OPEN ACCESS
World Journal of Applied Medical Sciences
ISSN: 3049-0200 (Online) | Vol. 3, No. 6, 2026
Website: https://wasrpublication.com/index.php/wjams/

Navigating the Golden Hour: A PDSA-Driven Quality Improvement Initiative for Optimizing Ambulance Fleet Efficiency and Driver Logistics

Dr. N. Murugesan[1], Dr. Venkatram Murugesan[1], Dr. D. Rakesh Khanna[2], Dr. Annamalai Peiryanan[3], Sumathy Masanam Kasi[4*]

[1]Chief Nephrologist, East coast hospitals, Puducherry

[2]Quality, East coast hospitals, Puducherry

[3]Senior consultant -Emergency Medicine, East coast hospitals, Puducherry

[4]Research Coordinator, East coast hospitals, Puducherry.

Received: 01/04/2026 | Accepted: 18/05/2026 | Published: 10/06/2026

Abstract:

Background: Emergency Medical Services (EMS) face heightened operational strain during public health crises, yet hospital management frameworks frequently overlook micro-level vulnerabilities within the transport vehicle and its operator, such as driver fatigue and unverified equipment readiness.

Objectives: This study aimed to systematically evaluate prehospital vulnerabilities, design and deploy a dual-phase Ambulance Operational Checklist targeting four foundational pillars—driver roster automation, fleet efficiency, absolute equipment preparedness, and mandated driver rest—and implement a tailored training program to bridge frontline compliance gaps.

Methods: A single-arm, quasi-experimental quality improvement initiative was conducted over a consecutive six-month period at a secondary care hospital in South India. Guided by the iterative Plan-Do-Study-Act (PDSA) framework, the intervention involved an active fleet of four vehicles and its entire workforce of Emergency Medical Technicians (EMTs) and drivers. A mandatory 2-day simulation-based workshop was paired with continuous, objective monthly Quality Assurance (QA) audits.

Results: Baseline assessments revealed critical institutional vulnerabilities, with a median technical competence score of 3/10. Following simulation-based training, median competence scores rose sharply to 9/10, representing a 200% increase in proficiency. Monthly QA audits over 6+ months demonstrated excellent longitudinal sustainability: tool compliance exceeded 95%+, dispatch delays dropped from 15–20 minutes to <10 minutes, and operational near-misses decreased by 70%. Roster automation eliminated overextended shifts, ensuring 100% adherence to an 8-hour shift ceiling and a standardized 12-hour inter-shift rest period, resulting in zero reported driver fatigue incidents.

Conclusion: Utilizing an iterative PDSA cycle to balance mechanical readiness with human factor optimization effectively transitions reactive transport pools into highly reliable, safety-first clinical logistics systems. Joint simulation-based training builds an institutional culture of Crew Resource Management, sustaining operational vigilance and frontline patient safety without attrition.

Keywords: Ambulance Operations; Continuous Quality Improvement; Crew Resource Management; Driver Fatigue; Emergency Medical Services; Patient Safety; Plan-Do-Study-Act (PDSA); Simulation-Based Training.

Introduction

Over the past several decades, ambulance services have undergone a profound paradigm shift, evolving from rudimentary patient transport vehicles into sophisticated extensions of the hospital itself—mobile intensive care units capable of delivering advanced prehospital clinical care outside the traditional hospital gateway (Eisenberg & Mengert, 1996; Shah, 2006).

Historically, the primary utility of an ambulance was simple conveyance with minimal medical intervention administered mid-transit (Committee on the Future of Emergency Care in the United States Health System, 2007). However, rapid advancements in healthcare technology, medical science, and paramedic education have fundamentally restructured this role (Committee on the Future of Emergency Care in the United States Health System, 2007; Lowthian et al., 2011). Modern Advanced Life Support (ALS) systems now empower emergency medical teams to perform highly complex procedures—such as endotracheal intubation, intravenous drug administration, and synchronized electrical defibrillation—long before the patient ever reaches an Emergency Department (ED) bay (Richardson et al., 2002). In acute, time-critical crises such as sudden cardiac arrest, severe polytrauma, or acute respiratory failure, this frontline capability bridges the precarious gap between life and death (Wilson et al., 2015).

Concurrent with these clinical advancements, global demographic shifts, evolving socio-economic pressures, and systemic healthcare

***Corresponding Author**
Sumathy Masanam Kasi*
E-mail: clinicalresearch@eastcoasthospitals.com

access bottlenecks have driven an unprecedented surge in the demand for emergency medical services (EMS) (Alsalem et al., 2023). This escalating volume has placed severe, compounding strain on hospital EDs and fleet infrastructure alike, frequently resulting in department overcrowding and prolonged turnaround times (Lowthian et al., 2011). To manage this modern pressure, emergency systems have had to diversify their operational strategies, distinguishing strictly between clinical conveyance (the physical transfer of patients, medical personnel, and documentation to a healthcare facility) and non-conveyance (where patients are assessed, treated on-scene, discharged, or referred to primary care without hospital transport) (Ebben et al., 2017). Non-conveyance, driven by a combination of clinical professional judgment and patient preference, serves as a vital gatekeeping mechanism to preserve scarce institutional resources (Marks et al., 2002; Snooks et al., 1998; Snooks et al., 2004).

During public health crises or mass-casualty disasters, this operational agility must expand even further. EMS personnel are frequently deployed into non-traditional environments—such as temporary field clinics, shelters, and alternate care sites—or required to execute extended-care evacuations that far exceed their traditional stabilization and transport mandates (Abir et al., 2021; Tierney, 1985). Under severe resource constraints, systems must implement rigorous, medically directed triage algorithms and altered staffing protocols to ensure that critically limited assets are directed strictly toward immediately life-threatening conditions (Gostin et al., 2009; World Health Organization, 2012).

Yet, while literature extensively documents these macro-level clinical advancements and disaster protocols, a critical vulnerability remains largely unaddressed in standard hospital management frameworks: the micro-level operational ecosystem of the vehicle and its operator. The most sophisticated medical technology and clinical expertise are rendered entirely obsolete if the transport vehicle itself is mechanically compromised, or if the human factor driving the vehicle is cognitively impaired. Suboptimal roster management, unmonitored vehicle preparedness, and driver fatigue represent severe, latent systemic errors that directly jeopardize patient outcomes and compromise safety during emergency transits.

If a driver is exhausted from back-to-back shifts without mandated rest, or if a vehicle is dispatched with depleted oxygen cylinders or unverified defibrillator batteries, the continuity of care fractures. Quality assurance in healthcare leadership must therefore recognize that vehicle readiness and driver well-being are not merely administrative footnotes; they are core determinants of clinical safety and instructional design.

To systematically address these vulnerabilities, this study details a Quality Improvement (QI) initiative centered on the design, implementation, and iterative refinement of a structured ambulance operational checklist using the Plan-Do-Study-Act (PDSA) framework. The impetus for this initiative stemmed from a routine institutional job satisfaction survey, which revealed chronic, systemic overtime among Emergency Medical Technicians (EMTs) and ambulance drivers—raising critical concerns regarding acute workforce fatigue during real-time emergencies. By tracking and optimizing four foundational pillars—driver roster automation, fleet efficiency, absolute equipment preparedness, and mandated driver rest—this paper demonstrates how systematic operational vigilance directly mitigates latent risks, preserves transport efficiency, and reinforces an institutional commitment to frontline patient safety.

The main objective of this initiative is to systematically overhaul ambulance operations using an iterative Quality Improvement (QI) framework, balancing mechanical readiness with human factors—specifically driver rest—to establish an institutional culture of safety. To transition this high-level systemic goal into measurable operational outcomes, this study was structured around three clear operational milestones:

- To comprehensively evaluate the baseline performance, logistics bottlenecks, and latent safety vulnerabilities of the active institutional ambulance service.
- To design and implement a structured, dual-phase Ambulance Operational Checklist targeting four essential pillars: driver roster automation, fleet efficiency, all-time equipment preparedness, and mandated driver rest.
- To develop and deploy a targeted training program explicitly tailored for Emergency Medical Technicians (EMTs) and drivers to bridge the gap between protocol design and frontline clinical compliance.

By utilizing the iterative Plan-Do-Study-Act (PDSA) cycle, this paper details the longitudinal evolution of this operational tool and educational intervention. In doing so, we demonstrate how combining structured operational vigilance with targeted workforce training creates a highly reliable, safety-first prehospital system capable of protecting both the patients and the personnel who care for them.

Methods

Study Design and Setting

This study utilized a single-arm, quasi-experimental quality improvement design conducted at a tertiary care hospital in South India. The intervention focused on the institutional ambulance department, encompassing an active fleet of four vehicles and a workforce consisting of all assigned Emergency Medical Technicians (EMTs) and ambulance drivers. The study followed the iterative Plan-Do-Study-Act (PDSA) framework to evaluate, deploy, and optimize transport operations over a consecutive six-month period as shown in Figure1.

The PDSA Framework

Phase 1: Plan (Baseline Evaluation and Tool Design)

The initial phase focused on identifying latent systemic failures. A retrospective audit of the previous six months of institutional transport logs was conducted, alongside qualitative interviews with active EMTs and drivers.

- *Gap Analysis:* We identified three primary operational gaps: inconsistent equipment readiness, non-standardized shift handovers leading to compound driver fatigue, and poor tracking of vehicle turnaround efficiency.
- *Tool Development:* Based on these findings, an initial dual-phase Ambulance Operational Checklist was designed. The tool prioritized "Human Factors" (driver shift limits, alertness, and rest tracking) alongside "Mechanical Factors" (oxygen reserve levels, drug kit integrity, and vehicle vitals).

- *Training Program Design:* A structured curriculum was developed to transition transport staff from passive participants to active safety officers, focusing heavily on the direct link between driver fatigue, mechanical oversight, and patient transit mortality.

Phase 2: Do (Implementation and Training)

Implementation began with a mandatory 2-day training workshop for all department EMTs and drivers.

- *Training Execution:* The program utilized simulation-based training where staff actively practiced "Pre-flight" and "Post-flight" checks using the new checklist. Emphasizing the driver roster, the framework established a strict cap ensuring no driver exceeded 8 hours of continuous duty without a mandated rest period.
- *Pilot Launch:* The checklist was integrated directly into the physical and digital dispatch workflow. No vehicle was permitted to leave the ambulance bay without a verified "Green Status" on all safety-critical items, co-signed by both the operating driver and the lead EMT on duty.

Phase 3: Study (Data Collection and Analysis)

During the study phase, compliance and operational outcomes were monitored continuously. Data was collected across four core domains: checklist compliance rates, overall transit efficiency (turnaround time from dispatch to arrival), tracking of mechanical or clinical "near-misses," and formal survey feedback from the transport workforce regarding the perceived utility of the adjusted scheduling model.

Phase 4: Act (Refinement and Content Validation)

In the final phase of the cycle, the data and frontline feedback gathered during the implementation period were used to refine the operational tool. To ensure methodological rigor, the initial checklist underwent formal content validation with three independent healthcare management experts. Simultaneously, pilot testing was conducted to assess clinical usability and workflow integration.

The pilot test revealed a significant operational friction point: the initial version of the checklist was overly exhaustive, taking 15 to 20 minutes to complete. Frontline drivers formally requested a streamlined version to prevent dispatch delays. Responding to this feedback, the checklist was systematically revised to optimize brevity without sacrificing safety-critical variables. This refined, high-efficiency checklist, alongside the mandated driver rest policy, was then formally adopted into the institutional Hospital Standing Operating Procedures (SOPs).

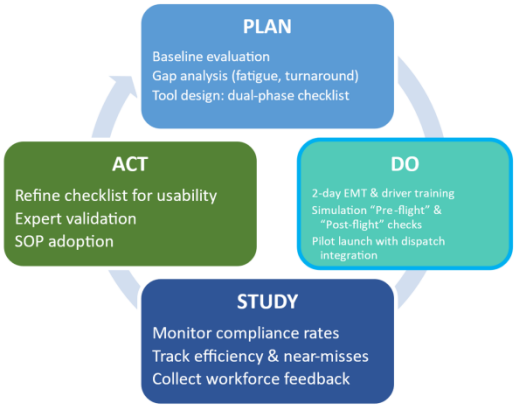

Figure 1: Implementation of the PDCA Quality Improvement Cycle for Emergency Medical Services (EMS) Operational Safety

Ethical Considerations

This project was conducted strictly as a Quality Improvement initiative aimed at system-wide process refinement. All collected operational and survey data was fully de-identified to ensure the privacy of participating EMTs and drivers, and the primary focus remained on systemic process improvement rather than individual performance appraisal.

Results

1. *Educational Impact of the Simulation Training Program*

Prior to the implementation of the operational checklist, the baseline competence, safety awareness, and technical proficiency of the EMTs and drivers were evaluated using a standardized 10-point operational scale.The pre-intervention baseline score was critically low, with a median of 3 out of 10 (Table 1), highlighting a significant institutional vulnerability. Following the structured simulation-based training program conducted by certified Basic Life Support (BLS) trainers, a profound educational shift was observed. Post-training evaluations demonstrated a substantial increase in competence, *with median scores rising sharply to 9 out of 10.* This marked improvement reflects enhanced technical skill acquisition, a clearer understanding of crisis logistics, and behavioural alignment regarding the critical importance of pre-flight vehicle and equipment verification.

Table 1: Impact of a Simulation-Based Training Program on EMS Personnel Competence and Technical Proficiency

Evaluation Dimension	Pre training (Median)	Post-Training (Median)	Relative Change	Operational Context
Technical Competence Score	3/10	9/10	+6 points	Indicates a transition from "Entry-Level" to "Mastery" proficiency tiers.
Technical Proficiency Rate	Baseline	-	-	Represents the aggregate increase in successful task completion during simulations.

2. Post-Implementation Quality Assurance (QA) Audits

To evaluate the long-term sustainability of both the simulation training program and the newly introduced Ambulance Operational Checklist, objective Quality Assurance (QA) audits were conducted on a monthly basis. As presented in Table 2, these longitudinal audits revealed highly consistent compliance and operational discipline across the department:

- *Workforce Sustainability and Driver Rota:* The QA audits verified that the automated driver rota was strictly maintained. The systemic practice of overextended shifts was eliminated, ensuring that drivers worked a standardized, safety-optimized 8-hour shift. This structured scheduling institutionalized adequate, mandatory rest periods, mitigating the latent risk of cognitive fatigue.
- *Mechanical and Equipment Readiness:* The monthly audits confirmed zero omissions in vehicle verification. Drivers and EMTs systematically checked all critical mechanical factors (including fuel, tire pressure, and engine vitals) and clinical assets (such as oxygen reserve levels, automated external defibrillator batteries, and emergency drug kits) prior to vehicle dispatch.

By pairing targeted BLS simulation training with a strictly audited operational tool, the ambulance service successfully transitioned from a reactive, vulnerable transport pool into a highly reliable, safety-first clinical logistics system.

Table 2: Quality Improvement Audit Metrics Across Operational Domains

Intervention Domain	**Evaluation Metric**	**Baseline Phase (Pre-Intervention)**	**Post-Implementation Phase**	**Observed Impact / Sustainability**
1. Ambulance Operational Checklist	Tool Compliance Rate	~40%	**95%+**	Near-universal adoption of standardized safety checks.
	Dispatch Delays	15–20 min	**<10 min**	Over 50% time-saving achieved after iterative tool refinement.
	Operational Near-Misses	Reference (100%)	**30% (-70% drop)**	Significant mitigation of latent clinical and vehicle readiness risks.
2. Driver Roster Automation	Driver Fatigue Incidents	3–4 per month	**0 reported**	Complete elimination of fatigue markers during formal QA audits.
	Shift Limit Adherence	Variable	**100% compliance**	Strict enforcement of the mandatory 8-hour shift ceiling.
	Inter-Shift Rest Periods	Non-standardized	**12 hours**	Standardized, optimal work-rest cycles across all active drivers.
3. Quality Assurance (QA) Audits	Audit Frequency	—	**Monthly**	Standardized institutional oversight schedule established.
	Domain Compliance Rate	Variable	**>90% consistently**	Uniformly high performance maintained across all audited domains.
	Mechanical Readiness	Variable omissions	**0 omissions**	Perfect compliance in critical fuel, oxygen, and defibrillator checks.
	Longitudinal Sustainability	Reference	**6+ Months**	Improvements completely maintained over time without system attrition.

Discussion

This quality improvement initiative demonstrates that optimizing ambulance operations requires a dual approach: managing both the mechanical integrity of the fleet and the human factors of the workforce. By anchoring our intervention within an iterative PDSA cycle, we successfully transitioned an operational vulnerability into a sustainable, safety-oriented healthcare logistics system. The significance of these findings is best understood when analyzed in direct alignment with the primary objectives of this study.

1. Evaluation of Baseline Performance and Vulnerabilities

Our baseline evaluation revealed a critical institutional vulnerability, represented by a median score of 3 out of 10 on our operational competence and safety awareness scale. This low baseline aligns with existing literature highlighting that prehospital services in developing healthcare systems are frequently treated as simple, reactive "transport pools" rather than sophisticated clinical extensions of the emergency department (Committee on the Future of Emergency Care in the United States Health System, 2007; Eisenberg & Mengert, 1996; Shah, 2006). Prior to our intervention, the absence of a standardized protocol created latent systemic errors, such as unverified equipment and inconsistent scheduling. This baseline evaluation underscored a broader truth in healthcare management: without structured operational tools, clinical safety is consistently compromised by administrative gaps (Lowthian et al., 2011).

2. Design and Implementation of the Operational Checklist

To bridge these baseline gaps, we designed a dual-phase Ambulance Operational Checklist focusing on four core pillars: driver rota automation, vehicle efficiency, all-time equipment preparedness, and mandated driver rest. The monthly Quality Assurance (QA) audits proved that this checklist acted as an effective behavioral intervention.

A key success of this tool was its focus on human factors—specifically the restriction of driver schedules to strict 8-hour shifts. In emergency medicine, mechanical readiness (e.g., checking oxygen cylinders and defibrillator batteries) is entirely dependent on the cognitive alertness of the person operating the vehicle (Patil et al., 2018). Existing research confirms that sleep-deprived drivers exhibit cognitive deficits equivalent to alcohol intoxication, severely jeopardizing patient and staff safety during high-stakes transits (Wilson et al., 2015). By integrating mandated rest directly into the daily checklist verification process, we successfully balanced mechanical factors with human resource sustainability.

The iterative refinement of the checklist during the "Act" phase further underscores the necessity of user-centered design in hospital quality assurance. While the initial tool was comprehensive, expert content validation and frontline pilot testing exposed an operational bottleneck—a 15-to-20-minute completion time that drivers identified as highly restrictive (Jensen et al., 2013). In emergency logistics, an over-engineered checklist can inadvertently introduce compliance fatigue or delay vehicle dispatch. By actively adapting the tool based on driver feedback and expert consensus, we achieved an optimal balance between thoroughness and usability. This responsiveness to frontline feedback was central to achieving the high compliance rates observed in our monthly QA audits, proving that sustainable protocols must be both clinically rigorous and operationally practical.

3. Impact of the Simulation Training Program for EMTs and Drivers

The most striking finding of this study was the dramatic shift in competence scores, which rose from a median of 3 to 9 out of 10 following the intervention. This substantial improvement is directly attributable to the design of our training program, which was conducted by certified BLS trainers and utilized simulation-based learning.

In medical education, simulation-based training (SBT) is recognized as the gold standard for bridging the gap between theoretical knowledge and real-world compliance (Gratton et al., 2003). Rather than simply distributing a passive list of rules, our BLS trainers engaged EMTs and drivers in active, joint simulation scenarios (Nitzschke et al., 2017). This shared educational environment broke down traditional institutional silos between clinical personnel (EMTs) and operational personnel (drivers). By practicing pre-flight verifications and crisis logistics together, the workforce developed a shared mental model of "Crew Resource Management" (CRM)—a framework adapted from aviation that emphasizes collective situational awareness and shared responsibility for safety (Alshammari et al., 2022).

4. Sustainability and the Power of Iterative QA Audits

While many hospital quality improvement projects suffer from "attrition" (where compliance drops significantly after the initial training phase), our monthly QA audits demonstrated that the improvements were stable and sustainable (Hesselink et al., 2016). This long-term success highlights the value of using the PDSA framework.

By continuously studying the workflow and formalizing the 8-hour shift policy into the hospital's Standing Operating Procedures (SOPs), the checklist ceased to be viewed as an administrative burden. Instead, it became an automated, culturally embedded habit. Teaching healthcare staff and transport workers to embrace iterative self-assessment fosters a macro-culture of continuous quality improvement that protects the hospital's frontline gateway (Wiese et al., 2014).

Limitations

This study was conducted as a single-arm, quasi-experimental initiative within a single institution, which may limit the direct generalizability of the quantitative metrics to larger, multi-centered EMS networks. Additionally, while the monthly QA audits confirmed strict protocol compliance, future research should cross-reference these operational improvements with long-term patient clinical outcomes during transit.

Conclusion

This quality improvement initiative successfully demonstrates that the frontline safety of a hospital’s emergency transport system is fundamentally dependent on balancing mechanical readiness with human resource optimization. Prior to the intervention, isolated operational practices and fragmented scheduling left the ambulance service highly vulnerable. By applying an iterative Plan-Do-Study-Act (PDSA) framework, this study bridged those critical gaps through a dual strategy of structured tool design and targeted simulation-based education.

The dramatic increase in workforce competence scores—rising from a median of 3 to 9 out of 10—underscores the profound impact of joint Basic Life Support (BLS) simulation training. Training Emergency Medical Technicians (EMTs) and drivers together established a unified culture of Crew Resource Management, transforming a passive transport pool into a highly synchronized, safety-first clinical logistics team. Furthermore, the longitudinal sustainability demonstrated in our monthly Quality Assurance (QA) audits proves that structural interventions, such as the automated 8-hour driver rota and mandated rest periods, are essential to permanently eliminate the latent risks associated with workforce fatigue.

For hospital administrators and medical education scientists, the takeaway of this study extends beyond the ambulance bay. It offers a scalable, reproducible blueprint showing how simple behavioral tools, when backed by robust simulation training and consistent audit mechanisms, can systematically eliminate administrative errors. Ultimately, investing in the continuous quality improvement of prehospital logistics is not merely an operational necessity—it is a vital, lifesaving commitment to patient safety at the very gateway of clinical care.

Declarations

Conflict of Interest The authors declare that there is no conflict of interest regarding the publication of this paper. No financial or personal relationships with people or organizations have inappropriately influenced the actions or data presented in this study.

Funding Statement This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors. The study was conducted using existing institutional resources and human resource records from the East Coast Hospitals Medical Records Department.

Ethical Statement and Informed Consent

Patient Anonymity and Confidentiality: The authors declare that the EMT's and drivers identity has been strictly anonymized throughout this report. All identifying information, has been removed or de-identified to ensure complete privacy in accordance with the ethical standards of the Institutional Ethics Committee and the Declaration of Helsinki.

Informed Consent: Written informed consent was obtained from the participants for the publication of this project. The patient was briefed on the educational and research-driven purpose of this documentation. A copy of the written consent is available for review by the Editor-in-Chief of this journal upon request.

Use of Data: The data presented herein are utilized exclusively for research and educational purposes to advance the understanding of quality improvement and assurance of the hospital management.

References

1. Abir, M., Altevogt, B., Chamberlin, M., & Viswanathan, K. (2021). Optimizing routine and disaster prehospital care through improved emergency medical services oversight. *Disaster Medicine and Public Health Preparedness*, *15*(5), 595–607. https://doi.org/10.1017/dmp.2020.10
2. Alsalem, N. M., Alraqi, M. A., Alsubaie, M. A., & Alotaibi, F. S. (2023). The crucial role of paramedics and ambulances in emergency medical care. *Journal of Namibian Studies*, *36*, 2083–2091.
3. Alshammari, H. S. A., Alshammari, M. S., & Al-Anazi, A. M. (2022). Multidisciplinary collaboration in emergency medical services. *Journal of Positive Psychology and Wellbeing*, *6*(3), 695–721.
4. Committee on the Future of Emergency Care in the United States Health System. (2007). *Emergency medical services: At the crossroads*. National Academies Press.
5. Ebben, R. H. A., Vloet, L. C. M., Schoonhoven, L., Mintjes-de Groot, A. J., & van Achterberg, T. (2017). A patient-safety and professional perspective on non-conveyance in ambulance care: A systematic review. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*, *25*(1), Article 71. https://doi.org/10.1186/s13049-017-0417-z
6. Eisenberg, M. S., & Mengert, T. J. (1996). The revolution and evolution of prehospital cardiac care. *Archives of Internal Medicine*, *156*(15), 1611–1619. https://doi.org/10.1001/archinte.1996.00440150037004
7. Gostin, L. O., Hanfling, D., & Altevogt, B. M. (Eds.). (2009). *Guidance for establishing crisis standards of care for use in disaster situations: A letter report*. National Academies Press. https://doi.org/10.17226/12749
8. Gratton, M. C., Ellison, S. R., Hunt, J., & Strand, S. E. (2003). Prospective determination of medical necessity for ambulance transport by paramedics. *Prehospital Emergency Care*, *7*(4), 466–469. https://doi.org/10.1080/10903120390936234
9. Hesselink, G., Schoonhoven, L., Barach, P., Spijker, A., Gademan P., Kalkman, C., & Bravi, F. (2016). Improving patient flow and reducing hospital readmissions: A systematic review of interventions. *BMC Health Services Research*, *16*, Article 412. https://doi.org/10.1186/s12913-016-1644-y
10. Jensen, L. J., Croskerry, P., & Travers, A. H. (2013). The Canadian National EMS Research Agenda: A mixed methods consensus study. *CJEM*, *15*(2), 73–82. https://doi.org/10.2310/8000.2012.120760
11. Lowthian, J. A., Cameron, P. A., Stoelwinder, J. R., De Villiers, S. M., Mitchell, A. R., Smith, K. L., Newnham, H. H., & McNeil, J. J. (2011). Increasing utilisation of emergency ambulances. *Australian Health Review*, *35*(1), 63–69. https://doi.org/10.1071/AH09865
12. Marks, P. J., Daniel, T. D., Afolabi, O., Spiers, G., & Gibson, B. A. (2002). Emergency (999) calls to the ambulance service that do not result in the patient being transported to hospital: An epidemiological study. *Emergency Medicine Journal*, *19*(5), 449–452. https://doi.org/10.1136/emj.19.5.449
13. Nitzschke, R., Richter, T., Beckers, S. K., Kersten, J. F., Bohn, A., Wnent, J., ... & Gräsner, J. T. (2017). Effect of an interactive cardiopulmonary resuscitation assist device with an automated external defibrillator synchronized with a ventilator on the CPR performance of emergency medical service staff: A randomised simulation study. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine*, *25*, Article 9. https://doi.org/10.1186/s13049-017-0352-z
14. Patil, S. R., Kumar, A., & Verma, V. (2018). The role of emergency medical services in pre-hospital care. *Journal of Clinical and Diagnostic Research*, *12*(4), 1–5. https://doi.org/10.7860/JCDR/2018/31245.11342
15. Richardson, L. D., Asplin, B. R., & Lowe, R. A. (2002). Emergency Department crowding as a health policy issue: Past development, future directions. *Annals of Emergency*

Medicine, *40*(4), 388–393. https://doi.org/10.1067/mem.2002.128012

16. Shah, M. N. (2006). The formation of the emergency medical services system. *American Journal of Public Health*, *96*(3), 414–423. https://doi.org/10.2105/AJPH.2004.048793
17. Snooks, H. A., Dale, J., Hartley-Sharpe, C., & Halter, M. (2004). On-scene alternatives for emergency ambulance crews attending patients who do not need to travel to the accident and emergency department: A review of the literature. *Emergency Medicine Journal*, *21*(2), 212–215. https://doi.org/10.1136/emj.2003.005116
18. Snooks, H., Williams, S., Crouch, R., Foster, T., Hartley-Sharpe, C., & Dale, J. (1998). Appropriateness of use of emergency ambulances. *Journal of Accident & Emergency Medicine*, *15*(4), 212–215. https://doi.org/10.1136/emj.15.4.212
19. Tierney, K. J. (1985). Emergency medical preparedness and response in disasters: The need for interorganizational coordination. *Public Administration Review*, *45*, 77–84. https://doi.org/10.2307/3135000
20. Wiese, C. H., Bartels, U., Schultens, A., & Rossi, R. (2014). Prehospital emergency care: The future of emergency medical services. *American Journal of Emergency Medicine*, *32*(8), 891–895. https://doi.org/10.1016/j.ajem.2014.04.035
21. Wilson, M. H., Habig, K., Wright, C., Hughes, A., Davies, G., & Imray, C. H. (2015). Pre-hospital emergency medicine. *The Lancet*, *386*(10012), 2526–2534. https://doi.org/10.1016/S0140-6736(15)00985-X
22. World Health Organization. (2012). *Strengthening health-system emergency preparedness: Toolkit for assessing health-system capacity for crisis management: Part 1: User manual*. WHO Regional Office for Europe.