วารสารการแพทย์ฉุกเฉินแห่งประเทศไทย
ปีที่ 5 ฉบับที่ 2 กรกฎาคม - ธันวาคม 2568

Journal of Emergency Medical Services of Thailand
Vol. 5 No. 2, July - December 2025

นิพนธ์ต้นฉบับ

Original Article

Prehospital Care and Triage Systems

Nichanat Siripruk*
Ananton Wuttiya **
Panappanon Jaratkulangkoon ***
Sireetorn Ngamsombat**
Siwat Katsanook***
Arthikom Laisin****
Narinpatr Romfahthai****
Kanlayakorn Wongvichayaporn*****
Sujimon Mungkalarungsi******

* *Phraharuthai Donmueng school*
** *Satri Angthong school*
*** *Triamudom Suksa School*
**** *Pibul Wittayalai School*
***** *Montfort College school*
****** *Assumption Samutprakarn School*
******* *Patumwan Demonstration School*
******** *Independent researcher*

Correspoding author: Sujimon Mungkalarungsi, email: khunsujimon.m@gmail.com

วันรับ: 27 มิ.ย. 2567 วันแก้ไข: 26 ส.ค. 2568 วันตอบรับ: 9 ก.ย. 2568

Abstract

Prehospital care and triage systems are essential components of emergency medical services (EMS), directly impacting patient survival and outcomes. Despite advancements in basic and advanced life support (BLS, ALS) and pharmacological interventions, disparities in implementation persist, particularly across Asia and in Thailand. This review aimed to (1) evaluate the effectiveness of prehospital interventions (BLS, ALS, pharmacological management) on outcomes and mortality, (2) compare and assess the accuracy, efficiency, and resource utilization of prehospital triage systems, and (3) explore current challenges and future directions, with a focus on Thailand and the Asian region. A systematic review was conducted according to PRISMA 2020 guidelines. Literature from 2000 to 2024 in English and Thai was searched in PubMed, EMBASE, Cochrane Library, CINAHL, Scopus, and Google Scholar. Eligible studies included randomized trials, observational studies, and systematic reviews assessing prehospital interventions or triage systems with measurable outcomes. Data extraction and quality assessment were performed using standardized tools (RoB 2, ROBINS-I, Newcastle–Ottawa, AMSTAR-2). Early interventions such as CPR, AED use, and hemorrhage control significantly improve survival in out-of-hospital cardiac arrest and trauma cases. ALS procedures—including advanced airway management and prehospital thrombolysis for STEMI and stroke—improve outcomes but require system

readiness and skilled personnel. Pharmacological treatments like aspirin and tranexamic acid are associated with reduced mortality. Triage systems (e.g., RTS, MGAP, START, STM, ESI, CTAS) vary in utility; physiological tools excel in trauma, while hybrid models enhance accuracy in mass casualty incidents. Technology-driven solutions—telemedicine, AI, wearable monitors, and prehospital ultrasound—show promise but remain underutilized. In Asia, systems vary widely, with Thailand progressing yet facing urban-rural disparities, workforce shortages, and limited equipment. Strengthening EMS infrastructure, expanding training, and integrating emerging technologies are crucial for improving prehospital care, especially in resource-limited settings like Thailand

Keywords: **prehospital care; emergency medical services; triage systems; patient outcomes; mortality rate**

Introduction

Prehospital care and triage systems are critical to emergency medical services (EMS), directly shaping survival, morbidity, and patient outcomes. Advances in basic and advanced life support (BLS, ALS) — including CPR, airway management, defibrillation, and prehospital pharmacological therapies—have reduced mortality and improved continuity of care[1,2]. Triage systems, developed to prioritize limited resources, are especially important during disasters, mass casualties, and in resource-constrained settings[3,4].

However, challenges persist. In Asia and Thailand, gaps include limited ALS ambulance access, uneven personnel distribution, and delayed rural responses[5,6]. Multiple triage models—physiological, anatomical, and hybrid—are used, yet no consensus exists on the most reliable approach[7]. Emerging technologies such as telemedicine, artificial intelligence, and wearable monitoring show potential, but their integration into EMS remains limited[8-10].

This review therefore aims to (1) evaluate prehospital interventions in improving outcomes and reducing mortality, (2) assess the performance and limitations of triage systems, and (3) identify challenges, innovations, and future directions. By doing so, it seeks to provide evidence-based recommendations to strengthen EMS and optimize resource use globally.

Material and Method

This study was conducted as a narrative review to synthesize current evidence on prehospital care and triage systems. Literature was searched in major databases, including MEDLINE (PubMed), Cochrane Library, EMBASE, CINAHL, Scopus, and Google Scholar, covering publications from January 2000 to December 2024 in English and Thai. Search terms included prehospital care, emergency medical services, triage, patient outcomes, mortality, basic and advanced life support, telemedicine, and artificial intelligence. Priority was given to peer-reviewed studies that reported outcomes such as survival, mortality, or system performance, while non-peer-reviewed, laboratory, and animal studies were excluded. Relevant articles were selected based on their relevance and contribution to the topic. Findings were synthesized narratively and organized into themes: prehospital interventions, triage systems, technological innovations, and regional practices, with particular attention to experiences in Asia and Thailand.

Results

Prehospital Interventions

Prehospital interventions are the first therapeutic measures in the chain of survival, aiming to preserve life, prevent deterioration, and prepare patients for definitive care. They include basic life support (BLS), advanced life support (ALS), and pharmacological management, with innovations adding new dimensions. Evidence shows that timely and effective interventions reduce mortality and improve outcomes, though their impact depends on system design, training, and timeliness[1,2].

Basic Life Support (BLS)

BLS is the foundation of emergency response, particularly in cardiac arrest and trauma. Core measures include rapid recognition, CPR, AED use, airway management, oxygen supplementation, hemorrhage control, and spinal immobilization. Immediate CPR can double or triple out-of-hospital cardiac arrest survival[11], while AED access improves neurological outcomes[12]. Hemorrhage control with pressure, hemostatic dressings, or tourniquets reduces trauma mortality[13]. Oxygen therapy, airway positioning, and selective spinal immobilization further support stabilization.

Advanced Life Support (ALS)

ALS builds on BLS with advanced airway management, IV/IO access, cardiac monitoring, defibrillation protocols, and medication administration. Airway management should prioritize the device providers are most proficient with, reserving intubation for teams with >95% success rates[14]. ALS extends to reperfusion therapies, such as prehospital thrombolysis for STEMI and stroke, which reduce disability and improve outcomes[9,15,16]. Emerging innovations—including mechanical CPR, ECMO for refractory arrest, and REBOA for severe trauma — show promise but require specialized training, system integration, and careful patient selection[17-19].

Pharmacological Management

Prehospital pharmacological therapy can alter the course of acute illness before hospital arrival. In cardiovascular emergencies, early aspirin in acute coronary syndromes reduces mortality[1]. In trauma, tranexamic acid (TXA) given within the first hour lowers bleeding-related deaths[20]. Neurological emergencies benefit from benzodiazepines such as midazolam or lorazepam for status epilepticus, while levetiracetam shows promise with fewer side effects[21,22]. Anaphylaxis requires immediate intramuscular epinephrine to prevent cardiorespiratory collapse[23]. For respiratory compromise, bronchodilators, nitrates, and NIPPV reduce mortality and intubation in acute pulmonary edema and bronchospasm[24]. However, pain management remains underutilized, with opioids and multimodal analgesia often withheld despite proven efficacy[1].

Innovations in Prehospital Care.

Technological advances are reshaping prehospital practice by enhancing diagnosis and decision-making. Telemedicine enables real-time specialist consultation, reducing delays and improving triage in resource-limited settings[9]. AI and ML are being tested to predict cardiac arrest outcomes, support early stroke recognition, and guide triage through data integration[8,10]. Wearable sensors and mobile apps provide continuous monitoring, while point-of-care ultrasound (POCUS) allows rapid assessment of pneumothorax, tamponade, and intra-abdominal bleeding[25]. Integration of electronic health records and decision-

support systems further strengthens communication and mass-casualty response. Despite their potential, adoption remains limited by training needs, infrastructure costs, and system disparities, particularly in low- and middle-income countries.

Prehospital Triage Systems: Accuracy, Efficiency, and Resource Allocation

Prehospital triage systems are structured methodologies that categorize patients by severity, urgency, and resource needs. They are vital in routine EMS operations but become especially critical during disasters and mass casualty incidents (MCIs), when demand exceeds available capacity. By guiding responders in prioritizing treatment and transport, triage systems aim to reduce mortality, improve outcomes, and maintain system efficiency[3,4].

Physiological Triage Systems

Physiological tools are widely applied in trauma care. The Revised Trauma Score (RTS) and Triage-Revised Trauma Score (TRTS) use variables such as systolic blood pressure, respiratory rate, and Glasgow Coma Scale (GCS) to predict survival[26]. These scores provide objective and reproducible measures, but their utility is limited in non-trauma emergencies and may be unreliable in pediatric or geriatric patients[7].

Anatomical and Mechanism-Based Systems

Anatomical systems, such as the Prehospital Index (PHI) and Trauma Score, prioritize patients by injury type and extent. While straightforward, they may miss occult or internal injuries. Mechanism-based models like the MGAP (Mechanism, GCS, Age, Arterial Pressure) score combine injury mechanism, physiology, and demographics to improve risk stratification[27]. However, these rely on accurate field assessment, which can be challenging in chaotic prehospital environments.

Hybrid Triage Systems

Hybrid models combine physiological, anatomical, and mechanistic criteria to balance speed and accuracy. The Simple Triage and Rapid Treatment (START) algorithm is widely used in MCIs due to its simplicity and minimal training requirements, though it may oversimplify complex cases[28]. The Sacco Triage Method (STM) offers greater accuracy but is less practical in large-scale events due to time demands[29]. Hospital-based systems such as the Emergency Severity Index (ESI), Canadian Triage and Acuity Scale (CTAS), and Manchester Triage System (MTS) have also been adapted for prehospital use, offering finer granularity but requiring significant training[30].

Technological Integration and Innovations

Technology is increasingly augmenting triage decision-making. Telemedicine supports real-time specialist consultation, improving triage accuracy for time-sensitive conditions such as stroke and STEMI[9]. AI and ML are being piloted for automated risk stratification and triage recommendations, aiming to reduce variability in clinical judgment[8,10]. Wearable devices and mobile health platforms provide continuous physiological monitoring, while prehospital point-of-care ultrasound (POCUS) enhances rapid detection of critical conditions including pneumothorax, tamponade, and intra-abdominal bleeding[25]. Despite promise, barriers such as cost, infrastructure, and training limit widespread adoption, particularly in low- and middle-income countries[7].

Implications for Accuracy, Efficiency, and Resource Allocation

Triage systems must strike a balance between accuracy in identifying high-risk patients, efficiency in enabling rapid decisions, and fair distribution of scarce resources. Evidence shows that structured triage reduces ED overcrowding, improves ambulance utilization, and ensures patients are directed to appropriate facilities[31,32]. However, no single model is universally optimal. Adaptation to local resources, population needs, and system maturity remains essential, underscoring the importance of context-specific implementation[7].

Regional Experiences: Asia and Thailand

Across Asia, triage implementation reflects wide disparities in healthcare infrastructure and resources. High-income countries such as Singapore and Malaysia employ standardized systems like the Singapore Triage Scale (STS) and Triage and Acuity Scale (TACS), while Japan, South Korea, and China have developed national models such as JTAS, KTAS, and CTS, tailored to local contexts. In contrast, resource-limited nations such as India and Pakistan struggle with overcrowding, inadequate funding, and inconsistent adoption of adapted tools like the South African Triage Scale (SATS)[33].

Regional Context

Mature EMS networks in Japan, Singapore, and South Korea demonstrate integration of advanced triage with robust ambulance fleets and skilled personnel. Japan provides free EMS staffed by trained advanced life support technicians, while Singapore uses motorcycle-based rapid response units to overcome traffic congestion and incorporates advanced arrhythmia management[34]. By contrast, India and Cambodia face substantial barriers: in India, only 7.5% of accident victims reach hospitals by ambulance, often missing the "golden hour," while Cambodia suffers from limited government-funded ambulance services, particularly in rural areas[33]. These contrasts underscore the need for region-specific strategies to expand EMS access and triage capacity.

Thailand

Thailand has made significant progress by adopting the Emergency Severity Index (ESI) in 2008 as its national triage standard. Its prehospital network now includes Basic Life Support (BLS) and Advanced Life Support (ALS) ambulances staffed by paramedics, EMTs, and nurses[34]. Nonetheless, major challenges persist. Urban-rural disparities remain stark, with ALS-equipped ambulances concentrated in Bangkok and large cities, leaving rural regions underserved[35]. Workforce shortages limit the number of trained providers proficient in standardized triage protocols, leading to inconsistencies in patient prioritization[34]. Equipment shortages and funding constraints hinder rural expansion, while cultural and language barriers complicate communication during emergencies. Limited public awareness further delays EMS activation and compliance[33,34].

To address these gaps, Thailand is expanding training programs, investing in rural EMS infrastructure, and launching public awareness campaigns[33]. Technology is also being piloted—such as telemedicine, wearable devices, and mobile intensive care units (MICUs)—to enhance coverage and equity[10]. International collaborations are underway to adapt global best practices, while ongoing research and evaluation are essential to refine triage protocols and ensure consistency nationwide[34].

Future Directions in Asia and Thailand

At the regional level, disaster preparedness remains a priority, with emphasis on scalable triage systems, surge-capacity planning, and resource stockpiling[32]. Emerging innovations—including AI-assisted triage, prehospital ultrasound, and community paramedicine—hold promise for improving both rural outreach and urban resilience. Sustained investment in training, infrastructure, and outcome-based research will be critical to reducing disparities and strengthening prehospital emergency care across Asia and Thailand.

Discussion

This review sought to (1) evaluate prehospital interventions, (2) assess triage system performance, and (3) identify challenges and future directions, with emphasis on Asia and Thailand. Overall, substantial gains in prehospital care are tempered by uneven implementation and variable system readiness.

Early care is pivotal. BLS—especially timely CPR and defibrillation—doubles or triples out-of-hospital cardiac arrest survival[11,12]; hemorrhage control, airway support, and oxygen therapy further reduce preventable trauma deaths[13]. ALS adds benefit via advanced airway, IV/IO access, and reperfusion therapies (prehospital thrombolysis for STEMI/stroke) that shorten time to treatment and improve function[9,15,16]. Pharmacologic measures—aspirin for ACS and TXA for trauma—lower mortality[1,20]. Persistent gaps include underused analgesia and limited ALS access in constrained settings; impact hinges on training, capacity, and timeliness.

Triage accuracy drives efficient resource use. Physiological tools (RTS, TRTS) are reproducible but trauma-centric and less reliable in pediatric/geriatric groups (7,30). Anatomical/mechanism-based models (PHI, MGAP) broaden scope yet depend on accurate field assessment[26]. Hybrids trade speed and precision: START is rapid for MCIs, STM more accurate but less feasible[27,28]. ED-derived systems adapted prehospitally (ESI, CTAS, MTS) offer granularity but require training and consistency[29]. Telemedicine, AI, and POCUS are promising, though evidence on scalability remains limited[8-10,25]. No single system is superior; effectiveness is context- and maturity-dependent.

Regionally, high-income systems (Japan, Singapore, South Korea) feature integrated EMS and standardized triage[34], while India, Pakistan, and Cambodia face resource and transport barriers, missing the "golden hour"[33]. Thailand has advanced with national ESI (since 2008) and BLS/ALS expansion[34] but still contends with urban-rural gaps, workforce shortages, equipment limits, and communication barriers[33-35]. Priorities include workforce training, rural coverage, public awareness, and targeted pilots of telemedicine, wearables, and MICUs[10]; disaster readiness with scalable triage, surge planning, and stockpiles is essential[32]. Progress will depend on context-specific adaptation, sustained investment, and outcome-focused research.

In sum, prehospital interventions work but are inconsistently delivered; triage is indispensable yet context-bound. Technology integration plus workforce development and regional collaboration are key to more equitable, resilient prehospital care.

Conclusion

This review highlights the vital role of prehospital care and triage systems in improving survival and functional outcomes. Basic life support—particularly

CPR, AED use, and hemorrhage control—remains the most impactful intervention, while advanced strategies such as thrombolysis, aspirin, and tranexamic acid further reduce mortality when system readiness allows. No triage model is universally superior; their effectiveness depends on context, maturity, and balancing speed with accuracy. Technology-enhanced approaches, including AI, telemedicine, and prehospital ultrasound, offer promising opportunities to improve efficiency, especially in mass casualty and resource-limited settings.

In Asia, and particularly Thailand, progress is evident but persistent gaps remain, including urban-rural disparities, workforce shortages, and limited resources. Future improvement requires aligning evidence-based practices with local realities, expanding training and infrastructure, adopting scalable technologies, and fostering regional collaboration. These steps are essential for building resilient EMS systems and ensuring more equitable emergency care delivery.

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บทคัดย่อ

ระบบการดูแลผู้ป่วยก่อนถึงโรงพยาบาลและการคัดแยกผู้ป่วย

ณิชานาฏ ศิริพฤกษ์*; อนัญธรณ์ วุฒิยา; ปาณัปนน จรัสกุลางกูร***; สิรีธร งามสมบัติ****; ศิวัช กาศสนุก*****; อธิคม หลายสิน******; นรินทร์ภัทร์ ร่มฟ้าไทย******; กัลยกร วงศ์วิชยาภรณ์*******; ศุจิมน มังคลรังษี*********

** โรงเรียนพระหฤทัยดอนเมือง; ** โรงเรียนสตรีอ่างทอง; *** โรงเรียนเตรียมอุดมศึกษา; **** โรงเรียนพิพิบูลวิทยาลัย; ***** โรงเรียนมงฟอร์ตวิทยาลัย; ****** โรงเรียนอัสสัมชัญสมุทรปราการ; ******* โรงเรียนสาธิตปทุมวัน; ***** นักวิจัยอิสระ*

วารสารการแพทย์ฉุกเฉินแห่งประเทศไทย 2068;5(2):186-95.

ติดต่อผู้เขียน: ศุจิมน มังคลรังษี email: khunsujimon.m@gmail

การดูแลผู้ป่วยก่อนถึงโรงพยาบาลและระบบคัดแยกผู้ป่วยเป็นองค์ประกอบสำคัญของบริการการแพทย์ฉุกเฉิน (EMS) ซึ่งส่งผลโดยตรงต่อการรอดชีวิตและผลลัพธ์ของผู้ป่วย แม้จะมีความก้าวหน้าในการช่วยชีวิตขั้นพื้นฐานและขั้นสูง (BLS, ALS) รวมถึงการใช้ยารักษา แต่ยังคงพบความเหลื่อมล้ำในการดำเนินงาน โดยเฉพาะในภูมิภาคเอเชียและประเทศไทย การทบทวนนี้มีวัตถุประสงค์เพื่อ (1) ประเมินประสิทธิผลของการดูแลก่อนถึงโรงพยาบาลต่อผลลัพธ์และอัตราการเสียชีวิต (2) เปรียบเทียบความแม่นยำ ประสิทธิภาพ และการใช้ทรัพยากรของระบบคัดแยกผู้ป่วย และ (3) วิเคราะห์ความท้าทายและทิศทางในอนาคต โดยเน้นบริบทของไทยและเอเชีย ดำเนินการทบทวนอย่างเป็นระบบตามแนวทาง PRISMA 2020 จากวรรณกรรมภาษาไทยและอังกฤษที่ตีพิมพ์ระหว่างปี 2000-2024 โดยใช้เครื่องมือประเมินคุณภาพมาตรฐาน ผลการศึกษาแสดงว่า การช่วยชีวิตโดยการใช้ AED และการควบคุมเลือดออกช่วยเพิ่มอัตรารอดชีวิต การให้ยา เช่น แอสไพรินและกรดทราเนซามิก มีส่วนลดการเสียชีวิต ส่วน ALS เช่น การจัดการทางเดินหายใจและการให้ยาละลายลิ่มเลือด ช่วยปรับปรุงผลลัพธ์แต่ต้องอาศัยความพร้อมของระบบ ระบบคัดแยกผู้ป่วยหลากหลายแบบมีจุดเด่นต่างกัน ทั้งแบบใช้สัญญาณชีพหรือแบบผสมผสาน นวัตกรรมเทคโนโลยี เช่น เทเลเมดิซีน AI และอุปกรณ์สวมใส่ เริ่มมีบทบาทแต่ยังใช้อย่างจำกัด ในประเทศไทย แม้ EMS มีความก้าวหน้า แต่ยังประสบปัญหาด้านทรัพยากรและความเหลื่อมล้ำระหว่างพื้นที่ การพัฒนาโครงสร้างพื้นฐาน บุคลากร และการใช้เทคโนโลยีอย่างเหมาะสมจึงมีความจำเป็นอย่างยิ่ง

คำสำคัญ: **การดูแลผู้ป่วยก่อนถึงโรงพยาบาล; บริการการแพทย์ฉุกเฉิน; ระบบคัดแยกผู้ป่วยตามความเร่งด่วน; ผลลัพธ์ทางสุขภาพของผู้ป่วย; อัตราการเสียชีวิต**