Academic Degree, Mean (*SD*)	Mean Δ (Yes–No)	99% CI	*p*	*d*
Opportunity	79.8 (21.6)	74.7 (23.2)	+5.1	[-1.2, +11.4]	0.037	0.23
Threat	23.5 (18.8)	31.2 (23.7)	-7.6	[-13.3, -1.9]	<0.001	0.36
Dominance (D)	56.2 (33.5)	43.5 (41.7)	+12.7	[+2.6, +22.8]	0.001	0.34

Note. SD = standard deviation; CI = 99% confidence intervals; Mean Δ (Yes–No) = difference between respondents with and without an academic degree; p = p-value from Welch's t-test; d = Cohen's d effect size. Scores reflect 0–100 VAS values for Opportunity and Threat and the Dominance Index (-100 to +100). Because no academic degrees specific to EMS currently exist in Switzerland, academic degrees refer to degrees obtained outside paramedicine.

Table 3. Comparison of opportunity, threat, and dominance scores by academic degree status (n = 590).

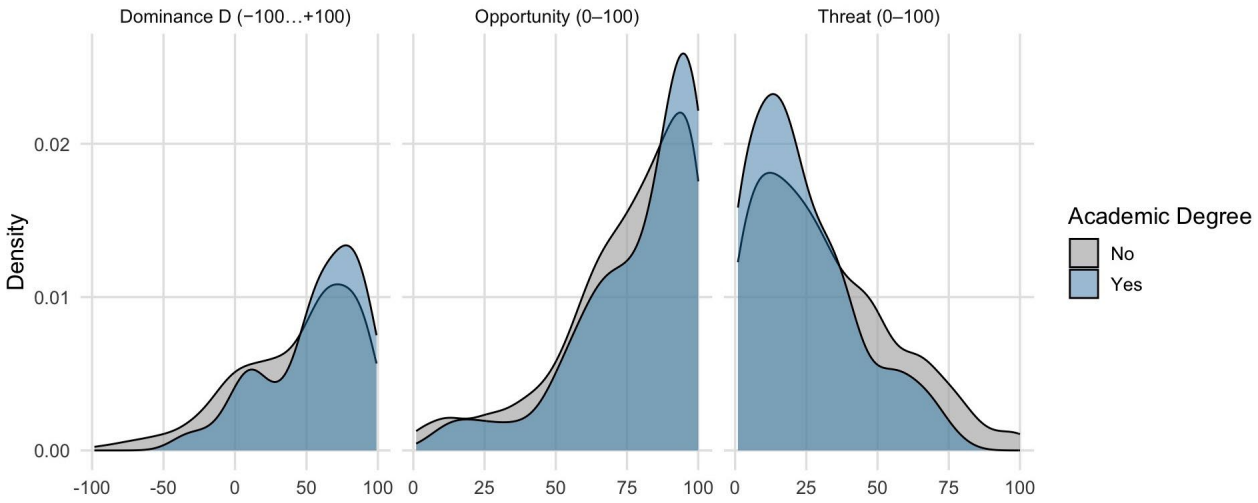


Figure 2. Score distributions for opportunity, threat, and dominance by academic degree status.

Note. Kernel-density plots showing the distribution of Opportunity and Threat scores (0-100 VAS) and Dominance Index scores (-100 to +100; Dominance = Opportunity - Threat), stratified by academic degree status. Shaded curves represent smoothed density estimates; vertical dashed lines indicate group means (blue = academic degree; gray = non-academic degree).

Applicability of Prior Academic Training

Among respondents with an academic degree, 92/98 (93.9%) answered the applicability question. Of these, 69.6% (64/92; 99% CI [56.2, 80.3]) reported that their degrees were applicable in daily practice. The remaining six respondents with an academic degree had missing applicability information. The correlation between applicability (yes/no) and the Dominance Index was -0.16 (99% CI [-0.41, 0.12]), with the CI spanning zero. The proportion classified as Opportunity-leaning was 84.4% (54/64) among those who considered their degree applicable and 89.3% (25/28) among those who did not (difference = -4.9 percentage points).

Associations with Opportunity-Leaning Classification

Logistic regression results are summarized in Table 4. Academic degree status and Opportunity-leaning classification were available for all respondents; the reduced sample size reflects the six missing applicability responses among respondents with an academic degree. Respondents without an academic degree served as the reference category. Respondents with an academic degree not applicable in practice had an *OR* of 2.37 (99% CI [0.61, 18.07], $p = 0.16$), and those with an academic degree applicable in practice had an *OR* of 1.54 (99% CI [0.65, 4.30], $p = 0.23$). In the academic-only model ($n = 92$), the *OR*

Model	Predictor Contrast	*OR*	99% CI	*p*
Full sample ($n = 584$)	Academic degree not applicable vs no academic degree	2.37	0.61, 18.07	0.16
	Academic degree applicable vs no academic degree	1.54	0.65, 4.30	0.23
Academic subgroup ($n = 92$)	Applicable vs not applicable	0.65	0.08, 3.43	0.54

Note. OR = odds ratio; CI = 99% confidence intervals. In the full-sample model, predictors are contrasted against the reference category of no academic degree. In the academic-subgroup model, the predictor compares respondents reporting their academic degree as applicable versus not applicable in current practice. Academic degree status and the Opportunity-leaning outcome were available for all respondents. Applicability was assessed only among respondents with an academic degree; six of 98 respondents had missing applicability information and were excluded from models involving applicability.

Table 4. Logistic regression predicting opportunity-leaning attitudes (D ≥ +10).

comparing respondents who reported their academic studies as applicable versus not applicable was 0.65 (99% CI [0.08, 3.43], $p = 0.54$).

DISCUSSION

Summary of Key Findings

SWISS PEAK examined questionnaire-based attitudes toward academic development in Swiss EMS within a system where paramedic education remains vocational and no discipline-specific academic pathway in paramedicine currently exists. Attitudes were structured along two related but distinct questionnaire-defined dimensions, capturing Opportunity and Threat as defined in the survey instrument.

Overall, respondents scored higher on Opportunity than on Threat, and most were classified as Opportunity-leaning according to the predefined Dominance threshold. Respondents with an academic degree showed somewhat higher Opportunity and lower Threat scores than respondents without an academic degree, although these differences were modest. Among respondents with an academic degree, perceived applicability of prior academic training to daily work was not clearly associated with attitudinal orientation; the slightly negative point estimate suggests that respondents who considered their degree applicable were, if anything, marginally less Opportunity-leaning, but the wide 99% CI argues against a strong interpretation. In this sample, the Opportunity-related items captured by the questionnaire were endorsed more strongly than the Threat-related items.

Interpretation in Context

The findings are most meaningful when interpreted in relation to what the Opportunity scale actually captured: academic qualifications as a means of making care quality visible, EMS-specific academic degrees, advanced or academic qualification options, educational progression after the HF diploma, and career development and workforce sustainability. The observed pattern therefore suggests that endorsement was directed less toward academization in the abstract than toward academic development linked to professional visibility, educational progression, and career development. The exclusion of Q11 adds an important nuance to this interpretation. Broad agreement that research improves prehospital care was not rejected; rather, it did not align closely enough with the retained Opportunity items to be treated as part of the same scale. This suggests that support for EMS research and support for formal academic pathways are related but not interchangeable dimensions of academic development.

That is especially notable in the Swiss context. Swiss paramedics carry substantial clinical responsibility, yet their educational pathway remains rooted in the higher vocational sector and formal academic progression remains limited (Brinkmann, 2024; Schmutz et al., 2022). At the same time, much of the evidence base, research production, and formal knowledge infrastructure relevant to paramedic work continues to be shaped outside the profession itself (Batt et al., 2019; Gonon & Bonoli, 2025; Makrides et al., 2022b; Olaussen et al., 2021; Reed et al., 2019; Regener & Trede, 2024; Xu et al., 2021). Under these conditions, academic development concerns more than qualifications alone. It also concerns whether paramedicine can participate more actively in generating, interpreting, and applying knowledge related to its own field, as well as how the profession is positioned

within a multiprofessional healthcare system (Bueter & Jukola, 2025; Feyereisen et al., 2021). Seen in that light, the retained Opportunity scale should be read as capturing one specific part of this broader development: respondents' views on formal academic pathways, professional visibility, educational progression, and career-related opportunities. Stronger endorsement of these items may therefore reflect interest in academic development that is tied to recognizable professional functions rather than to academic status alone.

This interpretation fits reasonably well with developments described in paramedicine and other health professions internationally. In several Anglo-American systems, academic development has been linked to professionalization, degree-level entry to practice, dedicated research agendas, and greater professional autonomy (Batt et al., 2019; Givati et al., 2018; Hanson & Burton, 2025; Makrides et al., 2022b; Reed et al., 2019). At the European level, calls for bachelor-level education standards have likewise been framed as a response to increasingly complex patterns of care and expanding professional demands (Dúason et al., 2021; Gottschalk et al., 2024; Marung et al., 2025). Switzerland has not followed the same institutional path. Even so, the present findings suggest that some of the themes commonly associated with academic development already resonate within this sample, despite the more limited institutional structures currently available.

The subgroup results sharpen this interpretation. Respondents with an academic degree tended to show somewhat more favorable response patterns, but the differences were limited, and most respondents without an academic degree were also classified as Opportunity-leaning. The overall pattern is therefore difficult to attribute simply to a small subgroup of respondents with an academic degree. The opportunity-related themes captured here appear to have broader relevance across this sample of the Swiss EMS workforce.

Implications

Because the opportunity-related themes identified here have relevance beyond a narrowly academic subgroup, the main implication is not simply that respondents viewed academic development favorably. More importantly, discussion in Swiss EMS may now move beyond abstract endorsement or rejection alone. The questionnaire did not ask only whether academic development was desirable in general. It asked whether it was associated with concrete professional and practice-related functions. Since these themes were endorsed more strongly than the structural concerns represented in the Threat items, a more useful next step for professional and policy discussion may be to ask what kinds of development are seen as meaningful, for whom, and under what conditions they are considered appropriate within Swiss EMS.

This matters because the practical context of EMS work is changing. Swiss mission data, consistent with those from other high-income settings, show that prehospital care includes a substantial volume of non-urgent but complex cases rather than only rare high-acuity emergencies (Vuilleumier et al., 2021). As case mixes shift in this direction, greater importance is placed on clinical reasoning, chronic and psychiatric care, interprofessional collaboration, and system integration (Corman et al., 2025; Dúason et al., 2021). These are also the domains in which academically structured roles are often discussed as useful (Dúason et al., 2021; Gottschalk et al., 2024; Marung et al., 2025). The

present study cannot determine which reforms would best address those demands, but it does suggest that the professional functions commonly invoked in such discussions are not being rejected across the board within this sample.

Once the issue is framed in those terms, the next question becomes one of design. In Swiss EMS, limited progression opportunities and unfavorable shift models have been identified as contributors to attrition (Regener & Trede, 2024), while previous Swiss survey data indicate substantial interest in academically oriented continuing education and further qualification pathways (Brinkmann, 2024). These observations do not show that such pathways would improve workforce retention, but they do suggest that progression, qualification, and longer-term role development are already salient concerns within the profession. International work further suggests that such pathways are most meaningful when they are linked to clearly defined roles in education, research, leadership, or advanced practice, rather than added as credentials without corresponding function (Cordrey et al., 2024; Willis, 2024; Yalniz et al., 2024). In that sense, the significance of future development in Swiss EMS is likely to depend less on expansion than on whether pathways are tied to concrete responsibilities, visible functions, and practice-relevant career trajectories.

At the same time, the study leaves open questions it was not designed to answer. It does not identify which specific forms of development EMS professionals consider most useful, feasible, or concerning, and it may not capture concerns beyond the relatively narrow Threat scale used here. Further qualitative research would therefore be valuable to clarify how different groups within EMS understand the opportunities, trade-offs, and risks associated with academic development, and to inform more specific educational and policy discussions in Switzerland.

LIMITATIONS

Several limitations should be considered. The cross-sectional design does not allow causal inferences. Participation was voluntary and relied on the Swiss Paramedic Association mailing list and supplementary promotion at a national prehospital research conference, yielding a convenience sample that may have overrepresented professionals with greater interest in science, education, and professional development. Recruitment through a professional association may also have introduced social desirability bias if respondents perceived academic development as institutionally endorsed. Because no centralized national workforce registry is available, sample representativeness could not be formally assessed, and a true population response rate could not be calculated. Some drop-out also occurred between access and completion, which may have led to underrepresentation of less engaged respondents. The questionnaire was exploratory. Because no validated instrument existed and no prior work had established the full range of perceived opportunities and threats related to academic development in EMS, item generation was theory- and expert-informed. The Opportunity and Threat scales therefore reflect predefined survey items rather than the full attitudinal landscape of academic development in Swiss EMS. This is especially relevant for the Threat scale, which captured only a limited subset of possible concerns and was represented by fewer items than the Opportunity scale. Although the Dominance Index was calculated from mean scale scores and therefore did not numerically weight the Opportunity scale more heavily because it contained more items, the narrower content coverage of the Threat scale may have limit-

ed the range of concerns contributing to the Threat score. The Dominance Index should therefore be interpreted as the relative endorsement of the included Opportunity- and Threat-related item sets, not as evidence that all possible concerns about academic development were less strongly endorsed. In addition, the removal of Q11 indicates that general endorsement of research improving prehospital care did not align closely with the retained Opportunity scale. The final Opportunity scale should therefore be interpreted as capturing selected attitudes toward academic pathways, qualifications, professional visibility, and career development, rather than general attitudes toward EMS research. Finally, the findings reflect the specific structures of the Swiss and Liechtenstein EMS and education systems and may not generalize directly to other jurisdictions.

Several features strengthen the interpretation of these findings, including the nationwide scope, broad linguistic and occupational coverage, and transparent questionnaire documentation. SWISS PEAK was conceived within and for the paramedic community, which strengthens contextual validity, while independent methodological oversight outside operational EMS supports analytical independence.

CONCLUSIONS

In this national sample of Swiss EMS professionals, the Opportunity-related items captured by the questionnaire were endorsed more strongly than the Threat-related items. Differences by academic degree status were modest, and perceived applicability of prior academic training showed no clear association with attitudinal orientation. These findings suggest that themes linked to academic qualifications, professional visibility, career development, and educational progression have relevance within Swiss EMS and can inform ongoing discussion of how academic development should be framed and linked to professional roles and practice needs.

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APPENDIX A: SWISS EMERGENCY MEDICAL SERVICES – SYSTEM, EDUCATION AND ROLES

System Context and Organization

Switzerland is a federal state composed of 26 cantons and four national languages (German, French, Italian and Romansh) (Federal Statistical Office, 2025). The three main language regions in Switzerland are German-speaking (~63%), French-speaking (~22%) and Italian-speaking (~8%). Romansh speakers represent approximately 0.5% of the population (Federal Statistical Office, 2025). Emergency medical services (EMS) are decentralized and regulated at the cantonal level, resulting in regional variation in EMS organization, staffing models, deployment of advanced providers, and integration with hospital systems (Brinkmann, 2024).

EMS systems are coordinated through regional emergency call centers and typically operate within a two-tiered response structure. Ambulance services are primarily staffed by paramedics, while emergency physicians are deployed depending on case severity and regional protocols. Although federal regulations define education pathways and certification standards, operational implementation is determined locally. The Swiss EMS system therefore represents a hybrid model combining paramedic-based and physician-supported approaches (State Secretariat for Education, Research and Innovation, 2025).

Professional Roles

Emergency Medical Technicians (EMTs)

Emergency Medical Technicians (EMTs) complete a federally regulated vocational training program and represent an entry-level role within Swiss EMS. Their responsibilities include patient transport, basic life support, and assistance during advanced interventions. EMTs typically work under the supervision of paramedics (Forum Berufsbildung Rettungswesen, 2022a). Holders obtain a Federal Diploma of Higher Education after passing a national professional examination. The qualification is classified at NQF/EQF level 5, placing it at post-secondary level and not as an academic degree (State Secretariat for Education, Research and Innovation, 2025). The structured preparatory program typically lasts one year and comprises about 1,800 hours of learning, combining school-based teaching with supervised practice in EMS and transport services (Forum Berufsbildung Rettungswesen, 2022a).

Official title in German (D), French (F), Italian (I) and English (E) (State Secretariat for Education, Research and Innovation & Federal Department of Economic Affairs, Education and Research, 2017):

- Transportsanitäterin mit eidg. Fachausweis / Transportsanitäter mit eidg. Fachausweis (D)
- Technicienne ambulancière avec brevet federal / Technicien ambulancier avec brevet federal (F)
- Soccorritrice ausiliaria d'ambulanza con attestato professionale federale (I)
- Emergency Medical Technician, Federal Diploma of Higher Education (E)

Registered Paramedics

Registered paramedics are the core clinical workforce in Swiss EMS. They are trained to provide autonomous prehospital emergency care, including patient assessment, initiation of life-saving interventions, and safe transport within defined protocols or in collaboration with emergency physicians (Forum Berufsbildung Rettungswesen, 2022b). They obtain an Advanced Federal Diploma of Higher Education after completing an accredited program and passing the national diploma examination. This qualification is classified at NQF/EQF level 6, corresponding to the level of a bachelor's degree in terms of competencies, but situated in Swiss tertiary level B (higher vocational education) rather than the university sector (State Secretariat for Education, Research and Innovation, 2025). It is therefore not an academic degree. Training comprises approximately 5,400 hours over three years, combining school-based instruction, supervised EMS practice, and clinical placements (Forum Berufsbildung Rettungswesen, 2022b).

Practical training in an EMS takes place in organizations that meet defined accreditation criteria. It includes working under educational supervision with a progressive increase in autonomy, as well as structured reflection on missions. This component is designed to ensure the acquisition and consolidation of all practical competencies, the integration of school-based training into real-world practice and the development of extensive operational experience.

Official title in German (D), French (F), Italian (I) and English (E) (State Secretariat for Education, Research and Innovation & Federal Department of Economic Affairs, Education and Research, 2017):

- Diplomierte Rettungssanitäterin HF / Diplomierter Rettungssanitäter HF (D)
- Ambulancière diplômée ES / Ambulancier diplômé ES (F)
- Soccorritrice diplomata SS / Soccorritore diplomato SS (I)
- Registered Paramedic, Advanced Federal Diploma of Higher Education (E)

Emergency Physicians

Emergency physicians (EPs) are medically qualified doctors who provide advanced prehospital care in high-acuity cases (Hirslanden Group, 2025). They obtain a Certificate of Competence in Prehospital Emergency Medicine (SGNOR/SSMUS) following postgraduate clinical training and completion of required prehospital case experience (Schweizerisches Institut für ärztliche Weiter- und Fortbildung, 2018). The SGNOR curriculum requires 50 documented missions (NACA ≥ 4), including at least five missions with direct on-scene supervision, while other cases may be supervised retrospectively (Schweizerisches Institut für ärztliche Weiter- und Fortbildung, 2018). In practice, many EPs are still in postgraduate training and may act as the sole physician on scene, resulting in variation in experience across regions. Some EMS systems employ exclusively board-certified physicians, leading to more standardized expertise.

Official title in German (D), French (F), Italian (I) and English (E) (State Secretariat for Education, Research and Innovation & Federal Department of Economic Affairs, Education and Research, 2017):

- German (D): Fähigkeitsausweis Präklinische Notfallmedizin / Notarzt (SGNOR)
- French (F): Attestation de formation complémentaire en médecine d'urgence préhospitalière / médecin d'urgence (SSMUS)
- Italian (I): Attestato di capacità in medicina d'urgenza preospedaliera / medico d'urgenza (SSMUS)
- English (E): Certificate of Competence in Prehospital Emergency Medicine (SGNOR)

Critical Care Paramedics

Critical care paramedics (CCPs) are registered paramedics with additional postgraduate training, most commonly an Advanced Federal Diploma of Higher Education in Anesthesia Care (NQF/EQF level 7) (OdASanté & Verband Bildungszentren Gesundheit Schweiz, 2022). Training lasts approximately two years and includes anesthesia and intensive care placements. CCP roles involve extended competencies under medical delegation and are implemented in selected cantons. National standardization is lacking, and CCP and physician-based models coexist.

Practice Trainer, Educator and Lecturer

Ambulance services act as primary training sites for paramedic education and must meet requirements defined in the Vocational Education and Training Ordinance (BBV, Art. 10(3)). Trainees are supervised by qualified paramedics who serve as practice trainers. Practice trainers and educators require additional pedagogical qualifications in accordance with BBV (Art. 44 lit. a–c), typically obtained through the Swiss Association for Adult Learning (SVEB) framework. SVEB training is structured across four levels. Level I (approx. 405 hours) is sufficient for supervision of trainees in ambulance services, while higher levels lead to advanced teaching qualifications, including the Federal Certificate for educators (Brinkmann, 2024). In practice, qualification requirements vary by role. Practice trainers typically hold SVEB Level I, whereas lecturer or class teacher roles in ambulance service schools often require higher-level certification (e.g. SVEB IV) or equivalent qualifications. In some EMS organizations, educators are also integrated into leadership structures.

Limitations and Scope of this Appendix

This appendix focuses on core roles and training pathways relevant to operational EMS practice. Additional certifications and role-specific qualifications (e.g., incident command or HEMS crew functions) exist but are often short, locally defined, or limited in scope and are therefore not described in detail. Given Switzerland's federal structure and regional variation in EMS organization, this description is not exhaustive but reflects common structures and practices across the system.

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APPENDIX B: SURVEY INSTRUMENT

This appendix reproduces the exact survey items as presented to respondents and provides additional information on questionnaire development, administration, and scale construction. Items are numbered sequentially (Q1-Q30) for reference throughout the manuscript. The survey was administered in German, French, and Italian. Items are reproduced here in their original wording. The English version is an unofficial translation.

Questionnaire Development

The questionnaire was developed specifically for the SWISS PEAK project, as no validated Swiss instrument assessing attitudes toward academic development in Emergency Medical Services (EMS) was available.

Item development was informed by literature on professionalization, academic development, and research engagement in paramedicine and related health professions (Bowles et al., 2024; Hofmann, 2022; Runacres et al., 2024; Zünd et al., 2025), as well as prior academic development processes in Swiss health professions such as nursing and midwifery (Cignacco et al., 2024; Toffel, 2020). Based on this, the attitudinal framework was structured around two exploratory questionnaire-defined dimensions, labelled Opportunity and Threat.

Initial item pools were developed by the SWISS PEAK research team through iterative discussion and review. The team included members with clinical EMS backgrounds, academic researchers, and individuals with varying levels of academic training and differing perspectives on academic development. Members represented multiple language regions of Switzerland and contributed experience from prior survey-based research and EMS system analysis. This composition was intended to incorporate varied perspectives during questionnaire development.

Several rounds of internal review were conducted to refine wording, remove redundancies, and ensure interpretability within the Swiss EMS context. Attention was given to item clarity, relevance and interpretability. External input from experienced EMS stakeholders was incorporated during the development phase. These reviewers evaluated item clarity, relevance to current professional debates, and practical plausibility.

Item wording was designed to capture selected themes related to academic development. The initial Opportunity-oriented item pool addressed research improving care quality, professional visibility of care quality, EMS-specific academic degree programs, advanced or academic qualification options, educational progression after the HF diploma, and career development and workforce sustainability. Threat-oriented items addressed concerns related to team cohesion, job security, and the perceived necessity of additional formal qualifications. Because no prior qualitative work had established the full range of perceived opportunities and concerns related to academic development in Swiss EMS, these questionnaire-defined dimensions should be understood as exploratory and theory-informed rather than exhaustive.

All attitudinal items were measured using visual analog scales (VAS) ranging from 0 to 100 (0 = strongly disagree, 100 = strongly agree). The continuous response format was

chosen to capture nuanced attitudes and reduce information loss associated with categorical scales.

Cognitive pretesting was conducted with EMS professionals from different language regions (n = 17). Participants assessed clarity, interpretation, and response difficulty. Particular attention was given to consistent understanding of terms such as "academic qualification", "research", and "scientific evidence." Minor wording adjustments were made based on this feedback. Internal consistency estimates during pretesting ranged from Cronbach's alpha = 0.88 to 0.99 across preliminary scales. In accordance with the approved ethics protocol, no items were removed at this stage to preserve conceptual coverage prior to formal psychometric evaluation.

The questionnaire was translated into German, French, and Italian by native speakers and reviewed to ensure conceptual equivalence across language versions.

Survey Administration

The survey was administered online using Findmind between September 4 and September 25, 2025. Recruitment was conducted via the Swiss Paramedic Association mailing list (one initial invitation and one reminder) and was supplemented by a QR-code invitation at a national EMS research conference (Journée romande de recherche clinique pré-hospitalière 2025). Participation was voluntary and self-administered.

Findmind recorded 758 unique landing-page visitors. Of these, 736 proceeded to the consent page, 613 provided consent, and 590 completed the questionnaire. This corresponds to a completion rate of 77.8% among visitors. Relative to the association mailing list (n = 1,900), the sample represents 31.1% of reachable members. Based on an estimated EMS workforce of 3,669 professionals in Switzerland and Liechtenstein, the sample represents 16.1% of the target population. Because no complete national registry of EMS professionals with standardized role and qualification information is available, these figures should not be interpreted as a true population response rate or as evidence of sample representativeness.

Duplicate submissions were prevented using cookie-based controls, and manual checks did not indicate repeat participation. Data collection was anonymous; no direct identifiers were stored, and all data were transmitted via encrypted HTTPS connections. Access to the dataset was restricted to authorized team members.

Final Scale Composition

Following item screening using corrected item-total correlations (threshold 0.30) and internal consistency criteria, the Opportunity and Threat scales were refined. The initial Opportunity dimension included six items (Q11 and Q13-Q17). Item Q11, "Research in EMS improves the quality of prehospital care," showed a weak corrected item-total correlation with the initial Opportunity dimension (r = 0.19) and was excluded. Internal consistency improved from alpha 0.83 in the initial six-item Opportunity dimension to alpha = 0.90 in the final five-item Opportunity scale after removal of Q11.

This finding was not interpreted as evidence that respondents rejected research in EMS. On the contrary, Q11 was strongly endorsed overall (mean = 73.4, SD = 33.8; median = 86), with 62.9% of respondents scoring the item at 80 or higher. However, the item

showed greater dispersion than most retained Opportunity items and was only weakly associated with the remaining scale. This suggests that general agreement that research improves prehospital care formed a related but distinct attitude from endorsement of academic pathways, qualifications, professional visibility, and career development.

The final Opportunity scale therefore comprised five items (Q13-Q17), reflecting selected themes related to professional visibility of care quality, career development and workforce sustainability, EMS-specific academic degree programs, advanced or academic qualification options, and educational progression after the HF diploma. The final Threat scale comprised three items (Q18-Q20), reflecting a narrower set of concerns related to team cohesion, job security, and the perceived necessity of additional formal qualifications. Standardized factor loadings and corrected item-total correlations for the final retained items are presented in Table B1.

Domain	Item (Short Wording)	Conceptual Theme	Standardized Loading	Corrected Item-Total *r*
Opportunity	Academic qualifications make care quality visible	Professional visibility and legitimacy	0.74	0.70
Opportunity	Academic pathways reduce early career attrition	Career development and workforce sustainability	0.78	0.74
Opportunity	Dedicated academic degree programs could advance the Swiss EMS profession	Academic development of the profession	0.81	0.76
Opportunity	Support advanced or academic qualifications alongside existing EMS pathways	Additional qualification pathways	0.82	0.76
Opportunity	Support academic pathway after HF diploma	Educational progression opportunities	0.82	0.75
Threat	Higher education may negatively affect team cohesion	Workforce cohesion concerns	0.73	0.59
Threat	Academic expansion may threaten job security	Employment security concerns	0.67	0.60
Threat	No need for additional education in Swiss EMS	Perceived redundancy of academic training	0.70	0.53

Table B1. Final opportunity and threat scale items, conceptual themes, standardized factor loadings, and corrected item-total correlations.

German

Einwilligung

1. Ich bin mindestens 18 Jahre alt und habe die Studieninformationen gelesen und verstanden. Ich stimme der Speicherung und Verarbeitung meiner anonymen Daten zu. Diese Einwilligungserklärung stellt klar, dass die Daten nach der Übermittlung nicht zurückgezogen werden können, um die vollständige Anonymität der teilnehmenden Personen zu gewährleisten. Antwortoptionen: Zustimmen / Ablehnen

Soziodemografie und beruflicher Hintergrund

2. Wie alt sind Sie? Antwortformat: Drop-down (18–70 Jahre)
3. Welchem Geschlecht fühlen Sie sich zugehörig? Antwortoptionen: Weiblich; Männlich; Divers
4. Über wie viel Jahre Berufserfahrung im Rettungsdienst verfügen Sie? Antwortformat: Drop-down (0–40 Jahre)

5. Was ist Ihre aktuelle Funktion im Rettungsdienst? Antwortoptionen: Diplomierte/r Rettungssanitäter/in HF/NHF, Transportsanitäter/in eidg. FA, In Ausbildung (Diplomierte/r Rettungssanitäter/in HF/NHF), In Ausbildung (Transportsanitäter/in eidg. FA), Berufsbildner/in, Dozent/in an einer höheren Fachschule, Leitstellendisponent/in, Kader/Leitung, Andere, bitte angeben
6. Was ist Ihre höchste abgeschlossene Berufsausbildung? Antwortoptionen: Eidgenössisches Fähigkeitszeugnis/-ausweis (EFZ/FA), Höhere Fachschule (HF), Fachhochschulabschluss Bachelor, Fachhochschulabschluss Master, Universitätsabschluss Bachelor, Universitätsabschluss Master, Promotion/Doktorgrad, Andere, bitte angeben
7. Bitte geben Sie Ihren Abschluss an. Antwortformat: Freitext
8. Können Sie die im Studium erlernten Kenntnisse und Fähigkeiten in Ihrem Berufsalltag anwenden? Antwortoptionen: Ja / Nein
9. In welchen Bereichen setzen Sie die Kenntnisse aus Ihrem Studium im Rettungsdienst ein? Antwortoptionen: Forschung und Wissenschaft, Qualitätsmanagement, Aus-, Fort- und Weiterbildung, Statistik, Managementaufgaben, Andere, bitte angeben
10. In welchem Kanton gehen Sie hauptsächlich Ihrer Arbeit nach? Antwortformat: Drop-down (alle Kantone + Liechtenstein)

Einstellungsitems (VAS 0–100, 0 = stimme überhaupt nicht zu, 100 = stimme voll zu).

11. Forschung im Rettungsdienst erhöht die Qualität der prähospitalen Versorgung.
12. Ich denke, dass wissenschaftliche Daten, die von Rettungskräften selbst erhoben und analysiert werden, objektivere Ergebnisse liefern können, die bei Entscheidungen im Rettungsdienstmanagement berücksichtigt werden sollten.
13. Qualifikationen (z.B. Certificates of Advanced Studies, Bachelor, Master) könnten dazu beitragen, die hohe Versorgungsqualität von Rettungsfachpersonal sichtbar und belegbar zu machen.
14. Ich denke, dass rettungsdienstspezifische akademische Zertifikate und Abschlüsse bessere Möglichkeiten zur Weiterbildung und beruflichen Weiterentwicklung bieten können, wodurch ein frühzeitiger Ausstieg aus dem Beruf verringert werden kann.
15. Eigene Studiengänge für Rettungsfachpersonal könnten Schweizer Rettungsfachpersonal voranbringen.
16. Ich würde es befürworten, neben den etablierten Ausbildungswegen im Rettungsdienst die Möglichkeit zu haben, weiterführende oder akademische Qualifikationen zu erwerben.
17. Ich würde es befürworten, nach dem HF-Abschluss auch noch einen akademischen Weg einschlagen zu können, wie es zum Beispiel in der Pflege möglich ist.
18. Die Einführung höherer Bildungswege (z.B. Bachelor- und Masterabschlüsse) könnten den Teamzusammenhalt im Rettungsdienst negativ beeinflussen.
19. Die Etablierung akademischer Qualifikationen im Rettungsdienst könnte die Arbeitsplatzsicherheit gefährden.
20. Für mich besteht kein Bedarf an zusätzlicher Ausbildung oder weiterführenden Qualifikationen im Schweizer Rettungsdienst.
21. Ich finde es sinnvoll, Entscheidungen im Rettungsdienst auf wissenschaftlicher Grundlage zu treffen.

22. Praktische Erfahrungen sind wichtiger als wissenschaftliche Erkenntnisse. (Reverse-coded)
23. Ich würde mir wünschen, dass in Schweizer Rettungsdiensten mehr wissenschaftlich geforscht wird.
24. Ich würde gerne selber an Forschung teilnehmen und so zur Evidenzbasierung beitragen.
25. Ich habe während des Dienstes Zugang zu wissenschaftlichen Quellen (zum Beispiel Fachzeitschriften, Leitlinien usw.).
26. Ich finde es ausreichend, dass die Arbeitsqualität von Rettungskräften von anderen Berufsgruppen (Ärztinnen, Ärzte, Pflegefachpersonen etc.) erhoben, analysiert, bewertet und publiziert wird. (Reverse-coded)
27. Es stört mich, wenn andere Berufsgruppen Rettungsfachpersonal als Forschungsobjekt betrachten und bewerten.
28. Ich bin der Meinung, dass Rettungsfachpersonal gemeinsam mit Pflegefachpersonen, Ärztinnen und Ärzten als gleichberechtigte Partner gemeinsam Forschung betreiben sollten.
29. Es kann für den Schweizer Rettungsdienst von Vorteil sein, wenn wissenschaftliche Studien von Rettungsfachpersonal für Rettungsfachpersonal durchgeführt werden.

Offene Frage

30. Was ist Ihrer Meinung nach der wichtigste Vorteil oder das grösste Risiko von mehr Wissenschaft im Rettungsdienst? Antwortformat: Freitext

French

Déclaration de consentement

1. Je suis âgé(e) d'au moins 18 ans et j'ai lu et compris les informations relatives à l'étude. Je consens à la conservation et au traitement de mes données anonymes. Cette déclaration de consentement clarifie que les données ne peuvent pas être retirées après soumission, afin de garantir l'anonymat complet des participants. Options de réponse: Accepter / Refuser

Sociodémographie et parcours professionnel

2. Âge Format de réponse: Liste déroulante (18–70 ans)
3. Sexe Options de réponse: Féminin; Masculin; Divers; Non spécifié
4. Expérience professionnelle dans les services d'urgence préhospitaliers (formation incluse) Format de réponse: Entrée numérique (années)
5. Fonction actuelle Options de réponse: Ambulancier/ère diplômé/e ES ou equivalent, Technicien/ne ambulancier/ère avec BF ou equivalent, Étudiant/Étudiante ambulancier/ère, Technicien/ne ambulancier/ère en formation, Practicien/ne formateur/rice, Enseignant/e dans une haute école supérieure, Régulateur/rice sanitaire, Cadre / Direction / Responsable de service de secours, Autre (veuillez préciser)
6. Niveau de formation Options de réponse: Certificat fédéral de capacité (CFC) / Brevet fédéral EP, École supérieure (ES), Bachelor d'une Haute école spécialisée (HES), Master d'une Haute école spécialisée (HES), Bachelor universitaire, Master universitaire, Doctorat (PhD), Autre, veuillez préciser

7. Veuillez préciser votre titre (p. ex. BSc en gestion d'événements, BA en marketing international). Format de réponse: Champ libre
8. Utilisez-vous vos qualifications académiques dans votre travail quotidien? Options de réponse: Oui / Non
9. Dans quels domaines utilisez-vous vos connaissances académiques? (Afficher uniquement si « Oui ») Options de réponse: Recherche, Gestion de la qualité, Formation professionnelle et continue, Statistiques, Tâches managériales, Autre (veuillez préciser)
10. Votre lieu de travail se situe dans le canton suivant: Format de réponse: Liste déroulante (tous les cantons suisses + FL)

Énoncés d'attitude (VAS 0–100, 0 = pas du tout d'accord, 100 = tout à fait d'accord)

11. La recherche améliore la qualité des soins préhospitaliers.
12. Je pense que les données scientifiques obtenues et analysées par des ambulanciers ères peuvent fournir des résultats objectifs et fiables, qui devraient être pris en compte dans les décisions de gestion des services préhospitaliers.
13. Les qualifications académiques (p. ex. certificats avancés et diplômes) pourraient contribuer à démontrer la haute qualité des soins préhospitaliers fournis par les ambulanciers ères.
14. L'établissement de programmes de certificats et de titres académiques en paramédecine offre davantage d'opportunités d'acquisition de compétences et d'évolution de carrière, réduisant ainsi les départs précoces.
15. Je pense que des titres académiques spécifiquement dédiés aux ambulanciers ères pourraient bénéficier à la profession en Suisse.
16. J'aimerais avoir la possibilité de suivre des formations avancées ou des diplômes académiques parallèlement aux parcours déjà existants.
17. Je suis favorable à la possibilité de suivre un parcours académique après l'obtention d'un diplôme de niveau ES, comme dans la profession infirmière.
18. L'introduction de parcours de formation supérieure pourrait nuire à la cohésion des équipes.
19. L'expansion des diplômes académiques ou tertiaires pourrait menacer ma sécurité d'emploi.
20. Il n'y a pas besoin d'éducation ou de qualifications avancées supplémentaires dans les services préhospitaliers suisses.
21. Je pense qu'il est pertinent de prendre des décisions dans les services préhospitaliers sur la base de données scientifiques.
22. L'expérience pratique est plus importante que les résultats scientifiques. (Reverse-coded)
23. J'aimerais voir davantage de recherche scientifique dans les services préhospitaliers suisses.
24. J'aimerais participer à des recherches et contribuer à établir une pratique fondée sur les données probantes.
25. J'ai accès à des ressources scientifiques (p. ex. revues, directives, etc.) pendant mes heures de service.
26. Je considère qu'il est suffisant que la qualité du travail soit évaluée par d'autres groupes professionnels (médecins, infirmiers, etc.). (Reverse-coded)
27. Cela me dérange d'être perçu et évalué comme sujet de recherche par d'autres groupes professionnels.

28. Je pense que les ambulanciers ères devraient mener des recherches en collaboration avec médecins et infirmiers ères en tant que partenaires égaux.
29. Il pourrait être plus bénéfique pour la profession que les études soient menées par des ambulanciers ères pour des ambulanciers ères.

Question ouverte

30. Selon vous, quel est le principal avantage ou risque d'une plus grande diffusion de la science dans les services d'urgence? Format de réponse: Champ libre

Italian

Dichiarazione di consenso

1. Dichiaro di avere almeno 18 anni e di aver letto e compreso le informazioni relative allo studio. Acconsento alla conservazione e al trattamento dei miei dati anonimi. Questa dichiarazione chiarisce che i dati non possono essere ritirati dopo l'invio, garantendo l'assoluto anonimato dei partecipanti. Opzioni di risposta: Accettare / Rifiutare

Sociodemografia e percorso professionale

2. Età Formato di risposta: Menù a tendina (18–70 anni)
3. Genere Opzioni di risposta: Femmina; Maschile; Altro; Non specificato
4. Esperienza lavorativa nel soccorso (inclusa la formazione) Formato di risposta: Menù a tendina (0–40 anni)
5. Attuale funzione nel servizio di soccorso Opzioni di risposta: Soccorritore/Soccorritrice (SSS), Soccorritore/Soccorritrice ausiliario/a (APF), In formazione (Soccorritore/Soccorritrice SSS), In formazione (Soccorritore/Soccorritrice ausiliario/a APF), Formatore/Formatrice, Docente presso SSS, Operatore/Operatrice di centrale, Quadro/Dirigente, Altro, specificare
6. Titolo conseguito Opzioni di risposta: Attestato Professionale Federale (APF), Scuola Specializzata Superiore (SSS), Bachelor Scuola Universitaria Professionale, Master Scuola Universitaria Professionale, Bachelor Università, Master Università, Dottorato, Altro, specificare
7. P.F. specifichi il titolo ottenuto (es. BSc Statistics o BA International Marketing). Formato di risposta: Campo libero (Mostrato solo per titoli di livello terziario)
8. Ha modo di mettere in pratica le conoscenze e competenze apprese con il titolo di studio? Opzioni di risposta: Sì / No
9. In quale ambito mette in pratica le sue competenze accademiche? (Mostrato solo se risposta = Sì) Opzioni di riposta: Ricerca, Gestione della qualità, Formazione, Statistica, Attività manageriali, Altro (specificare)
10. Luogo di lavoro (Cantone) Formato di risposta: Menù a tendina (tutti i Cantoni + FL)

Affermazioni attitudinali (VAS 0–100, 0 = completo disaccordo, 100 = completo accordo).

11. La ricerca scientifica contribuisce a migliorare la qualità delle cure preospedaliere.
12. Sono dell'opinione che dati scientifici raccolti e analizzati dal personale paramedico possano fornire risultati oggettivi e affidabili, e dovrebbero essere inclusi nelle decisioni dei Servizi Ambulanza.
13. Offerte accademiche (es. CAS, programmi di Bachelor o Master) possono contribuire a evidenziare l'elevata qualità del soccorso preospedaliero.

14. Formazioni e certificati specifici per il personale di soccorso possono offrire possibilità di sviluppo professionale su misura, riducendo il rischio di abbandono precoce grazie a maggiori prospettive.
15. L'accademizzazione aiuterebbe a rendere visibile l'elevata qualità delle prestazioni erogate dal personale di soccorso.
16. Ritengo che formazioni accademiche destinate esclusivamente al personale di soccorso sarebbero un'opportunità di sviluppo della figura professionale.
17. Sarei favorevole a un percorso accademico dopo il diploma SSS, come per il personale infermieristico.
18. L'introduzione di nuovi percorsi di studio (es. CAS, SUP) potrebbe avere un influsso negativo sulla coesione del personale di soccorso.
19. L'estensione a titoli terziari o accademici potrebbe rappresentare una minaccia per la sicurezza del posto di lavoro.
20. Non vedo necessità di ulteriori percorsi di studio di livello avanzato nel soccorso preospedaliero.
21. Ritengo ragionevole che le decisioni nel soccorso siano basate su evidenza scientifica.
22. L'esperienza pratica è più importante delle conoscenze scientifiche. (Reverse-coded)
23. Desidero che venga svolta più ricerca nel soccorso in Svizzera.
24. Vorrei partecipare personalmente alla ricerca scientifica e contribuire alla base di evidenza.
25. Quando sono in servizio ho accesso a fonti scientifiche (es. riviste, linee guida).
26. Mi dà fastidio essere considerato e trattato come oggetto di studio da altri gruppi professionali. (Reverse-coded)
27. Mi dà fastidio essere considerato e trattato come oggetto di studio da altri soccorritori. (Reverse-coded, versione italiana specifica)
28. Ritengo che i soccorritori dovrebbero svolgere ricerca assieme a medici e infermieri in condizioni paritarie.
29. Ritengo che può essere più vantaggioso se gli studi scientifici vengono condotti dal personale paramedico per il personale paramedico.

Domanda aperta

30. Qual è secondo lei il principale vantaggio oppure il maggiore rischio dell'accademizzazione nel soccorso preospedaliero? Formato di risposta: Campo libero

Unofficial English Translation

Consent

1. I am at least 18 years old and have read and understood the study information. I consent to the storage and processing of my anonymous data. Response options: Accept / Decline

Sociodemographic and professional background

2. Age Response options: Drop-down (18–70 years)
3. Gender Response options: Female; Male; Diverse; Not specified
4. EMS work experience (years, including training) Response options: Drop-down (0-40 years)

5. Current function Response options: Registered Paramedic ES, Emergency Medical Technician (Federal Certificate), Student paramedic, Student EMT, Practice trainer, Instructor at a higher vocational school, EMS dispatcher, Management / leadership, Other (specify)
6. Highest qualification Response options: CFC / Federal Certificate, Professional College (ES), University of Applied Sciences Bachelor, University of Applied Sciences Master, University Bachelor, University Master, Doctorate, Other (specify)
7. Please specify your degree. Format: Free text
8. Do you apply the knowledge from your studies in daily practice? Response options: Yes / No
9. In which areas do you apply academic knowledge? Response options: Research, Quality management, Education, Statistics, Management, Other
10. In which canton do you work? Format: Drop-down (all cantons + FL)

Attitude Items (VAS 0–100, 0 = strongly disagree, 100 = strongly agree)

11. Research in EMS improves the quality of prehospital care.
12. I believe that scientific data collected and analyzed by EMS professionals themselves can provide more objective and reliable results that should be considered in EMS management decisions.
13. Academic qualifications (e.g., CAS, Bachelor, Master) could help make the high quality of care provided by EMS professionals visible and demonstrable.
14. I think that EMS-specific academic certificates and degrees can provide better opportunities for continuing education and career development, thereby reducing early career attrition.
15. Dedicated academic degree programs for EMS professionals could advance the Swiss EMS profession.
16. I would support having the option to pursue advanced or academic qualifications alongside the established EMS training pathways.
17. I would support the possibility of taking an academic route after completing the HF diploma, similar to what is possible in nursing.
18. The introduction of higher education pathways (e.g., Bachelor and Master degrees) could negatively affect team cohesion in EMS.
19. The establishment of academic qualifications in EMS could threaten job security.
20. In my view, there is no need for additional or more advanced education in Swiss EMS.
21. I think it is sensible for decisions in EMS to be based on scientific evidence.
22. Practical experience is more important than scientific evidence. (Reverse-coded)
23. I would like to see more scientific research conducted within Swiss EMS organizations.
24. I would personally like to participate in research and contribute to evidence-based practice.
25. I have access to scientific resources (e.g., journals, guidelines) during my work shifts.
26. I think it is sufficient for the quality of EMS work to be assessed, analyzed, evaluated and published by other professional groups (e.g., physicians, nurses). (Reverse-coded)
27. It bothers me when other professional groups treat EMS personnel as research subjects and evaluate them.

28. I believe that EMS professionals should conduct research together with nurses and physicians as equal partners.
29. It may be beneficial for Swiss EMS if scientific studies are conducted by EMS professionals for EMS professionals.

Open question

30. In your opinion, what is the main advantage or greatest risk of academization in EMS? Format: Free text

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APPENDIX C: SENSITIVITY ANALYSIS

This appendix summarizes predefined sensitivity analyses assessing the robustness of attitudinal classifications and educational-group comparisons. All analyses used the same complete-case datasets as the primary analyses (n = 590 for descriptive statistics; n = 584 for regression models).

Dominance Index Cutoff Sensitivity

The Dominance Index (D = Opportunity - Threat) was categorized using a ±10 tie zone in the primary analysis. Two alternative thresholds (±5 and ±15) were examined.

Across both alternatives, the distribution of respondents classified as Opportunity-leaning, Neutral, or Threat-leaning changed only marginally. In all cases, Opportunity-leaning respondents remained the majority across all thresholds, and the relative ordering of the three categories was unchanged. No alternative threshold affected group differences or regression conclusions.

Attitudinal Profile Cutoff Sensitivity

Attitudinal profiles were derived using a 60-point cutoff on both the Opportunity and Threat scales (High ≥ 60; Low < 60). Alternative cutoffs (55 and 65) were examined to assess stability.

Profile distributions remained substantively unchanged across all examined cutoffs. Under the primary cutoff, the High-Opportunity / Low-Threat profile accounted for 74.1% of respondents (99% CI [69.2, 78.4]). Alternative cutoffs produced near-identical patterns, with the same profile remaining dominant. No cutoff variation altered subgroup differences or the overall interpretation of attitudinal structure.

Academic Degree Status Sensitivity (Narrow vs Broad Definition)

A broad definition of academic degree status (including CAS, DAS, and MAS degrees) was used to evaluate whether results were sensitive to the coding scheme. This increased the number of respondents classified as having an academic degree from 98 (16.6%) under the narrow definition to 104 (17.6%) under the broad definition.

Under the broad definition, differences between respondents with and without an academic degree remained fully consistent with the primary analysis:

- Opportunity: +5.40 (99% CI [-0.70, 11.51])
- Threat: -8.21 (99% CI [-13.68, -2.73])
- Dominance: +13.61 (99% CI [3.83, 23.39])

Logistic Regression Robustness

The full-sample model was re-estimated using the broad definition of academic degree status (including CAS, DAS, and MAS qualifications). Odds ratios, confidence intervals, and significance levels were consistent with the primary analysis based on the narrow definition. Results were consistent across all model specifications, with no changes in direction or magnitude of effects.

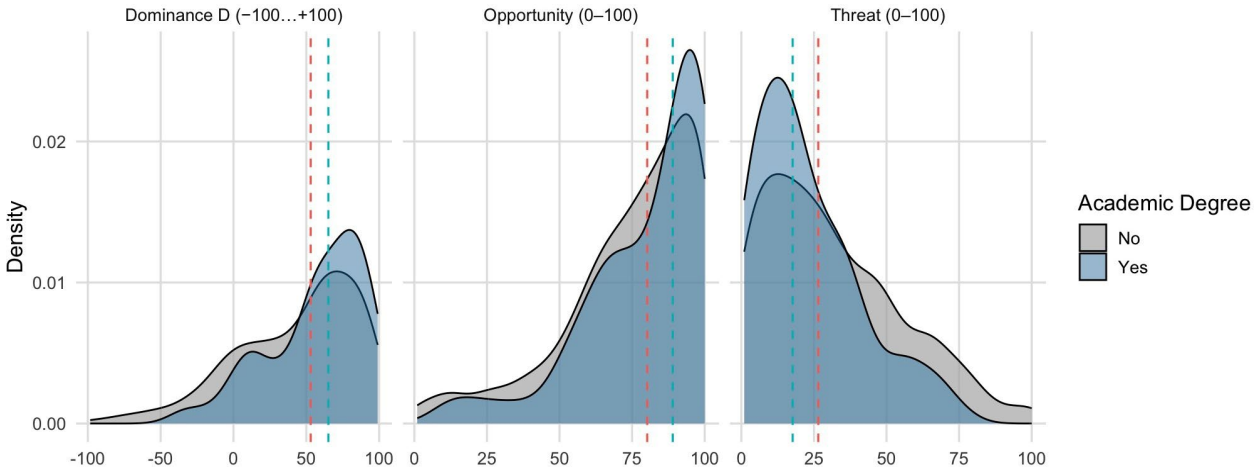


Figure C1. Kernel-density distributions of opportunity, threat, and dominance scores by academic degree status (broad definition).

Note. Kernel-density plots of Opportunity and Threat scores (0-100 VAS) and Dominance Index scores (-100 to +100; Dominance = Opportunity - Threat), stratified by academic degree status using the broad definition of academic degree status. The broad definition classifies respondents as having an academic degree if they hold a Bachelor, Master, Doctorate, EMBA, or postgraduate CAS/DAS/MAS degree. Shaded curves represent smoothed distributions; vertical dashed lines mark group means (blue = academic degree; grey = no academic degree). "Prefer not to answer" responses were excluded.

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REVIEWS

WHEN GUIDELINES MEET THE ROAD: A CFIR-INFORMED SYSTEMATIC REVIEW OF IMPLEMENTATION IN AMBULANCE SERVICES

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ABSTRACT

Introduction: Clinical practice guidelines are central to safe, consistent, and evidence-informed ambulance care, yet their implementation is rarely straightforward. Ambulance services operate across complex, time-sensitive, and geographically dispersed settings, where organizational capacity, local context, and workforce engagement can influence whether guidelines are adopted and sustained in practice. This review aimed to identify and synthesize the barriers and facilitators influencing the implementation of clinical practice guidelines in ambulance services, and to map these determinants using the Consolidated Framework for Implementation Research (CFIR).

Methods: This systematic review followed Joanna Briggs Institute methodology for mixed-methods systematic reviews and was registered with PROSPERO (CRD42024580204). Searches were conducted in MEDLINE (PubMed), CINAHL, EMBASE, Cochrane Library, JBI Database, Scopus, and Web of Science. Qualitative, quantitative, and mixed-methods studies published in English within the past 20 years were included. Data were extracted and mapped to the domains of the CFIR.

Results: Forty-two studies were included, revealing substantial variability in CPG implementation contexts and outcomes. Key barriers included resource limitations, protocol complexity, and organizational resistance, especially in rural and under-resourced areas. Facilitators identified included leadership engagement, effective communication, adaptable protocols, and targeted education. The most frequently reported determinants were within the CFIR's 'Inner Setting' and 'Process' domains.

Conclusion: The implementation of clinical practice guidelines in ambulance services depends on more than the quality of the guideline itself. Successful uptake requires organizational readiness, local adaptation, leadership support, workforce engagement and sustained implementation planning. By mapping implementation determinants to the CFIR, this review provides a structured evidence base to guide future implementation strategies, policy development and research in ambulance services.

INTRODUCTION

Clinical practice guidelines (CPGs) are important tools for promoting standardized, high-quality, and evidence-informed care across healthcare systems. In ambulance services, CPGs support clinical decision-making in dynamic, unpredictable, and often resource-limited environments. Paramedics deliver care across diverse emergency and non-emergency contexts, frequently with

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limited personnel, equipment, and direct clinical oversight. Consistent application of CPGs is therefore important for supporting safe and reliable patient care (Maria, 2021).

Despite their recognized benefits, the implementation of CPGs in ambulance services is frequently challenged by significant contextual and organizational barriers. Ambulance services vary widely in their structures, workforce capacities, and available resources, contributing to marked differences in the adoption and application of CPGs (Maria et al., 2024). Barriers such as resource scarcity, limited training opportunities, and logistical constraints are especially acute in rural and underserved settings, where maintaining adherence to guidelines can be particularly difficult (McCaul et al., 2018). Additionally, the diversity within paramedic scope of practice levels, such as Advanced Life Support (ALS) and Basic Life Support (BLS), requires that guidelines often be adapted to match the skills and resources available within each service type (Wilkinson-Stokes et al., 2021).

Previous reviews have identified an unstructured range of barriers and facilitators to CPG implementation in out-of-hospital care. Commonly reported obstacles include insufficient inter-agency coordination, lack of dedicated funding, and inconsistent access to technology for disseminating and tracking guidelines (Lord et al., 2012; Maria et al., 2024; McCaul et al., 2019). To date, our understanding of the challenges remains limited, and there remains a need for a comprehensive synthesis that systematically maps the determinants of CPG implementation across different service contexts. Such synthesis can inform the development of targeted, context-sensitive interventions to improve guideline uptake and sustainability.

The Consolidated Framework for Implementation Research (CFIR) was selected because it provides a comprehensive structure for examining implementation determinants across intervention, organizational, individual and process-related domains (Damschroder et al., 2009). Its multidimensional structure is well suited to ambulance services, where guideline implementation is influenced by interactions between clinical protocols, workforce capability, organizational systems and external service contexts. This systematic review aimed to identify and synthesize the barriers and facilitators influencing CPG implementation in ambulance services, and to map these determinants across the five CFIR domains: Intervention Characteristics, Outer Setting, Inner Setting, Characteristics of Individuals, and Process.

The primary research question was: What are the main barriers and facilitators of clinical practice guideline implementation in ambulance services, and how do these map to the domains of CFIR?

METHODS

Study Design and Protocol Registration

This systematic review was conducted in accordance with the Joanna Briggs Institute (JBI) methodology for mixed methods systematic reviews (MMSR), as outlined in Chapter 8 of the JBI Manual for Evidence Synthesis (JBI, 2024). Studies of all designs, including qualitative, quantitative, and mixed methods studies, were included to address the review question comprehensively. A convergent integrated approach was used; whereby quantitative data were transformed into textual descriptions ("qualitized") and synthesized alongside qualitative findings to generate integrated categories and

findings (Joanna Briggs Institute, 2024b). The review was reported in accordance with PRISMA 2020 guidelines (Page et al., 2021). The protocol was registered in PROSPERO (CRD42024580204).

The CFIR guided data extraction and synthesis. CFIR identifies determinants of implementation across five domains: Intervention Characteristics, Outer Setting, Inner Setting, Characteristics of Individuals, and Process. Mapping findings to these domains supported structured synthesis of barriers and facilitators influencing CPG implementation in ambulance service settings.

Eligibility Criteria

Studies were eligible if they involved paramedics, ambulance clinicians, or other out-of-hospital care providers and examined implementation of clinical practice guidelines in ambulance service or out-of-hospital care settings. Outcomes of interest were barriers, facilitators, or other implementation determinants that could be mapped to CFIR domains. Studies of any design, including randomized controlled trials, quasi-experimental studies, observational studies, qualitative studies, and mixed-methods studies, were eligible if published in English within the last 20 years. Case reports, editorials, opinion pieces, studies involving non-EMS healthcare providers, and studies conducted solely in hospital-based settings were excluded.

Search Strategy

Searches were conducted in MEDLINE (PubMed), CINAHL, EMBASE, Cochrane Library, JBI Database, Scopus, and Web of Science. Search terms related to clinical practice guidelines, ambulance services and out-of-hospital care, and implementation determinants, including "clinical practice guidelines", "ambulance services", "implementation", "training", and "leadership support". Searches were limited to English-language publications from the previous 20 years. Additional records were identified through citation searching and supplementary Google Scholar searching. Google Scholar was searched using simplified keyword combinations based on the main database strategy, and the first 200 results were screened for potentially relevant studies. The full search strategy is available in Appendix 1.

Study Selection

Study selection was undertaken in Covidence (Veritas Health Innovation, 2024). After duplicate removal, three independent reviewers screened titles and abstracts against the inclusion and exclusion criteria. Full-text review was then undertaken in the same way to confirm eligibility. Disagreements were resolved through discussion. The PRISMA flow diagram was used to report the study selection process.

Data Extraction

Data was extracted in Excel (Microsoft Corporation, 2024) using a standardized template based on JBI methodology. Extracted items included study characteristics, participant details, intervention characteristics, reported barriers and facilitators, and implementation determinants relevant to CFIR domains. Two reviewers independently extracted data and mapped each reported barrier and facilitator to the most relevant CFIR domain and, where appropriate, construct. The two extracted and mapped datasets were then com-

pared, with discrepancies resolved through discussion and consensus. Where agreement could not be reached, a third reviewer adjudicated.

Critical Appraisal and Risk of Bias Assessment

Methodological quality was assessed using the JBI Critical Appraisal Checklists, with the checklist matched to each study design (Joanna Briggs Institute, 2024a). Two reviewers independently appraised included studies and assigned overall ratings of high, moderate, or low quality. Discrepancies were resolved through discussion or consultation with a third reviewer. The critical appraisal results were used to inform interpretation of the synthesis, particularly when considering the strength and consistency of findings within and across CFIR domains.

Data Synthesis

Data analysis followed the convergent integrated approach for mixed methods systematic reviews recommended by JBI (Joanna Briggs Institute, 2024b). Quantitative findings were transformed into textual descriptions ("qualitized") and synthesized alongside qualitative findings. All qualitative findings, qualitized quantitative results, and relevant findings from mixed-methods studies were pooled based on similarity of meaning.

Synthesis was undertaken using the meta-aggregative approach described in the JBI Manual for Evidence Synthesis, with findings examined and categorized into themes based on shared meaning. Categories were developed using both deductive and inductive coding. CFIR provided the deductive framework, with extracted findings initially organized according to the five CFIR domains: Intervention Characteristics, Outer Setting, Inner Setting, Characteristics of Individuals, and Process. Within each domain, recurring patterns in the extracted barriers and facilitators were then examined inductively to develop subthemes and categories based on shared meaning. This supported a structured and theory-informed synthesis of implementation determinants across diverse study types.

A formal certainty or confidence assessment was not undertaken. This review used a framework-based synthesis, mapping heterogeneous qualitative, quantitative, and mixed-methods evidence to CFIR domains rather than synthesizing it as discrete effect estimates or standalone qualitative findings. Methodological quality was therefore considered when interpreting the strength and consistency of findings within and across CFIR domains.

Given the heterogeneity of study designs, interventions, and reported outcomes, meta-analysis was not appropriate. Findings were therefore synthesized narratively and presented by CFIR domain. The frequency and nature of reported barriers and facilitators were described, including convergent, divergent, and complementary findings across study types.

RESULTS

Study Selection and Characteristics

A total of 42 studies were included following screening and eligibility assessment (Figure 1). The database search identified 940 records, with a further 13 references located

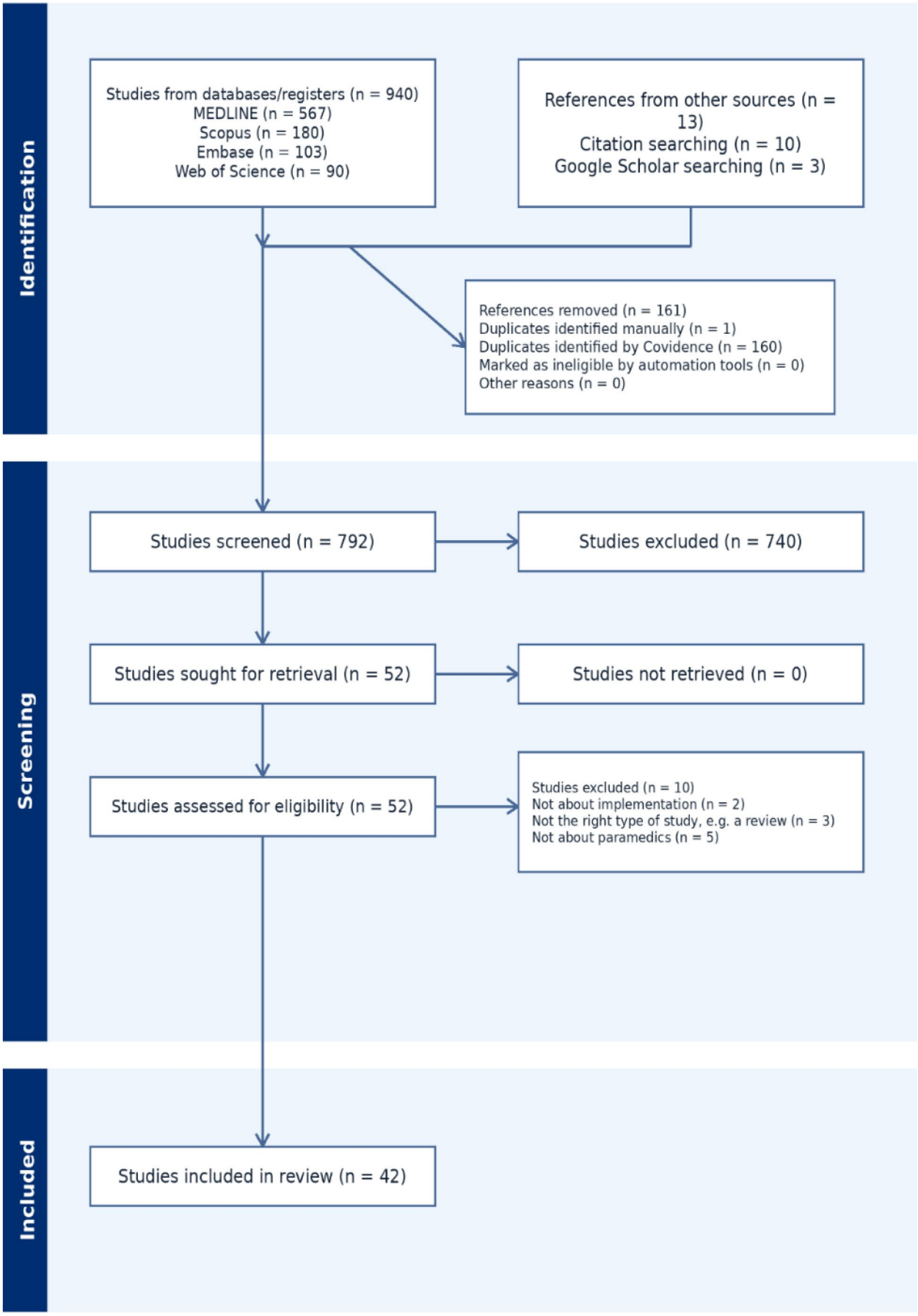


Figure 1. PRISMA.

through manual citation searching and Google Scholar. After removal of 161 duplicates, 792 records were screened. Fifty-two full-text articles were assessed for eligibility, of which 10 were excluded because they focused on non-paramedic populations, lacked an implementation focus, or were review or commentary papers.

A summary of included study characteristics is provided in Table 1, with detailed study-level characteristics provided in Appendix 2.

Characteristic	Summary
Number of included studies	42
Publication years	2004–2024
Countries/regions represented	USA, Canada, Australia, New Zealand, England, Northern Ireland, Netherlands, Germany, Finland, Sweden, Norway, South Africa, Europe, and multi-country studies across Asia, Latin America and Europe
Study designs	Qualitative studies, surveys, mixed-methods studies, retrospective and prospective observational studies, before-and-after studies, quasi-experimental studies, interrupted time series, process mining, and implementation/evaluation reports
Population/setting	Paramedics, ambulance clinicians, EMS leaders, EMS agencies, emergency response organizations, helicopter emergency medical services, and related out-of-hospital care settings
Guideline/protocol focus	Pain management, cardiac arrest and resuscitation, trauma and traumatic brain injury, pediatric care, referral pathways, thrombolysis, prehospital anesthesia, transport safety, quality improvement, and evidence-based guideline implementation
Implementation focus	Barriers and facilitators to CPG uptake, protocol adherence, training and education, leadership, organizational readiness, audit and feedback, implementation strategies, and sustainability
Detailed study-level characteristics	Provided in Appendix 2

Table 1. Summary characteristics of included studies.

Included studies used a range of designs, including mixed methods, retrospective and prospective observational studies, cross-sectional surveys, quasi-experimental studies, and qualitative research. Some also used cohort, controlled before-and-after, national evaluation, or longitudinal designs. Studies were conducted across the USA, Canada, Australia, Europe, and South Africa (Figure 2). Interventions included training programs, leadership strategies, and technological supports, with outcomes relating to clinical care, documentation, guideline adherence, and paramedic knowledge. Full study characteristics are provided in Appendix 2.

Critical Appraisal and Risk of Bias Results

Overall, studies were of moderate to high methodological quality. Of the 42 included studies, 22 were rated as high quality and 20 as moderate quality; no studies were rated as low quality. Appraisal considered study design, sampling and recruitment, appropriateness of data collection methods, and management of potential confounding. Common limitations included reliance on self-reported data, incomplete reporting of sampling or recruitment, limited reporting of researcher positioning or reflexivity in qualitative studies, and limited control for confounding in observational and survey-based studies. Detailed study-level appraisal notes are provided in Appendix 3. Given the heterogeneity of study designs and outcomes, risk of bias assessments were used to inform interpretation of the findings rather than to exclude or weight studies.

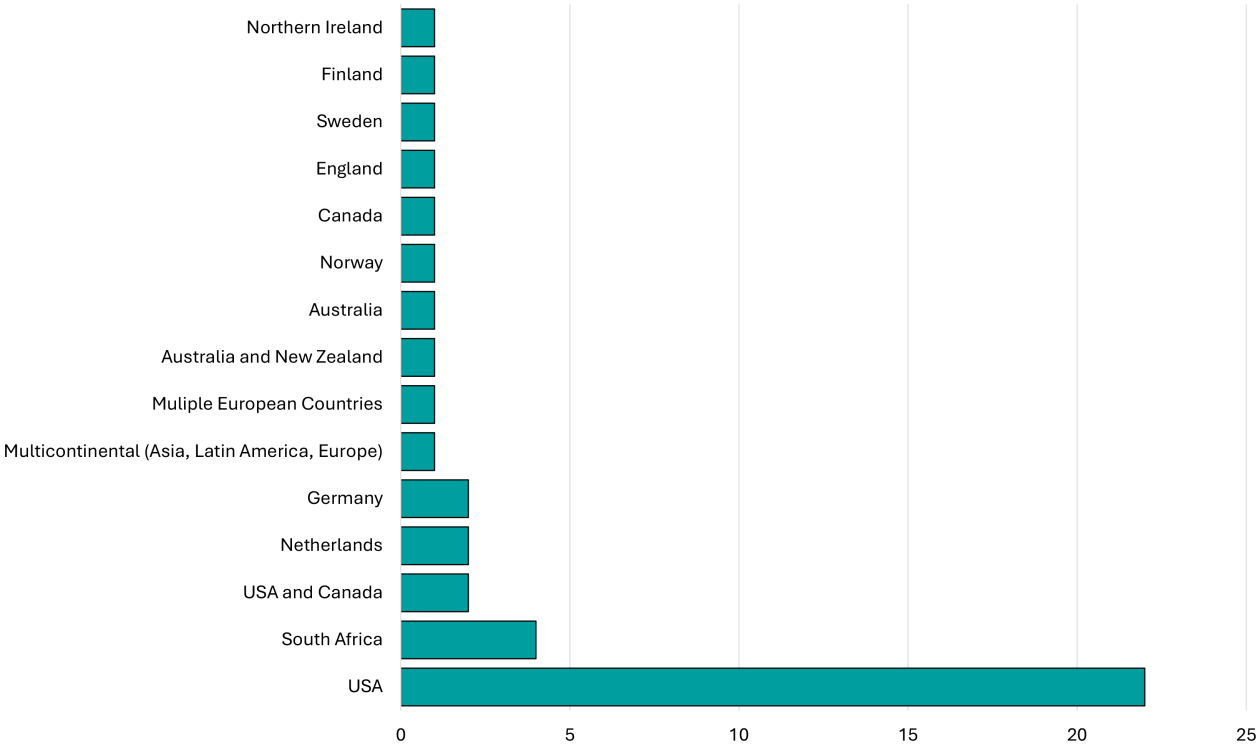


Figure 2. Distribution of studies by country.

Synthesis of Results Organized by CFIR Domains

Findings were extracted and organized using CFIR as the framework for synthesis. The full study-level CFIR extraction is provided in Appendix 4. Each included study was examined against the five CFIR domains: Intervention Characteristics, Inner Setting, Outer Setting, Characteristics of Individuals, and Process. Therefore, the domain summary should be interpreted as a framework-based organization of extracted determinants rather than as mutually exclusive frequency counts. Some determinants were mapped across more than one domain, reflecting the interaction between intervention, organizational, individual and system-level factors. For example, resource constraints appeared as both an Inner Setting issue, relating to staffing, equipment, training capacity and organizational infrastructure, and an Outer Setting issue, relating to broader funding, geography and service-system variation. Similarly, rural and under-resourced contexts influenced implementation across multiple domains, including workforce capacity, access to training, inter-agency coordination, and availability of alternative care pathways. Table 2 summarizes the recurring implementation determinants identified within each CFIR domain.

Intervention Characteristics

Implementation of CPGs in ambulance services was influenced by guideline complexity, adaptability, and the extent to which protocols depended on resources available in the local service context.

Complexity was a consistent barrier to implementation. Lengthy protocols, high cognitive demands, and poor fit with prehospital practice reduced uptake, particularly in stressful or time-critical situations (Adelgais et al., 2019; Bosse et al., 2011; Hagiwara et al.,

CFIR Domain	Role in Synthesis	Recurring Determinants Identified
Intervention Characteristics	Captured features of the guideline, protocol, pathway, checklist, training package or implementation intervention that influenced uptake.	Complexity, adaptability, clarity, accessibility, evidence alignment, compatibility with clinical workflow, format, need for local contextualization.
Inner Setting	Captured organizational conditions within ambulance services and related agencies.	Organizational readiness, leadership support, available resources, staffing, training infrastructure, communication, organizational culture, feedback systems, local governance.
Outer Setting	Captured external system, policy, regulatory and service-environment factors influencing implementation.	Funding, regulation, policy mandates, geography, rurality, inter-agency coordination, hospital feedback, community needs, system fragmentation.
Characteristics of Individuals	Captured clinician, leader and stakeholder factors influencing engagement with guidelines.	Knowledge, confidence, attitudes to change, professional autonomy, perceived risk, motivation, prior experience, comfort with new skills or protocols.
Process	Captured how implementation was planned, delivered, monitored and sustained.	Education and training, phased implementation, champions, stakeholder engagement, audit and feedback, monitoring, reinforcement, quality improvement, sustainability planning.

Table 2. Summary of recurring implementation determinants by CFIR domain.

2013; Sarmiento et al., 2013). This was evident in areas such as weight-based opioid dosing and advanced life support protocols, where adherence was often delayed and clinicians reverted to simpler approaches under pressure (Bigham, Koprowicz, et al., 2010).

Adaptability facilitated implementation. Guidelines tailored to local resources, equipment, and service context were associated with greater uptake and clinician confidence (Adelgais et al., 2019; Ciarletta et al., 2024; McManus et al., 2023). Locally adapted protocols and training were particularly useful in complex areas such as pediatric transport, asthma care, STEMI, and traumatic brain injury (Gaither et al., 2024; Kothari et al., 2021; Spaite et al., 2019).

Resource dependency remained a barrier where guidelines required staffing, equipment, funding, or implementation structures that were not consistently available (Angerman et al., 2023; Mai et al., 2023; Mould-Millman et al., 2023). This was particularly evident in rural, low-income, and volunteer-based services, where uptake was more variable and adherence was lower (Adelgais et al., 2019; McCaul et al., 2020; Spaite et al., 2019).

Inner Setting

Implementation of CPGs was influenced by organizational readiness, leadership engagement, and workplace culture.

Organizational readiness shaped implementation. Larger EMS agencies were generally better prepared due to stronger infrastructure, established training systems, and access to digital decision-support tools, supporting smoother implementation and higher compliance than less-resourced services (Angerman et al., 2023). Smaller or volunteer-based services faced greater implementation barriers, including limited staffing, funding, and access to training, contributing to less consistent uptake (Adelgais et al., 2019).

Leadership engagement also influenced implementation. Services with visible leadership support, protocol development activities, and performance review processes reported stronger adherence and greater accountability (Angerman et al., 2023; Feder et al., 2006). Where leadership was inconsistent, implementation was more variable and services appeared less able to support change effectively (Adelgais et al., 2019).

Workplace culture further shaped implementation. Collaborative cultures that supported shared decision-making and team-based learning were better positioned to embed new CPGs, while resistance to change remained a barrier, particularly where clinicians were reluctant to move away from established practices (Bosse et al., 2011; Carey et al., 2019; Kothari et al., 2021). Qualitative evidence also suggested that transport-focused organizational norms could limit uptake of referral pathways and alternative care options, while recognizing paramedics as autonomous clinicians supported practice change (Bloomer et al., 2024).

Outer Setting

Implementation of CPGs was shaped by regulatory requirements, external partnerships, and system-level resourcing.

Regulatory frameworks influenced adherence, with EMS services operating under national or regional mandates generally reporting stronger uptake than those without formal external requirements (Brown et al., 2014; Spaite et al., 2019). In the absence of such mandates, implementation was more variable and depended more heavily on internal leadership and organizational priorities, although strong leadership and training could partly offset this (Guerrier et al., 2023).

External relationships also affected implementation. Public awareness initiatives, such as CPR and AED campaigns, were associated with stronger alignment with evidence-based practice (Ezem et al., 2024). Collaboration with hospitals and other health services supported adoption of time-critical protocols, particularly in areas such as stroke, STEMI, and cardiac arrest care (Angerman et al., 2023; Carey et al., 2019; Jones Rhodes et al., 2016; Spaite et al., 2019). However, logistical and coordination challenges could limit the effectiveness of these partnerships.

System-level resource disparity was a major barrier. Rural agencies often had less access to equipment, trained personnel, funding, and implementation supports, contributing to lower adherence, particularly for complex protocols such as pediatric and trauma care (Mai et al., 2023; McCaul et al., 2020). Limited uptake of adhesive defibrillation pads, restricted access to video laryngoscopes and ePCRs, delays in software updates, and local protocol modifications further illustrate the effect of external resource constraints and operational misalignment on implementation (Bigham, Aufderheide, et al., 2010; Ebben et al., 2014; Krawczyk et al., 2016).

Characteristics of Individuals

Implementation of CPGs was influenced by paramedics' knowledge, beliefs, confidence, and attitudes towards guideline use.

Knowledge and skill deficits were a recurring barrier, particularly for complex protocols such as weight-based opioid dosing and pediatric trauma care, where clinicians reported uncertainty in high-pressure or resource-constrained environments (Adelgais et al., 2019; Angerman et al., 2023). Generational differences also contributed to variation in adherence, with younger paramedics more likely to adopt structured evidence-based guidelines, while more experienced clinicians were more likely to rely on established practice or personal judgement (Guerrier et al., 2023).

Beliefs and attitudes towards CPGs shaped implementation. Resistance to change was commonly reported, particularly among experienced clinicians, alongside concerns regarding medication dosing errors, adverse effects, reduced autonomy, and restrictions on clinical judgement (Bosse et al., 2011; Carey et al., 2019; Feder et al., 2006). In contrast, clinicians were more likely to adopt guidelines when they perceived clear clinical benefit, such as improved treatment accuracy or reduced medication error (McManus et al., 2023). Fear of complaints or regulatory scrutiny could also discourage use of alternative care pathways even when clinically appropriate (Bloomer et al., 2024).

Confidence and self-efficacy supported adherence, particularly where clinicians felt organizationally supported and protocols were embedded within routine practice (Ebben et al., 2015; Feder et al., 2006). However, experience could also contribute to deviation from protocols where feedback and monitoring were limited (Bosse et al., 2011).

Process

Implementation of CPGs was influenced by how guidelines were planned, introduced, reinforced, and evaluated.

Structured planning supported implementation. Evidence appraisal, stakeholder collaboration, phased rollouts, pilot programs, and staggered adoption schedules reduced uncertainty and supported adherence during transition to new guidelines (Angerman et al., 2023; Feder et al., 2006; Lang et al., 2012; McCaul et al., 2020; Spaite et al., 2019).

Engagement of frontline clinicians was also important. Passive dissemination limited confidence and uptake, whereas involving paramedics in implementation processes improved buy-in and alignment with operational realities (Thorvaldsen et al., 2019). Pre-implementation strategies that included clinician input and targeted training were associated with higher adherence and greater confidence in applying guidelines (Adelgais et al., 2019; Kothari et al., 2021).

Education and reinforcement strategies strengthened execution. Structured education, simulation-based training, checklists, interactive learning methods, provider prompts, and feedback improved familiarity, confidence, and adherence, particularly for complex protocols such as traumatic brain injury, opioid safety, seizure management, and pediatric airway care (Angerman et al., 2023; Carey et al., 2019; Kelleher et al., 2014; Siriwardena et al., 2014; Tomasone et al., 2014; Watts et al., 2004).

Ongoing monitoring and feedback supported sustained implementation. Regular audit processes, feedback sessions, ePCRs, and clinical audit systems improved documentation, reduced deviation from protocols, and helped maintain guideline use over time (Bosse et al., 2011; Feder et al., 2006; Kothari et al., 2021).

Across studies, determinants related to planning, clinician engagement, and early training appeared most relevant to initial implementation, while audit, feedback, monitoring, and integration into routine systems were more closely aligned with sustained practice.

The following figure visually represents the key determinants of CPG implementation in ambulance services identified across the five CFIR domains. Figure 3 provides a concise visual overview of the main guideline, clinician, organizational, process, and system-level influences discussed in the Results and Discussion.



Figure 3. CFIR determinants of clinical practice guidelines implementation in ambulance services.

DISCUSSION

This review identified multiple interacting determinants of CPG implementation in ambulance services, with barriers and facilitators evident across all CFIR domains. Implementation was shaped not only by the quality of the guideline, but by whether it could be applied in mobile, time-critical, geographically dispersed, and resource-variable care environments. Ambulance clinicians often make decisions with limited personnel, variable equipment access, minimal immediate clinical support, and little control over the physical or social environment. In this context, guideline usability, operational fit, training, feedback, and organizational support become central to implementation.

The CFIR mapping showed that implementation challenges were rarely confined to one level of influence. Protocol complexity, training access, workforce confidence, leadership support, resource availability, inter-agency coordination, and rurality frequently interacted across domains. For example, a clinically appropriate guideline may still be difficult to implement if it requires equipment that is inconsistently available, training that cannot be delivered across dispersed teams, or coordination with receiving services that varies by region.

Adaptability and usability emerged as central influences. Guidelines were more likely to be adopted when they were clear, operationally relevant, and adaptable to local service conditions. Complex protocols, high cognitive demands, and heavy resource requirements created barriers, particularly in rural and under-resourced settings. This aligns with wider implementation literature showing that intervention design and contextual fit are critical where workflow, staffing, and infrastructure constraints affect feasibility (Dev et al., 2020; Roldan et al., 2022; Tuyisenge et al., 2021). In ambulance care, these pres-

sures are intensified by mobile practice, time-critical decision-making, variable scope of practice, and uneven access to equipment and training.

Inner setting and process factors were also prominent. Leadership engagement, organizational readiness, supportive workplace culture, practical training, and ongoing feedback were associated with stronger uptake of CPGs. Services that involved clinicians in implementation and reinforced expectations through education, audit, and review appeared better positioned to embed guideline use into routine practice. Conversely, inconsistent leadership, limited organizational support, and resistance to change were linked with more variable adherence. This is consistent with broader healthcare evidence that leadership visibility, collaborative culture, and structured implementation processes support practice change and guideline compliance (Blok et al., 2021; Orangi, 2023; Stokes et al., 2016).

Determinants also appeared to differ between initial implementation and sustained practice. Initial uptake was most closely linked to protocol clarity, clinician awareness, early training, leadership communication, and resource availability. Sustained adherence relied more on refresher training, audit and feedback, access to outcome data, ongoing leadership support, protocol updates, and integration into routine organizational systems. This suggests that strategies used to introduce CPGs may not be sufficient to maintain their use over time.

Individual-level influences included knowledge gaps, lack of confidence with complex protocols, cognitive overload, and reliance on established routines. Practical and repeated training, particularly when linked to real-world application, helped clinicians build confidence, rehearse application, and receive reinforcement over time. This supports broader healthcare literature suggesting that education is more effective when active, iterative, and integrated into practice rather than delivered as one-off information transfer (Flynn et al., 2016; Stokes et al., 2016).

Outer setting factors, particularly regulation, inter-organizational collaboration, and resource disparity, further shaped implementation. Stronger regulatory or collaborative frameworks appeared to support guideline uptake, while rural and low-resource settings faced additional barriers related to equipment, training access, and specialist support. This reinforces that implementation is not solely a clinician-level issue; it is also shaped by service capability, geography, receiving hospital relationships, and broader system conditions. Broader health systems literature similarly shows that external partnerships, organizational linkages, and equitable access to resources influence whether evidence-based practices can be implemented consistently across settings (Luo et al., 2021; Perry et al., 2017; Valaitis et al., 2018).

Implications for Practice and Policy

Improving CPG implementation in ambulance services requires more than guideline publication alone. Services should assess local readiness and barriers before implementation, adapt guidelines to local workflows, identify local champions, and support uptake through practical education, simulation, audit, and feedback. These strategies align with the Expert Recommendations for Implementing Change (ERIC) taxonomy, which provides a structured set of approaches for supporting evidence uptake in healthcare (Powell et al., 2015; Waltz et al., 2015).

For guideline developers and educators, the findings highlight the importance of usability, clarity, and operational fit. Guidelines should be designed for mobile, time-critical, and resource-variable care environments, with education that helps clinicians apply recommendations in realistic practice conditions. For implementation leads, ongoing reinforcement, feedback systems, and decision-support tools may help move guideline use from initial adoption to sustained practice.

At a policy and service-planning level, the level at which CPGs are developed and implemented requires careful consideration. National CPGs can support consistency, reduce duplication, and provide a common minimum standard across services, but may be too broad to account for local workforce, geography, equipment, digital systems, or referral pathways. State or regional CPGs may better reflect jurisdictional legislation, scope of practice, governance, and service configuration, although this can create variation between jurisdictions. Local implementation allows services to tailor training, decision-support, equipment use, and referral processes to their own context, but may also increase inconsistency, duplication, and reliance on local implementation capacity.

Greater attention is also needed to rural and resource-related inequities. Implementation planning should include investment in training, digital infrastructure, essential equipment, feedback systems, and access to clinical support where appropriate. Overall, implementation is likely to be strongest when core standards are supported at national or jurisdictional levels, while allowing local adaptation of implementation processes to fit operational conditions.

LIMITATIONS

This review has several limitations. The included studies were heterogeneous in design, context, and outcome measures, which precluded meta-analysis and required narrative synthesis. Some studies relied on self-reported data, introducing the possibility of reporting bias. In addition, only English-language studies were included, which may limit the transferability of findings to non-English-speaking settings.

CONCLUSION

This systematic review synthesized barriers and facilitators influencing CPG implementation in ambulance services, using CFIR as the organizing framework. Findings indicate that effective implementation depends on more than guideline publication. Mapping these determinants to CFIR domains provides a structured basis for planning implementation strategies that are responsive to local ambulance service conditions.

Future research should evaluate implementation strategies in specific ambulance service contexts, including rural and under-resourced settings, and examine how sustained CPG adherence influences patient care and service outcomes.

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APPENDIX 1: CHARACTERISTICS TABLE

Study ID (author, year and country)	Study Design	Population and Setting	Intervention	Barriers to Implementation	Enablers of Implementation	Implementation Strategies	Outcomes	Key Findings
Adelgais et al., 2019, USA	Mixed-methods observational study	EMS agencies across five U.S. states	Implementation of statewide EBG for traumatic pain management	Lack of mandatory state protocols, delay in guideline publication, technical challenges with LMS	Local EBG champions, availability of toolkits, state-level champions for dissemination	State-specific implementation plans, dissemination toolkits, training modules	Increased pain score documentation, no significant increase in opioid use	EBG implementation requires local champions, robust training systems, and tailored state-level strategies
Ångerman et al., 2023, Finland	Retrospective observational study	2115 adult patients from helicopter emergency medical services (HEMS) in Finland	Implementation of a new prehospital anesthesia (PHEA) protocol that standardizes the process, including the use of mechanical ventilation, esketamine, and rocuronium	Challenges in sustaining protocol adherence over time and ensuring continuous team training across multiple EMS systems	Use of workshops, skill stations, lectures and simulations, and ongoing simulation training to support long-term sustainability of the protocol	A multifaceted approach with tailored training methods, team involvement, use of cognitive aids, and regular feedback loops	Significant improvements in on-scene time (OST), first-pass intubation success rate, and compliance with key indicators (use of mechanical ventilation and medications)	The systematic approach to implementing the PHEA protocol resulted in sustained improvements in clinical performance over a five-year period
Bigham et al., 2010, (a) USA and Canada	Survey of 176 EMS agencies	EMS agencies in the USA and Canada participating in the Resuscitation Outcomes Consortium (ROC)	Implementation of the 2005 American Heart Association (AHA) guidelines for CPR and ECC	Smaller agencies, non-transport agencies, and BLS-only agencies took longer to implement guidelines	Larger agencies with more vehicles and ALS services implemented guidelines more quickly	Survey conducted to determine implementation delays and investigate EMS system factors affecting speed	Mean implementation time was 416 days; large variability across agencies	Smaller agencies, BLS-only services, and non-transport agencies faced longer delays; larger, ALS agencies implemented more quickly
Bigham et al., 2010, (b) USA and Canada	Qualitative survey using semi-structured interviews and a grounded theory approach	EMS agencies in the USA and Canada participating in the Resuscitation Outcomes Consortium (ROC)	Implementation of the 2005 American Heart Association (AHA) guidelines for CPR and ECC	Delays in scheduling/accessing instructors, training materials, defibrillator upgrades, coordination with regulatory bodies and medical directors	Overcoming administrative and coordination barriers	Better coordination, timely development of training materials, collaboration with device manufacturers, engaging local champions	Variability in implementation timing, with agencies identifying multiple factors contributing to delays	Ten barriers identified across training, defibrillator reprogramming, and decision-making delays; proactive measures needed for timely future guideline implementation
Bloomer et al., 2024, Northern Ireland	Qualitative study using semi-structured interviews and thematic analysis	11 operational paramedics from the Northern Ireland Ambulance Service (NIAS); single-service study exploring clinician perspectives on referral pathway use	Use of patient care pathways (PCPs) that allow paramedics to refer patients to alternative services such as general practitioners, minor injury units, or community care rather than transporting all patients to emergency departments	Perceived clinical risk and fear of patient deterioration; concern about complaints or professional accountability; organizational culture historically focused on transport to hospital; variability in referral pathway availability across regions; communication challenges with receiving healthcare providers	Clear referral criteria within pathways; improved inter-professional communication; education and training on pathway use; cultural shift recognizing paramedics as autonomous clinical decision-makers; motivation to achieve better patient outcomes	Development and use of structured referral pathways; embedding referral decision-making and pathway education within paramedic training and professional development	Identification of key organizational and cultural factors influencing referral pathway utilization	Five themes were identified influencing pathway use: perceived risk, organizational culture, person-centered care, inter-professional communication, and operational infrastructure. Paramedics supported the use of referral pathways but described barriers including risk aversion, communication challenges, and inconsistent pathway availability across regions

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Bosse et al., 2011, Germany	Prospective cohort study	1000 EMS patient care reports in Germany (pre/post SOP introduction for aeCOPD)	SOP for pre-hospital treatment of COPD based on national guidelines	Insufficient knowledge among emergency physicians, resistance to changing routine practices	Availability of SOP in printed and electronic formats	Introduction of SOP through staff meetings, access to printed/electronic versions	Adherence to guidelines increased from 34.6% to 53.8%, but not statistically significant	SOP improved specific therapies but full guideline adherence remained suboptimal without further training
Brown et al., 2014, USA	Quasi-experimental, pre-post design	EMS agencies in Maryland, USA; focus on trauma and burn patients	Implementation of an evidence-based prehospital pain management protocol including weight-based morphine dosing and repeat dosing. And naloxone as rescue medication post opiate.	Challenges in pain score documentation, baseline high rate of morphine use, transition to new electronic medical record system during study	Statewide adoption, online training programs, use of the National Prehospital EBG Model Process, collaboration with Maryland EMS systems	Weight-based dosing protocols, online learning management systems for EMS provider training, inclusion in annual protocol updates	Increase in total morphine dosage (18.1% higher total dose, 14.9% greater mg/kg dose), no change in percentage of patients receiving morphine or pain score documentation	Evidence-based protocol adoption led to increased morphine dosing but no change in narcotic administration rate or pain score documentation. Evidence-based guidelines improve patient care for regional EMS
Browne et al., 2016, USA	Retrospective observational study using patient records	Children under 18 years from three EMS agencies: Charlotte (NC), Houston (TX), Milwaukee (WI)	Changes to pain management protocols: age-appropriate pain scales, decreased minimum age for opioids, fentanyl dosage updates. Frequency of pain severity assessments.	Inconsistent pain severity documentation, training gaps, provider reluctance, operational barriers, no quality improvement process	Mandatory in-person and online training on protocol changes. Access to continuing education through video sessions and resources.	Protocol development by local medical experts. Use of different training approaches across the three EMS agencies (e.g., in-service sessions, video education).	Minimal increase in opioid administration, no significant change in pain severity documentation. Intranasal fentanyl administration decreased from 27% to 17%.	Opioid administration remained low despite protocol updates, indicating further barriers to effective prehospital pain management in children
Carey et al., 2019, USA	Multicenter, qualitative study	Paramedics from Charlotte, Houston, and Milwaukee EMS systems caring for pediatric patients	Implementation of pediatric seizure protocols based on EBG	Equipment availability issues, respiratory depression concerns, infrequent pediatric training, protocol ambiguity	Point-of-care decision support tools, availability of multiple midazolam administration routes, online medical control for guidance	Semi-structured interviews, use of decision support tools	Identified multiple barriers and enablers to pediatric seizure protocol adherence	System improvements suggested, including dose standardization and more frequent pediatric-specific training
Ciarletta et al., 2024, USA	Qualitative study (focus groups and interviews)	EMS clinicians and leadership from Level I pediatric trauma center in Buffalo, NY	Evaluation of adherence to NHTSA guidelines for pediatric ground transport	Low knowledge of guidelines, equipment unavailability and incompatibility, lack of hands-on training	Organizational support for training, leadership engagement	Focus groups, interviews, pediatric restraint training	Low familiarity with pediatric transport guidelines, organizational and external barriers to safety standards	EMS clinicians require more hands-on training and knowledge reinforcement to improve adherence
Ebben et al., 2014, Netherlands	Qualitative (Semi-structured interviews)	Ambulance and emergency nurses, and EMS and emergency physicians in the Netherlands	Interviews exploring factors influencing protocol adherence	Lack of awareness of national protocols, preference for local protocols, limited involvement in development	Integration of ATLS, embedding protocols in training, and physician support	Tailoring strategies to individual, organizational, and protocol-related factors	Adherence is influenced by clinical experience, organizational support, and external factors, acting as barriers or facilitators	Multifaceted strategies and user involvement in development are essential to improve adherence
Ebben et al., 2015, Netherlands	Cross-sectional survey	248 ambulance nurses from four EMS services in the Netherlands	Adherence to National Protocol Ambulance Care (NPAC)	Complexity of protocol, frequent updates, professional autonomy	Colleague expectations, perception of improved patient outcomes, trust in protocol	NPAC distribution, questionnaire for measuring adherence	Self-reported adherence high (83.4%), but professional autonomy and protocol complexity limited full adherence	Adherence influenced by protocol complexity/support for diagnosis and treatment, and social factors

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Ezem et al., 2024, USA	Semi-structured qualitative interviews	Emergency response agencies in North Carolina, USA; 7 counties (high- and low-performing)	Implementation of community-based OHCA interventions (RACE-CARS trial)	Resistance from teams, difficulties building foundational relationships, financial challenges, approval requirements in hospital systems	Engaging content experts, relevant data, relationship building, regular feedback mechanisms	Focus on relationship building, clear communication, engaging local experts, providing updates and feedback	Differences in readiness between high- and low-performing counties	Engaging local experts, focusing on relationships, and providing feedback are effective for gaining support for interventions
Feder et al., 2006, USA	Observational study for one year	16 of 35 local EMS agencies in King County participated in the study, Washington, USA, involving 2770 patients with EMS-attended cardiac arrest	New guidelines allowing EMS personnel to withhold resuscitation in terminally ill patients based on verbal or written requests from patients or caregivers. Implemented by two of the authors.	Legal and risk management concerns from non-participating agencies, inconsistency in honoring verbal requests, and difficulty implementing guidelines across all agencies	Support from local physicians, EMS administrators, and legal consultants; involvement of multiple EMS personnel in developing and training for the new guidelines	A voluntary program with written manuals, 2-hour lectures, competency quizzes, and support from legal and medical professionals	Resuscitation was withheld in 11.8% of cases for participating agencies, compared to 5.3% in non-participating agencies; verbal requests accounted for the majority of withheld resuscitations in the intervention group	The guidelines led to more frequent honoring of verbal requests to withhold resuscitation, suggesting the potential for expanding EMS discretion in end-of-life decisions
Fishe et al., 2024, USA	Cross-sectional survey using Discrete Choice Experiments (DCEs)	183 paramedics registered with the National Registry of Emergency Medical Technicians (NREMT) in the USA	Preferences for implementation of Evidence-Based Guidelines (EBGs) in EMS (sepsis alerts, bag-valve mask devices, pain medication protocols)	Lack of hospital and agency feedback, reliance on email/online education, mismatch between preferences and current practices	In-person simulation/ classroom-based education, individualized feedback, hospital feedback on outcomes	Focus on individualized feedback, incorporating hospital and agency feedback, providing in-person training over online options	EMS clinicians preferred in-person education and feedback on performance, but agency practices did not match these preferences	Agencies should adjust implementation practices to align with EMS clinicians' preferences for hands-on training and feedback
Gaither et al., 2021, USA	Multisystem, before/after controlled study (secondary analysis of EPIC Study)	2,801 children with major TBI transported by EMS in Arizona (2007-2015)	Implementation of Prehospital Pediatric TBI Guidelines, focused on preventing hypoxia, hypotension, and hyperventilation	Variation in EMS agency participation and training schedules, limited sample size	Participation by over 130 EMS agencies, broad guideline implementation	Train-the-trainer model, focused on guideline-based care for TBI	Improvement in survival to hospital admission for severe TBI, but not moderate or critical cases	Guidelines improved care and survival in severe pediatric TBI cases, no significant change in moderate or critical TBI cases
Gaither et al., 2024, USA	Multisystem, intention-to-treat before/after controlled design	EMS patients with severe TBI in Arizona, USA	Prehospital TBI guidelines focused on preventing hypoxia, hyperventilation, and hypotension	Resistance to guideline adherence, variability in EMS agency training	Comprehensive guideline training, use of various airway interventions	Intensive training on preventing hypoxia, hyperventilation, and hypercapnia	Improved survival to hospital admission in severe TBI cases, no significant improvement in overall survival to discharge	Guidelines improved survival in severe TBI with PPV, highlighting the importance of early intervention in prehospital care
Guerrier et al., 2023, USA	Qualitative study using focus groups with EMS leaders, EBG authors, EMS medical directors	EMS leadership in the USA, including EMS EBG authors, medical directors, and professional organization leaders	Implementation of prehospital evidence-based guidelines (EBGs)	Data access issues, resource constraints, variations in EMS systems, lack of training in data analytics, mixed opinions on CFIR	Strong leadership engagement, consistent messaging, in-person and frequent training, trust between EMS clinicians and leadership	Frequent hands-on training, CFIR to guide implementation, standardized protocol design, fostering culture of change and trust	Varied success in EBG implementation, challenges in data analytics and outcomes evaluation	Leadership engagement and communication are key, but systematic barriers like cost and resource constraints persist

Study ID (author, year and country)	Study Design	Population and Setting	Intervention	Barriers to Implementation	Enablers of Implementation	Implementation Strategies	Outcomes	Key Findings
Hagiwara et al., 2013, Sweden	Single-case study using realistic evaluation methodology. Four phases	Ambulance organization in Sweden (urban and rural stations)	Use of prehospital guidelines and protocols for various emergency conditions	Physical format of guidelines, lack of context knowledge during development, need to memorize guidelines, implicit use in patient care	Positive view of guidelines by ambulance personnel, local implementation strategies including lectures and simulation	Development of guidelines based on informal consensus, use of simulations and manikin training for local adaptation	Implicit use of large guidelines (physically too large to carry on person), request for better formats and context-sensitive guidelines	Guidelines were indispensable, but the format needed improvement; personnel often developed their own homemade guidelines
Haley et al., 2016, USA	Retrospective before-and-after study	Adult patients transported by EMS with trauma or burn injuries in Milwaukee County, USA	System-wide interventions: pediatric-specific pain management education and protocol implementation	Poor pain score documentation over time, limited focus on feedback and quality improvement	Systematic pain management protocols, education improved opioid administration	Multi-day educational interventions, case-based scenarios, protocol adoption	Increased opioid administration but inconsistent pain score documentation	Education and protocol improved opioid administration; efforts needed to sustain pain score documentation
Jones Rhodes et al., 2016, USA	Qualitative study (semi-structured interviews)	EMS providers, educators, and hospital decision-makers in two counties in Colorado, USA	Implementation of spinal immobilization guideline with selective immobilization and vacuum splints	Resistance to change, challenges maintaining shared equipment (vacuum splints)	Strong leadership, community collaboration, EMS providers seeing themselves as 'on the cutting edge'	Intensive face-to-face education, collaborative workshops	Successful community-wide guideline adoption with strong provider buy-in	Education and leadership were crucial for overcoming challenges and implementing collaborative EMS initiatives
Kelleher et al., 2014, USA	Quantitative (Process Mining)	Pediatric trauma resuscitations at a Level I trauma center (Children's National Medical Center, Washington, DC)	Implementation of a pediatric trauma resuscitation checklist to improve adherence to ATLS protocol	Lack of pre-arrival notification, smaller initial teams, increased workload for providers	Checklist improved task completion and reduced variability in care	Use of a standardized checklist for trauma resuscitation tasks	Improved ATLS protocol adherence and reduced variability in task performance	Checklist standardized care and reduced impact of lack of pre-arrival notification
Kerner et al., 2017, Germany	Prospective, controlled, monocentric study	740 emergency missions by a mobile emergency response unit in Berlin, Germany	Introduction of checklists (general prehospital care, acute coronary syndrome, asthma/COPD)	Slight increase in time (approx. 1 minute), but generally well accepted	Checklists improved documentation, diagnostics, and treatment adherence with high staff acceptance	Training seminars to introduce checklists, monitored compliance	Significant improvement in guideline adherence, particularly in patient history documentation, diagnostics, and emergency treatment	Checklists significantly improved guideline adherence and documentation quality in prehospital emergency care
Kothari et al., 2021, USA	Longitudinal, prospective study with simulation-based training	EMS professionals in a single urban fire-based EMS system in the USA	Repetitive pediatric emergency simulation training over 6 months	Difficulty maintaining competency between training sessions, limited exposure to pediatric emergencies	High fidelity simulations, structured debriefing with video playback, practice of key interventions	Serial high-fidelity simulations, structured debriefing focusing on airway management, shock treatment, team skills	Improved team performance in managing pediatric emergencies, timely interventions, increased competence	Repetitive simulation improved team-based pediatric emergency care and cognitive/psychomotor skills in EMS professionals
Krawczyk et al., 2016, Europe	Cross-sectional survey	Healthcare providers from 27 European countries	Evaluation of defibrillation techniques and barriers to ERC guideline implementation	Economic constraints on adhesive pad availability, resistance to change and manual paddles use	Growing awareness and use of adhesive pads in prehospital settings	National surveys on defibrillation techniques, discussions with ERC representatives	Mixed adherence to guidelines, with economic and traditional factors influencing technique	Economic and cultural resistance hinder adhesive pad adoption despite guideline recommendations

Study ID (author, year and country)	Study Design	Population and Setting	Intervention	Barriers to Implementation	Enablers of Implementation	Implementation Strategies	Outcomes	Key Findings
Lang et al., 2012, USA	National model development and evaluation with a qualitative and consensus-based approach	EMS systems across the USA, involving various EMS stakeholders, including federal agencies and EMS professionals	Development and implementation of a national evidence-based guideline (EBG) model for prehospital care	Resource limitations, lack of common governance, challenges in standardizing care, and difficulties integrating EBGs into varied systems	Support from federal organizations, multidisciplinary expert involvement, structured consensus-building efforts	Eight-step model: evidence review, GRADE methodology, EMS protocol contextualization, multimedia dissemination, certification/recertification linkage	Development of a comprehensive national EBG model, improving patient outcomes and EMS care consistency and efficiency	National EBG model has potential to improve EMS care but needs to address resource constraints and challenges in local adaptation
Lynch et al., 2020, South Africa	Qualitative single-case study design using semi-structured interviews	Emergency Medical Services (EMS) in South Africa, focusing on a private EMS provider	Implementation of prehospital thrombolysis (PHT) for ST-segment elevation myocardial infarction (STEMI)	Cost of equipment, lack of medical coding for reimbursement, logistical issues, inadequate inter-professional collaboration, lack of cardiologists, organizational resistance to change, and leadership disengagement	Leadership engagement, inter-professional collaboration	Stage implementation scale-up, leadership commitment, network collaboration, dynamic training partnerships	PHT is underutilized in South Africa despite evidence of safety and effectiveness. A lack of strategic implementation has resulted in a poor introduction of EBP for cardiac care	Key barriers include high costs, logistical complexities, lack of coding, inadequate leadership, and skepticism about PHT in urban areas with PCI access
Mai et al., 2023, Asia, Latin America, Europe	Multicenter site survey study	24 emergency departments across 14 countries in Asia, Latin America, and Europe	Evaluation of pediatric TBI management practices in DTCs and NTCs	Lack of centralized prehospital services in low- and middle-income countries, variation in guideline implementation	Presence of formal TBI protocols, availability of neuroimaging and pediatric ICU services	Site-specific surveys on prehospital and ED TBI management practices	Limited differences between DTCs and NTCs in TBI management, variations in guideline adherence	Need for improved guideline adoption and prehospital trauma care in low-resource settings
Manson et al., 2018, USA	Mixed methods (surveys of paramedics and surgeons)	Paramedics and general surgeons in urban and rural Kentucky	Surveys assessing perceptions of trauma readiness and guideline implementation	Lack of trauma centers, discrepancy between paramedic perception of surgical readiness and surgeon willingness to operate	Trauma center proximity increased medic confidence in surgeons' willingness to operate	Enhancing communication and collaboration, developing destination determination protocols	Medics farther from trauma centers were less confident in surgical readiness and more likely to transport to nearest hospital regardless of surgical capabilities	Discordance between paramedic perception and surgeon willingness affects guideline implementation, especially in rural areas
Maria et al., 2024, Australia and New Zealand	Qualitative descriptive analysis using thematic analysis of interviews	Jurisdictional ambulance services in Australia and New Zealand	Development of paramedic clinical practice guidelines (CPGs) in jurisdictional ambulance services	Lack of formal training, over-reliance on existing guidance, consultation challenges, limited research capacity, resource constraints, lack of formal project management approaches	Collaboration between services, interest in inter-service cooperation, evidence evaluation tools, gradual expertise development	Adoption of project management frameworks, multidisciplinary teams, GRADE framework for evidence synthesis, targeted training programs, improved resource allocation	Significant variation in CPG development across services due to resource and expertise limitations	Need for formalized training, project management, national collaboration, and enhanced funding to improve CPG consistency and effectiveness
Martin-Gill et al., 2016, USA	Summary report on national strategy for EMS stakeholders	EMS organizations and stakeholders in the United States	Development of a National Prehospital Evidence-Based Guidelines (EBG) Strategy	Limited collaboration between national projects, implementation challenges	Collaborative efforts of 57 organizations, financial support from NHTSA and EMS for Children program	Creation of Prehospital Guidelines Consortium (PGC), promotion of research and collaboration, improved education	Facilitated EBG implementation by improving guideline dissemination and incorporation into protocols	Strategy supports sustainable relationships among stakeholders to facilitate EBG development and implementation

Study ID (author, year and country)	Study Design	Population and Setting	Intervention	Barriers to Implementation	Enablers of Implementation	Implementation Strategies	Outcomes	Key Findings
McCaul et al., 2019, South Africa	Descriptive qualitative research using nine focus groups with thematic analysis	56 operational emergency care providers from public and private sectors in South Africa	Implementation and dissemination of the first evidence-based emergency care clinical practice guidelines (CPGs) in South Africa's prehospital sector	Poor communication, challenges with training, limited capacity to upskill providers, changes in scope of practice, resource constraints	Use of technology, involvement of local champions, modular training, consistent communication	Creation of end-user documents, online modular training, local champions to promote adoption, better communication	Mixed reactions; excitement about scope increases but apprehension about loss of advanced skills like intubation	Importance of communication, accessible training, and structured career pathways for successful implementation; stakeholder involvement critical
McCaul et al., 2020, South Africa	Qualitative case study, one focus group and six interviews.	Key stakeholders involved in a prehospital CPG project in South Africa	Development and implementation of prehospital CPGs using alternative guideline development methods (CPG adaptation)	Limited local evidence, challenges aligning recommendations with local practice, communication gaps, lack of implementation support, conflicting interests	Stakeholder engagement, context-sensitive recommendations, transparency in decision-making, use of international evidence adapted for local contexts	Advisory boards, transparent decision-making processes, context-specific adaptations, clear communication of implementation strategies	Successful guideline development but challenges in consistent national implementation	Implementation hampered by communication gaps and local challenges; stakeholder engagement and adapting international evidence can improve the process
McManus et al., 2023, USA	Qualitative study using semi-structured interviews and five focus groups	EMS clinicians from four EMS systems in the USA (urban, suburban, and rural)	Implementation of oral systemic corticosteroids (OCS) for pediatric asthma in prehospital settings	Lack of pediatric experience, unfamiliarity with dosing, resistance to change, inadequate pediatric equipment, reliance on email-based training	Pediatric medical directors, laminated dosing cards, involvement of parents, feedback from receiving hospitals	Use of pediatric dosing tools (PRAM cards), tailored training, feedback mechanisms from hospitals	Positive feedback on the use of OCS but continued challenges with pediatric dosing and EMS resistance to change	OCS implementation was facilitated by strong leadership and feedback loops, but barriers related to pediatric knowledge and EMS culture need to be addressed
Mould-Millman et al., 2023, South Africa	Pragmatic, quasi-experimental, two-arm, mixed-methods study	EMS providers and trauma patients in Western Cape Government EMS, South Africa	Implementation of EMS-TrauSh-oC bundled trauma care using HEET (High-Efficiency EMS Training)	Limited access to tourniquets, pushback on transporting patients who appeared well but met shock criteria	HEET's operational fit and provider acceptance, support from station managers and dispatch centers	Peer-to-peer rapid training with high-frequency, short sessions using clinical case scenarios	Excellent implementation effectiveness (80.6%) but no significant clinical improvement in patient shock index	High implementation success through rapid training, but no significant clinical outcome improvements
Sarmiento et al., 2012, USA	Mixed-methods (survey and focus groups)	EMS professionals across the USA (536 survey participants, 54 focus group participants)	CDC-developed educational resources for the updated Field Triage Decision Scheme	Lack of awareness of materials, regional differences in EMS systems, lack of support and resources, and difficulties in implementing a universal protocol	Support from EMS leaders, use of various educational formats (posters, pocket cards, PowerPoint), and the perceived value of the materials	Engagement with EMS leaders as early adopters, multiple formats for educational materials (pocket cards, posters, training guides), and leveraging professional organizations for dissemination	Positive reception of materials by those who used them; increased knowledge and implementation of triage procedures among users	Significant proportion of EMS professionals had not seen or used the materials, suggesting a need for increased dissemination and support for implementation
Sasson et al., 2009, USA	Qualitative (Focus groups)	EMS physicians, paramedics, and EMS administrators in the United States	Focus groups discussing barriers to local implementation of national TOR guidelines	Financial incentives to transport, state mandates requiring transport, public and cultural expectations about survivability	National organizations (e.g., AHA) can advocate for reimbursement, legal changes, and public education	Engage payers, legislators, and communities to adopt national TOR guidelines	Identification of barriers and facilitators for adopting TOR guidelines, such as financial and legal hurdles, and misconceptions about survival	Payer incentives, legislative barriers, and cultural expectations hinder TOR adoption; national organizations can assist in overcoming challenges

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Siriwardena et al., 2014, England	Interrupted time series design within a national quality improvement collaborative (QIC)	12 English ambulance services, 22,117 clinicians providing care for AMI and stroke patients	National QIC to improve care bundles for AMI and stroke	Organizational barriers, lack of resources, competing pressures on QI teams	Engagement of frontline staff, leadership support, use of checklists, provider prompts, and individualized feedback	Local QI teams supported by workshops, teleconferences, and data feedback with control charts	Significant improvement in care bundles for AMI (43% to 79%) and stroke (83% to 96%)	QIC led to significant improvements through clinical engagement and QI methods
Spaite et al., 2019, USA	Statewide, multisystem cohort study with before/after controlled design	21,852 TBI patients across Arizona EMS agencies	Prehospital TBI treatment guidelines emphasizing prevention of hypoxia, hyperventilation, hypotension	Inconsistent EMS adherence, challenges in changing airway management practices	Statewide collaboration, guideline-based protocols on oxygenation, airway, and BP control	Statewide guideline implementation using train-the-trainer model	Significant improvement in survival to hospital admission for severe TBI patients, especially in intubated subgroups	Guidelines improved survival for severe TBI patients, particularly in intubated groups, supporting prehospital protocol adoption
Thorvaldsen et al., 2019, Norway	Nationwide survey	938 prehospital personnel across 18 EMS services in Norway	Implementation of Norwegian guideline for prehospital spinal injury management with e-learning	Lack of approval by some health trusts, limited training opportunities, confusion about the guideline's name	Open access to guidelines, developed based on perceived needs of care providers	Development of e-learning course, passive dissemination through conferences and repositories	56% of respondents with knowledge reported its implementation, e-learning did not significantly affect implementation	Guideline implemented despite not being mandatory; passive dissemination was somewhat effective
Tomasone et al., 2014, Canada	Pre–post intervention pilot study	34 paramedic and nurse trainees in British Columbia and Ontario, Canada	Online educational module 'ABCs of AD' to improve knowledge and use of AD-CPGs	Decline in participant engagement over module sections, no social cognitive improvements for AD-CPG use	Positive feedback on educational content quality	Online educational outreach using video modules and case studies	Significant improvement in knowledge of AD-CPGs, no change in social cognitions (attitudes, control, norms) for using the CPGs	Knowledge alone is insufficient for practice change; module should target social cognitive determinants for AD-CPG use
Watts et al., 2004, Australia	Qualitative evaluation	Australian paramedics using CPGs in prehospital care	Evaluation of clinical practice guidelines (CPGs) and their use	Lack of awareness or understanding of CPGs, inconsistent application across services	In-service training to improve guideline familiarity, organizational support	In-service training and educational initiatives to enhance guideline adherence	Improved guideline familiarity but variability in application among paramedics	Training improved understanding, but challenges in consistent application across services

APPENDIX 2: QUALITY APPRAISAL OF INCLUDED STUDIES

Study	Quality Rating	Key Notes
Adelgais et al., 2019, USA	High	Clear research objectives, justified mixed-methods design, reliable quantitative measurements, comprehensive thematic analysis for qualitative data, integration of quantitative and qualitative data adds value, though integration could be enhanced.
Ångerman et al., 2023, Finland	High	Appropriate sample frame, detailed setting descriptions, valid exposure measurement, adequate follow-up, confounders identified, appropriate statistical analysis.
Bigham et al., 2010a, USA	Moderate	Clear inclusion criteria, valid and reliable survey measures, identified confounding factors, appropriate statistical analysis.
Bigham et al., 2010b, USA	High	Congruent methodology with research objectives, detailed thematic analysis, participant voices well-represented, rigorous ethical practices.
Bloomer et al., 2024 Northen Ireland	High	Clear qualitative design with semi-structured interviews and thematic analysis; appropriate recruitment, data saturation and ethical governance reported. Participant perspectives well represented, though limited to a single service and volunteer sample.
Bosse et al., 2011, Germany	High	Well-defined comparison groups, valid SOP implementation, identified confounders, robust statistical analysis for pre-post intervention outcomes.
Brown et al., 2014, USA	High	Clear cause-effect relationship, valid pre-post intervention comparison, reliable outcome measures, adequate statistical analysis.
Browne et al., 2016, USA	High	Valid retrospective design, consistent exposure measurement, identified confounders, robust statistical analysis.
Carey et al., 2019, USA	Moderate	Congruent methodology with research objectives, participant voices adequately represented, rigorous analysis using NVivo software, minor gaps in researcher positioning.
Ciarletta et al., 2024, USA	High	Qualitative design aligns with objectives, rigorous use of CFIR framework, participant voices well-represented, valid ethical approval.
Ebben et al., 2014, Netherlands	High	Qualitative design with in-depth thematic analysis, detailed participant representation, ethical considerations addressed.
Ebben et al., 2015, Netherlands	Moderate	Valid and reliable survey-based measures, appropriate statistical methods, limited confounder control.
Ezem et al., 2024, USA	High	Qualitative design with structured analysis, CFIR-guided approach, participant voices well-represented, rigorous ethical review.
Feder et al., 2006, USA	Moderate	Observational study with valid exposure measurement, identified confounders, limitations in addressing bias, appropriate statistical analysis.
Fishe et al., 2024, USA	High	Structured discrete choice experiments, robust statistical methods, identified limitations (e.g., selection bias), valid and reliable outcome measures.
Gaither et al., 2021, USA	High	Before-and-after controlled design, valid survival outcome measures, consistent exposure application, robust statistical analysis.
Gaither et al., 2024, USA	High	Intention-to-treat design, valid and reliable survival outcomes, consistent measurement across phases, comprehensive statistical analysis.
Guerrier et al., 2023, USA	High	Focus group-based qualitative study, CFIR-guided thematic analysis, participant voices well-represented, ethical approval received.
Hagiwara et al., 2013, Sweden	High	Realistic evaluation methodology, in-depth data collection through various methods, robust thematic analysis, ethical approval obtained.
Haley et al., 2016, USA	High	Valid pre-post design, reliable outcome measures, appropriate statistical analysis, minor gaps in confounder control.
Jones Rhodes et al., 2016, USA	Moderate	Congruent qualitative methodology, thorough participant representation, valid ethical approval, minor gaps in researcher positioning.
Kelleher et al., 2014, USA	High	Clearly defined sample criteria, valid adherence measurement, multivariable control for confounders, appropriate statistical analysis (regression).
Kerner et al., 2017, Germany	High	Cause-effect clarity, control group present, consistent outcome measurement, reliable adherence recording, appropriate chi-square analysis.
Kothari et al., 2021, USA	Moderate	Clear cause-effect, no separate control group, consistent measurements with high inter-rater reliability, appropriate use of chi-square and Kruskal-Wallis tests.
Krawczyk et al., 2016, Europe	Moderate	Clear sample and setting details, reliable measurement via structured survey, partial confounding factors identified but not fully controlled, basic descriptive statistics used.
Lang et al., 2012, USA	Moderate	Well-defined sample and setting, reliable exposure measurement through expert review, partial confounder acknowledgment, no statistical methods as study is descriptive.
Lynch et al., 2020, South Africa	Moderate	The study effectively identifies barriers to PHT implementation using thematic analysis and the CFIR framework. However, it lacks explicit philosophical alignment, researcher reflexivity, and detailed theme validation, which limits rigor.
Mai et al., 2023, Asia, Latin America, Europe	Moderate	Clear sample and setting details, structured survey for data collection, partial identification of resource-related confounders, appropriate chi-square and t-tests.
Manson et al., 2018, USA	Moderate	Defined sample criteria, reliable measurement via surveys, partial confounding control, chi-square and ANOVA tests applied.
Maria et al., 2024, Australia and New Zealand	High	Well-defined sample, reliable thematic analysis, partially addressed confounding factors, no statistical analysis as it was qualitative.
Martin-Gill et al., 2016, USA	Moderate	Clear sample and setting, reliable exposure measurement through stakeholder engagement, partial confounder control, qualitative approach without statistical analysis.
McCaul et al., 2019, South Africa	Moderate	Clear sample criteria, thematic analysis used for reliability, partial confounder identification, qualitative method without statistical testing.
McCaul et al., 2020, South Africa	Moderate	Clear sample and setting, semi-structured interviews and focus groups, partial confounding factors identified but not controlled, thematic analysis applied.
McManus et al., 2023, USA	Moderate	Clear inclusion criteria, structured interviews and focus groups, partial control of regional variability, reliable thematic analysis based on CFIR framework.

Study	Quality Rating	Key Notes
Mould-Millman et al., 2023, South Africa	High	Clear sample and structured intervention, consistent RE-AIM framework for measurement, partial confounder control, appropriate difference-in-differences analysis.
Sarmiento et al., 2012, USA	Moderate	Clear inclusion criteria, reliable thematic analysis with survey and focus group data, regional confounders acknowledged, descriptive and chi-square tests used.
Sasson et al., 2009, USA	Moderate	Clear sample criteria, reliable thematic analysis, regional confounders identified but not controlled, qualitative design with no statistical testing.
Siriwardena et al., 2014, England	High	Clear inclusion criteria, systematic QIC intervention, partial confounder control, appropriate interrupted time series and logistic regression analyses.
Spaite et al., 2019, USA	High	Well-defined sample criteria, valid guideline adherence measurement, multivariable regression for confounder control, consistent trauma registry data.
Thorvaldsen et al., 2019, Norway	Moderate	Clear sample criteria, reliable survey measurement, partial confounding factors identified, chi-square analysis applied.
Tomasone et al., 2014, Canada	Moderate	Defined sample criteria, reliable pre-post intervention measurement, partial confounding control, paired t-tests and effect size calculations used.
Watts et al., 2004, Australia	Moderate	Clear inclusion criteria, structured observations for measurement, partial confounding factors identified, descriptive statistics applied.

APPENDIX 3: INCLUDED STUDIES EXTRACTED TO CFIR DOMAINS

Study	Intervention Characteristics	Inner Setting	Outer Setting	Characteristics of Individuals	Process
Adelgais et al., 2019	The intervention was the statewide implementation of an evidence-based guideline (EBG) for traumatic pain management in EMS settings. The guideline provided detailed recommendations on opioid use, dosing, and pain reassessment intervals. Each state received an implementation toolkit and standardized training materials to support the rollout. However, the non-mandatory nature of the protocol limited uptake in some regions.	EMS agencies within the states demonstrated varying organizational readiness. Larger agencies with strong administrative support adopted the guidelines more easily, while smaller agencies faced resource and time limitations. Internal barriers included limited instructor availability and difficulty tracking training and adoption progress within individual agencies. A lack of communication between state and local leadership created additional challenges in aligning protocols across the regions.	The implementation faced regulatory challenges since the guidelines were voluntary and not enforced through state mandates. Differences in local EMS structures, such as varying levels of regional autonomy and leadership coordination, further hindered statewide adoption. Some states chose not to adopt the national guideline, citing concerns about prescriptive dosing and lack of alignment with local protocols. States also faced technical issues with learning management systems (LMS), which disrupted training efforts.	EMS providers exhibited mixed attitudes toward the guidelines, with some skeptical about the use of opioids due to safety concerns. Providers varied in their familiarity and comfort with the new recommendations, particularly those in smaller or volunteer-based agencies. Champions within the EMS systems emerged as key facilitators, using their influence to engage providers and promote guideline adoption, though not all agencies had strong leadership for the initiative.	The implementation followed a multi-year process involving the distribution of toolkits, training modules, and monthly state meetings to monitor progress. However, delays in publication and training rollout diminished enthusiasm among participating agencies. The project relied on self-assessments and regional champions to track adoption, but data collection across states was inconsistent. While three states implemented the guidelines, two did not, citing administrative shifts and lack of resources. Despite the available training, many EMS providers did not complete the modules, resulting in incomplete adoption.
Ångerman et al., 2023	The intervention involved the implementation of a prehospital anesthesia protocol (PHEA) within helicopter emergency medical services (HEMS) and collaborating EMS units. The protocol included structured airway management practices, including the use of specific medications (esketamine and rocuronium) and video laryngoscopes for intubation. The goal was to standardize practices, improve patient safety, and ensure effective airway management. The protocol also involved role allocation and pre-arrival communication among EMS teams to enhance coordination.	Variability in training resources and infrastructure affected implementation across EMS units. Regular on-duty training and simulation-based education were conducted, but uptake varied between providers. Some EMS personnel were reluctant to engage in new practices, especially given the complexity of managing intubations in high-pressure situations. Regular protocol development days were implemented to address ongoing challenges and sustain adherence to the protocol over time.	Collaboration between the HEMS and EMS units was essential but presented logistical challenges, particularly with coordinating efforts across multiple employers and regions. External regulatory pressures were minimal, limiting enforcement of the new protocol. However, strong collaboration between emergency dispatch services and rescue departments improved protocol execution by ensuring all roles were prepared and aligned before arrival at the scene.	Staff knowledge, attitudes, and comfort levels with the protocol varied. While physicians were experienced in anesthesia, paramedics and other EMS personnel required additional training to adapt to the new practices. Simulation-based training helped improve familiarity, but some personnel were hesitant about using new medications and equipment, such as the video laryngoscope. Active opinion leaders within the EMS community were identified to promote the protocol and address concerns among their peers.	The implementation process was multifaceted, including lectures, simulations, workshops, academic detailing, and e-learning. Implementation occurred in phases, beginning with preparation workshops, followed by intensive training and protocol dissemination over three months. Continuous support was provided through regular audits and feedback loops to maintain compliance. Key performance indicators, such as on-scene time (OST), first-pass success (FPS) rate, and use of rocuronium and esketamine, were monitored throughout the five-year follow-up. The results demonstrated significant improvements, including a reduction in OST and increased FPS rates, reflecting successful implementation and sustainability.
Bigham et al., 2010a	The 2005 AHA guidelines introduced new recommendations for prehospital management of cardiac arrest, emphasizing single-shock defibrillation and uninterrupted CPR. The changes required equipment updates and new training protocols for EMS providers.	EMS agencies faced internal barriers such as limited financial resources, challenges coordinating training, and inconsistent organizational readiness. Smaller and non-transport agencies reported significant difficulties in accessing instructors and aligning the changes with existing educational cycles.	The lack of external mandates and delayed regulatory approvals affected guideline adoption. Agencies were also dependent on external manufacturers for defibrillator reprogramming, creating further bottlenecks in implementation.	EMS providers experienced uncertainty about the new protocols and expressed concerns about adopting single-shock defibrillation. Some providers lacked confidence in deviating from established practices, which slowed adoption.	Implementation involved surveys to track adoption timelines, revealing a median delay of 415 days. The guidelines were disseminated through meetings and newsletters, but follow-up mechanisms were limited, resulting in slow and uneven adoption.

Study	Intervention Characteristics	Inner Setting	Outer Setting	Characteristics of Individuals	Process
Bigham et al., 2010b	The study focused on identifying barriers to the implementation of the 2005 AHA guidelines. Key challenges included instructional delays and the need for defibrillator updates to align with the new protocols.	Agencies reported difficulties accessing trained instructors, and smaller agencies struggled to align training schedules with operational needs. In some cases, management was unable to communicate the changes effectively to field providers.	External factors, such as slow regulatory processes and delays in securing equipment upgrades, posed significant challenges. Coordination between EMS agencies and external partners was inconsistent, contributing to implementation delays.	Some EMS providers resisted the changes, particularly those with more experience in previous CPR practices. Staff turnover also impacted the consistency of training and guideline uptake across different shifts.	The study used qualitative interviews to identify three main barriers: instructional delays, equipment challenges, and decision-making uncertainty. Member validation confirmed these themes, but no active follow-up strategies were implemented to address the identified barriers.
Bloomer et al., 2024	Use of ambulance service patient care referral pathways allowing paramedics to refer suitable patients to alternative care services rather than transporting all patients to emergency departments. Pathways included defined referral criteria and links with community and primary care services.	Organizational culture within the ambulance service influenced pathway use. A legacy perception of ambulance services as primarily transport-focused discouraged use of referral pathways. Cultural shifts recognizing paramedics as autonomous clinicians and supportive organizational leadership facilitated pathway adoption.	Availability of referral pathways depended on external healthcare system capacity, including access to community services, general practitioners, and alternative care destinations. Variability in service availability and communication with receiving services affected pathway utilization.	Paramedics' perceptions of clinical risk, professional accountability, and confidence in decision-making influenced pathway use. Some clinicians expressed concern about patient deterioration, complaints, or professional scrutiny when deviating from traditional transport practices.	Implementation involved introducing structured referral pathways and encouraging their use through operational guidance and organizational messaging. Adoption relied on paramedic judgement, communication with external services, and gradual cultural change within the ambulance service.
Bosse et al., 2011	The intervention involved the introduction of a standard operating procedure (SOP) for the treatment of acute exacerbated COPD (aeCOPD). The SOP was developed based on national guidelines and distributed in both printed and electronic formats. It consisted of three components: immediate measures, patient history, and extended measures.	The SOP was introduced within EMS systems in Berlin, Germany. Internal challenges included variability in staff familiarity with the national guidelines, limited structured training on the SOP, and difficulty coordinating adoption across EMS providers. Self-assessed knowledge was high (67%), but when tested, physicians' actual knowledge was only 33%. Physicians frequently relied on outdated practices instead of following new guidelines.	No national enforcement mechanisms were in place to mandate the adoption of the SOP. The lack of external coordination and incentives likely contributed to inconsistent guideline implementation across EMS agencies. Physicians perceived the SOP as helpful in 80% of cases but saw limitations in real-world applicability.	Emergency physicians expressed overconfidence in their knowledge of the SOP and national guidelines. Although they believed they adhered to evidence-based care, interviews revealed that reliance on routine practices often took precedence over adherence to guidelines. This discrepancy between perceived and actual knowledge emerged as a barrier to successful SOP adoption.	The SOP was introduced through a staff meeting and passive dissemination. Eight weeks post-implementation, 500 EMS reports were reviewed to assess adherence, but no follow-up strategies (e.g., refresher training, feedback loops) were included. SOP implementation led to some improvements, such as increased use of 2-mimetics, but it failed to significantly improve overall guideline adherence. The study highlighted that passive dissemination alone was insufficient for meaningful implementation, suggesting a need for continuous education and active engagement strategies.
Brown et al., 2014	The intervention involved the implementation of a prehospital pain management protocol for patients with injuries and burns. The protocol was developed using the National Prehospital Evidence-based Guideline (EBG) Model Process. It introduced weight-based and repeat dosing of morphine to improve pain management.	EMS services faced challenges related to staff knowledge and engagement with the new protocol. Adoption varied between basic life support (BLS) and advanced life support (ALS) providers, with ALS providers more actively involved. Some EMS providers expressed discomfort with adopting new dosing guidelines. Training was required across all levels, but participation in the learning modules varied, indicating uneven engagement across the system.	The Maryland EMS system served as the pilot site, with external support from national organizations like the National Highway Traffic Safety Administration (NHTSA). However, the lack of mandatory national adoption resulted in variable implementation across different EMS systems. Limited regulatory pressure affected the consistency of implementation.	EMS providers reported mixed confidence in administering weight-based morphine doses. Staff expressed concerns about dosing pediatric patients, leading to delays in adoption. There was also over-reliance on routine practices despite the new protocol, and some providers struggled to shift away from previously established dosing norms.	The protocol was introduced through a statewide education program using online learning management systems and DVD materials. The training included separate modules for BLS, ALS, and hospital personnel, but follow-up was limited. Protocol adherence was monitored via electronic patient care reports (ePCRs), and data analysis showed an 18% increase in the average total dose of morphine administered, although no change was observed in the frequency of morphine administration or pain score documentation.

Study	Intervention Characteristics	Inner Setting	Outer Setting	Characteristics of Individuals	Process
Browne et al., 2016	The study examined changes in prehospital pain management protocols, focusing on opioid administration in injured children. Protocol changes included adding age-appropriate pain scales, reducing the minimum age for opioid use, and adjusting fentanyl dosing. Complexity arose from training requirements and the need for providers to adapt to new practices.	External influences included national evidence-based guidelines (NHTSA/EMSC), funding from the HRSA, and pediatric emergency care networks. Additionally, societal concerns about opioid use and the socio-political environment surrounding opioid administration may have impacted adherence.	Each EMS agency independently developed and implemented protocols, reflecting local organizational structures. Challenges included limited documentation of pain assessments and varied training practices across agencies (e.g., in-person vs. video-conferenced training). organizational climate influenced the degree of adoption, with some providers more comfortable than others in administering opioids to pediatric patients.	Providers' skills and comfort with opioid administration varied. Barriers included concerns over side effects, lack of pediatric pain assessment training, and biases about the necessity of opioid use for short transport times. Provider experience and confidence in managing pediatric pain influenced adherence to the updated protocols.	Implementation strategies varied: some agencies provided mandatory in-service training or video recordings, while others included quarterly education. Protocol adherence was evaluated retrospectively through patient records. However, a lack of dedicated pain management quality improvement initiatives limited continuous monitoring and feedback. Despite training efforts, there was no significant change in opioid administration rates post-implementation, indicating the need for additional strategies to embed new practices.
Carey et al., 2019	The intervention focused on evidence-based seizure protocols for pediatric patients. The protocols emphasized non-IV routes (e.g., intramuscular (IM), intranasal (IN)) and medication like midazolam. Adaptations included protocol improvements suggested by paramedics, such as dose standardization and route preferences.	External factors included the National Highway Traffic Safety Administration (NHTSA) and EMS for Children (EMSC) initiatives. Funding and training resources were limited, impacting protocol adherence.	organizational support varied across sites, with protocols differing in their details (e.g., weight-based dosing). Resources, such as pediatric equipment and reference tools, were not consistently available. Training was infrequent, and access to online medical control was sometimes helpful for complex decisions.	Paramedics' comfort and confidence varied, influenced by individual experience, preferences for routes, and concerns about side effects like respiratory depression. Some used personal methods (e.g., asking parents about the child's weight) instead of recommended tools like length-based tapes.	Implementation strategies included in-service training, point-of-care reference tools, and online medical control. The process faced challenges like equipment barriers, dosing ambiguity, and variations in protocol clarity. Paramedics recommended improvements, such as better stocking of equipment and clearer guidelines.
Ciarletta et al., 2024	Focused on pediatric transport safety through use of best practice guidelines for ground ambulances. Adaptability depended on equipment and personnel training. Barriers included device incompatibility and time-sensitive emergency conditions.	Influenced by regulatory mandates, such as New York State EMS training requirements. Manufacturer designs often conflicted with practical needs, and pediatric patient volumes were low, limiting exposure to protocols.	organizational support varied with some agencies enforcing pediatric restraint policies, while others relied on informal guidelines. Lack of compatibility between equipment and stretchers was reported, impacting adherence to protocols.	EMS clinicians expressed anxiety when managing pediatric patients, with many lacking confidence in restraint device use. There was a reliance on personal preferences, with occasional resistance to change, particularly among experienced clinicians.	Implementation strategies included in-service and online training modules, though most participants preferred hands-on training. Documentation was used for compliance monitoring, and some agencies-imposed consequences for non-adherence. However, practical challenges often influenced compliance.
Ebben et al., 2014	Implementation of national ambulance (ANP) and emergency department protocols (EDNP) aimed to standardize clinical care. However, protocols were perceived as too general, limiting practical relevance. Integration with the Advanced Trauma Life Support (ATLS) approach was identified as a key feature supporting adherence.	External influences included patient needs, receiving hospital policies, on-scene circumstances like bystander expectations, and regulatory frameworks. Factors such as environmental safety and aggression at the scene also shaped adherence.	Limited involvement of nurses in protocol development led to perceptions of medical dominance. Some nurses felt disconnected from the protocols, with insufficient feedback mechanisms and inconsistent training integration. Monitoring of adherence through patient records was viewed as punitive.	Nurses valued clinical experience over protocols, with some seeing protocols as legal protection and others preferring local guidelines. Awareness of protocols was limited, especially among emergency department staff. Physician support for aligning medical and nursing protocols varied.	Training strategies included in-service education and online modules, though the lack of practical hands-on training limited impact. Protocol adherence was monitored, but feedback was inconsistent. Nurses recommended clearer integration between local practice and national guidelines to enhance adherence.
Ebben et al., 2015	The intervention involved the National Protocol Ambulance Care (NPAC), a standardized guideline for ambulance services. The protocol covered topics from hygiene to emergency treatment, including symptom-based flowcharts. Updates were provided every three years, requiring nurses to adapt to protocol changes. Nurses were allowed to deviate with proper justification.	External factors included societal expectations, policies at receiving hospitals, and the influence of EMS physicians. National regulations required protocol adherence, but differences in local policy sometimes conflicted with the NPAC.	EMS organizations provided varying levels of support, with inconsistencies in education and access to resources for implementing the NPAC. Some organizations lacked structured feedback mechanisms, and deviations from the NPAC were monitored through patient records, which was viewed as disciplinary by nurses.	Ambulance nurses valued autonomy and clinical experience, often preferring personal judgment over strict adherence. Professional autonomy was seen as both a motivator and a barrier, with nurses reporting that complex protocols constrained their ability to act independently. Nurses' agreement with the NPAC and integration of the protocol into daily routines positively influenced adherence.	Implementation strategies included in-service training and providing hardcopy and digital access to the NPAC. Some organizations ensured quick adoption of protocol updates, but practical barriers such as complexity and lack of hands-on training limited full implementation. Social influences, including the expectations of colleagues and EMS physicians, also shaped adherence behaviors.

Study	Intervention Characteristics	Inner Setting	Outer Setting	Characteristics of Individuals	Process
Ezem et al., 2024	The intervention focuses on community-based out-of-hospital cardiac arrest (OHCA) interventions. It includes public CPR and AED training, improved telecommunicator-assisted CPR, and enhanced first responder performance for earlier defibrillation. Complexity arises from adapting the program across diverse counties with varying resources.	External influences include policies and local healthcare regulations, societal expectations for EMS performance, and funding challenges. Differences in outcomes between high- and low-performing counties also shaped implementation efforts.	organizational structures varied, with high-performing counties benefiting from prior success with interventions. Challenges included limited collaboration with health departments and access to necessary resources. Monitoring was sometimes perceived as punitive.	Individuals included EMS, telecommunicators, fire responders, and hospital representatives. Leadership buy-in was crucial for maintaining support, with high-performing counties showing greater engagement from senior staff. Staff in low-performing counties expressed resistance to new changes.	Strategies included initial engagement meetings, frequent follow-ups, and data-sharing to demonstrate intervention effectiveness. Hands-on training was preferred, and regular updates with outcome data were essential for sustained support.
Feder et al., 2006	The intervention involved new guidelines permitting EMS personnel to withhold resuscitation based on verbal or written requests for patients with terminal conditions. These guidelines increased discretion for EMS providers and were implemented voluntarily by 16 of 35 agencies. Training included a printed manual, lectures, and competency quizzes.	Factors shaping implementation included legal and risk management concerns among agencies, public expectations around end-of-life care, and the presence of statewide DNR regulations. Some agencies hesitated to participate due to perceived liability risks.	organizational differences affected guideline uptake, with participating agencies showing greater willingness to adopt changes. Agencies shared a common medical director and continuing education program, but internal policies varied, affecting participation. Monitoring withheld resuscitation cases was seen by some EMS personnel as potentially punitive.	EMS personnel, including EMTs and paramedics, expressed varying degrees of confidence in following the new guidelines. Leadership buy-in was essential for guideline adoption, with EMS personnel showing a preference for clear instructions and autonomy in decision-making.	Implementation strategies included in-service training, structured guidelines, and ongoing monitoring through medical incident reports. Hands-on engagement with staff during the rollout was crucial. Feedback loops were limited, though initial success increased participation over time.
Fishe et al., 2024	The intervention focused on using Discrete Choice Experiments (DCEs) to assess EMS clinicians' preferences for implementing evidence-based guidelines (EBGs). Scenarios included changes such as a sepsis alert protocol, a new bag valve mask, and switching pain medication from morphine to fentanyl. The goal was to align future implementations with clinicians' preferences.	External influences included national EBG requirements and EMS agency policies. Agencies faced challenges like data-sharing limitations with hospitals, resource constraints, and difficulties in collecting outcome feedback. The COVID-19 pandemic also shaped training modalities.	EMS agencies varied in their approach to protocol updates and training, with classroom-based training available in some but not all agencies. Inconsistent feedback mechanisms and different levels of agency support were reported. Protocol updates were usually led by medical directors or educators.	EMS clinicians expressed strong preferences for individual-level feedback, practical hands-on training, and knowledge of the evidence behind new protocols. Some participants preferred classroom education, while others valued simulation-based learning, particularly for skill-based interventions.	Strategies included in-service training, regular protocol updates, and feedback loops from EMS agencies and hospitals. However, many clinicians reported a mismatch between their preferences and existing agency practices, such as the use of online-only education.
Gaither et al., 2021	Implementation of prehospital pediatric TBI guidelines focusing on oxygenation, ventilation, and prevention of hypotension through structured protocols. A train-the-trainer approach was employed for statewide rollout.	The study was influenced by national guidelines, local EMS policies, and public expectations around pediatric care. The COVID-19 pandemic impacted training delivery modes. Funding and data-sharing challenges between EMS and hospitals also affected implementation.	organizational variations included differing levels of support and readiness across participating EMS agencies. Agencies with better collaboration and support were more successful in adopting the guidelines. Feedback mechanisms were inconsistent across agencies.	EMS providers, including paramedics and EMTs, were the key personnel involved. Clinicians expressed varying levels of confidence in applying the guidelines, with leadership support proving critical for success. Many staff preferred hands-on training for effective learning.	Implementation strategies included structured in-service training, regular updates to protocols, and monitoring through patient care reports. A phased rollout with follow-up support ensured gradual adoption across agencies. Feedback was gathered, but inconsistently applied across regions.
Gaither et al., 2024	Implementation of evidence-based guidelines (EBGs) in EMS agencies focused on improving clinical outcomes. Intervention complexity included adapting protocols across different agencies with varying resources. Costs associated with in-person training and resource limitations posed challenges.	Influences included public expectations, external policy mandates, and resource limitations. The heterogeneity of EMS agencies (urban vs. rural, fire-based vs. EMS-only systems) created barriers. Receiving hospital practices and ED feedback also impacted EMS protocol adherence.	EMS agency culture and learning environment significantly influenced the uptake of EBGs. Leadership engagement, structural characteristics, and availability of resources were key factors. Agencies with a strong learning climate showed better engagement with new protocols.	EMS clinicians and leadership had varying levels of knowledge and motivation. Generational differences impacted attitudes toward change, with younger clinicians preferring more structured protocols. Clinicians expressed a preference for in-person, hands-on training over online education.	Implementation strategies included a phased rollout, train-the-trainer models, and continuous feedback. However, inconsistent access to data and analytics limited evaluation efforts. Clear, prescriptive protocols were easier for EMS clinicians to follow, improving adherence.

Study	Intervention Characteristics	Inner Setting	Outer Setting	Characteristics of Individuals	Process
Guerrier et al., 2023	Implementation of evidence-based guidelines (EBGs) focused on improving prehospital care through standardization and training. Adaptations were necessary for different EMS systems, and complexity arose from diverse EMS protocols. A "train-the-trainer" approach was used, and protocols required updates based on new evidence.	External factors included differences in community needs, healthcare policies, and national guidelines. Funding constraints and challenges in collaboration with hospitals impacted implementation efforts. Agencies struggled with data-sharing barriers, especially in obtaining hospital outcome data to evaluate guideline effectiveness.	organizational readiness varied across EMS agencies. Strong leadership engagement and a positive learning climate facilitated better adoption. Inconsistent access to training and limited feedback mechanisms created challenges. Agencies with collaborative cultures showed higher guideline uptake.	EMS clinicians' knowledge, attitudes, and motivation impacted adherence. Generational differences influenced preferences for training, with younger clinicians favoring more prescriptive protocols and older clinicians relying on past practices. Clinicians preferred hands-on training but faced challenges with online modules.	Implementation strategies included structured, repetitive training, feedback loops, and data monitoring. Consistent messaging and simulation-based learning were emphasized. However, resource limitations and logistical constraints, such as the COVID-19 pandemic, created barriers to regular in-person training.
Hagiwara et al., 2013	Implementation of prehospital care guidelines with an informal consensus approach. Guidelines were developed without input from end-users, leading to poor contextual adaptation. A simulation-based training approach was part of the implementation strategy.	External influences included societal expectations and differences between rural and urban EMS stations. There were also challenges with collaboration between hospital-based physicians and ambulance personnel.	The organization struggled with the practical application of the guidelines due to limited involvement of stakeholders in their development. Feedback mechanisms were minimal, and agencies lacked tools for continuous monitoring of adherence.	Ambulance personnel found the guidelines useful but impractical in their current format. They preferred flexible, easy-to-access protocols. Personnel often developed their own “homemade” guidelines, stored on personal devices for convenience.	Implementation included lectures, simulations, and IT-based certification. However, the poor format of guidelines limited their use during patient assessments, leading to implicit, memory-based application. Personnel expressed a need for a more user-friendly, integrated system.
Haley et al., 2016	Implementation of pain management interventions, including pediatric-focused education modules and a comprehensive pain management protocol for EMS providers. The protocol standardized opioid administration and emphasized pain score documentation.	Influences included local healthcare policies, public expectations for pain management, and funding challenges. Collaboration with hospitals was limited by data-sharing barriers. The COVID-19 pandemic impacted training delivery and protocol application.	Agencies exhibited varying levels of support and readiness for protocol adoption. Training opportunities were inconsistent, and feedback mechanisms were weak. Leadership engagement and organizational structure influenced adoption success.	EMS providers’ knowledge and comfort with pain management varied. Some preferred hands-on training, while others struggled with new protocols due to a reliance on past practices. Motivation to adopt the new practices depended on leadership support and the clarity of guidelines.	Implementation strategies included education modules, in-service training, and a phased protocol rollout. Monitoring systems were used to track opioid administration and pain score documentation, though sustainability of improvements varied across agencies.
Jones Rhodes et al., 2016	Implementation of prehospital spinal immobilization guidelines aimed to reduce unnecessary immobilization and improve patient comfort. The guidelines emphasized provider discretion and the use of vacuum mattresses instead of rigid spine boards.	External factors included public expectations, healthcare regulations, and inter-agency collaboration challenges. Hospitals and EMS agencies worked together, despite a history of competition, to secure shared equipment and ensure proper implementation.	organizational readiness varied across agencies. A collaborative learning environment and leadership engagement were essential for success. Ownership of shared equipment, such as vacuum mattresses, posed challenges, with smaller agencies showing better maintenance.	EMS personnel valued autonomy and expressed openness to change due to perceived patient discomfort with rigid boards. Some staff struggled with adopting new protocols that required a shift from long-standing practices. Leadership involvement motivated staff, though not all embraced the paradigm shift.	Intensive, hands-on training and collaborative workshops were critical components of implementation. Ongoing quality assurance processes monitored compliance with the new guidelines. Continuous training sessions were necessary to reinforce the protocol and ensure sustainability.
Kelleher et al., 2014	Implementation of a pediatric trauma resuscitation checklist to improve adherence to ATLS protocols. The checklist standardized task sequences and addressed common workflow deviations. The complexity involved integrating the checklist with existing resuscitation procedures.	External factors included societal expectations for trauma care, healthcare regulations, and pre-hospital notification limitations. Limited collaboration between EMS and hospital staff affected pre-arrival coordination. Some patients arrived by private vehicle, complicating team preparation.	organizational readiness varied, with some trauma teams more familiar with the ATLS protocol than others. Limited feedback loops hindered continuous improvement. Resources such as video-recorded reviews were used to monitor compliance with protocols.	Trauma team members, including junior surgical residents and nurses, had to adjust to the new checklist approach. Leadership support was essential for adoption. Staff expressed differing levels of confidence in following the ATLS protocols with and without the checklist.	Implementation strategies included process mining to assess workflow conformance, in-service training, and regular protocol reviews. Ongoing monitoring of task sequences was conducted using video logs to ensure standardization. Improvements in protocol adherence were observed post-implementation.

Study	Intervention Characteristics	Inner Setting	Outer Setting	Characteristics of Individuals	Process
Kerner et al., 2017	Implementation of three prehospital emergency care checklists: general prehospital care, acute coronary syndrome (ACS), and asthma/COPD. The checklists aimed to standardize care and improve adherence to standard operating procedures (SOPs). Adaptability was integrated through on-scene use after stabilization, and their laminated format ensured ease of use.	External factors included societal expectations for emergency care quality and regulatory guidelines. Limited pre-hospital collaboration with hospitals impacted seamless care delivery. Resource constraints, such as access to equipment, shaped the application of checklists.	Leadership engagement varied across emergency teams, with higher-performing units demonstrating better uptake. Some units lacked consistent feedback mechanisms and collaboration between EMS teams and physicians. Video reviews were used to monitor compliance with protocols.	EMS personnel, including paramedics and physicians, expressed acceptance of the checklists, recognizing improvements in care quality but noting the additional workload. Generational differences in attitudes were evident, with younger staff more receptive to structured protocols.	The implementation strategy included a phased rollout with seminars and hands-on training. Ongoing monitoring was conducted via video logs to assess adherence, and feedback was used to refine practices. Continuous training sessions were recommended to maintain protocol compliance.
Kothari et al., 2021	Implementation of repetitive high-fidelity simulation training to improve EMS team performance in pediatric emergencies. Scenarios were designed with increasing complexity and included airway management, respiratory failure, and fluid resuscitation. Adaptability was ensured through scenario variation.	External factors included societal expectations for pediatric care, regulatory requirements for EMS professionals, and limited access to pediatric education. EMS agencies faced challenges due to the infrequency of pediatric emergencies and resource limitations.	organizational culture varied across the EMS teams, with some teams demonstrating higher baseline preparedness. Leadership buy-in and a positive learning environment were essential to promote participation. Access to pediatric equipment varied between agencies.	EMS professionals, including paramedics and EMTs, expressed increased confidence in their pediatric care skills after training. Teams demonstrated a need for repeated practice to maintain competency, with younger clinicians more receptive to structured simulation.	Implementation strategies included three simulation sessions spaced over six months, each followed by structured debriefing. Video-based performance review and real-time feedback were provided. Training focused on airway management, medication administration, and fluid resuscitation.
Krawczyk et al., 2016	Implementation of resuscitation guidelines, focusing on the use of adhesive pads for defibrillation instead of manual paddles. The guidelines aimed to improve safety, speed, and effectiveness by minimizing delays during defibrillation. Economic constraints and tradition impacted adoption across different regions.	External influences included national healthcare policies and financial constraints. Public expectations and inter-country differences in defibrillation practices shaped the adoption. Some countries preferred manual paddles due to tradition and familiarity.	The organizational culture within EMS agencies varied, with some preferring traditional methods (manual paddles) over the recommended adhesive pads. Lack of structured feedback mechanisms limited continuous improvement.	Healthcare providers, including physicians, nurses, and paramedics, expressed mixed attitudes towards the guidelines. Some preferred manual paddles due to familiarity, while others recognized the benefits of adhesive pads but were hindered by cost and resistance to change.	Implementation strategies included distributing the guidelines, training sessions, and monitoring compliance through surveys. However, sustainability was challenged by economic constraints, lack of standardization across countries, and inconsistent equipment availability.
Lang et al., 2012	Development and implementation of a national model for evidence-based guidelines (EBGs) in EMS. The intervention involved an eight-step model focusing on structured evidence synthesis, stakeholder engagement, and contextual adaptation. It emphasized flexibility to address local and regional differences while maintaining scientific rigor.	Influenced by national healthcare standards and policy recommendations, with key input from agencies like the National Highway Traffic Safety Administration (NHTSA). Public expectations and funding constraints shaped the adoption process. Inter-agency collaboration was a challenge due to varying operational policies and resources.	Varying levels of organizational readiness and differences in EMS system structures influenced the implementation. Leadership engagement and alignment with national strategies played essential roles. Feedback and quality improvement systems were integrated to monitor effectiveness.	EMS personnel and leaders showed varying levels of engagement and understanding of the guidelines. Motivation to adopt the guidelines depended on clear alignment with operational practices and local needs. Some EMS providers required additional training on evidence-based practices.	Implementation included stakeholder conferences, structured dissemination through online platforms and publications, and quality improvement measures. The process focused on feedback loops and alignment with national certification and accreditation programs to ensure sustainable adoption.
Lynch et al., 2020	Implementation of prehospital thrombolysis (PHT) to treat ST-segment elevation myocardial infarction (STEMI) in South Africa. The intervention faced challenges with complexity due to drug logistics, equipment availability, and the absence of standard billing codes for the procedure.	Barriers included lack of PCI facilities, interprofessional collaboration challenges, and regulatory constraints. Public expectations for rapid care and disparities between urban and non-urban areas also impacted implementation.	Varying organizational readiness, limited leadership engagement, and inadequate infrastructure affected implementation. The absence of feedback loops and limited access to cardiologists hindered systematic adoption.	EMS personnel expressed mixed attitudes toward PHT, with some skeptical about its necessity in urban settings. Concerns over skill decay and competency were raised due to infrequent use of thrombolysis. Training gaps were evident.	Implementation involved strategic planning, limited training, and pilot projects. Monitoring systems were insufficient, with no widespread evaluation. Recommendations included phased scale-up, collaboration across networks, and leadership involvement.

Study	Intervention Characteristics	Inner Setting	Outer Setting	Characteristics of Individuals	Process
Mai et al., 2023	Implementation of pediatric TBI management guidelines. Focus on CT protocols, neuroimaging, ICP management, and prehospital interventions. Guidelines varied in adoption across designated trauma centers (DTCs) and non-trauma centers (NTCs).	Public expectations, healthcare disparities between urban and rural areas, and regulatory constraints shaped the implementation. Differences in prehospital services impacted the speed and quality of care, especially in LMICs.	organizational structure influenced guideline adherence, with better resourced DTCs showing more frequent adoption of CT protocols and proactive ICP interventions. Leadership and interprofessional collaboration were key to improving outcomes.	Clinicians varied in their familiarity with the guidelines. Some EMS providers expressed discomfort with performing advanced prehospital procedures, such as ICP management, without sufficient resources. Training gaps and the availability of specialists were highlighted.	Implementation strategies included phased guideline rollout, quality monitoring, and survey-based evaluations of adherence. Recommendations focused on improving inter-agency collaboration and developing context-specific protocols for better adoption in diverse regions.
Manson et al., 2018	Implementation of CDC trauma triage guidelines focused on directing trauma patients to appropriate facilities based on injury severity and resource availability. Complexity arose from variations in trauma center availability and proximity.	External factors included limited access to verified trauma centers in rural areas and inconsistent surgeon availability. Regulatory requirements and public expectations for quick, high-quality care shaped the implementation.	organizational readiness varied, with differences in protocol adherence between urban and rural settings. Leadership engagement was limited in some areas, and collaboration between medics and surgeons was inconsistent.	Paramedics and surgeons expressed differing perceptions of trauma readiness and guideline adherence. Paramedics lacked confidence in rural surgeons' willingness to operate, which impacted decision-making. Experience level influenced paramedic perceptions of surgeon availability.	Implementation strategies included local surveys, pilot protocols for destination determination, and training initiatives. Feedback was limited, and adherence to protocols varied significantly between rural and urban regions. Recommendations highlighted the need for better alignment and communication between stakeholders.
Maria et al., 2024	Development of clinical practice guidelines (CPGs) for paramedic services in Australia and New Zealand, emphasizing evidence-based practices. The guidelines address patient care and resource allocation but lack standardization in development processes across jurisdictions.	Limited access to resources, disparities between urban and rural services, and healthcare policies affecting guideline implementation. Public expectations and funding constraints shape adoption.	Inconsistent project management frameworks across ambulance services, varying levels of leadership engagement, and limited internal resources affect guideline development. organizational readiness differs among services.	Paramedics and other healthcare professionals involved in guideline creation possess diverse skill levels, with many lacking formal training in CPG development. Some rely on external guidance due to limited experience.	Implementation strategies include voluntary capacity building, inter-service collaboration, and thematic analysis of interviews. The study highlights the need for multidisciplinary approaches, formal training, and dedicated funding for CPGs.
Martin-Gill et al., 2016	Implementation of a national strategy for prehospital evidence-based guidelines (EBGs) to enhance EMS care. The strategy focused on standardized development and dissemination, promoting flexibility for regional adaptations.	Public expectations for high-quality emergency care and variability in healthcare policies between states influenced guideline adoption. Limited funding and disparities between urban and rural EMS services shaped the outer environment.	organizational readiness varied, with differences in EMS agency structures impacting guideline implementation. Leadership involvement and inter-agency collaboration were crucial for aligning guidelines with local practices.	EMS providers, researchers, and physicians demonstrated varying levels of engagement. Training gaps were identified, especially for providers unfamiliar with evidence-based medicine principles. Motivation was influenced by leadership support and clarity of guidelines.	The strategy employed structured collaboration through stakeholder meetings, phased implementation, and monitoring. Evaluation tools such as GLIA and feedback loops were recommended to assess adoption. Continuous updates and funding were emphasized to maintain sustainability.
McCaul et al., 2020	The CPGs were adapted from international guidelines to suit the South African prehospital care context. The intervention aimed to align best practices with local needs but was challenged by limited resources and the complexity of guideline adaptation. Resource constraints and timeline pressures shaped the intervention scope.	Public and regulatory expectations shaped implementation, with reliance on international guidelines due to a lack of local evidence. There were challenges in applying international standards to local prehospital realities, particularly in rural areas, where disparities in care and resources were most acute.	Implementation varied across provinces due to different levels of organizational readiness, leadership engagement, and access to funding. There was no national standardization, resulting in variability in adoption. Poor collaboration between stakeholders across regions hampered guideline integration and sustainability.	Guideline developers and implementers included paramedics and advisory board members. Skills in CPG development varied, with many lacking expertise in translating international evidence to local contexts. Personal attitudes toward guideline use and skepticism about applicability influenced adoption. Motivation was impacted by resource constraints and a lack of formal training in guideline development.	Implementation followed a phased rollout with stakeholder engagement through workshops and consultations. However, post-development communication gaps, limited monitoring, and weak feedback loops hindered consistent adoption. There were calls for better coordination at a national level to address these challenges.

Study	Intervention Characteristics	Inner Setting	Outer Setting	Characteristics of Individuals	Process
McManus et al., 2023	Implementation of oral corticosteroids (OCS) for pediatric asthma management in EMS treatment protocols. The intervention aimed to reduce reliance on intravenous steroids by leveraging oral administration, which was faster, safer, and less invasive. Complexity involved unfamiliarity with pediatric dosing and occasional resistance due to the unpleasant taste of the medication.	The need for OCS stemmed from a lack of timely access to intravenous treatments, particularly in rural areas. Public expectations for quick, high-quality EMS care influenced the demand. Inter-agency collaboration, including feedback from hospitals, played a critical role in shaping protocol compliance.	EMS agencies varied in organizational readiness, with some services demonstrating stronger leadership and feedback loops. Barriers included inconsistent communication about protocol changes and limited pediatric-specific equipment. The presence of a pediatric medical director in some agencies improved uptake.	EMS clinicians had varying degrees of familiarity and confidence with pediatric care. Clinicians with personal experience caring for children reported greater ease in managing pediatric patients. Skepticism toward new interventions was more common among older EMS providers, who were resistant to changing established practices.	Implementation strategies included stakeholder engagement, phased rollout of protocols, and feedback loops with hospitals. Successful adoption was linked to real-time feedback on patient outcomes. However, challenges persisted due to limited ongoing education and resistance to change within some EMS units.
Mould-Millman et al., 2023	EMS-TruShoC was designed as a bundled care approach for managing traumatic shock. Key elements included reducing scene time, hemorrhage control, large-bore IV placement, oxygen delivery, and direct trauma center transport. The HEET program provided rapid, peer-led, case-based training sessions.	The intervention was implemented in a resource-constrained EMS setting in the Western Cape, South Africa, where trauma from interpersonal violence and road collisions is prevalent. The study noted issues related to external trauma care protocols and transport constraints influencing implementation.	The organizational setting was within government-operated EMS, emphasizing trauma as a high-priority condition. Implementation was supported by station and shift managers, enhancing training access. The organization valued pragmatic, brief training that could fit into operational demands.	Participants included EMS providers with varying qualifications (BLS, ILS, ALS). Providers reported increased confidence through peer-led training and appreciated the non-intimidating environment. Facilitators noted personal satisfaction and increased confidence from leading the training.	The process included delivering five biweekly training modules, each focusing on trauma management through practical scenarios. Implementation monitoring was guided by the RE-AIM framework, with effectiveness evaluated by knowledge, skills, and self-efficacy improvements.
Sarmiento et al., 2013	Implementation of the CDC's Field Triage Decision Scheme to improve trauma triage practices. The scheme included educational resources such as pocket cards, posters, and training guides to assist EMS providers with decision-making. Adaptation challenges arose from regional variability and the complexity of the protocol.	Public expectations for effective triage, disparities in trauma center availability, and inter-agency coordination impacted implementation. Rural areas faced particular challenges due to long distances to trauma centers.	organizational readiness varied across EMS agencies, with some adopting the Decision Scheme more readily due to strong leadership and available resources. Poor collaboration and inconsistent buy-in across agencies hampered broader adoption.	EMS providers and leaders demonstrated varying engagement levels. Leadership often acted as early adopters, while some providers were skeptical about the scheme's relevance. Training gaps and resistance to change were identified as barriers.	Implementation involved a phased rollout with surveys and focus groups to evaluate uptake. Challenges included communication gaps between leadership and staff, as well as a lack of formal feedback loops. Recommendations emphasized the need for stronger leadership involvement and better communication strategies.
McCaul et al., 2019	The clinical practice guidelines (CPGs) transitioned from skills-based protocols to evidence-based guidelines, requiring changes in scope of practice and introducing modular training.	Providers highlighted challenges like lack of communication from regulators and fragmented release of guidelines via informal channels. There was a reliance on technology and local champions for better dissemination.	The organizational environment was marked by limited resources for upskilling and lack of alignment between higher education and industry needs. Hierarchical silos were a barrier to collaboration.	Individual providers faced uncertainty, mixed emotional responses, and concerns about professional identity, particularly related to changes in scope of practice (e.g., intubation). Their motivation varied between embracing evidence-based care and resistance due to perceived loss of competencies.	The guideline rollout involved a phased release, public consultations, and efforts to engage with end-users. However, it suffered from poor communication strategies. Solutions proposed included modular online training and use of professional societies.
Sasson et al., 2009	National guidelines for termination of resuscitation (TOR) protocols, validated by multiple studies. Local adaptation of protocols varies widely. Concerns about protocol complexity and misapplication.	Public expectations for resuscitation outcomes are high and unrealistic. Legislative mandates in some areas require transport for cardiac arrest, limiting protocol implementation. Reimbursement systems incentivize transport rather than TOR in the field.	EMS agencies face operational barriers such as limited resources and inconsistent alignment with higher-level policies. Agencies function independently across states, and policies are often shaped by state laws.	EMS providers expressed concerns about professional judgment and emotional stress related to stopping resuscitation efforts. Some providers reported resistance to TOR due to fear of public backlash and legal liability.	TOR implementation involves local EMS agencies working with national organizations. Strategies include educational campaigns, training, and advocacy for policy change at the legislative and payer levels. Efforts to align protocols nationally face delays due to fragmented local policies.
Siriwardena et al., 2014	Implementation of the Ambulance Services Cardiovascular Quality Initiative (ASCQI), which focused on improving care bundles for AMI and stroke. Interventions included provider prompts, team feedback, and care bundles for standardizing prehospital care.	Public and policy expectations for consistent care delivery. Financial incentives and quality indicators from national and local agencies promoted engagement. Challenges included regional variations in resources and policy alignment.	Each ambulance service developed local quality improvement (QI) teams with national support. Some services struggled with internal silos, while others benefited from collaborative teamwork and leadership. Lack of consistent resources was noted.	EMS providers' skills in using care bundles varied. Motivation among providers fluctuated, influenced by engagement opportunities and feedback. Resistance to change was observed initially but improved with individual recognition and organizational support.	The QI process was structured with phases: workshops, feedback loops, and national meetings. Plan-Do-Study-Act (PDSA) cycles were used to implement and refine changes. Monthly teleconferences and feedback reports provided continuous improvement data.

Study	Intervention Characteristics	Inner Setting	Outer Setting	Characteristics of Individuals	Process
Spaite et al., 2019	Implementation of the Prehospital Traumatic Brain Injury (TBI) Treatment Guidelines across Arizona. The intervention aimed to standardize prehospital care for severe TBI patients through evidence-based protocols. It emphasized the use of specific care bundles, including blood pressure and oxygenation management, but required significant resources for full implementation.	Arizona's geographic diversity and healthcare disparities between urban and rural areas affected adoption. Public awareness and expectations for high-quality trauma care increased demand for consistent care practices. Policy support from state-level stakeholders influenced implementation.	Variability in EMS agency resources impacted protocol adherence, with better-equipped urban centers achieving more consistent compliance. Leadership engagement within agencies was critical for sustaining changes, but funding gaps created challenges for smaller, rural agencies.	EMS providers demonstrated mixed attitudes toward the guidelines, with early adopters advocating for the changes, while others expressed concerns about the added workload. Familiarity with evidence-based practices varied, and ongoing training was essential to sustain motivation and competency.	The implementation involved a phased statewide rollout with continuous monitoring and feedback. Key strategies included regular training sessions, collaboration between EMS and hospitals, and the use of clinical audits to ensure protocol adherence. Long-term success relied on leadership support and ongoing funding.
Thorvaldsen et al., 2019	Developed evidence-based guidelines for trauma management using a systematic review, AGREE tool, and GRADE framework. E-learning was designed to complement the guideline.	Need identified among EMS providers for consistent spinal stabilization to prevent secondary injuries. External policies did not mandate the adoption of the guideline, limiting its authority.	EMS organizations with decentralized management, each requiring local guideline approval. Limited inter-organizational collaboration hindered national uniformity.	EMS personnel had varying levels of experience, training, and roles. Low completion rate of the e-learning module was reported. Lack of confidence among some staff in applying the guideline due to infrequent exposure to relevant cases.	Guidelines disseminated through conferences, journals, and e-learning modules. Passive dissemination strategy used. 18 months after guideline release, some services still in the process of implementation. Surveys were used to assess guideline adoption.
Tomasone et al., 2014	The "ABCs of AD" is an online educational module focused on increasing knowledge about autonomic dysreflexia (AD) guidelines. It provides both informational content and videos of patient experiences. The module is divided into six sections, covering definitions, symptoms, diagnosis, and management of AD. Optional quizzes are included. The primary target group is pre-hospital emergency care workers (paramedics, nurses).	The educational content responds to a need for better recognition and management of AD by healthcare professionals, as mismanagement can lead to life-threatening conditions like myocardial infarction. Limited previous knowledge about AD among healthcare workers is identified, with only 50% recognizing key symptoms.	The educational module is intended for use within healthcare training environments, aiming to influence future clinical practice. organizations involved include two Canadian healthcare training programs and multiple institutional ethics boards. Participants noted challenges in completing all sections due to time constraints and lack of perceived personal importance.	Participants included paramedic and nursing trainees, mostly second-year students. The study found that trainees lacked previous experience with AD and rated their knowledge as "Poor" or "None." While knowledge improved significantly post-module, social cognitions toward using the AD-CPGs (attitudes, norms, behavioral control) did not show significant change.	The implementation process involved a pre- and post-module survey design. Participants completed questionnaires assessing knowledge and social cognitions before and after engaging with the module. Module feedback was collected to identify areas for improvement. The study emphasizes that knowledge alone is insufficient for behavioral change, recommending future iterations target social cognitive determinants.
Watts et al., 2004	Implementation of prehospital care guidelines to standardize procedures among EMS providers. The guidelines were developed to improve clinical decision-making and reduce variability in care. Complexity arose from ensuring relevance across diverse EMS environments.	Variability in patient needs and public expectations across urban and rural regions. External influences included health policies and funding structures, which impacted access to resources needed for guideline adherence.	Some EMS organizations demonstrated strong leadership in supporting guideline implementation, while others lacked structured processes for adoption. organizational readiness varied, with limited feedback systems in place to monitor guideline use.	EMS providers expressed mixed attitudes toward the guidelines, with some questioning their applicability to real-life situations. Providers reported feeling constrained by protocols that limited autonomy, particularly in complex cases.	The guidelines were introduced through training workshops, printed manuals, and on-the-job reinforcement. Monitoring was inconsistent, with some services lacking formal mechanisms for feedback and continuous evaluation. Adoption was hindered by a lack of follow-up training and resources.

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REVIEWS

COMMUNITY PARAMEDICINE AND MOBILE INTEGRATED HEALTH FOR CARDIOVASCULAR RISK AND HEART FAILURE: AN ANALYSIS AND SYNTHESIS OF EVIDENCE ON OUTCOMES

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ABSTRACT

The objective of this narrative review was to synthesize evidence on how community paramedicine and mobile integrated health programs have been implemented to assess and manage cardiovascular risk and heart failure in community and home-based settings, and to assess reported effects on health care utilization, adherence-related outcomes, and feasibility of care delivery. PubMed/MEDLINE was searched for English-language, human-subject literature published from January 2016 through January 2026, with the final search completed February 28, 2026. Eligible studies described community paramedicine or mobile integrated health interventions addressing cardiovascular risk assessment, heart failure-related monitoring, or cardiopulmonary post-discharge care in community or home-based settings and reported patient-level clinical, utilization, adherence, feasibility, or implementation outcomes. Studies focused exclusively on non-cardiovascular conditions, emergency response-only care, protocols, conference abstracts, non-peer-reviewed reports, or program descriptions without outcomes were excluded. The search identified 44 PubMed/MEDLINE records, and citation linking identified 12 additional records. Twenty-nine sources were included, including eight core empirical studies prioritized for model-based synthesis. No formal risk-of-bias tool was applied; study quality was considered narratively according to design, comparison group, sample size, follow-up duration, outcome definition, and potential confounding. Three intervention models predominated: post-discharge home-based follow-up, community-based screening and linkage, and high-utilizer home-visit programs. Post-discharge follow-up demonstrated heterogeneous effects on utilization, with more consistent reductions in targeted, higher-risk populations and programs with defined visit frequency and escalation pathways. Screening programs showed improvements in intermediate cardiovascular risk factors and modest reductions in emergency medical services use, although downstream utilization effects were variable. Feasibility of paramedic-led cardiovascular assessment and follow-up was consistently demonstrated. Results highlight the need for future research to clarify the effectiveness of community paramedicine and mobile integrated health programs in cardiovascular care. Key limitations include single-database searching, single-reviewer screening, and absence of formal risk-of-bias assessment.

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INTRODUCTION

Burden of Cardiovascular Disease and Heart Failure

Cardiovascular disease (CVD) and heart failure (HF) remain leading contributors to morbidity, mortality, and health care utilization, with a substantial proportion of disease burden occurring outside traditional outpatient care settings (Palaniappan et al., 2026; Savarese et al., 2017). The American Heart Association (AHA) estimates that nearly 128 million U.S. adults (approximately 48%) live with CVD, which accounts for over one-third of all deaths nationally, while HF affects more than 6.7 million adults and continues to rise in prevalence as survival improves and the population ages (Palaniappan et al., 2026; Savarese et al., 2017). HF is characterized by recurrent exacerbations and high rates of acute care use. Approximately 20-25% of patients are readmitted within 30 days of hospitalization, most often within the first two weeks following discharge (Dharmarajan et al., 2013, 2017). Many drivers of recurrent utilization, such as medication nonadherence, food insecurity, housing instability, limited transportation, inadequate access to primary or specialty care, and limited health literacy, arise primarily in community and home environments rather than clinical settings (Havranek et al., 2015; Johnston et al., 2019; Van Spall et al., 2017). Recent literature highlights persistent socioeconomic, geographic, and racial disparities in cardiovascular outcomes, and rural residence and limited specialist access are independently associated with higher mortality and preventable hospitalizations (Johnston et al., 2019; Palaniappan et al., 2026). Frequent health care utilization coupled with significant inequities in outcomes suggest a misalignment between accumulation of cardiovascular risk and traditional care delivery, driving interest in care designed to promote the extension of assessment and coordination beyond clinic-centered systems and into community settings.

Community Paramedicine and Mobile Integrated Health as Models for Cardiovascular Care

Community paramedicine (CP) and mobile integrated health (MIH) programs extend emergency medical services (EMS) capabilities beyond traditional response roles into preventive, transitional, and chronic disease management contexts (Gregg et al., 2019; Harring et al., 2025; Lurie et al., 2023; Wilder et al., 2021). CP programs commonly deploy paramedics in expanded roles that include home visits, chronic disease screening, medication review, patient education, and referral support. MIH models further integrate EMS teams within broader clinical and social service networks through shared protocols and structured communication with primary care and specialty services (Bourdages et al., 2024; Gregg et al., 2019). Combining EMS personnel, traditionally used for acute care settings, with community-based programs implemented to improve chronic care outcomes has been increasingly applied to populations with high acute care utilization and persistent barriers to clinic-based follow-up.

Rationale for Focusing on Cardiovascular Risk and Heart Failure

Despite the growing number of CP and MIH programs targeting cardiovascular risk and heart failure, interventions vary substantially in design, intensity, target population, and outcome measurement, limiting direct comparability (Agarwal et al., 2016, 2019; Burnett et al., 2023; Gingold et al., 2021; Sokan et al., 2022). Prior CP and MIH-focused literature largely adopts broad analytic scopes without systematically characterizing cardiac-specific intervention models or examining how implementation features and care context

influence outcomes (Dharmarajan et al., 2013, 2017; Johnston et al., 2019). As a result, the existing evidence base remains fragmented across intervention models, populations, and settings, with limited synthesis clarifying when and for whom community paramedic-led cardiovascular interventions are most effective, or how program design elements such as visit structure, escalation pathways, and linkage to longitudinal care shape observed utilization and risk-related outcomes (Agarwal et al., 2016, 2019; Burnett et al., 2023; Gingold et al., 2021; Harring et al., 2025; Rasku et al., 2019; Sokan et al., 2022; Ulintz et al., 2025; Wilder et al., 2021). This gap is particularly salient for cardiovascular risk and heart failure, where time-sensitive clinical deterioration, post-discharge vulnerability, and recurrent EMS contact intersect with social and structural barriers to clinic-based follow-up (Dharmarajan et al., 2013; Dharmarajan et al., 2017; Johnston et al., 2019). Addressing this gap requires a focused, model-based synthesis of cardiovascular- and heart failure-specific community paramedicine and mobile integrated health interventions, rather than their aggregation within broader EMS or population health frameworks.

Objective and Research Question

This narrative review examines how CP and MIH programs have been implemented to assess and manage cardiovascular risk and HF in community settings and what effects have been observed on health care utilization, patient adherence, and feasibility of care delivery. The review focuses on empirical evaluations of defined CP and MIH interventions reporting patient- or system-level outcomes, while drawing on contextual literature to explain program rationale and implementation constraints. Across programs, this review suggests that the effects of community paramedicine and mobile integrated health interventions on cardiovascular risk and heart failure outcomes are conditional rather than uniform, with the most consistent benefits observed in targeted models that are closely integrated with outpatient care pathways.

METHODS

Literature Review

A narrative literature review was conducted using PubMed/MEDLINE-indexed sources published between January 2016 and January 2026. PubMed/MEDLINE was selected to support a focused synthesis of peer-reviewed clinical and health services literature relevant to community paramedicine, mobile integrated health, cardiovascular risk, and heart failure. No additional bibliographic databases, trial registries, or grey literature sources were searched. This approach was intended to support a reproducible narrative synthesis rather than an exhaustive systematic review.

The final PubMed/MEDLINE search was completed on February 28, 2026, using the complete search strategy reported in Appendix 1. The search was limited to English-language studies involving human subjects and returned 44 records. Records were stored in Zotero. Because the search was conducted in a single database, no duplicate PubMed records were identified. Citation linking was also performed as part of the original search workflow by manually reviewing reference lists of included studies and relevant reviews; this process identified 12 additional records. In total, 56 records were considered for relevance. Search terms and limits were developed for this review and were not adapted from a published search filter. The January 2016 through January 2026 date

range was selected to emphasize contemporary CP/MIH models and current implementation contexts.

Selection Approach and Classification

Records were screened manually by a single reviewer. All 44 PubMed/MEDLINE records were screened by title and abstract for relevance to community paramedicine, mobile integrated health, cardiovascular risk assessment, heart failure-related monitoring, cardiopulmonary post-discharge care, or community-based care delivery. Fifteen PubMed/MEDLINE records advanced to full-text review. The 12 records identified through citation linking were also reviewed for relevance and eligibility as part of the same selection process. No formal screening software beyond Zotero record storage was used, and no formal extraction table was created.

Eligible empirical studies described community paramedicine or mobile integrated health interventions delivered in community, home-based, post-discharge, or other nontraditional clinical settings and addressed cardiovascular risk assessment, heart failure-related monitoring, cardiopulmonary post-discharge management, or closely related cardiovascular outcomes. Included studies reported at least one patient-level, system-level, feasibility, adherence-related, clinical, utilization, or implementation outcome. Studies involving mixed cardiopulmonary populations were retained when cardiovascular or heart failure-related outcomes were explicitly reported.

Studies were excluded if they focused exclusively on non-cardiovascular conditions; described emergency response-only care without a preventive, post-discharge, screening, or longitudinal care component; lacked patient-level, utilization, feasibility, or implementation outcomes; were conference abstracts, protocols, commentaries, editorials, or non-peer-reviewed reports; were not conducted in community or home-based settings; or addressed cardiovascular conditions only tangentially within broader chronic disease interventions. Study authors were not contacted for clarification or additional data.

Following screening and full-text review, 29 sources were included in the review. Of these, eight were classified as core empirical studies and prioritized for analytic synthesis because they reported a clearly specified CP/MIH intervention model, explicit cardiovascular or heart failure-related outcomes, and sufficient methodological detail to permit comparison across intervention types. The remaining 21 sources were used as contextual or supporting literature to describe disease burden, prior CP/MIH evidence, implementation rationale, health system context, and interpretation of findings.

Given the narrative design and heterogeneity of included studies, no formal risk-of-bias tool or quantitative scoring framework was applied. Instead, methodological rigor was considered qualitatively during synthesis according to study design, presence or absence of a comparison group, sample size, follow-up duration, clarity of outcome measurement, and potential confounding. Findings from studies with stronger methodological designs were given greater interpretive weight when comparing intervention models, whereas smaller, uncontrolled, or feasibility-focused studies were used primarily to inform contextual and implementation considerations.

For the purposes of analytic synthesis, health care utilization outcomes, including emergency department visits, hospital admissions, readmissions, and EMS utilization, were

treated as primary outcomes. Intermediate clinical outcomes, including blood pressure, cardiovascular risk scores, and medication adherence, as well as cost or resource measures, were considered secondary outcomes. Feasibility, acceptability, and implementation process measures were used to contextualize intervention delivery rather than to determine effectiveness.

Study (year)	Design and setting	Population	Intervention	Outcome
Gingold et al., 2021	Retrospective observational cohort study with propensity-score matched controls	Adults 18 years discharged home from internal/family medicine services at an academic and affiliated community hospital in Baltimore, MD	30-day MIH/CP transitional care program including home visits by community paramedics, CHWs, medication reconciliation via telepharmacy, interdisciplinary coordination, and telemedicine support	No significant difference in 30-day inpatient readmissions or ED visits compared with matched controls; increased observation hospitalizations at 30 days (adjusted IRR 1.78, 95% CI 1.01–3.14) that did not persist at 60 days
Sokan et al., 2022	Pilot observational; matched controls	HF or COPD post-discharge patients (n = 83)	MIH/CP post-discharge follow-up	Medication adherence (PDC) showed higher adjusted values at 30 days (HF +8%, COPD +14%), though not statistically significant; differences attenuated after 30 days
Abrashkin et al., 2024	Prospective observational; home-based urgent response	Homebound older adults (1,159 patients; 2,378 responses)	Community paramedic evaluation and treatment of high-acuity conditions in the home	Low emergency department transport rates following community paramedic responses; descriptive outcomes only with no comparison group
Agarwal et al., 2018	Pragmatic cluster RCT; subsidized seniors' housing	Residents in 6 housing buildings	Paramedic-led cardiovascular risk assessment, education, and referrals; ongoing for 1 year	Ambulance calls decreased (0.88 calls/100 units/month); SBP decreased 5.0 mmHg; DBP decreased 4.8 mmHg
Agarwal et al., 2017	Prospective pre-post observational study; subsidized seniors' housing	Older adults (n = 79)	Weekly drop-in assessment, education, referrals, and primary care clinician reports	EMS calls decreased 25%; SBP decreased by 3rd visit; DBP decreased by 5th; CANRISK category decreased in 15%
Agarwal et al., 2020	Feasibility study; community and faith-based clinic sites	South Asian adults (n = 71)	Clinic-based paramedic-led cardiovascular screening with volunteer translation	Feasible with language support; elevated BP in 46.5%; moderate/high diabetes risk in 42.3%
Agarwal et al., 2024	Pragmatic RCT; home-visit model	Frequent EMS users (1,025 vs 994)	Up to 3 community paramedic home visits	No statistically significant difference in EMS call rate overall (IRR 0.88); significantly reduced lift-assist call rate in the lift-assist subgroup (IRR 0.73)
Burnett et al., 2023	Prospective cohort; matched historical control	Cardiopulmonary discharges (n = 78 vs 78)	1–2 home visits/week for 30 days post-discharge	Readmissions decreased at 120 days (34.6% vs 64.1%) and 210 days (43.6% vs 75.6%); ED visits decreased 40.7%; acute care bed-days saved: 218; estimated cost decreased $410,428 (USD)

Abbreviations: BP, blood pressure; CI, confidence interval; CP, community paramedicine; ED, emergency department; EMS, emergency medical services; HF, heart failure; IRR, incidence rate ratio; MIH, mobile integrated health; PDC, proportion of days covered; RCT, randomized controlled trial; SBP, systolic blood pressure; DBP, diastolic blood pressure; COPD, chronic obstructive pulmonary disease; CHW, community health worker; CANRISK, Canadian Diabetes Risk Questionnaire.

Table 1. Primary research of community paramedicine and mobile integrated health interventions addressing cardiovascular risk and heart failure.

Synthesis Approach

Given substantial heterogeneity in intervention design, patient populations, outcome measures, and follow-up periods, quantitative pooling and meta-analysis were not deemed appropriate. A narrative synthesis approach was therefore used to interpret patterns across studies and explain variability in reported effects. Outcomes from core

empirical evaluations were grouped by implementation model (post-discharge home-based follow-up, community-based screening and linkage programs, and high-utilizer home-visit interventions) and summarized with attention to outcome direction and key operational characteristics, including visit frequency, setting, and integration with outpatient care pathways. No generative AI tools were used in the preparation of this manuscript.

RESULTS

Post-Discharge Home-Based Follow-Up Models

Post-discharge home-based follow-up represents a common application of community paramedicine and mobile integrated health for patients recently hospitalized with heart failure or other cardiopulmonary conditions. Programs in this category enrolled patients shortly after hospital discharge and delivered time-limited, home-based follow-up by community paramedics, often supported by interdisciplinary teams. Core components across studies included in-home clinical assessment, medication reconciliation, symptom monitoring, and coordination of outpatient follow-up.

In an observational, propensity-matched study of a 30-day MIH/CP transitional care program, Gingold et al. found no difference in 30-day inpatient readmissions compared with matched controls (adjusted IRR 1.19, 95% CI 0.89–1.60) among 464 enrolled patients, while hospital observation stays were more frequent in the intervention group (adjusted IRR 1.78) (Gingold et al., 2021). Sokan et al. evaluated a post-discharge MIH/CP program for patients with heart failure and chronic obstructive pulmonary disease and reported higher medication adherence at 30 days, measured by proportion of days covered (heart failure +8%, COPD +14%), with differences attenuating over time (Sokan et al., 2022). In contrast, Burnett et al. reported reductions in longer-term utilization in a prospective observational cohort with matched historical controls. Among patients discharged with cardiopulmonary conditions (n = 78 per group), the intervention—consisting of 1–2 community paramedic home visits per week for 30 days—was associated with lower all-cause readmissions at 120 days (34.6% vs 64.1%) and 210 days (43.6% vs 75.6%), fewer emergency department visits (40.7%), reduced hospital bed-days (218), and estimated total system-level cost savings of $410,428 (Burnett et al., 2023).

Across post-discharge models, outcomes varied by study design and follow-up duration.

Community-Based Screening and Linkage Models

Community-based screening and linkage models embedded community paramedics in non-clinical settings, most commonly subsidized housing or senior living environments, to conduct cardiovascular risk assessment and facilitate referral to primary care. These programs emphasized repeated blood pressure measurement, cardiovascular risk screening, patient education, and linkage to outpatient services, with delivery occurring in fixed community sites rather than patient homes.

In a cluster randomized trial conducted in subsidized senior housing, Agarwal et al. reported reductions in ambulance calls (0.88 calls per 100 units per month) and decreases in systolic and diastolic blood pressure (5.0 mmHg and 4.8 mmHg, respectively) over one year of paramedic-led assessment and education (Agarwal et al., 2018). A pre-post

evaluation of the Community Health Assessment Program through Emergency Medical Services (CHAP-EMS) similarly reported a 25% reduction in EMS call volume during the intervention year, with early reductions in blood pressure and improvements in diabetes risk categorization among a subset of participants (Agarwal et al., 2016).

In a feasibility-focused implementation study adapting the CP@clinic model for a South Asian population, Agarwal et al. conducted 26 paramedic-led screening sessions over 14 months, enrolling 71 participants in community and religious settings (Agarwal et al., 2020). Among the 26 participants with complete or near-complete risk factor data, 46.5% had elevated blood pressure (140/90 mmHg) and 65.4% had at least one indicator of cardiometabolic disease. Utilization outcomes were not assessed in this evaluation. Across community-based screening models, reported outcomes were concentrated in utilization and intermediate clinical measures.

High-Utilizer Home-Visit Models

High-utilizer home-visit models targeted individuals with recurrent EMS contact, with interventions delivered through short-term, home-based visits by community paramedics. Programs focused on patients with frequent emergency service use driven by complex medical, functional, or social needs and provided a limited number of visits over defined follow-up periods.

In a randomized controlled trial of frequent EMS users, Agarwal et al. delivered up to three community paramedic home visits over approximately 6-8 weeks and evaluated EMS call rates over a 6-month post-intervention period. The intervention was not associated with a statistically significant reduction in overall EMS calls (IRR 0.88, 95% CI 0.76–1.01), but was associated with a reduction among patients requiring recurrent lift assists (IRR 0.73, 95% CI 0.58–0.92) (Agarwal and Angeles, et al., 2024).

Abrashkin et al. evaluated a community paramedicine program embedded within an advanced illness management practice, serving an elderly, medically complex population. Across 2,378 paramedic responses over four years, 17.9% resulted in emergency department transport, with low rates of delayed transport among patients initially managed in the community (Abrashkin et al., 2024).

Across high-utilizer models, utilization effects varied by population subgroup and follow-up period.

Cross-Model Comparative Synthesis

Patterns of outcomes differed across models in relation to recruitment pathway, target population, intervention intensity, and level of health system integration. A structured comparison of these features is presented in Table 2. Distinct contrasts emerged across post-discharge home-based follow-up, community-based screening and linkage, and high-utilizer home-visit models.

Hospital Readmissions

Hospital readmissions were primarily evaluated in post-discharge MIH/CP programs targeting recently hospitalized patients with heart failure or cardiopulmonary conditions. Across transitional care models, findings ranged from reductions in selected

Dimension	Post-Discharge Home-Based Follow-Up	Community-Based Screening and Linkage	High-Utilizer Home-Visit Model
Primary recruitment pathway	Hospital discharge referral	Place-based outreach (e.g., subsidized housing, community sites)	Identification through EMS utilization records
Target population	Recently hospitalized patients with cardiopulmonary conditions	Community-dwelling adults with cardiovascular risk factors	Individuals with recurrent EMS use and complex medical or social needs
Typical intervention structure	Home visits, typically 1-2 visits per week	Repeated screening sessions	Structured home visits (commonly up to 3 visits)
Level of health system integration	High; coordination with hospital discharge teams, outpatient clinicians, and pharmacies	Moderate; linkage to primary care through standardized reports and referral	Moderate; coordination with EMS systems and outpatient providers
Common study designs	Observational cohorts; matched comparisons; pilot studies	Cluster randomized trials; pre-post evaluations; implementation studies	Randomized controlled trials; prospective observational studies
Hospital readmissions assessed	Frequently assessed	Infrequently assessed	Infrequently assessed
Observed readmission effects	Mixed findings; short-term effects often not statistically significant, with reductions reported in selected cohorts	Not a primary outcome in most evaluations	Not a primary outcome in most evaluations
EMS or emergency department utilization effects	Variable; some programs reported shifts in utilization patterns	Reductions in EMS call volume reported in controlled and pre-post evaluations	Variable; reductions observed in prespecified high-frequency subgroups
Intermediate clinical outcomes	Medication adherence improvements reported in short-term evaluations	Reductions in blood pressure and improved cardiovascular risk identification reported across screening models	Intermediate clinical outcomes infrequently evaluated
Cost outcomes assessed	Evaluated in selected studies with variable findings	Cost analyses uncommon	Cost analyses uncommon

Table 2. Cross-model comparison of community paramedicine and mobile integrated health cardiovascular intervention models.

cohorts to no statistically significant differences in 30-day readmissions compared with matched controls (Gregg et al., 2019; Lurie et al., 2023; Sokan et al., 2022). HF-specific MIH programs frequently reported feasibility and patient engagement, whereas short-term reductions in readmissions were less consistently demonstrated. Post-discharge "heart failure house calls" and rural MIH programs similarly reported stable readmission rates and were not powered to detect significant changes (Bourdages et al., 2024; Sokan et al., 2022). In contrast, community-based screening and high-utilizer models did not routinely assess hospital readmissions.

Emergency Department and EMS Utilization

Reductions in EMS utilization were most consistently observed in community-based screening programs implemented in subsidized housing settings, where cluster randomized and pre-post evaluations demonstrated fewer ambulance calls compared with control or baseline periods (Agarwal et al., 2016, Agarwal et al., 2018). Among frequent EMS users, a randomized controlled trial of a high-utilizer home-visit intervention reported mixed overall effects but identified reductions within prespecified high-risk subgroups, including patients requiring recurrent lift assists (Agarwal and Angeles et al., 2024). In contrast, post-discharge MIH programs more commonly reported shifts in patterns of utilization, such as increased outpatient contact or short-term observation stays, rather than consistent reductions in emergency service use (Gingold et al., 2021; Gregg et al., 2019; Lurie et al., 2023).

Intermediate Clinical and Medication-Related Outcomes

Intermediate clinical outcomes were most frequently evaluated in community-based screening and linkage models, where repeated assessments were associated with reductions in systolic and diastolic blood pressure and improved identification of cardiometabolic risk factors (Agarwal et al., 2015, Agarwal et al., 2016, Agarwal et al., 2019, Agarwal et al., 2020; Agarwal and Pirrie, et al., 2024). In contrast, post-discharge MIH programs more commonly examined medication-related outcomes, with pilot studies reporting short-term improvements in adherence that attenuated over time (Sokan et al., 2022). High-utilizer home-visit models rarely assessed intermediate cardiovascular or medication-related outcomes.

Cost and Resource Outcomes

Economic outcomes were evaluated in a limited number of studies, most commonly within post-discharge MIH programs. Propensity-matched and controlled evaluations generally did not demonstrate consistent short-term differences in total charges or health care costs compared with usual care, although some programs reported shifts in utilization patterns, including short-term increases in observation stays (Gingold et al., 2021; Sokan et al., 2022). Community-based screening and high-utilizer models infrequently included formal economic analyses, limiting cross-model cost comparison.

DISCUSSION

Effectiveness Across Community Paramedicine and MIH Models

Across CP and MIH interventions targeting cardiovascular risk and heart failure, effectiveness varied by intervention model and outcome domain. Utilization outcomes, particularly hospital readmissions, differed across studies, whereas improvements in intermediate outcomes such as cardiovascular risk identification, adherence support, and linkage to follow-up care were more frequently reported. Where reductions in acute care use occurred, they were often confined to specific populations or delivery contexts. These patterns suggest that observed effects reflect differences in intervention design, target population, and care context rather than a uniform program effect.

Recruitment Context and Target Population as Mechanisms of Utilization Variability

Observed heterogeneity in utilization outcomes may reflect differences in how intervention models identify and engage patients, in addition to differences in intervention intensity. Post-discharge MIH programs and interventions focused on high EMS utilizes concentrated services among patients identified during periods of heightened clinical vulnerability, commonly through hospital-based referral workflows or utilization-based screening (Feldman et al., 2022; Sokan et al., 2022). While this approach targeted individuals at elevated risk for acute care use, enrollment constraints may have limited participation among patients with greater social or medical complexity, resulting in intensive follow-up for a narrower subset of eligible individuals.

In contrast, community-based screening initiatives engaged broader populations through place-based delivery in trusted settings, supporting higher participation and sustained engagement (Agarwal et al., 2016; Agarwal et al., 2019). These screening models primarily enrolled individuals with lower immediate acuity, which may have con-

strained their ability to influence short-term utilization while supporting improvements in upstream outcomes such as risk identification and linkage to care. Across models, barriers related to housing instability, communication access, and language were reported to restrict reach among individuals at elevated cardiovascular risk (Agarwal et al., 2020; Bourdages et al., 2024; Feldman et al., 2022). Collectively, these contrasts suggest that differences in utilization effects may be associated with model-specific recruitment contexts rather than intervention intensity alone.

Alignment Between Intervention Scope and Consistency of Intermediate Outcomes

Differences in workforce design and scope of practice further distinguish how outcomes emerged across intervention models. Preventive screening programs emphasized standardized assessment, education, and referral—activities that are routine in paramedic practice and less dependent on downstream system responsiveness (Agarwal et al., 2016, Agarwal et al., 2019; Choi et al., 2016). Across screening models, alignment between intervention scope and clearly defined targets is consistent with the more frequent reporting of improvements in intermediate outcomes.

By comparison, post-discharge and high-utilizer programs pursued more complex objectives, including medication optimization and early identification of clinical deterioration (Feldman et al., 2022; Sokan et al., 2022). These higher-acuity models required broader paramedic competencies and more intensive clinical governance, often supported by multidisciplinary teams addressing medical and social complexity (Feldman et al., 2022; Gregg et al., 2019). While such configurations enabled comprehensive follow-up, they also introduced additional dependencies on timely escalation and coordination, which may have contributed to variability in utilization outcomes. Collectively, these contrasts suggest that intermediate outcomes were reported more consistently in models where intervention goals aligned closely with paramedic scope and activities under immediate operational control.

Health System Integration as a Conditional Determinant of Utilization Impact

Differences in utilization outcomes suggest that variation in health system integration may influence the observed impact of CP and MIH interventions, rather than functioning as a uniform feature across models. Community-based screening programs relied primarily on informational integration with primary care, typically through standardized assessment reports intended to prompt follow-up (Agarwal et al., 2016; Choi et al., 2016). While this level of integration supported awareness of cardiovascular risk, its influence on utilization appeared limited by workflow burden and constraints in data interoperability (O'Meara et al., 2015).

In contrast, post-discharge MIH and high-utilizer programs required deeper functional integration with hospital systems and cross-sector care networks. HF-focused interventions depended on access to electronic health records, coordination with pharmacies, and linkage to outpatient clinicians to support medication reconciliation and continuity of care (Feldman et al., 2022; Gregg et al., 2019; Sokan et al., 2022). Differences in utilization outcomes appeared to correspond with variation in the degree of integration achieved, rather than the presence of home visits alone, suggesting that observed effectiveness may depend in part on integration capacity in addition to intervention structure.

Implications and Directions for Future Research

Viewed collectively, these cross-model contrasts suggest that CP and MIH programs may have the greatest impact when intervention scope, recruitment context, and integration capacity are aligned. Variability in utilization outcomes appears related to differences in model design and implementation context rather than inconsistent implementation or intervention intensity alone. Interpretation of these patterns is tempered by heterogeneity in study design, outcome definitions, and follow-up duration, which limits causal inference and cross-study comparability. In contrast to prior CP or MIH-focused literature that aggregates heterogeneous interventions, this model-based synthesis highlights that observed variability may correspond to structural differences in intervention design and care context rather than inconsistent intervention performance (Bigham et al., 2013; Choi et al., 2016; O'Meara et al., 2015).

Future evaluations would benefit from comparative designs that explicitly assess differences across intervention models, standardize outcome measurement, and more clearly characterize how integration mechanisms interact with patient complexity and care infrastructure. Such approaches may help clarify when improvements in intermediate outcomes are associated with sustained reductions in acute care use and inform the design of context-appropriate CP and MIH interventions.

LIMITATIONS

The available literature on CP and MIH programs for cardiovascular risk and heart failure remains limited in scope and consistency. Most core empirical studies were single-site program evaluations, feasibility studies, or observational analyses, with relatively few randomized or contemporaneously controlled designs. Sample sizes were often modest, and follow-up periods frequently emphasized short-term utilization outcomes, limiting assessment of sustained cardiovascular risk modification, longer-term heart failure trajectories, patient adherence, or downstream clinical outcomes.

Outcome measures were inconsistently defined across studies, with primary emphasis on emergency department visits, EMS utilization, and hospital readmissions rather than disease-specific clinical endpoints, patient-reported outcomes, functional status, or objective cardiovascular risk markers. Economic outcomes were variably assessed, with few studies employing standardized cost accounting approaches, limiting comparability across programs. Interpretation is further constrained by heterogeneity in program structure, visit frequency, scope-of-practice regulations, degree of health system integration, and availability of downstream referral resources. These differences limit direct comparison across models and precluded quantitative pooling.

In addition to limitations of the evidence base, this review is subject to methodological constraints. The literature search was limited to PubMed/MEDLINE and English-language, human-subject literature, and no additional bibliographic databases, trial registries, grey literature sources, or non-peer-reviewed reports were searched. Relevant literature indexed in databases such as CINAHL, Embase, Scopus, or Web of Science may therefore have been missed, particularly given the interdisciplinary nature of community paramedicine and mobile integrated health research. Citation linking was used to supplement the database search, but this approach may preferentially identify studies connected to already retrieved literature.

Screening and study selection were conducted manually by a single reviewer, and no formal extraction table was used. Study authors were not contacted for clarification or missing data. No formal study-quality or risk-of-bias tool was applied; instead, methodological rigor was considered narratively according to study design, presence of a comparison group, sample size, follow-up duration, outcome definition, and potential confounding. Accordingly, conclusions regarding conditional effectiveness should be interpreted as hypothesis-generating rather than definitive.

CONCLUSIONS

Community paramedicine and mobile integrated health programs extend cardiovascular risk assessment, monitoring, and care coordination beyond traditional clinical settings and are consistently feasible across diverse contexts. Evidence of benefit is most consistent in preventive screening initiatives, early post-discharge monitoring, and narrowly targeted high-utilizer populations, while effects on early hospital readmissions remain variable. Patterns suggested by the reviewed literature highlight the importance of intervention intensity, population selection, and integration with existing care systems. Future research should prioritize standardized outcome measures, longer follow-up, and implementation-focused evaluation to inform scalability and optimize the role of paramedic-led models in cardiovascular and heart failure care.

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APPENDIX

PubMed/MEDLINE Search Strategy

The following PubMed/MEDLINE search was completed on February 28, 2026, and returned 44 records:

("community paramedicine"[tiab] OR "community paramedic"[tiab] OR "community paramedics"[tiab] OR "mobile integrated health"[tiab] OR "mobile integrated healthcare"[tiab] OR "mobile integrated health care"[tiab] OR "MIH-CP"[tiab] OR "MIH CP"[tiab]) AND ("heart failure"[tiab] OR "congestive heart failure"[tiab] OR "Heart Failure"[Mesh] OR hypertension[tiab] OR hypertensive[tiab] OR "Hypertension"[Mesh] OR "blood pressure"[tiab] OR "cardiovascular risk"[tiab] OR "cardiometabolic risk"[tiab] OR "cardiovascular disease"[tiab] OR "cardiovascular diseases"[tiab] OR "Cardiovascular Diseases"[Mesh] OR cardiopulmonary[tiab] OR "post-discharge"[tiab] OR postdischarge[tiab] OR readmission*[tiab]) AND ("2016/01/01"[Date - Publication] : "2026/01/31"[Date - Publication]) AND english[Language] AND humans[Filter]

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CASE REPORTS

CPR-INDUCED CONSCIOUSNESS FROM THE PATIENT PERSPECTIVE: A CASE REPORT

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Keywords: consciousness, cardiopulmonary resuscitation, out-of-hospital cardiac arrest, emergency medical services, EMS, paramedicine

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ABSTRACT

Background: Cardiopulmonary resuscitation-induced consciousness (CPRIC) is increasingly recognized during high-quality chest compressions, but the patient's lived experience is under-reported.

Case: A 70-year-old man collapsed from witnessed ventricular fibrillation (VF) arrest. Bystanders began CPR within two minutes; EMS arrived at ten minutes. During compressions he displayed eye opening, groaning, lateral rolling, and purposeful localization that intermittently impeded compressions. Airway adjuncts were limited by trismus; bilateral nasopharyngeal airways and two-person bag-valve-mask ventilation were used. Three 200 J shocks were delivered; return of spontaneous circulation occurred approximately 17 minutes after collapse.

Patient perspective: Post-event he described vivid, dream-like awareness of being restrained and struggling to breathe described as "almost like being buried alive" without sound or ability to communicate. He recalled sharp left tibial pain with intraosseous access, the road journey, and emergency department handover.

Outcomes: Coronary angiography showed no obstructive disease. An implantable cardioverter-defibrillator was placed. He was discharged neurologically intact.

Conclusion: Patients may form explicit and distressing memories during CPR and early post-ROSC. Anticipatory communication, rapid recognition of interfering CPRIC, and titrated sedation/analgesia may improve care while preserving CPR quality. Systems should include structured follow-up to address psychological sequelae.

CASE REPORT

On a weekday morning in February 2026, paramedics were dispatched to a cardiorespiratory arrest involving a 70-year-old male. Response time of the first paramedic was ten minutes. The patient was witnessed by three bystanders collapsing. The patient later recalled that he had "suddenly felt very lightheaded" immediately prior to losing consciousness. Effective cardiopulmonary resuscitation (CPR) commenced by bystanders two minutes after collapse prior to ambulance arrival.

The patient had a past medical history of hypertension and type 2 diabetes mellitus (T2DM). He had a known left bundle branch block (LBBB) on prior EKGs, confirmed on hospital admission.

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Apart from brief lightheadedness immediately before collapse, he denied chest pain, palpitations, dyspnea, or previous syncope. Regular medications included aspirin, cholecalciferol, metformin, and latanoprost. There was no family history of premature sudden cardiac death in a first-degree relative.

A single paramedic was applying defibrillation pads on arrival of a second crew member. Initial rhythm was coarse ventricular fibrillation (VF). Manual CPR continued per high-performance CPR principles, and anterolateral pads delivered 200 J biphasic defibrillation.

During compressions the patient exhibited features consistent with CPR-induced consciousness (CPRIC), including eye opening and blinking, groaning, attempts to roll laterally, and purposeful localization to the sternum. Neurological assessment recorded a maximum Glasgow Coma Scale (GCS) score of 9 (E2, V2, M5) in the absence of palpable pulses. Motor agitation intermittently impaired compression efficacy. The patient later described his recollections as:

> *"My first conscious thought was like a dream. I was in a dark place and seemed to be struggling to breathe. I saw faces… and they seemed, at first, to be attacking me, pushing me down but I was trying to get up… Probably almost like being buried alive by people and trying to get up. I had no awareness of sound, and I couldn't communicate with these people. What were these people doing to me? It was a vivid dream. It was black and grey."*

Airway management was complicated by marked trismus, preventing placement of oropharyngeal adjuncts. Bilateral nasopharyngeal airways were inserted with bag-valve-mask (BVM) ventilation commenced. Two-person BVM was adopted once additional resources arrived, with visible improvement in central cyanosis.

Three 200 J biphasic shocks were delivered for coarse VF during paramedic-led advanced life support (ALS), each accompanied by an audible groan from the patient. At seven minutes into ALS (17 minutes from collapse), return of spontaneous circulation (ROSC) was achieved, in pulsed polymorphic ventricular tachycardia (VT), then stabilized with synchronized cardioversion at 100 J biphasic to sinus tachycardia. Figure 1 shows the EKG during this defibrillation sequence.

Approximately 30 seconds post-ROSC, intraosseous access was established in the left proximal tibia following two unsuccessful intravenous attempts during resuscitation. On saline flush, the patient demonstrated a marked pain response, withdrawing his leg and attempting to sit upright. He later recalled:

> *"Then I [sic] felt a sharp pain in my left shin near my knee. I think I tried to kick. I think I tried to look towards my left leg."*

Neurological recovery was rapid. Within two minutes post-ROSC, the patient obeyed commands, including opening his mouth to facilitate oropharyngeal suctioning of secretions. Within five minutes he was verbally responsive. No advanced airway was required. The patient described this period:

> *"The black faded as the faces became more visible and I noticed the uniforms and realized the people around me were paramedics. It was still 'grey,' but this gradually became daylight. I had no awareness of where I was."*

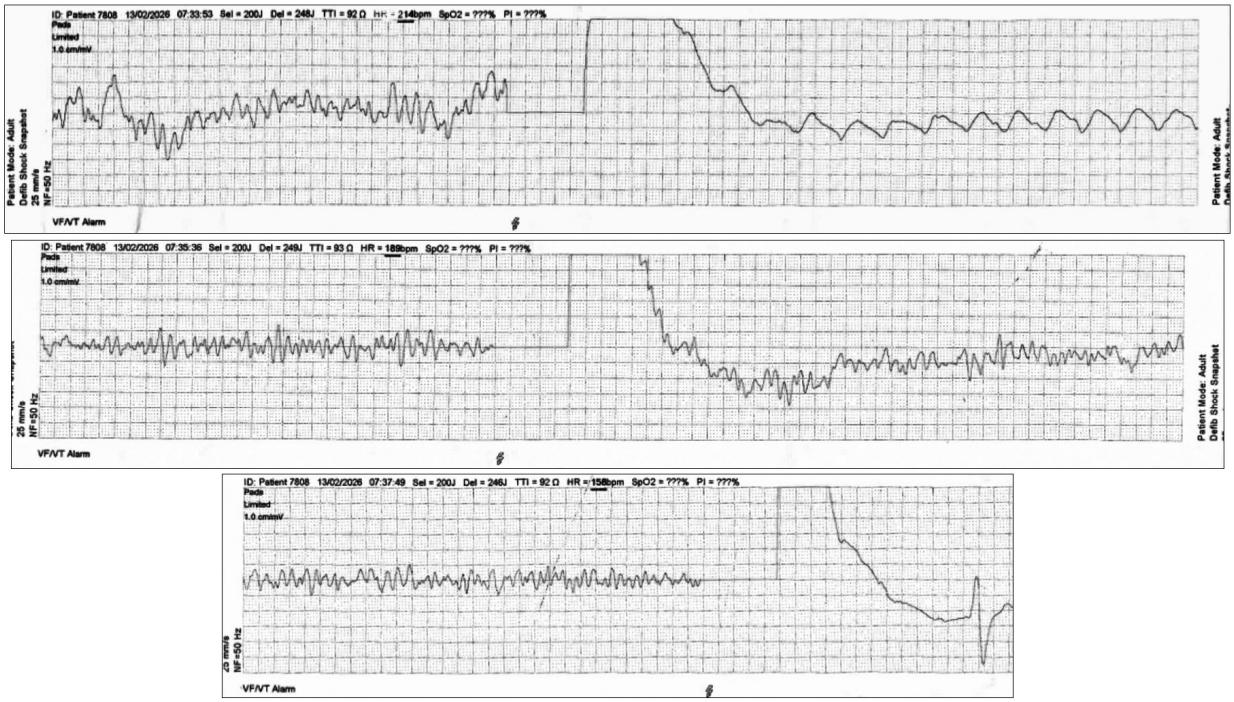


Figure 1. Arrest rhythm and defibrillation sequence.

For analgesia, 40 mg of 1% lidocaine was administered intraosseously, followed by 50 mcg of fentanyl approximately two minutes post-ROSC. This was provided for anticipated post-compression pain, guided by the patient's level of consciousness. The patient later stated:

> *"I can't recall any pain during the entire process to this point except for the sharp pain in my left shin."*

Extrication occurred 13 minutes after ROSC. During extrication and transport, the patient was hemodynamically stable, maintained conversation, and a GCS of 15. A 12-lead EKG showed sinus tachycardia with left bundle branch block, consistent with his known baseline pattern (Figure 2). The patient later described his recollection of arriving at hospital:

> *"I remember the drive back to the hospital, and at times trying to work out where I might be on the journey. The pulling into the ambulance bay, the removal from the ambulance, the wheel into emergency is all quite vivid in my memory. I have a good recollection of people coming into the room and the paramedic talking with me and then briefing the ER team on the sequence of events."*

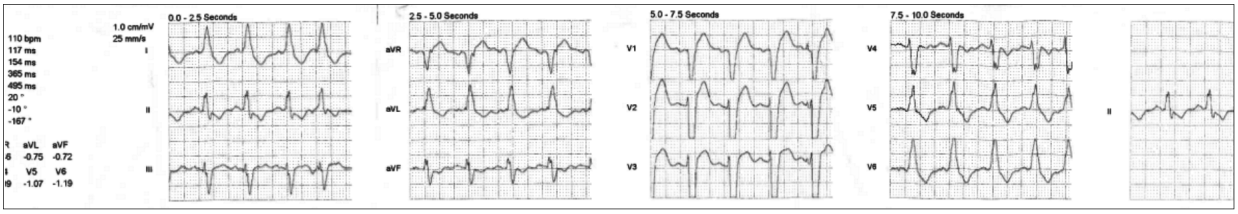


Figure 2. Post-ROSC EKG. Sinus tachycardia with left bundle branch block, consistent with baseline pattern.

Initial laboratory testing showed isolated hyperglycemia with no other abnormalities. Chest radiography was unremarkable. Transthoracic echocardiography showed normal left ventricular (LV) size and preserved LV systolic function, with no significant valvular disease or right ventricle (RV) dilation. Coronary angiography the following day revealed no obstructive coronary artery disease.

The differential diagnosis for ventricular fibrillation arrest included acute coronary occlusion, electrolyte disturbances (hypo- or hyperkalemia, hypomagnesemia), drug or toxin effects, pulmonary embolism, primary electrical disorders (e.g., Brugada syndrome, long-QT syndrome, catecholaminergic polymorphic ventricular tachycardia), and structural cardiomyopathy. Acute coronary occlusion was considered less likely given the absence of new ischemic changes on EKG and non-obstructive coronary angiography. Electrolyte results were within reference ranges. There were no history or examination findings to suggest toxin exposure. Echocardiography showed no structural abnormality to account for the arrest. A primary arrhythmogenic cause was presumed, and an implantable cardioverter-defibrillator (ICD) was placed. The patient was discharged home neurologically intact, with no apparent deficits. A concise visual timeline is provided in Table 1.

Time (min)	Event	Details
0	Collapse	Witnessed by three bystanders after brief lightheadedness
2	Bystander CPR	Effective CPR initiated prior to EMS arrival
10	Paramedics arrive / ALS begins	Initial rhythm coarse VF; high performance compressions; anterolateral pads; 200 J biphasic defibrillation planned
10-16	Ongoing ALS	CPRIC behaviors observed (eye opening, groaning, lateral rolling, purposeful localization), intermittently impairing compressions; three 200 J biphasic shocks delivered
16	ROSC	ROSC in pulsed polymorphic VT; stabilized to sinus tachycardia with synchronized cardioversion 100 J
17	IO access	Left proximal tibia; patient exhibits marked pain response and later recalls sharp shin pain
18	Neuro recovery	Obeys commands; oropharyngeal suctioning facilitated
21	Verbal	Conversational; no advanced airway required
29	Extrication	Hemodynamically stable; 12 lead EKG later shows sinus tachycardia with LBBB (Figure 2)
43	ED arrival	Handover; patient recalls journey and ED entry
Next day	Angiography	No obstructive CAD; arrhythmogenic cause presumed
3 days post collapse	ICD	implantable cardioverter-defibrillator (ICD) placed without complication
4 days post collapse	Discharge	Neurologically intact; ICD in situ; follow up arranged

(Times are approximate and referenced to collapse as t = 0 min)

Abbreviations: CPR, cardiopulmonary resuscitation; EMS, emergency medical services; ALS, advanced life support; VF, ventricular fibrillation; CPRIC, CPR-induced consciousness; ROSC, return of spontaneous circulation; VT, ventricular tachycardia; IO, intraosseous; EKG, electrocardiogram; LBBB, left bundle branch block; ED, emergency department; CAD, coronary artery disease; ICD, implantable cardioverter-defibrillator.

Table 1. Timeline of events from collapse to discharge.

DISCUSSION

This case report describes out-of-hospital ventricular fibrillation arrest complicated by CPRIC with explicit recall. During high-quality chest compressions the patient demonstrated eye opening, vocalization, and purposeful motor activity that intermittently impeded compressions, yet had no spontaneous cardiac output and no ability to communicate. Post-event, he described distressing sensations of being restrained and unable to

breathe, likened to being buried alive, as well as sharp pain at intraosseous cannulation and recollection of transport and handover. These observations illustrate that CPRIC can involve both complex, life-like behavior and psychologically charged conscious experience, even when arrest is relatively brief and neurological recovery is rapid.

The patient completed a solicited, open-ended written narrative of the event. The three authors independently reviewed the narrative and cross-checked content against the electronic prehospital care record (ePCR) and hospital electronic medical record to confirm timing and interventions; discrepancies, if any, were resolved by consensus. Tolerability and adverse effects were derived from contemporaneous clinical observations during resuscitation and transport and from patient self-report at follow-up. Adverse events and tolerability findings are outlined in Table 2.

Domain	Event/ Description	Timing/ Context	Patient Reported Experience	Observed Effect and Management	Impact on Care
Immediate intra arrest discomfort	Audible groaning with each 200 J shock and during CPR	During defibrillation and while CPR ongoing	Distress recalled without sound perception	Defibrillation continued as indicated; team noted groans	Some movement by the patient during the arrest may have impacted CPR quality
Airway related discomfort	Trismus prevented oropharyngeal adjuncts	During CPR	Patient didn't report awareness of airway adjuncts	Bilateral nasopharyngeal airways inserted; two person BVM once additional resources arrived; cyanosis improved	Limited effective early airway management
Vascular access pain	Sharp pain at left proximal tibial IO flush	Approximately 30 seconds post-ROSC	Focal shin pain later recalled	Leg withdrawal and attempted sit up observed; proceeded with analgesia	Potential for dislodgement of IO – did not occur in this case.
Abbreviations: CPR, cardiopulmonary resuscitation; BVM, bag-valve-mask; IO, intraosseous; ROSC, return of spontaneous circulation.					

Table 2. Adverse events and tolerability. Summary of intra-arrest and post-ROSC adverse events, patient-reported experiences, observed effects, and management.

CPRIC is increasingly recognized as a complication of contemporary resuscitation practice, particularly in the context of high-performance CPR, compression-only CPR, and mechanical compression devices. It is characterized by life-like behavior in patients who remain in cardiac arrest, including eye opening, jaw tone, speech, and purposeful body movement (Olaussen et al., 2017; Pinto et al., 2020; Pourmand et al., 2019). Expert consensus has defined CPRIC as a demonstration of consciousness during ongoing CPR in the absence of measurable spontaneous circulation and has further distinguished between interfering and non-interfering subtypes according to whether observed activity impedes resuscitative interventions (Howard et al., 2024). This patient's attempts to roll, localize to the sternum, and withdraw from painful stimuli, together with his later narrative of struggling against perceived restraint, are consistent with interfering CPRIC.

The patient's account provides insight into the phenomenology and potential psychological impact of CPRIC. He recalled a dark, grey environment in which he felt he was being attacked and pushed down while trying to get up, with no perception of sound and no sense that he could communicate. Only later did he recognize the uniforms of paramedics and reframe the experience as an attempted rescue. These descriptions mirror reports from the AWARE II study and other cases, in which survivors have described pain, pressure, bouncing, and the presence of electrodes during CPR (Parnia et al., 2023; Pound et al., 2017), and they align with observational data on CPRIC in out-of-hospital

cardiac arrest (Doan et al., 2020). Patients who experience CPRIC may therefore be at risk of psychological distress and longer-term sequelae, which supports the value of post-resuscitation debriefing and psychological support.

CPRIC also presents practical and ethical challenges for resuscitation teams. Interfering movements may lead clinicians to mistakenly interpret patient activity as sustained return of spontaneous circulation and cease compressions prematurely, or may physically hinder compressions, airway management, and vascular access (Pourmand et al., 2019). In this case, motor agitation intermittently impaired compression quality and complicated airway management in the setting of trismus, requiring bilateral nasopharyngeal airways and two-person bag-valve-mask ventilation. Rescuers must reconcile the imperative to continue potentially life-saving interventions with the apparent distress and resistance of a conscious patient.

Current international guidance on the management of CPRIC remains limited. The International Liaison Committee on Resuscitation Advanced Life Support Task Force suggests that, where feasible, small doses of sedative and or analgesic drugs may be considered to prevent pain and distress in conscious patients during CPR, cautions against the use of neuromuscular blockade in this context, and notes that the optimal drug choice is uncertain and should be guided by local guidelines (West et al., 2021). A scoping review identified multiple prehospital guidelines that include management options for CPRIC and demonstrated wide variation in recommended medications and doses, with ketamine, fentanyl, and midazolam most frequently listed (Howard et al., 2022). This variability reflects both the emerging nature of the evidence base and differing priorities regarding hemodynamic stability, ease of use, and potential psychological benefit.

The most comprehensive attempt to standardize the definition and management of CPRIC to date is a Delphi study that proposed operational definitions and expert-consensus recommendations (Howard et al., 2024). In that work, interfering CPRIC, defined as activity that actively impedes resuscitative interventions such as resisting compressions, removing lines or airway devices, or exhibiting higher-level responses including verbalization, was considered to warrant pharmacological management. Non-interfering CPRIC, characterized by less disruptive signs such as blinking, eye movements, groaning, or minor limb movement, generated more divergent views. Experts expressed concern that sedatives given for non-interfering CPRIC might worsen hemodynamics, but some also supported treatment on humane grounds to reduce pain and potential psychological trauma (Howard et al., 2024; Rice et al., 2016).

Expert consensus favors ketamine as the first-line agent for interfering CPRIC, at 0.5 to 1.0 mg per kg administered as an intravenous bolus (Howard et al., 2024). There was no clear consensus on second-line therapy, with fentanyl and midazolam both commonly proposed (Howard et al., 2024). Ketamine, already carried by paramedics in many systems, has several features that make it attractive in this setting, including combined sedation and analgesia with typically mild sympathetic stimulation rather than cardiovascular depression (Medical Advisory Committee, Ambulance Victoria, 2021; Rice et al., 2016). Although there is a theoretical concern that ketamine could increase myocardial oxygen demand through sympathetic activation, this has not been demonstrated in cardiac arrest and preserved or enhanced perfusion pressures may be advantageous (Medical Advisory Committee, Ambulance Victoria, 2021; Rice et al., 2016). Co-administration

of opioids or benzodiazepines may attenuate sympathetic responses and emergence phenomena but carries a greater risk of hypotension. During arrest, ventilatory support is already in place, but cardiovascular compromise remains a key concern (Medical Advisory Committee, Ambulance Victoria, 2021).

This case should be interpreted in light of its limitations. As a single case report, it cannot determine the incidence of CPRIC, the effectiveness or safety of specific pharmacological strategies, or the long-term psychological outcomes associated with different management approaches. Neurologic prognosis after brief arrest with rapid recovery is generally favorable (Park et al., 2022). However, patients who recall CPR may experience persistent psychological symptoms, including intrusive memories, anxiety, sleep disturbance, and features consistent with post-traumatic stress (Sawyer et al., 2020). In systems with follow-up pathways, structured screening and support are recommended (Sawyer et al., 2020). For this patient, follow-up included ICD clinic review within 4 to 6 weeks and an offer of psychological support, which was not required. Formal screening with tools such as the Impact of Event Scale-Revised (IES-R) and subsequent referral or self-management resources should be considered for patients who have experienced CPRIC (Wagner et al., 2025).

The patient's recollections may also be influenced by peri-arrest hypoxia, analgesia administered post-ROSC, and subsequent discussions with clinicians. Nonetheless, his detailed account is consistent with observational studies and case reports describing CPR-related awareness and distress, and it contributes a patient perspective from an Australian out-of-hospital setting (Al Atbi et al., 2022; Brede et al., 2024; Doan et al., 2020; Kalawila & Weerasingha, 2024; Mittelman et al., 2024; Pinto et al., 2020; Pound et al., 2017; Silvestri et al., 2023; Talikowska et al., 2024; West et al., 2021; Zhou & Sun, 2024). The case also highlights the need for structured post-resuscitation follow-up to identify and address psychological sequelae. No diagnostic challenges related to access, financial, language, or cultural factors were encountered in this case.

CONCLUSIONS

This case provides a detailed, time-anchored prehospital narrative of CPRIC with explicit patient recall. It integrates patient-reported experience with clinical observations and links airway, analgesia, and communication decisions to system-level follow-up. The account offers novel insights into the content and timing of recall during CPR and the immediate post-ROSC period, informing humane and performance-preserving practice. This case reinforces that CPRIC is a clinically important phenomenon associated with vivid, sometimes distressing awareness during arrest and early post-ROSC. For clinicians and systems, these observations support several practical steps: proactive recognition of CPRIC; anticipation and mitigation of its effect on compression quality; consideration of titrated sedation and analgesia, particularly when movements interfere with resuscitation; clear local guidelines aligned with emerging consensus; and structured post-resuscitation follow-up with psychological screening. Further research should clarify the global epidemiology of CPRIC, determine the hemodynamic and survival effects of different sedative and analgesic regimens, and optimize patient-centered outcomes in this growing survivor population.

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SPECIAL REPORTS

QUALITY IMPROVEMENT IN CRIME SCENE ACCESS TRAINING FOR EMS FIRST RESPONDERS

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ABSTRACT

This article evaluates the effectiveness of specialized training for Emergency Medical Services personnel (EMS) and first responders in managing crime scenes without compromising forensic integrity. EMS personnel involved in this study came from Italian pre-hospital services. They were involved in two distinct simulation-based events.

The authors adopted a multidisciplinary approach to develop an evaluation grid that highlights problems, risks, and opportunities for staff training. The authors analyzed case reports and historical cases to create scenarios. The authors emphasize the need for a standardized solution to equip a wide range of first responders to handle crime scenes. Additionally, a VR (Virtual Reality) solution was tested to educate students. The article identifies critical gaps in crime scene recognition, contamination prevention, and inter-agency communication when first responders lack dedicated preparation.

The primary findings concern EMS first responders' ability to recognize and manage potential crime scenes. Comparing two simulation cohorts – untrained crews and trained crews – correct scene recognition increased from 28.5% to 60%. Accurate notification to the Dispatch Center and timely law-enforcement request rose from 36% in untrained teams to 80% in trained teams. Evidence handling benefited as well. Teams that moved victims while preserving evidence increased from 25% to 76.6%. Correct egress from the scene – considered scenario-dependent – reached 80% in the suicide scenario, 60% in the sexual-assault scenario, and 20% in the domestic-violence scenario. Together, these results indicate that structured, multidisciplinary training strengthens scene recognition, inter-agency communication, and preservation of forensic integrity during EMS operations. Without proper training, EMS first responders are at risk of compromising crime scenes and safety. Structured programs that combine theory, simulation, and inter-agency collaboration could improve these aspects. Priority training areas include dispatch communication, safety, evidence handling, and documentation. This study lays the groundwork for standardized national protocols and advocates for expanded use of Virtual Reality (VR) training technologies.

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Acronym	Definition
First Responder	An EMS provider - professional or volunteer - trained to provide basic life support and trauma management. Usually called "soccorritore" in Italy. first responders involved in the trainings came from Red Cross, ANPAS, and Misericordie as volunteers (Metelmann, C. et al., 2025).
Crime scene	Any location containing physical evidence that can help to reconstruct past activities related to a criminal act or event (Miller, 2002).
Contamination	The unwanted alteration of evidence that could affect the integrity of the original exhibit or the crime scene. This unwanted alteration of evidence can wipe away original evidence transfer, dilute a sample, or deposit misleading new materials onto an exhibit(Gehl & Plecas, 2016).
VR (Virtual Reality)	Virtual Reality is a three-dimensional, computer-generated simulated environment, which attempts to replicate real world or imaginary environments and interactions, thereby supporting work, education, recreation, and health (Abbas et al., 2023).
Ambulance Nurse	Nurses specialized in critical care or emergency care involved in the EMS. The nurses involved in this study are registered in the SIIET scientific society (Società Italiana Infermieri di Emergenza Territoriale) (Baldini et al., 2020).
Trauma and ALS Doctors	Doctors specialized in anesthesiology or emergency care are usually involved in EMS. The doctors involved in this study are registered in the HEMS Association society (Bulger et al., 2014).

Table 1. Definition of acronyms.

INTRODUCTION

Emergency medical interventions represent a critical phase in rescue operations. Good performance requires meticulous preparation, adequate training, extensive experience, and the proper use of equipment and medical devices. In Italy, EMS teams are often the first to arrive at the scene in cases of medical emergencies (Commissione Consultiva Permanente Stato-Regioni, 2018), including crime scenes. The foremost priority for any first responder (medical or technical) is to assist the victim through life-saving measures such as Basic Life Support-Defibrillation (BLSD) (Daibes et al., 2025) or hemorrhage control (Gehl & Plecas, 2017).The responsibility of providing life-saving care while navigating the complexities of a crime scene presents unique challenges. Emergency first responders may unintentionally compromise the site, potentially erasing or altering evidence vital to legal proceedings (Gomes, 2021). Furthermore, inadequate preparation for a criminal scenario can lead to various challenges, including safety risks. These risks include the presence of weapons and violent individuals, as well as the high likelihood of contamination/destruction of evidence.

Due to the complexity of such scenarios, adequate training should be mandatory. The authors propose a simple approach to the crime scene for EMS first responders, grounded in specific training and multidisciplinary guidelines. This quality improvement article aims to suggest a standardized training schema on this topic.

The authors defined four scenario types to test First Responder capabilities. The training missions' focus has been on sexual assault, domestic violence, suicide, and disputes with injuries. The authors organized the assessment into five major domains: arrival on scene; recognition of a potential crime scene; movement of victims/objects; exit from the scene; and notification/reporting to law enforcement. Across these domains, we specified 20 item-level criteria and applied a simplified three-point scale (0 = not performed; 1 = performed; 2 = performed with risk anticipation) to quantify intervention effectiveness with respect to preserving the crime scene.

We developed an evaluation procedure following a scientific approach, even considering the lack of literature in emergency medicine and forensic sciences (Gunshin et al., 2020).

The authors highlighted the absence of a common pattern for practical instruction to improve access at crime scenes.

This quality improvement article aims to demonstrate the need for harmonized goals, to provide immediate medical care, and to preserve forensic evidence. In January 2023, the multi-professional group involved in this project began approaching the topic by designing a real-scale simulation training. Collaboration also facilitated the evaluation of alternative methods that enhance evidence preservation without compromising the distinct objectives of medical intervention (Figure 1).

This experience and the present article aim to serve the EMS community. The authors hope that the delicate aspect of training will find an appropriate place within interdisciplinarity through the application of generally accepted rules and procedures, distancing education from any form of self-referential approach.



Figure 1. Final group participating in crime scene training.

BACKGROUND

EMS first responders must be aware of the needs of a crime scene. To rescue and preserve the victim's health, these needs must be appropriately recognized and managed by the EMS first responders. The best way forward was collaboration between healthcare workers and law enforcement officers to define a single, shared course of action (Hayes, 2000). According to studies published in 2023 by the Institute for Economics and Pace, Italy ranks 32nd (out of 163 countries in the world) for safety and security (Imbriaco et al., 2025).

At first glance, emergency rescue procedures and crime scene preservation may seem irreconcilable: EMS operates with different objectives (International Coaching Federa-

tion, 2024) than Law Enforcement and Scientific Police Departments (James et al., 2014). However, alternative methods, modalities, and procedures that do not detract from the distinctiveness of rescue while still favoring the proper preservation or documentation of important evidence that will be subsequently handled and analyzed by forensic experts (Khan & Amyotte, 2004).

The frequency with which health and safety personnel find themselves operating in violent crime scenarios before law enforcement arrives is the starting point of the training organized by the authors of this article. In Italy, EMS first responders are present at the crime scene long before law enforcement arrives, who are often mobilized after the Medical Emergency crew departs (Noor et al., 2024). Therefore, it is difficult for EMS responders to determine whether they are dealing with a criminal event. Contributing factors to crime scene recognition are related to:

- knowledge of the situation by the caller;
- accuracy of information gathered by dispatch (Presidenza della Repubblica, 1992);
- EMS responders' ability to find and share information gathered appropriately on scene.

The greatest risk of intervening at a potential crime scene without adequate information concerns the safety of responders, bystanders, and the scene itself (Repetto et al., 1998).

Acting carelessly on a crime scene can modify it and potentially lead to the loss of information needed to identify the perpetrator. Having examined the meager literature on the subject and found that there are no standard guidelines for managing medical intervention at crime scenes in Italy (Sacco et al., 2024), the decision was made to conduct a specific test. Our article aims to investigate the most suitable techniques for approaching crime scenes to propose a qualitative improvement in training courses.

Emergency System Activation Phase

Dispatchers' training is not part of this study, but it is important to note that, in the case of a crime scene, early recognition of an abnormal situation is crucial. Calling the unified emergency number (NUE112) usually triggers the activation of several entities that will operate concurrently at the event scene. Starting from a forensic perspective, crime scene intervention consists of two phases: first response and crime scene investigation activity. In Italy, ambulances often arrive at the target more quickly than other forces (Noor et al., 2024). To achieve these goals, the dispatcher must be aware of the mission's dynamics and, above all, remain open-minded enough to consider and recognize the need for multi-role activation.

Responsibilities of Responders at the Scene of the Crime

The first rule that medical first responders must follow concerns their own safety but the second concerns the medical rescue of the victim (Noor et al., 2024). Rescue maneuvers need to be proportional to the gravity of the situation and carried out as quickly as possible, especially when the injuries could result in life-threatening harm. Law enforcement is responsible – as soon as they reach the scene – for ensuring the protection of those present. Then, law enforcement is responsible for "bounding the scene, identifying those present, and taking into custody any material evidence" (Sharma, 2003).

Emergency medical personnel have an obligation to report any information they learn during a rescue. First responders must alert the operations center about the need for law enforcement. This task can also be supported by technology, with video footage and/or photographs (Repetto et al., 1998). As already mentioned, with the current organization of emergency systems for criminal events, the arrival at the scene of the crime generally happens in the following order:

1. BLS healthcare team (EMS ambulance response called "first responders" who can perform BLSD (Soar et al., 2022) and Trauma management (UN International Drug Control Programme, 2009).
2. Law enforcement (Carabinieri or Polizia di Stato)
3. Technical and/or advanced medical rescue crews (ALS medical response unit)

This occurs due to the distribution of operators, services, and ambulances in the area. In most cases, the first public service officer on the scene is, therefore, the BLS healthcare ambulance (Noor et al., 2024).

DESCRIPTION

In January 2023 the authors decided to conduct a simulation test to evaluate first responders' knowledge and competence in operating at a crime scene. The first training test was held in Borgotaro in June 2023 during the first responders exercise called "Tre Confini". On that occasion, first responders did not receive specific training.

After the first training, the authors organized an extended second session in Salsomaggiore in December 2023. The EMS first responders who attended the session followed a training session with the Italian Forensic specialist from the Scientific Investigation Department of Carabinieri. During the lessons, authors adopted coaching education solutions, which the International Coaching Federation recognizes as optimal for content learning and fostering personal awareness and responsibility to improve performance (United Nations Office on Drugs and Crime, 2013). After the training, the authors compared the teams' approaches to the crime scene.

In June 2023, during the rescue exercise in Borgotaro (Figure 2), 15 EMS crews faced a scenario with criminal activities, taking inspiration from a real case. The reconstructed scene involved an argument between two acquaintances. The initial dispatch intentionally did not warn the crews that they would encounter a crime scene. This was done to assess the rescuers' ability to recognize the main elements of such a scenario. The objectives of the crews onsite were to:

- identify the elements that mark the event as a "crime scene";
- alert the operations center appropriately regarding the situation;
- move the patient without contaminating the crime scene;
- correctly perform first aid to the victim;
- preserve the items at the crime scene correctly.

Out of 15 participating teams, 14 were included in the data collection. One team was excluded due to specific request of the team.

In December 2023 in Salsomaggiore Terme, five EMS crews were invited to participate in a crime scene exercise. This exercise was preceded by six online lectures by the Car-



Figure 2. Crime scene assessment in Borgotaro.

abinieri RIS of Parma on the main topics related to the crime scene, as well as a briefing lesson on the scene topics.

Crews were then administered 3 different simulation scenarios where crimes had been committed and one virtual simulation scenario, replicating the Borgotaro simulation with VR 360 technology. In both cases – Borgotaro and Salsomaggiore - it was possible to create high fidelity simulations cases with a crime scene using actors (from the Italian Red Cross of Parma and ANAPS Emilia-Romagna) following rules of high-fidelity simulation drill in EMS (Tartaglione et al., 2022) (Figure 4).



Figure 3. Training with the RIS in Salsomaggiore.

From this point, the evaluation assessed the rescuers' ability to identify the key elements of the crime scenario as quickly as possible. The objectives of the crews onsite were the same for both the exercises. All five participating teams in Salsomaggiore were included in the data collection. The crime scene scenarios created in Salsomaggiore's cases were:

- sexual assault
- domestic violence
- suicide
- disputes with injuries (crime scene performed in VR setting)



Figure 4. Management of relatives during domestic violence scenario.

METHODS

The authors created an evaluation grid with elements that evaluated the approaches taken by the teams when facing a crime scene. The first groups of first responders did not receive specific training. The second group of first responders attended a specific course led by an Italian Forensic specialist from the Scientific Investigation Department of the Carabinieri (RIS).

The evaluation grid includes the following main topics and sub-topics:

- Arrival on scene:
  - appropriate PPE use
  - identification of people involved
  - assessment of the need for law enforcement
- Evaluation of a potential crime scene:
  - identification of evidence/visible weapons
  - warning Dispatch Center of a potential crime scene
  - define a standard entry route
  - assessing the victim without tampering with evidence
  - coordination between rescuers
  - moving the victim without contaminating the evidence
- Moving the victim:
  - preemptive scene recording
  - preemptive weapon removal
  - warning/update Dispatch Center on the situation
  - safeguarding evidence on the victim's clothing
  - victim transfer on the stretchers (log-roll or other maneuvers)
- Leaving the scene:
  - assessment of post-intervention scene changes
  - recovery of materials used
  - stretcher exit on standard entry route
- Providing information to law enforcement:
  - description of initial scene
  - report on actions taken and evidence present

- description of witness behavior and statements

To evaluate the performance of individual rescue teams, the authors developed a unique table with three possible assessments: Action not performed (vote: 0), action performed (Vote: 1), and action performed with risk anticipation (Vote: 2). Despite the lack of specific training in the first group, there was minimal tolerance for delayed implementation of actions.

After the training, the authors compared access to the crime scene results in a single table to create a visual output of the main action that requires further improvements.



Figure 5. Correct movement of the suicide victim.

RESULTS

The crew performance evaluation was conducted on the scene through a visual check of the activity. authors played the role of referees during the examination, using the standard structure of a real scale simulation. In the following results, the first scenario (EMS crew with no training before the exercise) is called Borgotaro. The second scenario (EMS crew with training before and after the exercise) is called Salsomaggiore.

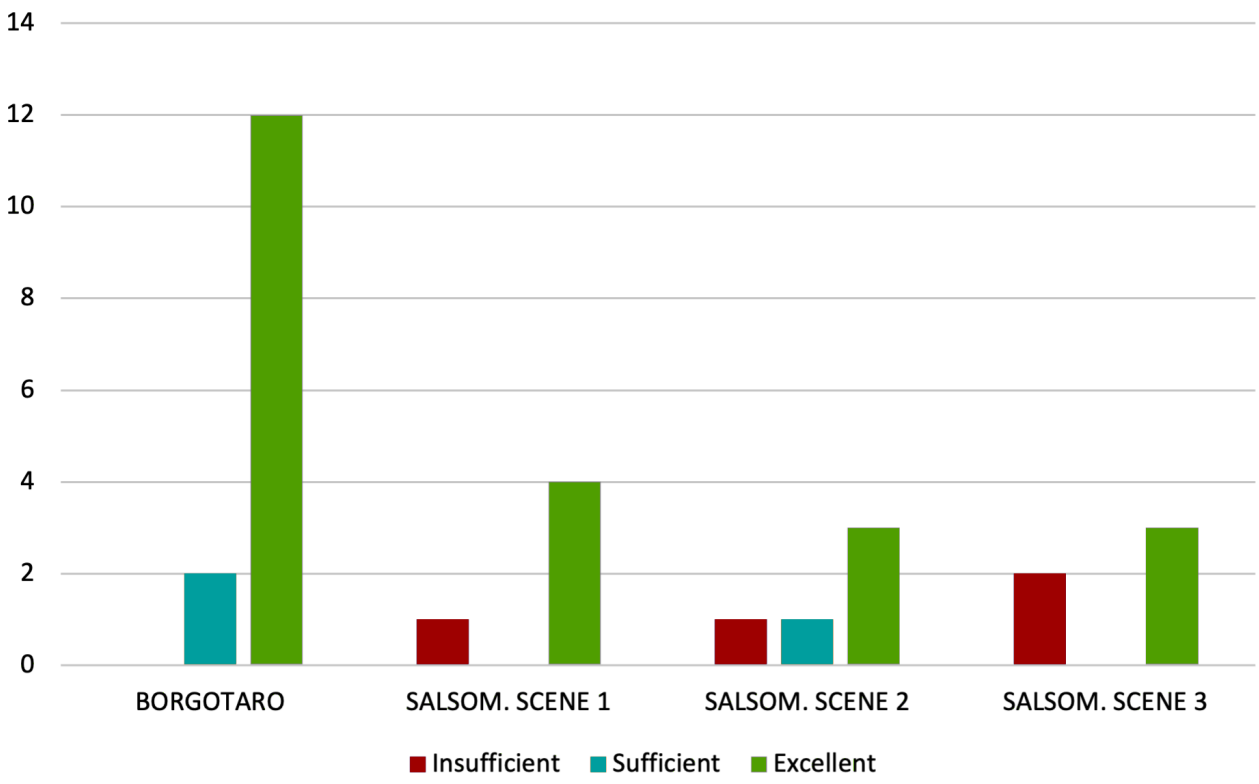


Figure 6. Identification of people involved.

Arrival at the Crime Scene and Recognition of the Crime Scene

See Figure 6. Crews showed competence in identifying individuals present and using appropriate protective PPE. However, differences were observed in their ability to assess the crime scene risk. In Borgotaro, 28.5% of crews demonstrated proper access to the crime scene, whereas in Salsomaggore, this figure increased to at least 60%.

Communication with Dispatch Center and Notification of Law Enforcement Needs

See Figure 7. 36% of the crews in Borgotaro had good communication with the Operations Center, while 28% had sufficient communication, and another 36% had poor communication. In Salsomaggiore, sexual harassment and suicide reach more than 80% of correct communication with the dispatch center. The domestic violence scenario was not included due to the presence of a law enforcement person close to the scene.

Reducing Contamination of the Crime Scene

See Figure 8. In Borgotaro, 42.8% of the crews correctly assessed the crime scene, using a common entry-exit route to the scene. In Salsomaggiore the mean value was 73%. In Borgotaro, 64.2% of the crews assessed the victim without manipulating evidence or took pictures of the scene at arrival, while 80% of the crews in Salsomaggiore performed correctly. In Borgotaro, 25% of the crews moved the victim while preserving evidence at the scene. This value is 76.6% in Salsomaggiore.

Behavior on Leaving

See Figure 9. The behavior of crews observed by the authors when leaving the crime scene is complex but important information. It means:

- correct assessment of post-intervention changes
- scene recovery of materials used (managing contamination)
- exit from the scene on the previous route

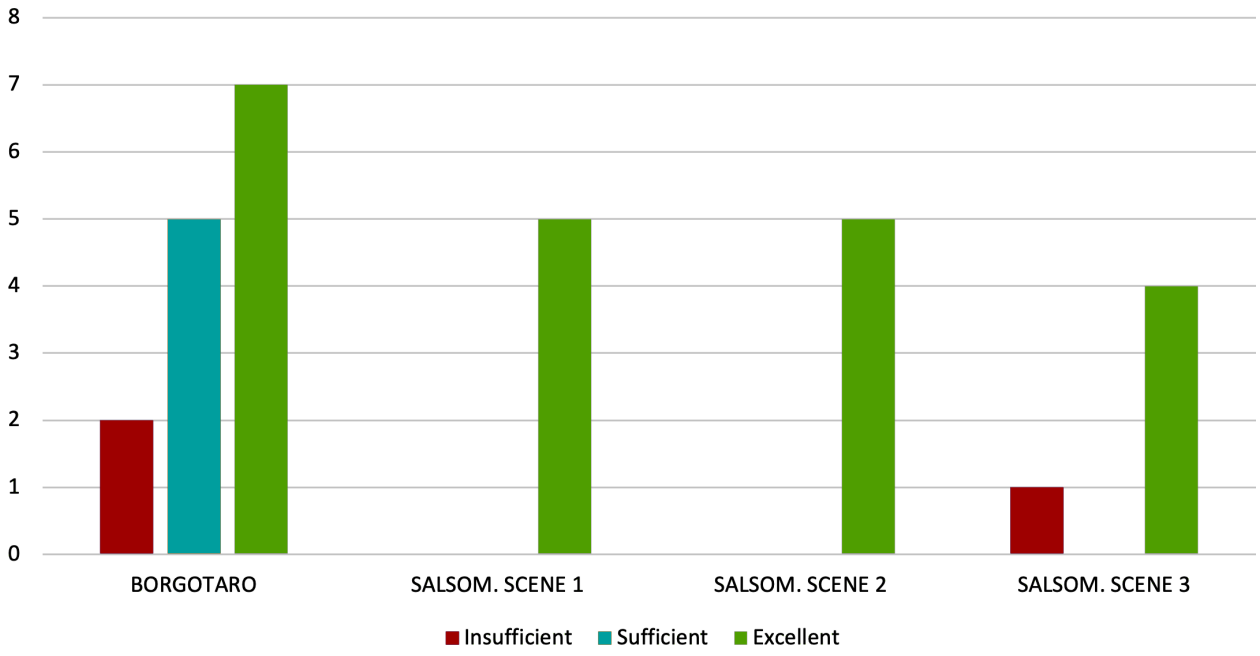


Figure 7. Warning dispatch of potential crime scenes.

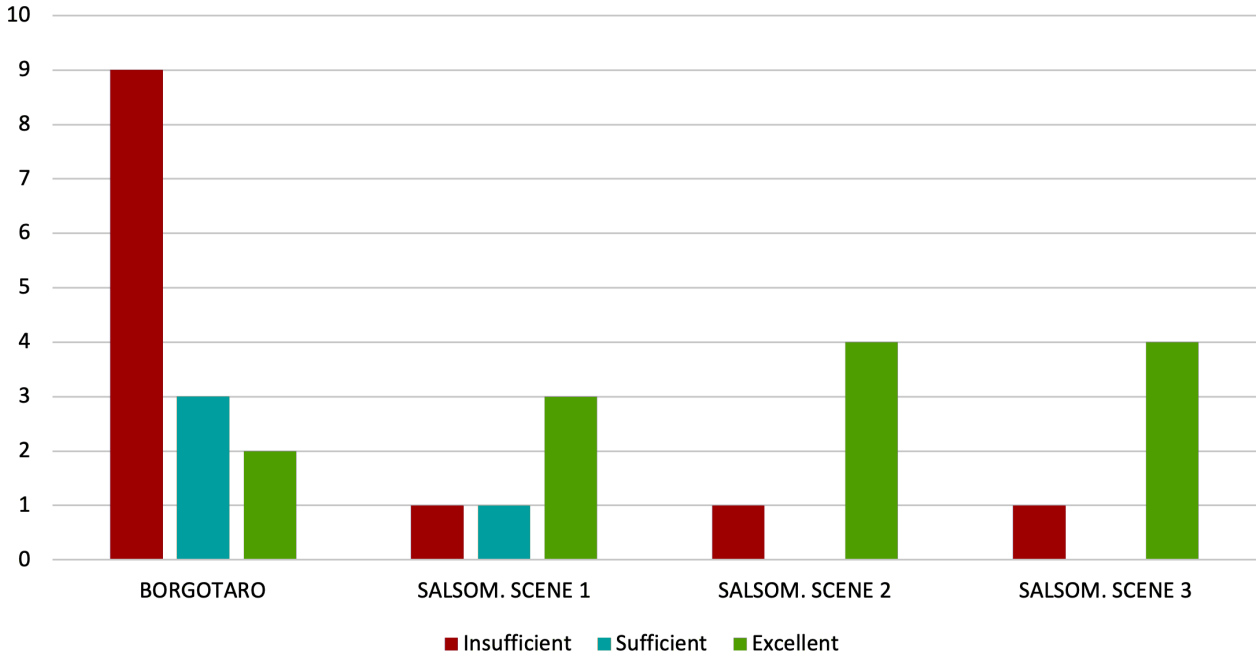


Figure 8. Reducing contamination of the crime scene.

Evaluation in Borgotaro was insufficient in 43% of the cases. In Salsomaggiore, the situation changed for each scenario. In domestic violence cases, 20% of the crews preserved the material correctly, without contamination or safety concerns. In suicide scenarios, 80% of participants left the scene correctly. In outdoor sexual assault scenarios, that percentage dropped to 60%.

Learning and Evaluation of Post-Intervention Changes

See Figure 10. Among the activities monitored, evaluating behaviors greatly interested the study group. According to the instructions, photographs of the crime scene could be

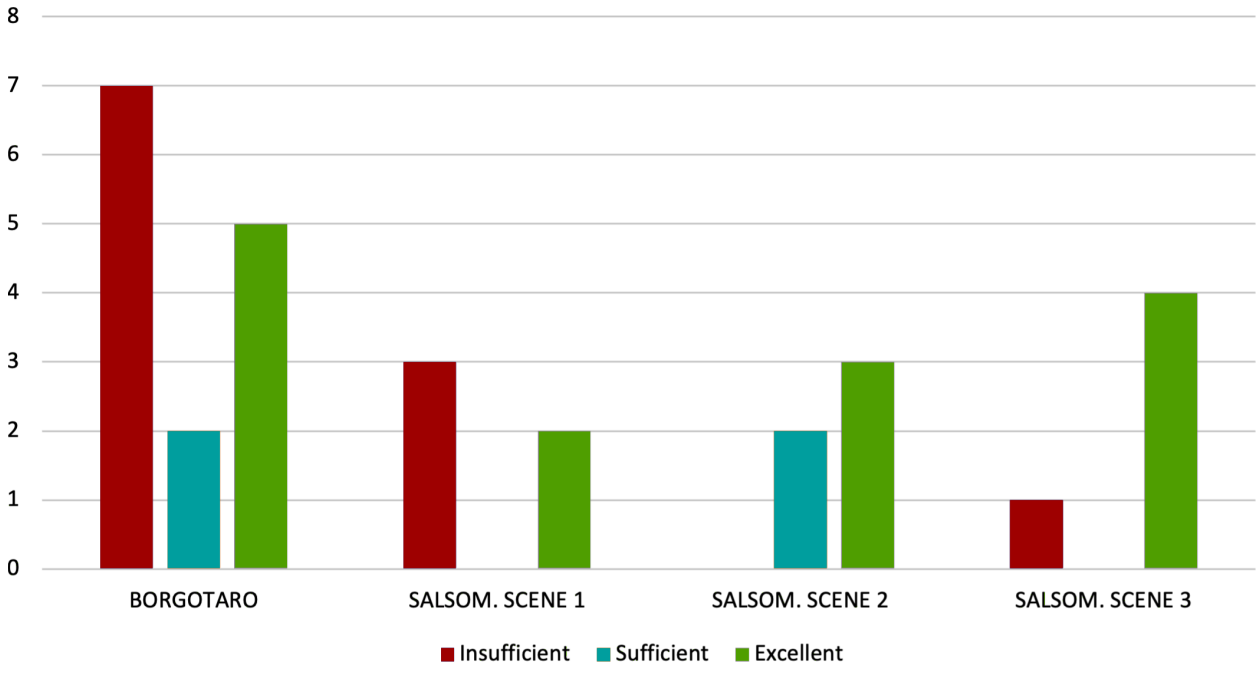


Figure 9. Safeguarding evidence on victim.

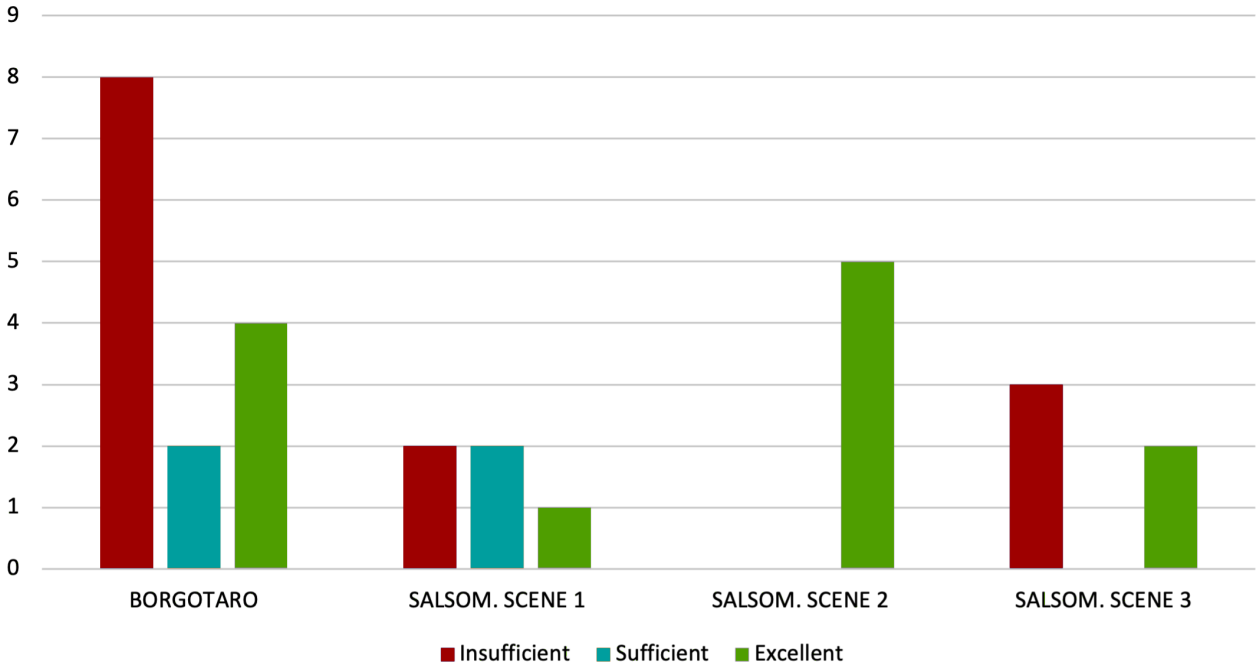


Figure 10. Correct assessment of post-intervention changes.

taken (Repetto et al., 1998). In Borgotaro, seven (50%) teams involved did not take photos, two (14%) teams took photos after making contamination, and four (28.5%) teams took pictures before entering the scene. One team was not rated on the topic as they pointed out the presence of highly restrictive privacy protocols. In Salsomaggiore, 60% of the teams took pictures correctly.

Post-Training: Analysis of Errors and Lessons Learned

At the end of the Salsomaggiore activity, all 27 participating rescuers compiled a satisfaction survey. Data analysis of the multiple-choice questionnaire administered to the trainees shows the outcomes. 96.3% had a correct response rate of 70% or higher. Only 3.7% of the students made more than three errors and did not reach the target.

CONCLUSION

The complexity and challenges of keeping a potential crime scene intact during rescue operations are multiple. The exercise organized by the authors identifies key stressor points. Scenarios involving confrontational bystanders and unidirectional access routes are the main difficulty for EMS first responders. Analysis and discussion suggest that EMS first responders could threaten both the safety of responders, of the victims, and the integrity of crime scenes. Common errors observed during simulations - including improper handling of witnesses, contamination of evidence, and unsafe practices - highlight the need for targeted improvements in training and protocols. This article suggests that the EMS community must define an integrated approach to potential crime scenes for first responders. It establishes the necessity of shared, standardized procedures and protocols to address the identified gaps, from the dispatch center through communication with the forensic team. Training that combines theoretical instruction with practical, scenario-based exercises has proven to be efficient. Confrontation and real scenarios enable participants to develop the skills required for complex, high-stakes environments.

Crime scene operations are inherently stressful, demanding a balance between providing life-saving care and preserving forensic evidence. The importance of comprehensive training programs and the implementation of unified national protocols cannot be overstated. Even though the number of training sessions analyzed is limited, the critical need to improve communication skills emerged - both within rescue teams and between first responders and the Dispatch Center. Communication is a key factor to enhance decision-making and situational awareness (van Dijk et al., 2019).

It is also interesting to analyze the approach of the EMS crew to simulation using VR scenarios. The software presented by the authors represents the crime scenario based on footage recorded during the Borgotaro session. All the first responders played that scenario and appreciated the VR solution. The use of innovative tools, such as VR360 technology, demonstrated significant potential to advance training methods by enabling realistic, repeatable practice scenarios. Given the high resource demands of traditional training setups, VR should play a central role in future educational strategies. Finally, this qualitative improvement article highlights five priority areas for training development:

- strengthening communication between Dispatch Centers and first responders;
- enhancing team coordination during crime scene interventions;
- improving safety management and the handling of agitated individuals;
- establishing protocols for evidence preservation;
- ensuring accurate and detailed documentation of interventions, including the use of photographic and video evidence where appropriate.

By addressing these areas, EMS first responders could reduce critical errors and safeguard the integrity of legal proceedings. This experience lays the groundwork for a more structured approach to crime scene management by EMS teams. Ultimately, this contributes to enhancing the quality of care and pursuing justice.

What additional actions could be considered? After this experience, the authors are wondering what could improve education and safety in a crime scenario. There are many options we would like to suggest working on:

- implement a mandatory national training cascade model (Vannucci & Kras, 2013) on the crime scene for EMS first responders.
- build a database of standard scenarios, to offer a realistic and defined training, with pre-defined complexity, to better face risk and needs of crime scenarios.
- Build a practical guide for EMS first responders created and updated by law enforcement, lawyers, and prosecutors (James et al., 2014) .

LIMITATIONS

The authors acknowledge the limitations of the data collected in this article. The purpose of the paper is not to conduct a validated scientific study, but rather to identify and suggest the most critical areas for future investment. The authors also acknowledge the lack of in-depth analysis of communication within the crew operations center. Future work should also include an analysis of this type of communication.

Regarding methodology, they acknowledge that crews' approaches to crime scenes varied because some data were collected with untrained responders and others with responders who received training just a few hours beforehand. It would be appropriate

and necessary to reevaluate the various working groups at least six months after training. Another challenge in the study is harmonizing medical and forensic terminology, which can sometimes lead to misunderstandings. However, we are confident that the use of realistic simulations helps first responders stay focused on their primary role: saving lives, not collecting evidence.

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International Journal of Paramedicine

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LITERATURE SURVEILLANCE

PARAMEDICINE CONTENTS: APRIL-JUNE 2026

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To help paramedicine professionals keep current with the literature in our discipline, the 'Paramedicine Contents' section shares recent tables of contents of scholarly journals that are primarily focused on the paramedicine discipline.

BRITISH PARAMEDIC JOURNAL

https://www.ingentaconnect.com/content/tcop/bpj

June 2026

Editorial: paramedic careers and research – why it matters and how to start. https://doi.org/10.29045/14784726.2026.3.31.1.1

Evaluation of three mechanical chest compression devices: a simulation-based mannequin study. https://doi.org/10.29045/14784726.2026.3.31.1.5

A survey of UK emergency medical services' approach to incidental identification of atrial fibrillation. https://doi.org/10.29045/14784726.2026.3.31.1.17

Advanced airway management in out-of-hospital cardiac arrest: a service evaluation from a regional English ambulance service. https://doi.org/10.29045/14784726.2026.3.31.1.24

Resuscitation attempts in patients with do not attempt cardiopulmonary resuscitation decisions attended by emergency medical services: contributing factors and predictors. https://doi.org/10.29045/14784726.2026.3.31.1.34

A service evaluation of the recognition, care and management of functional seizures within a UK ambulance service. https://doi.org/10.29045/14784726.2026.3.31.1.43

Student paramedic sexual safety in ambulance placement: a critical exploration. https://doi.org/10.29045/14784726.2026.3.31.1.50

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Development of a national consensus guideline for termination of resuscitation in the out-of-hospital environment. https://doi.org/10.29045/14784726.2026.3.31.1.56

When innovation pootles along: The need for clear stop-go decisions in ambulance-based service evaluations. https://doi.org/10.29045/14784726.2026.3.31.1.66

PARAMEDICINE

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May 2026

National consensus on the capabilities that inform the role of advanced practice paramedics: A Delphi study. https://doi.org/10.1177/27536386251360833

Ambulance personnel's experiences with prehospital births: a qualitative study in Aotearoa New Zealand. https://doi.org/10.1177/27536386251345488

Cost analysis of the pathfinder service as an alternative to the traditional ambulance response. https://doi.org/10.1177/27536386261417745

Implementing the rural advanced care community paramedics in rural and remote British Columbia: A qualitative study. https://doi.org/10.1177/27536386251400777

July 2026

Indigenous peoples research in paramedicine: Embracing ways of knowing. https://doi.org/10.1177/27536386261449518

Experiences, challenges, perceptions and facilitators associated with paramedic medication prescribing: A scoping review. https://doi.org/10.1177/27536386251405906

Exploring the lived experience of paramedics responding to individuals experiencing a mental health crisis in the community: A phenomenological study. https://doi.org/10.1177/27536386251341785

Parental perspectives on child participation in prehospital emergency care: A rights-based analysis using Shier's pathways to participation. https://doi.org/10.1177/27536386261433195

Threading the PhD journey through collaboration, balance and belonging among Middle Eastern paramedics: A reflexive thematic analysis. https://doi.org/10.1177/27536386251400781

JOURNAL OF EMS MEDICINE

https://jemsmed.org

May 2026

Thailand's nationwide development of the emergency medical services system: a focus on the Khon Kaen Model. https://doi.org/10.35616/jemsm.2026.00241

Emergency medical services medical directors in Korea: system operations and training status. https://doi.org/10.35616/jemsm.2025.00185

Non-catastrophic, self-inflicted nail gun discharge to the sinciput: a case report. https://doi.org/10.35616/jemsm.2025.00157

JOURNAL OF PARAMEDIC PRACTICE

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March 2026

Role of advanced paramedics in primary care, prehospital and hospital settings. https://doi.org/10.12968/jpar.2026.18.1.CPD1
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A shared vision. https://doi.org/10.12968/jpar.2026.0020
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Spotlight on Research. https://doi.org/10.12968/jpar.2026.0013

April 2026

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Level 6: being critical. https://doi.org/10.12968/jpar.2026.0035
Spotlight on Research. https://doi.org/10.12968/jpar.2026.0029

May 2026

Compassion under lights: navigating grief and ethics in emergency medical services. https://doi.org/10.12968/jpar.2026.18.5.CPD1
Protecting the protector. https://doi.org/10.12968/jpar.2025.0145
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The Goldfish Postulate: emotionally intelligent paramedic leadership. https://doi.org/10.12968/jpar.2024.0119
Direct involvement of paramedics in pressure ulcer care and identification. https://doi.org/10.12968/jpar.2025.0090
Mental health self-care. https://doi.org/10.12968/jpar.2026.0037

The quieter moments of being a paramedic. https://doi.org/10.12968/jpar.2026.0041
Spotlight on Research. https://doi.org/10.12968/jpar.2026.0038

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From textbook to reality: ethics, empathy and the culture of paramedic practice. https://doi.org/10.12968/jpar.2026.18.6.CPD1
A liminal space. https://doi.org/10.12968/jpar.2025.0143
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What paramedics need to know about Gen AI. https://doi.org/10.12968/jpar.2026.0050
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February 2026

Feasibility of Taiwanese Paramedics using ChatGPT (GPT-4) for Triaging with the Prehospital Taiwan Triage and Acuity Scale on Scene. https://doi.org/10.30216/JPER.202602_(7).0001
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January 2026

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International Journal of Paramedicine

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LITERATURE SURVEILLANCE

PARAMEDICINE LITERATURE SEARCH: MARCH-MAY 2026

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To help paramedicine professionals to keep abreast of the literature in our discipline, the Paramedicine Literature Search provides the results of a standardized search of the PubMed database. This search results will include articles from journals that many paramedicine professionals may already be familiar with. The search strategy is also designed to include articles in journals they may not be commonly monitoring, such an article about ambulance care for cancer patients that appeared in an oncology journal.

The formatting of the Paramedicine Literature Search allows the reader to scan the titles of articles and click into the article link, when provided, for additional details.

The authors have made a diligent effort in designing of the search strategy to balance sensitivity (i.e., getting all relevant articles in paramedicine) with the specificity (i.e., excluding articles not relevant to paramedicine). The balance is imperfect. As a result, it should be noted that the results do not include every relevant article and includes some non-relevant articles.

The search strategy is filtered to only include articles published in a time frame listed below. This will include articles with electronic and print publication dates in that date range. Some of the publication dates may fall outside of this range due to how the article metadata was indexed by the publisher.

The following results were obtained on June 28, 2026 from the PubMed website (https://pubmed.ncbi.nlm.nih.gov/) using the following search terms and Boolean logic:

"paramedic"[Text Word] OR "paramedics"[Text Word] OR "pre-hospital"[Text Word] OR "pre-hospital"[Text Word] OR "emergency medical technician"[Text Word] OR "emergency medical technicians"[Text Word] OR "Ambulance"[Text Word] OR "emergency medical services"[Text Word] OR "fire-rescue"[Text Word] OR "fire-rescue"[Text Word]

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Search Filter: Publication range of March 1, 2026 to May 30, 2026.

Prehospital Whole Blood in Traumatic Hemorrhage - A Randomized Controlled Trial. Smith JE. N Engl J Med. 2026 Jun 18;394(23):2305-2316. Epub 2026 Mar 17. https://doi.org/10.1056/NEJMoa2516043

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NEMSMA is a longtime collaborator with the National Association of EMS Physicians in support of *Prehospital Emergency Care (PEC)*. In continuation of that relationship, *IJOP* and *PEC* have established a collaborative relationship that will facilitate the exchange of submissions in certain circumstances, based in part on which journal may be the best fit for a particular manuscript.

SUBMISSION CHECKLIST

Authors need to register with the journal before submitting or, if already registered, can simply log in and begin the submission process.

Download the following worksheets to assist with the submission process. Complete the forms, use them to assist with the submission process, then upload them with the submission.

- Complete one of these forms per submission: IJOP Submission Info Form
- Complete one of these forms per author: IJOP Author Info Form

GENERAL GUIDELINES AND NOTES

- The *IJOP* only publishes material in English. Please use Academic English.
- The *IJOP* accepts submissions in the following categories:
  - Case Studies (≤2,000 words)
  - Concepts (≤3,000 words)
  - Correspondence / Commentary (≤1,000 words)
  - Education (≤3,000 words)
  - Empirical Investigations / Original Research (≤4,500 words)
  - Methodology (≤2,000 words)
  - Quality Improvement Project Reports (≤3,000 words)
  - Reviews / Synthesis (≤4,000 words)
  - Special Reports (≤2,000 words)
  - Toolbox (≤1,500 words)

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The word limits noted above are guidelines for the various submission types. Authors are encouraged to adhere to these guidelines and to be concise in their submissions.

- Merriam-Webster's Collegiate Dictionary (11th ed.) should be consulted for spelling.
- Contributions that explore non-clinical topics such as leadership, operations, education, professional practice, and the culture of paramedicine are strongly encouraged.
- Based on the international scope of the *IJOP*, contributions should provide a degree of generalizability and transferability to global settings and should have relevance to the *IJOP's* broad readership.
- *IJOP* discourages multiple publications derived from a single study.
- All original research submissions must have received approval from an Institutional Research Board (IRB) or Research Ethics Board (REB).
- Once a submission has been assessed for suitability by the editorial team, it will undergo a double-blind peer-review by independent, anonymized reviewers.

USE OF ARTIFICIAL INTELLIGENCE

IJOP recognizes that artificial intelligence (AI) tools are increasingly used in research, clinical education, and manuscript preparation. This policy establishes standards for the responsible, transparent, and ethical use of AI in all materials submitted for consideration in the Journal and is aligned with the policies of the International Committee of Medical Journal Editors (ICMJE, 2023; ICMJE, 2024) and the Committee on Publication Ethics (COPE, 2025).

The goal is to ensure academic integrity, patient safety, and accountability in the dissemination of paramedicine research and other scholarly content.

AI Authorship

Artificial intelligence tools, including large language models (LLMs) such as ChatGPT, Gemini, Claude, and similar systems, cannot be listed as authors or co-authors on any *IJOP* submission. Authorship requires the ability to take accountability for the work, approve the final manuscript, and respond to questions about the accuracy and integrity of the research. AI tools cannot fulfill these responsibilities. Any submission listing an AI tool as an author will be returned without review. This policy applies without exception, regardless of the extent of AI involvement in the work.

Permitted Uses of AI by Authors

AI tools may be used to assist authors in limited and transparent ways, including:

- Grammar, spelling, or stylistic editing
- Organizing or formatting reference lists (all references must be independently verified by authors against original sources prior to submission)
- Language translation for non-native English authors
- Programming support for simulations or modeling (when described in the Methods section)
- Statistical analysis or data visualization (when described in the Methods section)

AI tools may not be used to:

- Generate or fabricate data, patient information, or references
- Produce substantive portions of the manuscript, including but not limited to the introduction, results, discussion, or conclusions
- Create, alter, or enhance clinical photographs, diagnostic images, or figures without explicit disclosure and validation

- Circumvent originality or plagiarism checks
- Generate research questions, design the study, select participants, code or analyze data, or interpret findings
- Conduct literature searches that are not independently verified by the authors

Disclosure Requirements for Authors

Any use of AI tools in preparing a submission must be disclosed. The disclosure must appear in the Acknowledgements section of the manuscript and, where applicable, in the Methods section if AI was used in data collection, analysis, or figure generation. The disclosure must include:

- The name of the AI tool
- The developer and specific version or model (e.g., GPT-4o, claude-sonnet-4-6, Gemini 2.5 Pro)
- The date the tool was accessed
- A clear description of the specific purpose for which it was used
- An affirmation that the authors reviewed, verified, and take full responsibility for all AI-assisted output

Example disclosure statement:

> *Claude (Anthropic, claude-sonnet-4-6, accessed March 2026) was used to assist with sentence-level editing and language consistency across drafts. The authors reviewed all AI-assisted content, independently verified all citations against publisher and PubMed records, and take full responsibility for the accuracy and integrity of this manuscript.*

If no AI tools were used, authors must include the following statement in the Acknowledgements:

> *No generative AI tools were used in the preparation of this manuscript.*

AI in Studies Using LLMs as Research Instruments

Submissions that evaluate, benchmark, or deploy large language models as research instruments (rather than using them as writing aids) are subject to additional requirements. These submissions must:

- Specify the exact model name, version, and access date for each AI model evaluated
- Provide verbatim prompts submitted to each model in the methods section or as a supplemental appendix. Prompt text is a primary experimental variable. Studies that do not disclose it cannot be reproduced or audited and therefore will not be accepted for peer review.
- Describe the complete pipeline for hybrid or multi-step AI systems, including how outputs from one model were formatted and passed to subsequent models.
- Confirm that the study dataset was independent of any model's development or calibration data.
- Adhere to the TRIPOD+AI reporting standard (Collins et al., 2024, BMJ) and, for studies specifically deploying LLMs, the TRIPOD-LLM reporting guideline (Messaritakis et al., 2025, Nature Medicine)
- Acknowledge whether any AI tool evaluated is regulated as a Software as a Medical Device (SaMD) by the FDA or equivalent regulatory authority in the study's jurisdiction. Studies recommending clinical deployment of AI tools must document that the tool has received appropriate regulatory authorization

Note: As of 2026, the U.S. FDA has not approved any general-purpose consumer large language model for clinical diagnostic use. Studies recommending integration of such tools into clinical or prehospital workflows must acknowledge this regulatory status explicitly.

Citation Accuracy

Authors are responsible for the accuracy of all citations. AI-generated reference lists are known to contain fabricated citations at rates as high as 18–55%, depending on the model and topic area. All references must be independently verified by the authors against the original source prior to submission. The editorial team reserves the right to spot-check citations and to return submissions with unverified or fabricated references for correction prior to peer review.

AI Use by Peer Reviewers

Peer reviewers are strictly prohibited from uploading any portion of a submitted manuscript into any public-facing generative AI tool. Manuscripts submitted for review are the unpublished intellectual property of the authors. Using an external AI platform to process a manuscript violates the confidentiality obligations of peer review and may constitute a breach of intellectual property rights. Reviewers who require AI assistance for language support must use only locally deployed or institution-licensed tools that do not transmit manuscript content to external servers and must disclose this use to the Associate Editor that is managing that manuscript. Any reviewer found to have violated this provision will be removed from the *IJOP* reviewer database.

AI Use by Editors

Editors may use AI tools to assist with administrative functions such as formatting checks, metadata verification, or detecting common patterns associated with AI-generated manuscripts. Editors must not use AI tools to generate or substantially revise editorial decisions, correspondence with authors, or formal editorial assessments. All editorial decisions remain the responsibility of human editors. Editors are encouraged to attend to secondary signals associated with AI-generated manuscripts, including formulaic prose structure, hedged transition language, methodological gaps concentrated in areas of domain expertise, and citation anomalies, in addition to using automated detection tools.

Enforcement

Failure to properly disclose AI use, evidence of prohibited AI use, or submission of fabricated citations will be treated as a breach of ethical standards. Consequences may include:

- Immediate rejection or retraction
- Notification to authors' institutions or employers
- Reporting to relevant research integrity bodies

All cases involving suspected AI misuse will be handled in accordance with COPE and ICMJE guidelines. *IJOP* reserves the right to request raw prompts, model logs, or other documentation to investigate suspected misuse.

References for This Policy

Collins, G. S., Moons, K. G. M., Dhiman, P., et al. (2024). TRIPOD+AI statement: Updated guidance for reporting clinical prediction models that use regression or machine learning methods. *BMJ, 385*, e078378. https://doi.org/10.1136/bmj-2023-078378

Committee on Publication Ethics. (2025). *Authorship and AI tools* [COPE position statement]. https://publicationethics.org/guidance/cope-position/authorship-and-ai-tools

International Committee of Medical Journal Editors. (2023). *Recommendations for the conduct, reporting, editing, and publication of scholarly work in medical journals* [Section II.A.4 and V]. https://www.icmje.org

International Committee of Medical Journal Editors. (2024). *Updated recommendations: Section V — Use of artificial intelligence in publishing*. https://www.icmje.org/news-and-editorials/updated_recommendations_jan2024.html

Messaritakis, I., et al. (2025). The TRIPOD-LLM reporting guideline for studies using large language models. *Nature Medicine, 31*, 21–31. https://doi.org/10.1038/s41591-024-03425-5

U.S. Food and Drug Administration. (2025). *Artificial intelligence-enabled device software functions: Lifecycle management and marketing submission recommendations* [Draft Guidance]. https://www.fda.gov/media/184856/download

SUBMISSION ITEMS

As part of the submission process, authors will be required to confirm that their submission complies with all of the items below. Submissions may be returned that do not adhere to these guidelines.

Documents

- The submission cannot be previously published or in the submission process of another publication (or an explanation has been provided in a cover letter to the Editor).
- The Author and Funding File and the Main Submission File are all in Microsoft Word document file format (.doc or .docx).
- An ICMJE Form for Disclosure of Potential Conflicts of Interest is submitted for each author. The form is available at: https://icmje.org/disclosure-of-interest/
- All illustrations, figures, and tables should be placed within the text at the appropriate points AND submitted as separate files in a high-resolution format.
- Supplemental media files (e.g., spreadsheets, slides, audio or video files) may be included for reader access. The file should be hosted by the authors unless other arrangements have been made with the Editors.
- Where available, URLs for each reference have been provided. A DOI hyperlink is preferred.
- A completed AI use disclosure statement has been included in the Acknowledgements section (see Use of Artificial Intelligence above), either disclosing specific AI tools used or affirmatively stating that no AI tools were used.
- For submissions that evaluate or deploy AI as a research instrument, verbatim prompts for all AI queries have been included in the methods section or as a supplemental appendix.

Manuscript

- The text is double-spaced in a 12-point font.
- Page numbers and line numbering are used for the Main Submission File.
- The text adheres to the stylistic and bibliographic requirements outlined in these guidelines.
- IRB or REB approval documentation is included where required, with protocol number, approving body, and determination category specified.
- Authors are strongly encouraged to follow applicable EQUATOR (Enhancing the QUAlity and Transparency Of health Research)(https://www.equator-network.org) reporting guidelines. See below for the list applicable to common study types.
- Authors are encouraged to use the CRediT (Contributor Roles Taxonomy) to specify each author's contribution (https://credit.niso.org).
- Reporting Standards (EQUATOR Network)

The following EQUATOR reporting guidelines apply to common study designs submitted to *IJOP*. Authors should apply the guideline most appropriate to their study design and attach the completed checklist as a supplemental file. Where no single guideline applies, authors should follow the spirit of the applicable standard and consult the editorial team.

Note: A section of the EQUATOR network contains guidelines specific to emergency medicine that may also be applicable to studies in paramedicine: https://www.equator-network.org/reporting-guidelines-medical-specialty/emergency-medicine-2

Randomized trials

- CONSORT and its extensions (https://www.equator-network.org/reporting-guidelines/consort)

Observational studies

- STROBE and its extensions (https://www.equator-network.org/reporting-guidelines/strobe)

Systematic reviews and meta-analyses

- PRISMA 2020 and its extensions (https://www.equator-network.org/reporting-guidelines/prisma)

Study protocols

- SPIRIT and the PRISMA-P extension (https://www.equator-network.org/reporting-guidelines/spirit-2013-statement-defining-standard-protocol-items-for-clinical-trials)

Diagnostic and prognostic accuracy studies

- STARD (https://www.equator-network.org/reporting-guidelines/stard)

Prediction model studies (clinical AI and machine learning)

- TRIPOD+AI (Collins et al., 2024, BMJ) (https://doi.org/10.1136/bmj-2023-078378). Required for all studies developing or evaluating AI/ML prediction or diagnostic models. This guideline supersedes the 2015 TRIPOD checklist and must be used in its place for all new submissions. A completed TRIPOD+AI checklist must be submitted as a supplemental file.
- TRIPOD-LLM (Messaritakis et al., 2025, Nature Medicine) (https://doi.org/10.1038/s41591-024-03425-5). Required for studies specifically deploying large language models in healthcare settings. A 19-item checklist covering transparency, human oversight, and task-specific performance reporting. Use in addition to TRIPOD+AI for LLM studies.

Case reports

- CARE and its extensions (https://www.equator-network.org/reporting-guidelines/care)

Clinical practice guidelines

- AGREE and the RIGHT extension (https://www.equator-network.org/reporting-guidelines/agree)

Qualitative research

- SRQR and the COREQ extension (https://www.equator-network.org/reporting-guidelines/srqr)

Animal pre-clinical studies

- ARRIVE (https://www.equator-network.org/reporting-guidelines/improving-bioscience-research-reporting-the-arrive-guidelines-for-reporting-animal-research)

Quality improvement studies

- SQUIRE and its extensions (https://www.equator-network.org/reporting-guidelines/squire)

Economic evaluations

- CHEERS (https://www.equator-network.org/reporting-guidelines/cheers)

SUBMISSION FILES

The following describes the standard submission files that should be uploaded via the Journal submission website for each manuscript. Please refer to the specific submission guidelines for each submission category for more specific instructions that may apply.

Author and Funding Information File

Author Information

- All authors of a manuscript should provide their full name with up to four post-nominals and up to two organizational affiliations and titles, exactly as they should appear in the publication.
- The email addresses of all authors should be included.
- If available, please include ORCID ID numbers for each author (https://orcid.org)
- Social media handles (e.g., LinkedIn, X/Twitter) may also be included for each author.
- Please ensure that everyone who meets the ICMJE requirements for authorship is included as an author (https://www.icmje.org/recommendations/browse/roles-and-responsibilities/defining-the-role-of-authors-and-contributors.html)
- Authors are encouraged to specify individual contributions using the CRediT (Contributor Roles Taxonomy) framework (https://credit.niso.org)
- If an author changes their affiliation during the peer-review process, the new affiliation information can be given to the Editorial Team and will be handled as any other manuscript revision. No changes to affiliation can be made after the pre-publication galleys of the manuscript have been accepted for final publication.
- Identify one author as the corresponding author.
- If the work presented in the manuscript was presented at a conference or published in abstract form, identify the name of the event, location, format, and date of presentation.
- Acknowledgements, where applicable, should be brief and must include the required AI use disclosure statement (or the affirmative statement of no AI use).

Funding Information

- Please provide the details for any funding that supported the submitted work.
- For single agency grants: "This work was supported by the [Funding Agency] under Grant [number xxxx]."
- For multiple agency grants: "This work was supported by the [Funding Agency #1] under Grant [number xxxx]; [Funding Agency #2] under Grant [number xxxx]."
- If a funding source was not involved: "External funding was not used to support this work."
- If the study involved AI tools that are commercial products of a funder or that create a conflict of interest, this must be disclosed explicitly in both the funding information and the ICMJE disclosure forms.

Main Submission File

To provide a high level of objectivity in the peer-review process, *IJOP* uses a double-blind process. The identities of the authors and their institutions are not revealed to the reviewers, and the identities of the reviewers are not revealed to the authors.

Due to the double-blind review process, information about the authors and their institutions should not appear anywhere in the main submission file. This includes the removal of identifying information in the properties of the Microsoft Word files submitted.

Please do not use extensive formatting. Use single spaces between sentences. Separate paragraphs with a carriage return. Do not indent the first line of paragraphs with tabs or added spaces.

Title

- Provide the suggested title for the published article. The title used for publication is subject to editorial team approval.

Abstract, Keywords, Disclosures / Conflicts, Presentations, and Acknowledgements

- Abstracts must be limited to 300 words or fewer, including section headers. Use structured abstracts when possible.
- Include between three (3) and six (6) keywords or short phrases for search optimization. The keywords paramedicine, EMS, and emergency medical services will be added by default and do not count toward the keyword limit.
- State any disclosures or conflicts for each author, in addition to the completed ICMJE Disclosure Forms. If there are no conflicts, state "None."
- Include the required AI use disclosure statement (see Use of Artificial Intelligence section above).

Primary Manuscript Body

- The primary body of the manuscript follows the abstract page. Composition varies by category; refer to category-specific descriptions for details.
- Use a minimum of formatting. Indicate heading levels by placing (H1), (H2), (H3) directly after the heading text.
- Tables should summarize large amounts of information and must be labeled sequentially and referenced in the text.
- Figures must be labeled sequentially, referenced in the text, and also submitted as high-resolution supplemental files in PDF, JPEG, TIFF, or PNG format at a minimum of 300 dpi.

References

- Use APA7 style in-text citation and endnote formatting.
- Include a hyperlink for each reference. A DOI hyperlink in the format https://doi.org/XXXXX is preferred.
- Authors are responsible for the accuracy of all references, links, and in-text citations. AI-generated reference lists must be independently verified against the original source prior to submission (see Use of Artificial Intelligence above).

Appendices

- Where applicable, appendices to the manuscript are inserted at the end of the Main Submission File.
- For submissions evaluating AI as a research instrument, verbatim prompts submitted to each AI model must be included in the Methods section or as an appendix.

ICMJE Forms for Disclosure of Potential Conflicts of Interest

- One form per author should be submitted.
- The form is available at: https://icmje.org/disclosure-of-interest

Supplemental Media Files

- Supplemental tables or figures should each be uploaded individually.
- For spreadsheets used to generate tables, upload as individual files and clearly indicate which table they are associated with.
- For studies evaluating AI systems: verbatim prompts and any model output logs relevant to the study should be included in the Methods section or as supplemental files.
- Supplemental media files (e.g., spreadsheets, slide decks, audio or video files) must be readily accessible without passwords or other restrictions.

GUIDELINES FOR CATEGORY-SPECIFIC SUBMISSIONS

Case Reports (≤2,000 words)

These manuscripts share the experience of unusual clinical presentations, circumstances, or treatment approaches. Case reports should be structured as described in the Consensus-based Clinical Case Reporting Guideline (CARE; https://www.equator-network.org/reporting-guidelines/care).

Concepts (≤3,000 words)

These papers present a specific management or clinical concept, idea, or theory and describe its practical application. If the paper presents a new concept, it may also suggest research, improvement projects, or pilot implementations. The primary manuscript body should contain:

- Introduction: Describe the problem, issue, or circumstance that the concept is intended to address, the current literature that demonstrates a gap, and any pertinent background information.
- Concept Description: Provide a description of the concept and how it can be applied, with sufficient detail of any methods or procedures, the setting, and the population to which the concept applies.
- Discussion: Include a critical review of related research and a discussion that highlights how the concept contributes to the field of paramedicine. Address limitations.

Dialogues (≤1,000 words)

The Dialogues section publishes comments and questions from readers related to previously published articles. The primary manuscript body should include:

- Subject Paper Information: Provide the title, name of the first author, and the *IJOP* issue for the paper that is the subject of the correspondence.
- The narrative of the correspondence.

Editorials (≤2,000 words)

Editorials are a venue for the expression of opinion and perspective on topics relevant to the paramedicine community. They should make clear points in a concise manner with a scholarly approach and tone. They should not be used for the presentation of data, findings, or research that has not been previously published.

Educational Methods and Processes (≤3,000 words)

These submissions explore a specific educational process, approach, or method, and discuss issues to consider in its practical application. The primary manuscript body should contain:

- Introduction: Describe the problem or circumstance addressed, relevant literature demonstrating a gap, and pertinent background information.
- Description: Describe the educational process, approach, or method and how it can be applied, with sufficient detail of methods, procedures, setting, and population.
- Discussion: Include a critical review of related research highlighting how the approach contributes to paramedicine. Address limitations.

Empirical Investigations / Original Research (≤4,500 words)

Submissions may be clinical or non-clinical. Apply the applicable EQUATOR guidelines described above. Authors may provide, or editors may suggest, that some information be provided as a supplemental file so that the main paper remains concise. Supplemental content may include data sets, images, video clips, and in-depth methodological details.

Empirical investigations on clinical topics may be forwarded to *Prehospital Emergency Care (PEC)* for initial consideration with the author's consent.

Submissions that evaluate AI tools as research instruments must comply with the full AI research instrument requirements described in the Use of Artificial Intelligence section above, including prompt disclosure, model version specification, TRIPOD+AI/TRIPOD-LLM checklist submission, and regulatory status acknowledgment.

Methodology (≤2,000 words)

This category provides deep explorations of methods used, or that may be used in research studies or improvement projects. These methods should be novel in a way that makes them of significant interest in their own right, separate from the studies in which they are utilized. The primary manuscript body should contain appropriate elements from the applicable EQUATOR guidelines.

Quality Improvement Project Reports (≤3,000 words)

IJOP acknowledges the importance of quality improvement activities and welcomes manuscripts describing improvement projects. United States regulations do not require quality improvement activities to have IRB/REB approval, but the distinction between manuscripts requiring or not requiring approval can be subtle. Manuscripts that appear to have framed a research activity as quality improvement to circumvent compliance standards will be rejected.

Authors uncertain whether their work should be submitted as quality improvement or research are encouraged to contact the editorial office. When in doubt, submission to an IRB for an independent determination is encouraged.

Quality improvement project reports should adhere to SQUIRE guidelines (http://www.squire-statement.org). With permission of the Editorial Team, authors may use other generally accepted frameworks (e.g., IHI Model for Improvement; DMAIC).

Reports should describe the process examined; the process change(s) tested; baseline performance; methods for conducting tests and evaluating results; post-intervention performance; confounding variables and balancing measures; and process change iterations. Discussions and conclusions should highlight what the external audience can learn from the experience, not only the activity's internal success or failure.

Reviews / Synthesis (≤4,000 words)

IJOP invites the submission of reviews of all types, including those with and without meta-analytic components. All submissions in this category should be consistent with the PRISMA 2020 guidelines for reporting systematic reviews (https://www.equator-network.org/reporting-guidelines/prisma/). Reviews that incorporate AI tools in the literature search or screening process must disclose this in the Methods section, specifying the tool, version, and how AI-identified sources were independently verified.

Toolbox (≤3000 words)

These submissions explain a tool or technique and describe its practical use. Where applicable, the articles may include a supplemental file or link containing the tool and a data file where the reader may try it out. The primary manuscript body should contain.

- Introduction: An overview of the type(s) of projects the tool or technique could be used for, or the specifics of the project in which it was actually used.
- Description of the Tool / Technique: An in-depth examination of the tool or technique and its mechanics. Describe how it should be applied in a clinical, operational, or administrative setting.
- Discussion: The underlying rationale for the tool or technique, why it may be favored over other options, and a critique of related methods. Include a discussion of limitations.
- Exercise: Where applicable, describe how to use the tool or technique in conjunction with a sample data set or scenario.

KEY INTERNATIONAL STANDARDS REFERENCED IN THESE GUIDELINES

- ICMJE Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly Work in Medical Journals: https://www.icmje.org
- COPE Core Practices and Position Statements on AI: https://publicationethics.org
- EQUATOR Network Reporting Guidelines: https://www.equator-network.org
- TRIPOD+AI (Collins et al., 2024): https://doi.org/10.1136/bmj-2023-078378
- TRIPOD-LLM (Messaritakis et al., 2025): https://doi.org/10.1038/s41591-024-03425-5
- CRediT Contributor Roles Taxonomy: https://credit.niso.org
- U.S. FDA AI/ML Software as Medical Device: https://www.fda.gov/medical-devices/software-medical-device-samd/artificial-intelligence-software-medical-device

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ADDENDUM, CORRIGENDUM, AND ERRATUM

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Keywords: addendum, corrigendum, erratum, corrections, emergency medical services, EMS, paramedicine

Published: July 15, 2026

Occasionally, issues requiring clarification, correction, or supplementation are identified after publication. In accordance with the Committee on Publication Ethics (COPE) guidelines, the journal uses addenda, errata, and corrigenda to maintain the integrity, transparency, and reliability of the scholarly record. Addenda are published to provide additional information that was not available at the time of publication and that does not affect the validity of the original work. Errata are issued to correct errors introduced during the journal's editorial or production process. Corrigenda are issued to correct errors made by the authors.

APRIL 28, 2026

ADDENDA:

Newman, S., Kayanja, J., Rimstad, C., & Violato, E. (2026). Implementation of mental health supports for Canadian paramedic students during practicum placements. *International Journal of Paramedicine*. (14). 150-158.

A graphic and link to the video interview of the author was added to the frontmatter of the article.

- Article: https://doi.org/10.56068/KYEV3890
- Complete issue with corrected article: https://doi.org/10.56068/PRQM1802

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