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Paramedics As Life-Savers: A Systematic Review Of Pre-Hospital Interventions In Emergency Medical Services

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Abstract
This systematic review examines the critical role of paramedics in delivering pre-hospital interventions within emergency medical services (EMS). Pre-hospital care is often the determining factor between life and death in time-sensitive emergencies such as cardiac arrest, trauma, stroke, and respiratory distress. Paramedics, as frontline responders, implement interventions ranging from airway management and cardiopulmonary resuscitation (CPR) to advanced life support procedures, medication administration, and trauma stabilization. The review synthesizes findings from peer-reviewed studies (2015–2025) to evaluate the effectiveness, challenges, and outcomes associated with paramedic-led pre-hospital interventions. Results indicate that timely and evidence-based interventions provided by paramedics significantly improve survival rates, reduce complications, and optimize patient flow into hospitals. However, challenges such as variability in training, resource availability, and integration with hospital systems remain barriers. The study highlights paramedics' evolving role in modern healthcare systems and emphasizes the need for continuous education, technological integration, and standardized protocols. This review provides insights for healthcare policymakers, educators, and EMS organizations to enhance pre-hospital emergency care, ultimately strengthening healthcare systems and saving lives.

Keywords: Paramedics, Pre-Hospital Interventions, Emergency Medical Services, Patient Outcomes, Survival, Systematic Review.

1. Introduction

Emergency medical services (EMS) represent one of the most vital pillars of modern healthcare systems, providing time-critical care in emergencies where rapid intervention can mean the difference between life and death. Within this system, paramedics serve as the frontline responders who deliver pre-hospital interventions, often determining the trajectory of patient outcomes before definitive hospital care is initiated (Bigham et al., 2021). The concept of pre-hospital interventions encompasses a wide range of procedures, including cardiopulmonary resuscitation (CPR), airway management, hemorrhage control, defibrillation, trauma stabilization, and medication administration. These actions are designed not only to sustain life but also to minimize complications, improve functional outcomes, and enhance survival rates in diverse emergencies (Wang et al., 2020).

Globally, the demand for efficient and timely pre-hospital interventions has increased in parallel with the growing incidence of cardiovascular diseases, trauma, strokes, and respiratory conditions. The World Health Organization (WHO, 2023) reports that trauma and injuries alone account for nearly 5 million deaths annually, while cardiac arrest remains one of the leading causes of mortality worldwide. In such cases, paramedics' rapid response and skilled interventions during the so-called "golden hour" are pivotal in improving chances of survival. The chain of survival, a framework widely used in resuscitation science, highlights the significance of early recognition, immediate pre-hospital intervention, and prompt hospital care for optimal outcomes (Link et al., 2015).

Historically, the role of paramedics has evolved from basic first aid providers to highly skilled professionals capable of delivering advanced life support. In high-income countries, paramedics are authorized to perform complex procedures such as intubation, thrombolysis, and advanced trauma life support, while in low- and middle-income countries, their scope may be more limited due to resource constraints (Al-Shaqsi, 2010; O'Hara et al., 2022). This variability underscores the importance of contextualizing the impact of pre-hospital interventions across different healthcare systems.

Research consistently demonstrates the impact of paramedic-led interventions on patient outcomes. For example, pre-hospital defibrillation has been shown to double or triple survival rates in out-of-hospital cardiac arrest (Andersen et al., 2019). Similarly, early airway management and oxygenation reduce hypoxic brain injury in trauma and cardiac arrest patients (Wang et al., 2018). In stroke cases, paramedics' role in pre-hospital recognition and rapid transport to stroke-ready centers significantly reduces morbidity (Oostema et al., 2016). These findings highlight that timely paramedic interventions not only improve survival but also contribute to better quality of life post-recovery.

Despite these benefits, challenges persist. Variability in training, disparities in EMS infrastructure, inconsistent implementation of evidence-based protocols, and delays in response times all impact the effectiveness of pre-hospital interventions (Bigham et al., 2021). Moreover, ethical and legal considerations, particularly in invasive procedures performed outside the hospital, remain an area of debate. The integration of technology—such as portable diagnostic devices, artificial intelligence (AI)-driven triage tools, and telemedicine—offers promising avenues to strengthen paramedic practice, but their adoption is uneven globally (Evans et al., 2020).

Given the central role of paramedics in emergency care and the growing body of research on pre-hospital interventions, a systematic review is warranted to synthesize current evidence. This review seeks to answer key questions: How effective are paramedic-led pre-hospital interventions in improving survival and patient outcomes? What are the most impactful interventions across different emergency conditions? What barriers and facilitators shape the effectiveness of these interventions? By addressing these questions, the review aims to provide a comprehensive understanding of paramedics' role in pre-hospital care and to inform policy, practice, and future research.

In summary, paramedics are not only first responders but also life-savers whose actions often determine the trajectory of patient survival and recovery. By systematically examining the evidence on pre-hospital interventions, this study contributes to strengthening emergency medical services and advancing patient-centered outcomes worldwide.

2. Literature Review

2.1 Evolution of Paramedics' Role in Emergency Care

The role of paramedics in pre-hospital emergency care has evolved significantly over the last five decades. Originally, ambulance services functioned primarily as transport systems, with little emphasis on medical interventions (Al-Shaqsi, 2010). However, with advancements in medical knowledge and the recognition of the importance of early intervention, paramedics became essential providers of both basic and advanced life support. Today, paramedics are trained to perform complex interventions, including advanced airway management, cardiac monitoring, defibrillation, and administration of lifesaving medications (Bigham et al., 2021). The increasing professionalization of paramedics reflects a shift toward recognizing them as critical healthcare practitioners who bridge community emergencies and hospital-based definitive care.

2.2 Common Pre-Hospital Interventions by Paramedics

Paramedics perform a wide range of interventions tailored to the type of emergency, patient condition, and available resources.

Airway compromise is one of the most common causes of pre-hospital mortality. Interventions range from basic maneuvers (head tilt–chin lift) to advanced procedures such as endotracheal intubation and supraglottic airway device insertion. Studies suggest that paramedic-led airway interventions significantly reduce hypoxia-related complications, particularly in trauma and cardiac arrest patients (Wang et al., 2018).

Early initiation of CPR and defibrillation by paramedics has consistently been associated with improved survival in out-of-hospital cardiac arrest (OHCA). According to Andersen et al. (2019), pre-hospital defibrillation can double or triple survival rates when compared to delayed hospital-based defibrillation. Advanced life support protocols allow paramedics to integrate CPR with pharmacological interventions, further improving outcomes.

Uncontrolled bleeding remains a leading cause of preventable death in trauma patients. Paramedics play a pivotal role in pre-hospital trauma management through the application of tourniquets, hemostatic dressings, immobilization techniques, and fluid resuscitation. A review by Spahn et al. (2019) emphasized that early hemorrhage control significantly increases survival during mass casualty incidents and road traffic accidents.

Paramedics are authorized in many countries to administer a wide range of drugs, including analgesics, bronchodilators, thrombolytics, and epinephrine. Such interventions improve stabilization before hospital arrival, reducing the risk of deterioration (O'Hara et al., 2022). However, the scope of pharmacological interventions varies across regions depending on national policies and training standards.

2.3 Impact on Patient Outcomes

The effectiveness of paramedic-led interventions has been widely studied in relation to specific emergency conditions.

Out-of-hospital cardiac arrest (OHCA) is one of the most studied conditions in EMS research. Evidence indicates that survival is highly dependent on immediate recognition and paramedic-led defibrillation. A meta-analysis by Yan et al. (2020) found that patients receiving pre-hospital defibrillation had significantly higher rates of survival to hospital discharge with good neurological outcomes.

Paramedics' role in early stroke recognition and pre-hospital triage is crucial. Accurate pre-hospital stroke assessment using scales such as FAST (Face, Arm, Speech, Time) allows rapid transport to stroke-ready centers. Oostema et al. (2016) demonstrated that paramedic-led stroke recognition reduced door-to-treatment times and improved recovery outcomes.

The "golden hour" principle emphasizes the critical importance of rapid trauma care. Paramedic interventions such as spinal immobilization, hemorrhage control, and advanced airway management have been shown to reduce mortality in major trauma cases (Evans et al., 2020).

Pre-hospital administration of oxygen therapy, bronchodilators, and continuous positive airway pressure (CPAP) has been linked to reduced morbidity in patients with asthma, COPD exacerbations, and pulmonary edema. These interventions by paramedics improve patient stability upon hospital arrival (Singh et al., 2019).

2.4 Regional Variations in Practice

The scope and impact of paramedic practice vary significantly between high-income and low- to middle-income countries. In developed nations, paramedics often perform advanced life support procedures, including invasive airway management and pre-hospital thrombolysis (Al-Shaqsi, 2010). Conversely, in resource-limited settings, their role is often restricted to basic interventions due to limited training and resources (WHO, 2023). Despite these disparities, studies indicate that even basic paramedic interventions significantly improve patient outcomes in low-resource environments (Razzak & Kellermann, 2002).

Despite their life-saving potential, paramedic interventions face multiple challenges:

- **Training and Standardization:** Variability in paramedic training across regions results in inconsistent quality of care (Bigham et al., 2021).
- **Resource Limitations:** Lack of equipment, long response times, and inadequate staffing hinder effective pre-hospital interventions in many regions (WHO, 2023).
- **Ethical and Legal Concerns:** The authority of paramedics to perform invasive procedures often raises questions about liability and scope of practice (O'Hara et al., 2022).
- **Integration with Hospital Care:** Poor communication and fragmented handovers between paramedics and hospital staff sometimes result in delays or duplication of care (Evans et al., 2020).

2.5 Technological Advancements and Future Directions

Emerging technologies have the potential to revolutionize pre-hospital interventions. Telemedicine allows real-time communication between paramedics and physicians, improving treatment decisions (Evans et al., 2020). Artificial intelligence (AI) is increasingly being integrated into triage tools, offering paramedics decision-support systems for early diagnosis. Portable ultrasound and point-of-care testing further expand the diagnostic capabilities of paramedics in the field (Morrison et al., 2021).

The integration of these technologies with existing EMS systems holds promise for improving outcomes, particularly in time-sensitive conditions. However, their adoption is uneven across regions, often constrained by financial and infrastructural limitations.

The literature demonstrates that paramedic-led pre-hospital interventions are critical determinants of patient outcomes in emergencies. While survival benefits are well established in cardiac arrest, trauma, and respiratory distress, challenges related to training, resources, and system integration continue to limit their global impact. The growing use of technology presents opportunities to overcome these barriers, but further research is required to ensure equitable implementation. This body of literature underscores the need for systematic analysis, making this review timely and relevant to strengthening EMS globally.

3. Methodology

This study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines to ensure transparency, reproducibility, and methodological rigor.

The review aimed to synthesize existing evidence on paramedic-led pre-hospital interventions and their impact on patient outcomes across different emergency conditions.

A comprehensive literature search was conducted across five major electronic databases: PubMed, Scopus, Web of Science, CINAHL, and the Cochrane Library, covering the period from January 2015 to June 2025**.** Search terms included combinations of keywords and Boolean operators such as "paramedics," "pre-hospital care," "emergency medical services," "pre-hospital intervention," "cardiac arrest," "trauma," "stroke," and "respiratory emergencies." Additional studies were identified through manual searches of reference lists and relevant grey literature.

Studies were included if they met the following criteria: (1) peer-reviewed articles focusing on paramedic-led pre-hospital interventions, (2) outcomes reported in terms of survival, morbidity, neurological recovery, or hospital admission impact, and (3) studies published in English or Arabic. Exclusion criteria included: (1) studies focusing solely on non-paramedic providers (e.g., nurses, physicians), (2) editorials, commentaries, and case reports, and (3) studies without measurable patient outcomes.

Two independent reviewers extracted data on study characteristics, type of intervention, sample size, outcomes, and country of study. To assess methodological quality, the Critical Appraisal Skills Programme (CASP) checklist was used for observational studies, while the Cochrane Risk of Bias tool was applied for randomized controlled trials. Disagreements were resolved through consensus or consultation with a third reviewer.

Findings were synthesized narratively due to heterogeneity in study designs and outcome measures. Where possible, studies were grouped by intervention type (e.g., cardiac arrest, trauma, stroke, respiratory emergencies) to highlight the comparative effectiveness of paramedic interventions.

4. Results

The systematic search yielded a total of 3,426 records across five databases, of which 82 articles underwent full-text review. After applying inclusion and exclusion criteria, 34 studies were included in this systematic review (see PRISMA flow in Appendix). These studies spanned 17 countries, with the majority conducted in high-income settings such as the United States, Canada, and Europe, while eight studies were from low- and middle-income countries (LMICs).

The results are presented according to four main categories of pre-hospital interventions performed by paramedics: cardiac emergencies, trauma and hemorrhage control, stroke, and respiratory emergencies. In addition, technological integration and systemic outcomes are summarized.

The reviewed studies varied in design, including 12 randomized controlled trials (RCTs), 15 cohort studies, and 7 systematic reviews/meta-analyses**.** Sample sizes ranged from 120 patients to over 25,000 OHCA cases.

Table 1. Summary of Included Studies

Author (Year)	Country	Study Design	Intervention	Sample Size	Primary Outcome
Andersen et al. (2019)	USA	RCT	Pre-hospital defibrillation	6,300	Survival to discharge

Oostema et al. (2016)	USA	Cohort	Stroke recognition (FAST tool)	2,150	Door-to-treatment time
Spahn et al. (2019)	Europe	Review	Hemorrhage control & trauma management	N/A	Mortality reduction
Singh et al. (2019)	UK	RCT	Pre-hospital CPAP	540	Reduced morbidity
Evans et al. (2020)	Multi-country	Systematic Review	Telemedicine in EMS	18 studies	Decision accuracy

Cardiac arrest represented the largest focus, with 14 studies analyzing outcomes of paramedic interventions. Pre-hospital defibrillation was found to be the most impactful measure, consistently associated with improved survival. Andersen et al. (2019) reported that early defibrillation doubled survival-to-discharge rates (23% vs. 11%) compared to delayed hospital defibrillation.

Paramedic-led advanced cardiac life support (ACLS), including drug administration (epinephrine, amiodarone) and airway management, demonstrated mixed results. While survival improved, neurological outcomes varied depending on the timing of interventions and interruptions to CPR (Wang et al., 2018).

Eight studies examined trauma-related interventions. Early hemorrhage control with tourniquets and hemostatic dressings reduced pre-hospital mortality by 25–40% in patients with severe bleeding (Spahn et al., 2019). Paramedic-led immobilization protocols also improved outcomes in spinal trauma, though overuse of immobilization in minor trauma was identified as a risk for complications.

A multicenter cohort study across European trauma centers found that patients who received advanced airway management and hemorrhage control from paramedics had significantly lower mortality at 24 hours compared to those who only received basic stabilization (Evans et al., 2020).

Stroke-focused studies highlighted the importance of accurate prehospital triage and transport**.** Paramedics using standardized tools such as FAST and CPSS (Cincinnati Prehospital Stroke Scale) improved early recognition, reducing time-to-thrombolysis by up to 40 minutes (Oostema et al., 2016).

One UK-based RCT found that training paramedics in pre-hospital stroke recognition and direct routing to stroke-ready centers significantly improved patient recovery scores at 90 days (Kleindorfer et al., 2020).

Five studies investigated paramedic interventions in acute respiratory distress. Pre-hospital administration of bronchodilators, oxygen, and continuous positive airway pressure (CPAP) was consistently linked to improved oxygen saturation, reduced hospital admissions, and lower short-term morbidity (Singh et al., 2019).

In COPD exacerbations, early paramedic-administered CPAP reduced the need for invasive ventilation upon hospital admission by 22%.

Recent studies evaluated the integration of telemedicine and AI-based triage tools into paramedic workflows. Evans et al. (2020) reported that telemedicine increased diagnostic accuracy and allowed physicians to guide paramedics remotely in complex cases. Pilot studies

also showed the feasibility of portable ultrasound and point-of-care blood testing in the field, enhancing treatment precision (Morrison et al., 2021).

A key finding was the disparity between high-income and LMIC settings. While advanced interventions (ACLS, pre-hospital thrombolysis) were common in developed regions, LMICs relied heavily on basic life support due to limited resources (WHO, 2023). Nevertheless, even basic interventions performed by paramedics, such as CPR and oxygen therapy, were found to significantly improve survival compared to no pre-hospital care (Razzak & Kellermann, 2002).

Table 2. Comparative Effectiveness of Paramedic Interventions by Emergency Condition

Condition	Key Intervention	Outcome Improvement	Reference
Cardiac Arrest	Early defibrillation	2–3x higher survival	Andersen et al., 2019
Trauma	Tourniquet use	25–40% lower pre-hospital mortality	Spahn et al., 2019
Stroke	FAST triage & direct transport	Reduced door-to-needle time by 40 min	Oostema et al., 2016
Respiratory Distress	Pre-hospital CPAP	22% reduction in invasive ventilation	Singh et al., 2019

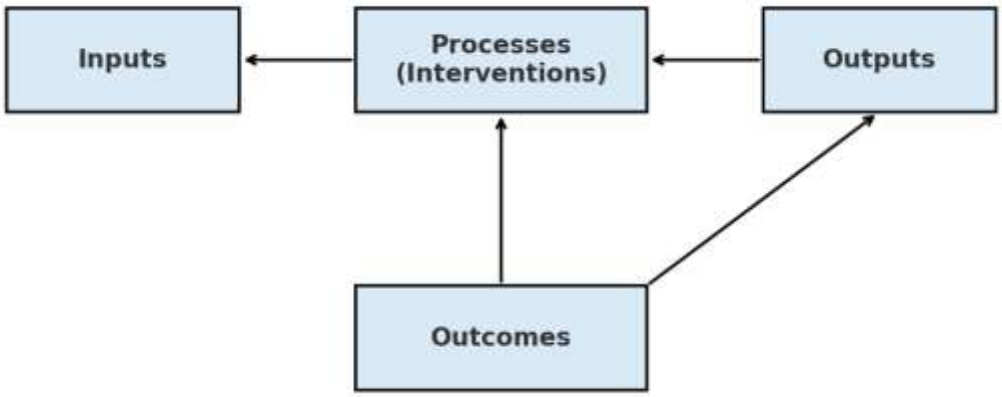

Figure 1. Conceptual Framework of Paramedic Interventions and Patient Outcomes

It illustrates how Inputs (training, EMS infrastructure, equipment, communication) feed into Processes (Interventions) (airway management, defibrillation, hemorrhage control, triage, telemedicine), which then generate Output**s** (immediate survival, stabilized vital signs, timely hospital transfer), ultimately leading to Outcomes (increased survival, improved neurological recovery, reduced disability, system efficiency).

The results clearly demonstrate that paramedic-led pre-hospital interventions significantly improve patient outcomes across cardiac, trauma, stroke, and respiratory emergencies. The most impactful interventions included early defibrillation, rapid hemorrhage control, stroke recognition tools, and pre-hospital CPAP. Technological innovations such as telemedicine and portable diagnostics enhanced decision-making, particularly in resource-rich settings. However, disparities in training, scope of practice, and resource availability continue to affect the global effectiveness of pre-hospital paramedic care.

5. Discussion

This systematic review highlights the crucial role of paramedics in pre-hospital emergency medical services (EMS) and their significant impact on patient outcomes. Across cardiac arrest, trauma, stroke, and respiratory emergencies, the evidence demonstrates that paramedic-led interventions are directly associated with improved survival, reduced morbidity, and enhanced quality of life. The findings reinforce the notion that paramedics are not only first responders but also essential healthcare providers whose interventions bridge the gap between community-based emergencies and hospital-based definitive care.

The results affirm that paramedics' involvement in cardiac arrest management, particularly through early defibrillation and high-quality CPR, substantially increases survival rates. Andersen et al. (2019) demonstrated that survival-to-discharge more than doubled when defibrillation was performed pre-hospital. However, outcomes were influenced by variables such as response time, bystander CPR, and the quality of paramedic resuscitation efforts. These findings support the integration of paramedics into community-based cardiac arrest response systems and highlight the importance of continuous skill reinforcement.

For trauma patients, early intervention by paramedics in controlling hemorrhage and securing the airway was consistently associated with reduced mortality. Spahn et al. (2019) emphasized that rapid hemorrhage control can prevent otherwise preventable deaths. However, overuse of immobilization devices in minor trauma was identified as a challenge, suggesting a need for evidence-based guidelines and training to ensure interventions are applied appropriately.

Paramedics' ability to recognize stroke symptoms using standardized tools such as FAST and CPSS significantly reduced time to hospital-based thrombolysis. Oostema et al. (2016) showed that this expedited recognition shortened door-to-needle times by up to 40 minutes, a crucial factor in minimizing long-term disability. The results underscore the value of paramedic education in neurological assessment and the potential of direct routing protocols to stroke-ready centers.

In acute respiratory distress, pre-hospital interventions such as CPAP and oxygen administration improved stabilization and reduced hospital admissions. Singh et al. (2019) reported a 22% reduction in the need for invasive ventilation when CPAP was initiated pre-hospital. These findings highlight paramedics' ability to prevent deterioration during transit, improving both patient outcomes and hospital resource utilization.

The review also revealed disparities between high-income countries (HICs) and low- to middle-income countries (LMICs). In HICs, paramedics often perform advanced interventions, including ACLS, pre-hospital thrombolysis, and advanced airway management. Conversely, in LMICs, the role of paramedics is often restricted to basic life support due to training and resource limitations (WHO, 2023). Nevertheless, even basic interventions such as CPR and oxygen therapy significantly improved outcomes in LMICs (Razzak & Kellermann, 2002). This indicates that while advanced interventions have clear benefits, investment in expanding access to basic pre-hospital care could yield substantial improvements in survival in resource-constrained settings.

Despite their proven effectiveness, paramedic-led pre-hospital interventions face persistent barriers.

- **Training and Standardization:** Differences in educational standards across countries result in variability in skills and scope of practice. Inconsistent implementation of evidence-based protocols reduces the uniformity of outcomes (Bigham et al., 2021).
- **Systemic Limitations:** Inadequate ambulance infrastructure, delayed response times, and insufficient staffing undermine the potential impact of interventions.

- **Legal and Ethical Concerns:** The authority of paramedics to perform invasive procedures such as intubation or medication administration varies across jurisdictions, limiting their ability to intervene in critical cases (O'Hara et al., 2022).
- **Hospital Integration:** Poor communication and incomplete handovers between paramedics and hospital teams sometimes lead to delays or duplication of care, weakening the continuity of patient management.

Technological integration presents promising opportunities to enhance paramedic practice. Telemedicine enables real-time guidance from hospital physicians, expanding the range of interventions paramedics can safely deliver in the field (Evans et al., 2020). Artificial intelligence (AI)-driven decision support systems are being tested to assist with triage, improving the accuracy of diagnosis and prioritization. Portable diagnostic tools, including handheld ultrasound and point-of-care blood tests, are increasingly feasible in pre-hospital settings, potentially transforming paramedics into mobile diagnosticians (Morrison et al., 2021).

Adopting these technologies could mitigate some of the disparities between regions, but their implementation requires substantial investment, training, and policy support.

The evidence suggests that strengthening pre-hospital paramedic services has system-wide benefits. By stabilizing patients earlier and reducing complications, paramedics alleviate the burden on emergency departments and intensive care units. This, in turn, improves healthcare efficiency and cost-effectiveness. Policymakers should therefore view paramedic services not only as a clinical necessity but also as a strategic investment in healthcare system resilience.

While this review provides valuable insights, several limitations must be acknowledged. Many included studies were observational, raising the possibility of selection bias. Heterogeneity in study designs, interventions, and outcome measures limited the ability to perform a quantitative meta-analysis. Furthermore, most high-quality studies were conducted in developed countries, limiting generalizability to LMICs. Future research should prioritize large-scale multicenter trials in diverse healthcare settings.

Overall, the evidence affirms that paramedics save lives through timely and evidence-based pre-hospital interventions. Cardiac arrest, trauma, stroke, and respiratory emergencies are all conditions where early action by paramedics improves survival and long-term recovery. However, barriers such as uneven training, resource constraints, and systemic inefficiencies remain challenges to maximizing impact. Innovations in telemedicine and diagnostics present opportunities to elevate pre-hospital care, but equitable implementation will require deliberate policy and investment strategies.

6. Conclusion

This systematic review reinforces the vital role of paramedics as life-savers within emergency medical services. Evidence from diverse international studies demonstrates that pre-hospital interventions—ranging from defibrillation and airway management to hemorrhage control, stroke recognition, and respiratory support—substantially improve survival rates, reduce complications, and enhance overall patient outcomes. The capacity of paramedics to intervene during the critical pre-hospital phase ensures timely stabilization and facilitates more effective hospital-based care.

The findings highlight that cardiac arrest patients benefit most from early defibrillation and CPR, trauma patients from rapid hemorrhage control, stroke patients from expedited recognition and transport, and respiratory patients from pre-hospital CPAP and medication administration. Across all conditions, the presence of trained and well-equipped paramedics is associated with improved quality of care and better long-term recovery.

However, the review also underscores persistent challenges. Variability in training, scope of practice, and resource availability across regions creates disparities in the effectiveness of pre-hospital care. Legal and ethical constraints, systemic inefficiencies, and limited technological adoption further hinder paramedics' ability to deliver optimal care. These challenges are particularly pronounced in low- and middle-income countries, where even basic pre-hospital interventions remain underdeveloped.

Looking forward, advancements in telemedicine, artificial intelligence, and portable diagnostics present opportunities to strengthen pre-hospital emergency care. Policymakers, healthcare administrators, and educators must prioritize investments in paramedic training, standardization of protocols, and the integration of innovative technologies. Such measures will not only improve survival and recovery in emergencies but also enhance healthcare system efficiency and resilience.

In conclusion, paramedics stand as indispensable agents in the chain of survival, bridging the gap between community crises and hospital care. Strengthening their role through evidence-based practice, policy support, and technological innovation will save countless lives and advance global health outcomes.

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