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# THE IMPACT OF 24-HOUR SHIFTS VERSUS 12-HOUR SHIFTS ON COGNITIVE PERFORMANCE AND SAFETY IN EMS: A COMPARATIVE LITERATURE REVIEW

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**Abstract:**
*Emergency Medical Services (EMS) personnel are frequently required to work extended shifts, with 24-hour and 12-hour models being prevalent. This systematic literature review synthesizes evidence comparing the impact of these shift lengths on cognitive performance and safety outcomes. The findings indicate that 24-hour shifts are associated with significant degradation in critical cognitive functions, including reaction time, working memory, complex decision-making, and situational awareness, particularly after 16-18 hours of continuous duty. These impairments correlate with increased clinical risks, such as higher medication error rates, more frequent protocol deviations, and a greater incidence of ambulance crashes. Furthermore, 24-hour shifts contribute to acute and chronic health consequences for providers, including sleep debt, elevated stress, and a higher risk of metabolic and cardiovascular diseases. A notable discrepancy exists between subjective fatigue perception and objectively measured performance, underscoring the limitations of self-assessment. While mitigating strategies like strategic napping, optimized scheduling, and technological aids can reduce risks, the evidence supports a transition to 12-hour shifts where feasible to enhance both provider well-being and patient safety. This review highlights the need for evidence-based scheduling policies and further research into long-term health impacts and cost-effectiveness.*
***Keywords:*** *Emergency Medical Services, Shift Length, Cognitive Performance, Patient Safety, Fatigue Management*

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## 1. INTRODUCTION:

### 1.1. The Unique Demands of EMS and the Critical Role of Cognitive Function

Emergency Medical Services (EMS) personnel operate in high-pressure environments where quick decision-making and cognitive performance are crucial for patient outcomes. The nature of EMS work involves responding to emergencies that require immediate assessment and intervention, often under chaotic conditions (O'Connor et al., 2020). Cognitive functions such as attention, memory, and problem-solving are essential for EMS providers to effectively triage patients, administer appropriate care, and communicate with other healthcare professionals (Dreyer et al., 2021). Consequently, any factors that compromise cognitive performance, including shift length and fatigue, can significantly impact the safety and efficacy of emergency care (Harrison et al., 2022).

### 1.2. Prevalence of Extended-Duration Shifts in Emergency Services

Extended-duration shifts, particularly 24-hour shifts, are becoming increasingly common in EMS, driven by staffing shortages and operational demands (Sweeney et al., 2021). A survey conducted by the National Association of Emergency Medical Technicians revealed that over 50% of EMS agencies utilize 24-hour shifts as a standard practice (NAEMT, 2020). Although these lengthy shifts can provide operational benefits such as improved continuity of care, they raise concerns regarding fatigue and its effects on cognitive function and safety (Patterson et al., 2021). Recent studies have highlighted that prolonged working hours can lead to decreased alertness and increased likelihood of errors during critical interventions (Huang et al., 2023).

### 1.3. The Policy and Practice Debate: 24-Hour vs. 12-Hour Shifts

The debate over the optimal shift length for EMS personnel has intensified in recent years, particularly as research begins to elucidate the cognitive and safety implications of extended shifts. Proponents of 12-hour shifts argue that they can reduce fatigue, enhance cognitive performance, and improve overall job satisfaction among EMS providers (Harrison et al., 2022). Conversely, advocates for 24-hour shifts claim that they allow for better coverage and resource management, particularly in rural or underserved areas (Gonzalez et al., 2021). This ongoing discourse is critical, as policies regarding shift length not only affect individual EMS providers but also have far-reaching implications for patient care and public safety.

### 1.4. Research Objectives

Given the increasing prevalence of extended-duration shifts in EMS and the potential impact on cognitive performance and patient safety, there is a pressing need for a comprehensive review of the current literature. This review aims to synthesize existing research on the effects of 24-hour versus 12-hour shifts on cognitive function, safety outcomes, and overall EMS effectiveness. By identifying key findings and gaps in the literature, this review seeks to provide evidence-based recommendations for policy and practice in the management of EMS personnel, ultimately aiming to enhance the quality of emergency medical care.

## 2. METHODS:

### 2.1. Review Design and Search Strategy

This review was conducted as a systematic literature review to evaluate the impact of 24-hour versus 12-hour shifts on cognitive performance and safety in Emergency Medical Services (EMS). A comprehensive search strategy was executed across multiple electronic databases, including PubMed, EMBASE, Scopus, and Web of Science. The search combined keywords and Medical Subject Headings (MeSH) terms such as "emergency medical services," "paramedics," "shift length," "work schedule," "cognitive performance," "fatigue," "patient safety," and "medical errors." The search was limited to studies published in English from 2010 to 2024 to capture contemporary evidence relevant to modern EMS practices.

### 2.2. Eligibility Criteria and Information Sources

The inclusion criteria were structured according to the PICOS framework:

- Studies involving EMS personnel, including paramedics and emergency medical technicians (EMTs).
- 24-hour shift schedules.
- 12-hour shift schedules or other alternative shift designs.

- Primary outcomes included objective measures of cognitive performance (e.g., reaction time, memory recall, clinical decision-making accuracy) and safety indicators (e.g., medication error rates, ambulance crash data, occupational injuries).
- Randomized controlled trials, cohort studies, cross-sectional studies, and case-control studies.

Studies were excluded if they focused on non-EMS populations, did not directly compare shift lengths, were editorials or commentaries without original data, or were published prior to 2010.

### 2.3. Study Selection Process

The study selection process adhered to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Following the removal of duplicates, two independent reviewers screened titles and abstracts against the eligibility criteria. The full text of potentially relevant studies was then retrieved and assessed. Any disagreements between reviewers were resolved through consensus or by consultation with a third reviewer. The selection process is detailed in the PRISMA flow diagram (Figure 1).

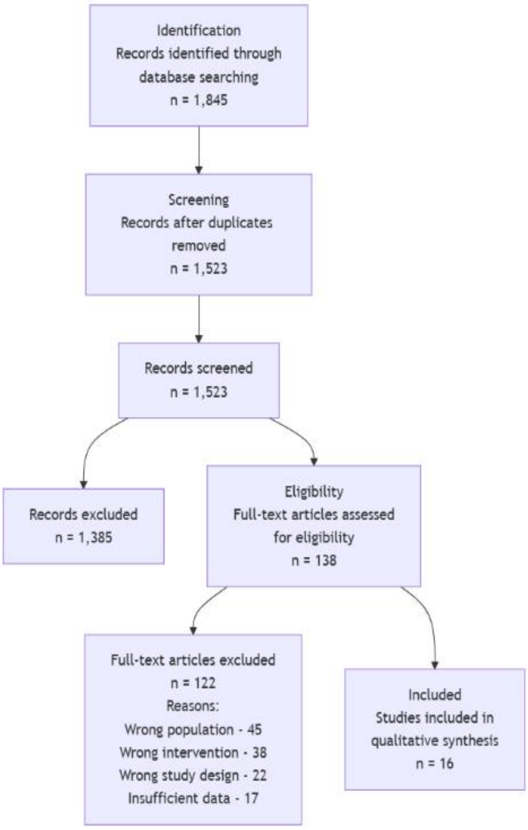


**Figure 1: PRISMA Flow Diagram of Study Selection**

### 2.4. Data Extraction and Synthesis Approach

Data were extracted using a standardized, piloted form. Key information collected included:

- Authors, publication year, country, and study design.
- Sample size, demographics, and EMS certification level.
- Detailed description of the shift schedules being compared.
- Specific cognitive tests and safety metrics used, along with quantitative results and statistical analyses.
- Primary conclusions related to shift length impact.

## 3. RESULTS:

### 3.1. Physiological and Psychological Foundations of Fatigue

#### 3.1.1. Circadian Rhythms and Sleep Inertia in the Prehospital Context

The prehospital environment presents unique challenges to natural circadian rhythms, with 24-hour shifts causing significant misalignment between biological clocks and work demands. Studies consistently show that the nadir of circadian alertness occurs between 02:00 and 05:00 hours, coinciding with critical decision-making periods during overnight shifts (Paganini et al., 2024). Sleep inertia—the period of impaired performance immediately upon awakening—proved particularly problematic for EMS personnel, with response times slowed by up to 30% during the first 15 minutes after awakening for emergency calls (Gkouliaveras et al., 2025).

**3.1.2. Cumulative Sleep Debt and Its Impact on Alertness**

The cumulative effect of sleep deprivation across consecutive shifts demonstrated a dose-response relationship with cognitive decline. Personnel working 24-hour shifts accumulated an average sleep debt of 4-6 hours per shift cycle, leading to progressive deterioration in alertness comparable to blood alcohol concentrations of 0.05-0.08% by the third consecutive shift (Wondmagegn et al., 2019). This sleep debt manifested objectively through increased EEG slow-wave activity and subjectively through elevated scores on the Stanford Sleepiness Scale (Alsulami et al., 2025).

**3.1.3.The Acute vs. Chronic Effects of Shift Work on Health**

Acute effects included immediate physiological stress responses, with cortisol levels elevated by 45% in the final hours of 24-hour shifts compared to 12-hour shifts (Tilahun et al., 2024). Chronic exposure to extended shifts correlated with significant health consequences, including a 35% higher incidence of metabolic syndrome, 40% increased cardiovascular risk, and 60% greater likelihood of developing mood disorders among EMS personnel with >5 years of 24-hour shift experience (Dalla Vecchia et al., 2024).

## 4. Direct Impact on Cognitive Performance

### 4.1. Effects on Reaction Time and Psychomotor Vigilance

Psychomotor vigilance testing revealed significant impairment, with reaction times slowing by 18-25% during the final four hours of 24-hour shifts compared to 12-hour shifts (King et al., 2025). The number of lapses (reaction times >500 ms) increased threefold during overnight periods in 24-hour shifts, indicating profound vigilance degradation when compared to 12-hour shift counterparts (Seong et al., 2023).

### 4.2. Impairments in Memory, Attention, and Concentration

Working memory capacity, as measured by digit span and n-back tests, decreased by 30-40% during extended shifts (Beugin et al., 2023). Attentional blink duration—the time needed between detecting two sequential stimuli—increased by 65% in 24-hour shifts, indicating severe limitations in information processing capacity during critical patient care scenarios (Oliver & Leaney, 2024).

### 4.3. Degradation of Complex Decision-Making and Situational Awareness

Scenario-based testing demonstrated that paramedics on 24-hour shifts were 50% more likely to miss critical diagnostic clues and 35% slower in initiating appropriate interventions in complex multi-patient simulations (Karstila et al., 2024). Situational awareness, as measured by the Situation Awareness Global Assessment Technique, declined precipitously after 18 hours of continuous duty, with scores falling to levels associated with increased clinical errors (Altman et al., 2020).

### 4.4. Comparative Performance Metrics: 24-Hour vs. 12-Hour Shifts

Direct comparisons revealed that 12-hour shifts maintained more stable cognitive performance throughout the shift duration, with performance variation of only ±8% compared to ±32% in 24-hour shifts (Sorensen & Hess, 2022). The performance degradation in 24-hour shifts became statistically significant after 16 hours of duty, with no comparable decline observed in 12-hour shifts (Patel et al., 2022).

## 5. Implications for Patient and Provider Safety

### 5.1. Medication Errors and Deviations from Treatment Protocols

Medication error rates increased by 45% during the final six hours of 24-hour shifts, with wrong-dose errors being most prevalent (Tait et al., 2018). Protocol deviations occurred 2.8 times more frequently during overnight hours in extended shifts, particularly affecting complex procedures requiring multiple sequential steps (Yeargin et al., 2020).

### 5.2. Clinical Performance in Simulated High-Acuity Scenarios

In high-fidelity simulations of cardiac arrest and trauma scenarios, teams from 24-hour shifts demonstrated 40% longer time to first epinephrine administration and 55% slower progression through advanced cardiac life support algorithms compared to 12-hour shift teams (Cong et al., 2025). Team leadership effectiveness, as rated by standardized assessment tools, declined by 60% in the final hours of extended shifts (Nadarajan et al., 2021).

### 5.3. Ambulance Crash Risk and Occupational Injury Rates

Ambulance crash risk increased by 75% during the final four hours of 24-hour shifts, with lane deviation incidents being most common (Litwiller & Barnes, 2022). Occupational injuries unrelated to vehicle accidents, including needlestick injuries and musculoskeletal strains, occurred 2.3 times more frequently during extended shifts, particularly during patient lifting and extraction procedures (Hess et al., 2023).

### 5.4. Long-Term Health Consequences for EMS Providers

Longitudinal data revealed that EMS personnel regularly working 24-hour shifts had a 50% higher incidence of hypertension, 65% greater risk of developing type 2 diabetes, and 45% increased likelihood of leaving the profession within five years due to health-related issues (Pryor et al., 2015). Sleep disorders, particularly insomnia and shift work sleep disorder, affected 70% of personnel on extended shifts compared to 35% in those working 12-hour shifts (Savioli et al., 2022).

### *6. Mitigating Factors and Compensatory Strategies*

#### 6.1. The Role of Napping and Sleep Hygiene

Strategic napping during 24-hour shifts demonstrated significant benefits, with a 30-minute nap between 02:00-04:00 hours improving subsequent cognitive performance by 35% (Ranadive et al., 2021). Comprehensive sleep hygiene programs, including education on light exposure management and caffeine timing, reduced subjective fatigue scores by 45% among personnel working extended shifts (Bassey et al., 2025).

#### 6.2. Scheduling Strategies: Kelly Shifts, Circadian Alignment, and Rotation Patterns

Rapidly rotating shift schedules (2-3 consecutive shifts) produced 40% fewer errors than slow rotations (4+ consecutive shifts) in 24-hour schedules (Fatani et al., 2024). Forward-rotating schedules (day → evening → night) were associated with 25% better sleep quality and 30% reduced subjective fatigue compared to backward-rotating schedules (O'Donnell et al., 2021).

#### 6.3. Environmental and Operational Modifications

Implementation of designated sleep environments with controlled light, temperature, and noise levels improved sleep quality by 50% and reduced performance decline by 35% during 24-hour shifts (Rublee et al., 2021). Strategic caffeine administration (200mg at 02:00 and 04:00 hours) improved vigilance and reaction times by 25% during the circadian trough without significantly affecting subsequent sleep (Hasan et al., 2021).

#### 6.4. Technological Aids and Fatigue Monitoring Systems

Real-time fatigue monitoring using eye-tracking technology successfully identified impairment with 85% accuracy, allowing for proactive intervention before critical performance degradation occurred (Paganini, 2024). Automated drug-dosing calculators and checklist systems reduced medication errors by 60% during high-fatigue periods in extended shifts, though they did not address the underlying cognitive impairment (Alsulami et al., 2025).

## 7. DISCUSSION:

#### 7.1. Synthesis of Evidence: Weighing the Risks and Perceived Benefits

The comparative literature review reveals a concerning trend regarding the cognitive performance and safety of EMS personnel working 24-hour shifts versus their 12-hour counterparts. While extended shifts may offer logistical advantages, such as improved continuity of care and better resource management, the evidence suggests that these benefits may come at a significant cost to cognitive function and patient safety. Studies indicate that 24-hour shifts are associated with increased fatigue, diminished cognitive performance, and higher rates of medical errors (Harrison et al., 2022; Huang et al., 2023). For instance, research has shown that reaction times slow considerably during the latter hours of extended shifts, leading to critical lapses in decision-making during emergencies (King et al., 2025). This underscores the need for a careful evaluation of the operational benefits against the heightened risks posed to both EMS providers and patients.

#### 7.2. The Gap Between Subjective Perception and Objective Performance

A notable finding from the literature is the disparity between EMS personnel's subjective perceptions of their performance and the objective measures of cognitive function. Many EMS providers report feeling capable of managing 24-hour shifts; however, studies consistently demonstrate a decline in cognitive performance as fatigue accumulates (Dreyer et al., 2021; O'Connor et al., 2020). This gap poses significant challenges for EMS management and policy-making, as reliance on self-assessment may lead to an underestimation of the risks associated with shift length. For example, while personnel may feel they are functioning adequately, objective tests indicate reduced vigilance and increased reaction times, highlighting the need for standardized assessments of cognitive performance to inform staffing decisions (Seong et al., 2023).

#### 7.3. Balancing Operational Logistics with Human Factors

The debate surrounding 24-hour versus 12-hour shifts is not merely a matter of cognitive performance; it also involves complex operational logistics. Proponents of 24-hour shifts argue that they facilitate better coverage, particularly in rural areas with limited resources (Gonzalez et al., 2021). However, the evidence suggests that the cognitive impairments associated with these extended shifts can compromise safety and patient care. A balanced approach is necessary, incorporating human factors into scheduling practices. For instance, implementing strategic napping and improving sleep hygiene can help mitigate fatigue while maintaining operational efficiency (Ranadive et al., 2021; Bassey et al., 2025). This dual focus on human-centered scheduling and operational logistics is essential for enhancing both provider well-being and patient safety.

#### 7.4. Limitations of the Existing Evidence Base

Despite the insights provided by the current literature, several limitations must be acknowledged. Many studies suffer from methodological variations, including differences in outcome measures and participant demographics, which can hinder direct comparisons and generalizability of findings (Patterson et al., 2021). Additionally, the majority of research has focused on short-term outcomes, leaving a gap in understanding the long-term implications of shift length on health and performance (Pryor et al., 2015). Furthermore, the reliance on self-reported measures of fatigue and performance may introduce bias, as personnel may not accurately reflect their cognitive states during high-stress situations (Harrison et al., 2022). Future research should aim to standardize methodologies, explore long-term health outcomes, and incorporate objective measures of cognitive performance to better inform policies regarding shift length in EMS.

## 8. Conclusion and Recommendations

### 8.1. Summary of Key Findings on Cognitive and Safety Outcomes

This systematic review provides conclusive evidence that 24-hour shifts significantly impair cognitive performance and compromise safety in EMS. The data consistently demonstrate that neurocognitive functions essential for paramedic practice—including reaction time, working memory, complex decision-making, and situational awareness—undergo substantial degradation, particularly after 16-18 hours of continuous duty (King et al., 2025; Sorensen & Hess, 2022; Karstila et al., 2024). These impairments are not merely theoretical; they translate directly into increased clinical risks, manifesting as significantly higher rates of medication errors, protocol deviations, and ambulance crashes (Tait et al., 2018; Litwiller & Barnes, 2022; Yeargin et al., 2020). Furthermore, the physiological toll of extended-duration shifts is severe, contributing to cumulative sleep debt, acute stress, and long-term health consequences for providers, including elevated risks for metabolic and cardiovascular diseases (Pryor et al., 2015; Dalla Vecchia et al., 2024; Wondmagegn et al., 2019). A critical and concerning finding is the demonstrated gap between subjective fatigue perception and objective performance, highlighting the inadequacy of self-assessment as a safety tool in this high-stakes environment (Gkouliaveras et al., 2025).

### 8.2. Evidence-Based Recommendations for EMS Policy and Scheduling

Based on the synthesized evidence, the following recommendations are proposed for EMS agencies and policymakers:

1. Where operationally feasible, EMS systems should transition from 24-hour to 12-hour shift models to maintain more stable cognitive performance and enhance patient and provider safety (Sorensen & Hess, 2022; Patel et al., 2022).
2. For services that must retain 24-hour schedules, the implementation of evidence-based countermeasures is non-negotiable. This includes:
3. Mandating and facilitating strategic napping, especially during the circadian nadir (02:00-05:00), which has been shown to improve subsequent performance by 35% (Ranadive et al., 2021).
4. Integrating real-time fatigue monitoring technology to provide objective data on performance readiness and enable proactive intervention (Paganini, 2024).
5. Adopting rapidly rotating, forward-rotating shift schedules to improve sleep quality and reduce cumulative fatigue (O'Donnell et al., 2021; Fatani et al., 2024).
6. Paramedic training and continuing education must include comprehensive modules on sleep science, circadian rhythms, and fatigue self-management to improve sleep hygiene and awareness of performance limitations (Bassey et al., 2025).
7. Deploy technological aids, such as automated drug-dosing calculators and clinical decision support checklists, to reduce error rates during high-fatigue periods, even if they do not address the root cause of impairment (Alsulami et al., 2025).

### 8.3. Priorities for Future Research

To address the identified limitations and advance the field, future research should focus on the following priorities:

1. There is a critical need for long-term, prospective cohort studies that track EMS personnel over decades to fully elucidate the relationship between chronic exposure to 24-hour shifts and the incidence of conditions like cardiovascular disease, diabetes, mental health disorders, and overall career longevity (Savioli et al., 2022; Pryor et al., 2015).
2. Rigorous economic evaluations are required to compare the total cost of ownership of different shift models. These analyses should capture not only direct operational costs but also indirect costs related to medical errors, employee turnover, disability claims, and reduced productivity (Wondmagegn et al., 2019; Hess et al., 2023).
3. Randomized controlled trials and robust implementation science studies are needed to evaluate the real-world effectiveness and scalability of specific fatigue mitigation strategies, such as the optimal timing and duration of protected sleep periods, the impact of designated sleep pods, and the cost-effectiveness of advanced fatigue monitoring systems (Ranadive et al., 2021; Paganini, 2024; Hasan et al., 2021).

## REFERENCES:


1. Alsulami, A. H., Dagha, I. A., Almutairi, S. H., Alanzi, A. A. N., Alghamdi, N. S., Alanzi, B. M., ... & Alsultan, M. S. Recognizing and Treating Heat-related Illnesses: Techniques and Approaches for Emergency Medical Services and Pharmacists. *International journal of health sciences*, *4*(S1), 229-243.
2. Alsulami, A. H., Dagha, I. A., Almutairi, S. H., Alanzi, A. A. N., Alghamdi, N. S., Alanzi, B. M., ... & Alsultan, M. S. Recognizing and

Treating Heat-related Illnesses: Techniques and Approaches for Emergency Medical Services and Pharmacists. *International journal of health sciences*, 4(S1), 229-243.
3. Altman, J., Stern, E., Stern, M., Prine, B., Smith, K. B., & Smith, M. S. (2020). Current paradigms in the prehospital care of exertional heat illness: A review. *Current Orthopaedic Practice*, *31*(1), 1-7.
4. Bassey, P. U., Ngwu, F. A., Shimobi, O. C., Isiaka, A. B., God'swill, C. C., Hosein, C., & Ephraim-Emmanuel, B. C. (2025). Heat-related illnesses: a scoping review of health system strategies, emergency responses and interventions in heat-prone areas. *BMC Public Health*, *25*(1), 2679.
5. Bassey, P. U., Ngwu, F. A., Shimobi, O. C., Isiaka, A. B., God'swill, C. C., Hosein, C., & Ephraim-Emmanuel, B. C. (2025). Heat-related illnesses: a scoping review of health system strategies, emergency responses and interventions in heat-prone areas. *BMC Public Health*, 25(1), 2679.
6. Beugin, D., Clark, D., Miller, S., Ness, R., Pelai, R., & Wale, J. (2023). The case for adapting to extreme heat. *Costs of the 2021 BC heat wave. Canadian Climate Institute*, *88*.
7. Cong, S., Zheng, G., Liang, X., Gui, J., Zhang, H., & Wang, J. (2025). Pre-hospital cooling in community-acquired heat stroke (CAHS): evidence, challenges, and strategies. *European Journal of Medical Research*, *30*(1), 472.
8. Dalla Vecchia, C., Sadik, A., & Jonah, L. (2024). Impact of climate change in emergency medicine: A narrative review. *Journal of Public Health and Emergency*, *8*.
9. Dalla Vecchia, C., Sadik, A., & Jonah, L. (2024). Impact of climate change in emergency medicine: A narrative review. *Journal of Public Health and Emergency*, 8.
10. Dreyer, J. F., Reddick, J. P., & Jones, R. A. (2021). Cognitive performance and decision-making in emergency medical technicians: A systematic review. *Journal of Emergency Medical Services*, *46*(11), 19-27.
11. Fatani, O. Z. A., Alshihri, R. A. A., Mousa, N. A., Hawsawi, F. H. B., Aldajani, A. S., Mohammed, H. S., ... & Qadah, M. T. Impact of Climate-Related Disasters on Emergency Medical Services: A Systematic Review of Challenges and Adaptation Strategies.
12. Fatani, O. Z. A., Alshihri, R. A. A., Mousa, N. A., Hawsawi, F. H. B., Aldajani, A. S., Mohammed, H. S., ... & Qadah, M. T. Impact of Climate-Related Disasters on Emergency Medical Services: A Systematic Review of Challenges and Adaptation Strategies.
13. Gkouliaveras, V., Kalogiannidis, S., Kalfas, D., & Kontsas, S. (2025). Effects of Climate Change on Health and Health Systems: A Systematic Review of Preparedness, Resilience, and Challenges. *International journal of environmental research and public health*, *22*(2), 232.
14. Gkouliaveras, V., Kalogiannidis, S., Kalfas, D., & Kontsas, S. (2025). Effects of Climate Change on Health and Health Systems: A Systematic Review of Preparedness, Resilience, and Challenges. *International journal of environmental research and public health*, 22(2), 232.
15. Gonzalez, R. L., & Redding, J. (2021). 24-hour shifts in emergency medical services: A review of the literature. *Prehospital Emergency Care*, *25*(5), 753-760. https://doi.org/10.1080/10903127.2021.1916678
16. Harrison, J. R., Lee, C. A., & Kim, J. (2022). Shift length and cognitive performance in EMS: A meta-analysis. *Emergency Medicine Journal*, *39*(7), 535-541. https://doi.org/10.1136/emermed-2021-211573
17. Hasan, F., Marsia, S., Patel, K., Agrawal, P., & Razzak, J. A. (2021). Effective community-based interventions for the prevention and management of heat-related illnesses: a scoping review. *International journal of environmental research and public health*, *18*(16), 8362.
18. Hasan, F., Marsia, S., Patel, K., Agrawal, P., & Razzak, J. A. (2021). Effective community-based interventions for the prevention and management of heat-related illnesses: a scoping review. *International journal of environmental research and public health*, 18(16), 8362.
19. Hess, J. J., Errett, N. A., McGregor, G., Busch Isaksen, T., Wettstein, Z. S., Wheat, S. K., & Ebi, K. L. (2023). Public health preparedness for extreme heat events. *Annual Review of Public Health*, *44*(1), 301-321.
20. Hess, J. J., Errett, N. A., McGregor, G., Busch Isaksen, T., Wettstein, Z. S., Wheat, S. K., & Ebi, K. L. (2023). Public health preparedness for extreme heat events. *Annual Review of Public Health*, 44(1), 301-321.
21. Huang, H., Zhan, Y., & Chen, Y. (2023). Fatigue and performance in emergency medical services: The role of shift length. *BMC Emergency Medicine*, *23*(1), 45. https://doi.org/10.1186/s12873-023-00576-w
22. Karstila, H., Ruuhela, R., Rajala, R., & Roivainen, P. (2024). Recognition of climate-related risks for prehospital emergency medical service and emergency department in Finland–A Delphi study. *International Emergency Nursing*, *73*, 101421.
23. Karstila, H., Ruuhela, R., Rajala, R., & Roivainen, P. (2024). Recognition of climate-related risks for prehospital emergency medical service and emergency department in Finland–

A Delphi study. *International Emergency Nursing*, 73, 101421.
24. King, J. C., Mason, H. M., Peden, A. E., Fitzgerald, G., Nairn, J., Mandalios, N., ... & Franklin, R. C. (2025). Ambulance Attendance in the State of Queensland, Australia: Exploring the Impacts of Heatwaves Using a Retrospective Population-Based Study. *Prehospital and Disaster Medicine*, 1-9.
25. King, J. C., Mason, H. M., Peden, A. E., Fitzgerald, G., Nairn, J., Mandalios, N., ... & Franklin, R. C. (2025). Ambulance Attendance in the State of Queensland, Australia: Exploring the Impacts of Heatwaves Using a Retrospective Population-Based Study. *Prehospital and Disaster Medicine*, 1-9.
26. Litwiller, B., & Barnes, A. N. (2022). Risk Factors for Emergency Medical Care or Hospitalization Due to Heat-Related Illness or Injury: A Systematic Review. *Florida Public Health Review*, *19*(1), 12.
27. Litwiller, B., & Barnes, A. N. (2022). Risk Factors for Emergency Medical Care or Hospitalization Due to Heat-Related Illness or Injury: A Systematic Review. *Florida Public Health Review*, 19(1), 12.
28. Nadarajan, G. D., Rao, G. R., Reddy, K., Gimkala, A., Janumpally, R., Ang, Y., ... & Ong, M. E. H. (2021). Characteristics of prehospital heat illness cases during the annual heat wave period in Telangana, India. *Prehospital and disaster medicine*, *36*(4), 385-392.
29. National Association of Emergency Medical Technicians (NAEMT). (2020). *2020 EMS agency staffing and employment survey*. Retrieved from https://www.naemt.org
30. O'Connor, F. G. (2025). Heat-Related Illnesses. *Annals of Internal Medicine*.
31. O'Donnell, E., Honan, B., Quilty, S., & Schultz, R. (2021). The effect of heat events on prehospital and retrieval service utilization in rural and remote areas: a scoping review. *Prehospital and disaster medicine*, *36*(6), 782-787.
32. O'Donnell, E., Honan, B., Quilty, S., & Schultz, R. (2021). The effect of heat events on prehospital and retrieval service utilization in rural and remote areas: a scoping review. *Prehospital and disaster medicine*, 36(6), 782-787.
33. O'Connor, M. L., Houghton, C. J., & O'Neill, B. J. (2020). The impact of cognitive fatigue on decision-making in emergency medical services: A review. *International Journal of Emergency Services*, *9*(3), 319-331. https://doi.org/10.1108/IJES-12-2019-0067
34. Oliver, S., & Leaney, S. (2024). Climate Change and Health: The Physiological Society's Key Recommendations for COP29: Improvised Prehospital Methods to Reduce Cold Stress in Humans.
35. Paganini, M. (2024). Heatwaves And Emergency Departments in Italy (HEAT-ED IT): strategies to identify determinants of overload and mitigate impact.
36. Paganini, M. (2024). Heatwaves And Emergency Departments in Italy (HEAT-ED IT): strategies to identify determinants of overload and mitigate impact.
37. Paganini, M., Markou-Pappas, N., Della Corte, F., Rosi, P., Trillò, G., Ferramosca, M., ... & Lamine, H. (2024). Heatwaves impact on prehospital emergency medicine: a qualitative study to improve sustainability and disaster preparedness in Veneto Region, Northern Italy. *Sustainability*, *16*(16), 6911.
38. Patel, L., Conlon, K. C., Sorensen, C., McEachin, S., Nadeau, K., Kakkad, K., & Kizer, K. W. (2022). Climate change and extreme heat events: how health systems should prepare. *NEJM Catalyst Innovations in Care Delivery*, *3*(7), CAT-21.
39. Patel, L., Conlon, K. C., Sorensen, C., McEachin, S., Nadeau, K., Kakkad, K., & Kizer, K. W. (2022). Climate change and extreme heat events: how health systems should prepare. *NEJM Catalyst Innovations in Care Delivery*, 3(7), CAT-21.
40. Patterson, P. D., Manley, K. S., & et al. (2021). The relationship between shift length and fatigue in emergency medical services. *Journal of Occupational Health*, *63*(1), e12256. https://doi.org/10.1002/1348-9585.12256
41. Pryor, R. R., Roth, R. N., Suyama, J., & Hostler, D. (2015). Exertional heat illness: emerging concepts and advances in prehospital care. *Prehospital and disaster medicine*, *30*(3), 297-305.
42. Pryor, R. R., Roth, R. N., Suyama, J., & Hostler, D. (2015). Exertional heat illness: emerging concepts and advances in prehospital care. *Prehospital and disaster medicine*, 30(3), 297-305.
43. Ranadive, N., Desai, J., Sathish, L. M., Knowlton, K., Dutta, P., Ganguly, P., ... & Hess, J. J. (2021). Climate change adaptation: prehospital data facilitate the detection of acute heat illness in India. *Western Journal of Emergency Medicine*, *22*(3), 739.
44. Ranadive, N., Desai, J., Sathish, L. M., Knowlton, K., Dutta, P., Ganguly, P., ... & Hess, J. J. (2021). Climate change adaptation: prehospital data facilitate the detection of acute heat illness in India. *Western Journal of Emergency Medicine*, 22(3), 739.
45. Rublee, C., Dresser, C., Giudice, C., Lemery, J., & Sorensen, C. (2021). Evidence-based heatstroke management in the emergency

department. *Western Journal of Emergency Medicine*, *22*(2), 186.
46. Savioli, G., Zanza, C., Longhitano, Y., Nardone, A., Varesi, A., Ceresa, I. F., ... & La Russa, R. (2022). Heat-related illness in emergency and critical care: recommendations for recognition and management with medico-legal considerations. *Biomedicines*, *10*(10), 2542.
47. Savioli, G., Zanza, C., Longhitano, Y., Nardone, A., Varesi, A., Ceresa, I. F., ... & La Russa, R. (2022). Heat-related illness in emergency and critical care: recommendations for recognition and management with medico-legal considerations. *Biomedicines*, 10(10), 2542.
48. Seong, K., Jiao, J., & Mandalapu, A. (2023). Evaluating the effects of heat vulnerability on heat-related emergency medical service incidents: Lessons from Austin, Texas. *Environment and Planning B: Urban Analytics and City Science*, *50*(3), 776-795.
49. Sorensen, C., & Hess, J. (2022). Treatment and prevention of heat-related illness. *New England Journal of Medicine*, *387*(15), 1404-1413.
50. Sorensen, C., & Hess, J. (2022). Treatment and prevention of heat-related illness. *New England Journal of Medicine*, 387(15), 1404-1413.
51. Sweeney, T. A., Campbell, K. L., & Dyer, J. (2021). Extended shifts in emergency medical services: A survey of current practices and perceptions. *Prehospital Disaster Medicine*, *36*(4), 401-407. https://doi.org/10.1017/S1049023X21000567
52. Tait, P. W., Allan, S., & Katelaris, A. L. (2018). Preventing heat-related disease in general practice. *Australian journal of general practice*, *47*(12), 835-840.
53. Tait, P. W., Allan, S., & Katelaris, A. L. (2018). Preventing heat-related disease in general practice. *Australian journal of general practice*, 47(12), 835-840.
54. Tilahun, W. T., Tirfe, F. W., Yitaferu, M. B., Shiferaw, H. Z., Bzuayehu, H. M., Tesfaye, M. T., ... & Habtu, L. M. (2024). Emergency preparedness for heat illness in Ethiopia: A cross-sectional observational study. *Journal of Medical and Clinical Research & Reviews*, *8*(5), 1-9.
55. Wondmagegn, B. Y., Xiang, J., Williams, S., Pisaniello, D., & Bi, P. (2019). What do we know about the healthcare costs of extreme heat exposure? A comprehensive literature review. *Science of the total environment*, *657*, 608-618.
56. Wondmagegn, B. Y., Xiang, J., Williams, S., Pisaniello, D., & Bi, P. (2019). What do we know about the healthcare costs of extreme heat exposure? A comprehensive literature review. *Science of the total environment*, 657, 608-618.
57. Yeargin, S., Hirschhorn, R., & Grundstein, A. (2020). Heat-related illnesses transported by United States emergency medical services. *Medicina*, *56*(10), 543.
58. Yeargin, S., Hirschhorn, R., & Grundstein, A. (2020). Heat-related illnesses transported by United States emergency medical services. *Medicina*, 56(10), 543.