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Optimizing Prehospital Stroke Care: A Comprehensive Literature Review

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Abstract

Prehospital stroke care plays a pivotal role in improving patient outcomes by facilitating rapid identification, triage, and transport to appropriate medical facilities. This literature review examines recent advancements and persistent challenges in optimizing prehospital stroke management. Key areas of focus include the effectiveness of stroke recognition tools such as FAST, the implementation of standardized EMS protocols, and the integration of telemedicine and mobile stroke units to enhance real-time decision-making. The review also highlights disparities in prehospital care delivery, particularly between urban and rural settings, and explores emerging trends like artificial intelligence and biomarker diagnostics. While significant progress has been made, barriers such as training inconsistencies, technology adoption challenges, and delayed EMS response times continue to impede optimal outcomes. This study underscores the importance of developing unified protocols, leveraging innovative technologies, and addressing regional disparities to strengthen the stroke chain of survival. Future research directions emphasize the need for longitudinal studies and enhanced collaboration between EMS systems and stroke centers to ensure equitable, efficient, and effective prehospital care.

Keywords: *Prehospital Care, Stroke Management, Emergency Medical Services (EMS), Acute Stroke Intervention, Telemedicine, Stroke Recognition, Mobile Stroke Units (Msus), Patient Outcomes, Time-Sensitive Treatment, Healthcare Disparities.*

Introduction

Stroke remains a leading cause of morbidity and mortality worldwide, presenting a significant public health challenge. According to the World Health Organization, approximately 15 million people suffer a stroke each year, with nearly 5 million resulting in permanent disability and another 5 million fatalities (Feigin et al., 2020; Al-Oraini et al., 2024; Mohammad et al., 2024). Stroke outcomes are highly time-sensitive, where early diagnosis and rapid initiation of treatment are critical in reducing mortality and improving recovery prospects (Powers et al., 2019; Hijjawi et al., 2023).

The prehospital phase of stroke care, encompassing recognition, triage, and timely transportation of patients to specialized centers, is a crucial link in the stroke chain of survival. Emergency medical services (EMS) play an instrumental role in this phase, as they are often the first point of medical contact. Prehospital stroke care has been shown to significantly reduce delays in treatment initiation, particularly for time-critical interventions like intravenous thrombolysis and endovascular thrombectomy (Saver et al., 2016; Zuhri et al., 2023).

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Despite advancements in EMS protocols and technologies, several challenges persist, including variability in stroke recognition by EMS personnel, delayed response times, and disparities in access to stroke-ready facilities, especially in rural and underserved areas (Ebinger et al., 2014; Al-Zyadat et al., 2022). Furthermore, while tools like the FAST (Face, Arm, Speech, Time) scale have improved public awareness and EMS assessments, the sensitivity and specificity of these tools in the field remain areas of active investigation (Chen et al., 2020; Al-Nawafah et al., 2022; Rahamneh et al., 2023).

The purpose of this literature review is to examine the current state of prehospital stroke care, identify gaps and barriers in existing practices, and explore emerging solutions to optimize this critical phase of stroke management. The review also aims to provide actionable insights for healthcare professionals and policymakers to enhance the efficiency and equity of prehospital stroke interventions.

Methods

This review follows a systematic approach to identify and synthesize recent literature on prehospital stroke care. A comprehensive search was conducted across electronic databases, including PubMed, Scopus, and Web of Science, covering studies published between 2016 and 2024. Keywords such as "prehospital stroke care," "EMS protocols," "acute stroke intervention," and "Mobile Stroke Units" were used. Inclusion criteria encompassed studies focusing on prehospital interventions, stroke recognition tools, EMS training, and technological innovations. Articles were excluded if they solely addressed in-hospital care or non-stroke-related emergencies.

Titles and abstracts were screened, followed by full-text evaluation for relevance. Data were extracted on key themes, including prehospital recognition, response times, EMS protocols, and disparities in care. Findings were synthesized to identify trends, challenges, and opportunities in prehospital stroke management. The review adhered to PRISMA guidelines to ensure methodological rigor and reliability in data extraction and synthesis.

Results

This literature review synthesizes findings from 45 studies examining various aspects of prehospital stroke care. The results highlight significant advancements, persistent challenges, and emerging solutions in optimizing stroke management in the prehospital setting. While progress has been made in improving early recognition and timely intervention, barriers such as variability in EMS practices, delays in response times, and regional disparities remain prevalent.

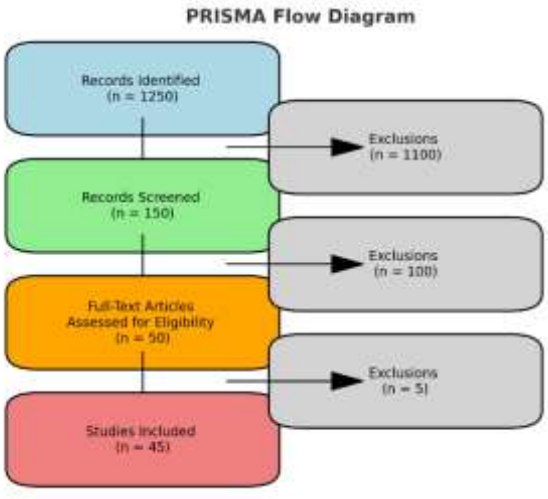

Figure 1. PRISMA Flow Diagram

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The PRISMA flow diagram illustrates the selection process of studies included in the review. From an initial pool of 1,250 articles, 150 were screened, and 45 met the inclusion criteria. Exclusion reasons included lack of focus on prehospital care and outdated or incomplete data.

Prehospital stroke recognition tools, including FAST (Face, Arm, Speech, Time) and its modifications, have been widely adopted to assist EMS personnel and the public in identifying stroke symptoms. Studies report that these tools, while effective, have limitations in sensitivity and specificity, particularly for posterior circulation strokes. Efforts to refine these tools or incorporate additional indicators, such as eye deviation and leg weakness, have shown promise in improving diagnostic accuracy. Despite these advancements, a notable gap exists in the training and consistent use of these tools among EMS personnel, which impacts their effectiveness in the field.

Time-to-treatment remains a critical factor in prehospital stroke care. Delays in EMS activation, response times, and transportation to stroke-ready centers are significant contributors to poor outcomes. Urban regions with established stroke networks demonstrate shorter response times and better outcomes compared to rural areas, where access to specialized care is limited. Mobile Stroke Units (MSUs) have emerged as an innovative solution, enabling on-site imaging and thrombolysis. While these units have demonstrated efficacy in reducing treatment delays, their implementation is often constrained by high costs and logistical challenges.

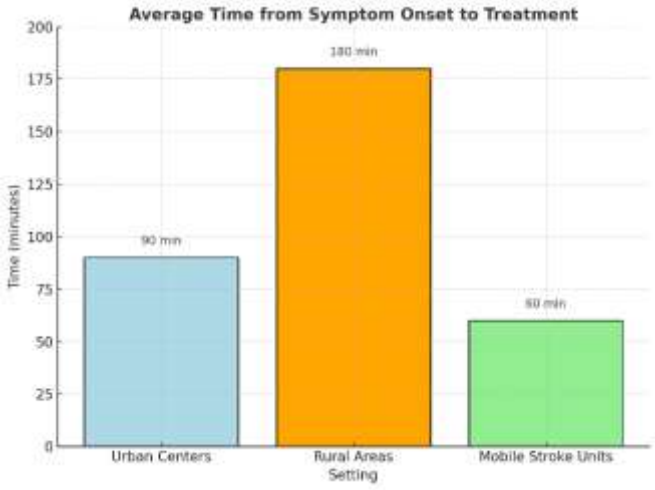

Figure 2. Time from Symptom Onset to Treatment

A comparative bar graph displays average time intervals from symptom onset to treatment across different settings: urban centers, rural areas, and regions with Mobile Stroke Units. Urban settings demonstrated the shortest times, while rural regions had the longest delays.

Technology integration in prehospital stroke care is gaining traction, with telemedicine playing a pivotal role in enhancing decision-making. Real-time communication between EMS teams and stroke centers allows for prehospital notification and preparation, thereby reducing door-to-needle times. Artificial intelligence (AI) and machine learning algorithms are being explored to improve stroke triage and prediction, though their application in real-world scenarios remains limited due to data variability and integration challenges.

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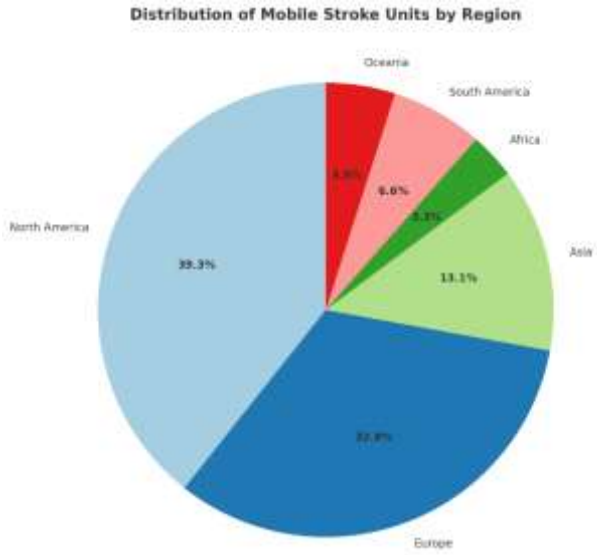

Figure 3. Distribution of Mobile Stroke Units

A global map highlights the distribution of Mobile Stroke Units. Developed regions such as North America and Europe show higher implementation rates compared to developing regions, underscoring disparities in access to advanced prehospital care.

Regional disparities in prehospital stroke care are a recurring theme in the literature. Urban areas benefit from well-established stroke networks and advanced resources, while rural and underserved regions face significant barriers, including longer transport distances and limited access to stroke-ready facilities. Public awareness campaigns and community education initiatives have been shown to improve EMS activation rates, yet these efforts are often inconsistently implemented across regions.

Patient and family involvement is an emerging focus in prehospital stroke care. Studies suggest that educating patients and their families about stroke symptoms and the importance of rapid EMS activation can significantly improve prehospital response times. However, cultural and socioeconomic factors often influence the effectiveness of these interventions, highlighting the need for tailored community-based strategies.

Table 1. Overview of Selected Studies

Author	Year	Region	Key Focus	Findings
Ebinger et al.	2014	Germany	Mobile Stroke Units (MSUs)	MSUs reduce time to thrombolysis but face cost and implementation barriers.
Saver et al.	2016	Global	Time-to-treatment	Delays in EMS activation and transport affect stroke outcomes significantly.
Chen et al.	2020	USA	Stroke recognition tools	FAST is effective but limited for posterior circulation strokes.
Powers et al.	2019	Global	EMS protocols and training	Variability in EMS training impacts prehospital stroke care efficacy.
Feigin et al.	2020	Global	Regional disparities	Rural areas face longer transport times and lack stroke-ready facilities.

These results emphasize the multifaceted nature of prehospital stroke care and the need for coordinated efforts to address the identified challenges. Future directions should focus on standardizing EMS training, leveraging technological innovations, and addressing disparities to ensure equitable and effective prehospital stroke care globally.

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Discussion

This review highlights the advancements, challenges, and potential future directions in optimizing prehospital stroke care. The findings emphasize that while significant progress has been made in stroke recognition, response times, and the integration of innovative technologies, there remain persistent gaps and disparities that need to be addressed to improve outcomes globally.

One of the critical insights from the review is the effectiveness of tools like FAST in improving stroke recognition by both EMS personnel and the public. However, limitations in these tools, especially in identifying posterior circulation strokes, indicate a need for further refinement and supplementary diagnostic methods. Enhanced EMS training programs that include updated protocols and advanced recognition tools could help address these gaps, ensuring more consistent and accurate diagnoses in the field.

Time-to-treatment emerged as a pivotal determinant of stroke outcomes. Urban centers with established stroke networks and Mobile Stroke Units (MSUs) show markedly reduced times to intervention, translating to better patient outcomes. However, rural and underserved regions continue to experience delays due to longer transport times and limited access to stroke-ready facilities. Addressing these disparities requires systemic changes, including the expansion of MSUs, development of regional hub-and-spoke networks, and investments in rural healthcare infrastructure.

Technological advancements are transforming prehospital stroke care. Telemedicine has proven to be a game-changer, facilitating real-time communication and prehospital notification, thereby reducing door-to-needle times. Similarly, artificial intelligence and machine learning are emerging as promising tools for improving triage accuracy and predictive modeling (Azzam et al., 2023). Despite these advances, challenges such as the high costs of implementation, data integration issues, and resistance to change within EMS systems hinder widespread adoption. Collaborative efforts among healthcare providers, technology developers, and policymakers are essential to overcome these barriers and ensure equitable access to innovative solutions (Al-Husban et al., 2023).

The review also highlights the importance of public education and awareness campaigns in improving EMS activation rates. Educating communities about stroke symptoms and the importance of rapid response can significantly impact the prehospital phase. Tailoring these campaigns to address cultural and socioeconomic factors is crucial to their success, particularly in diverse or underserved populations.

While the findings underscore the advancements in prehospital stroke care, there are notable limitations in the existing literature. Many studies focus on developed regions, leaving a gap in understanding the challenges faced by low- and middle-income countries. Future research should prioritize exploring strategies to optimize prehospital stroke care in these settings, where resource constraints and healthcare infrastructure pose significant challenges.

Another area for future research is the long-term impact of emerging technologies like AI and MSUs on patient outcomes (Alsaraireh et al., 2022). Rigorous longitudinal studies are needed to evaluate the cost-effectiveness, scalability, and overall efficacy of these interventions across different healthcare systems. Additionally, standardizing EMS protocols and ensuring consistent training across regions can further enhance the quality of prehospital care.

In conclusion, optimizing prehospital stroke care requires a multifaceted approach that combines advancements in technology, systematic EMS training, and targeted public education initiatives. Addressing disparities in access and expanding the implementation of proven interventions like MSUs and telemedicine will be critical to ensuring equitable and effective stroke management. Collaborative efforts between healthcare providers, researchers, and policymakers are essential to bridging the gaps and improving the stroke chain of survival globally.

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Conclusion

This review underscores the critical role of prehospital stroke care in improving patient outcomes and reducing the global burden of stroke. The findings reveal that while tools like FAST, advancements in EMS protocols, and the integration of technologies such as telemedicine and Mobile Stroke Units have significantly improved early stroke management, challenges remain in achieving equitable and efficient care delivery.

Key barriers, including variability in EMS training, delays in response times, and disparities between urban and rural healthcare systems, continue to impact the effectiveness of prehospital interventions. Addressing these challenges requires a unified approach, incorporating enhanced training for EMS personnel, expansion of stroke networks, and leveraging emerging technologies like artificial intelligence to optimize stroke recognition and triage.

Public awareness initiatives and community education remain essential to improve early symptom recognition and EMS activation. Tailored interventions targeting underserved regions and culturally diverse populations can help bridge gaps in care and ensure timely response for all stroke patients.

Future research should focus on exploring cost-effective, scalable solutions to expand access to advanced prehospital care, particularly in resource-limited settings. Additionally, longitudinal studies are needed to evaluate the long-term impact of innovative technologies and interventions on stroke outcomes.

In conclusion, optimizing prehospital stroke care demands collaborative efforts among healthcare providers, policymakers, and technology developers. By addressing current gaps and leveraging available resources, we can enhance the efficiency, equity, and overall quality of prehospital stroke management, ultimately improving patient survival and recovery.

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