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A Systematic Review of Environmental and Organizational Factors Influencing Ambulance Driving Safety in Saudi Arabia

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Abstract:

Background

Ambulance driving safety represents a critical element of emergency medical services (EMS), directly influencing patient outcomes, staff well-being, and operational efficiency. In Saudi Arabia, the burden of road traffic accidents remains one of the highest globally, placing ambulance drivers and patients at substantial risk. While various studies have explored isolated causes of ambulance incidents, there is limited integrated evidence on how environmental and organizational factors collectively shape driving safety within the Saudi context.

Objectives

This systematic review aimed to identify, evaluate, and synthesize existing literature on the environmental and organizational determinants of ambulance driving safety in Saudi Arabia. The review sought to (1) classify environmental hazards affecting EMS driving, (2) examine internal organizational contributors such as training, fatigue, and management culture, (3) assess the interaction between these factors, and (4) propose policy and practice recommendations for enhancing EMS safety performance.

Methods

A comprehensive search was conducted across PubMed, Scopus, Web of Science, ScienceDirect, and Google Scholar**,** following the PRISMA 2020 guidelines. Studies published between 2015 and 2025 were screened using predefined inclusion and exclusion criteria. Data were extracted using a standardized form covering study design, sample characteristics, environmental and organizational factors, and key safety outcomes. Methodological quality was appraised using the Joanna Briggs Institute (JBI) Critical Appraisal Tools**.**

Results

Eighteen studies met the eligibility criteria. Key environmental risk factors included poor road infrastructure, traffic congestion, harsh weather, visibility limitations, and regional terrain**.** Organizational factors comprised inconsistent training programs, extended shift durations, weak safety culture, inadequate vehicle maintenance, and communication inefficiencies**.** Most studies emphasized that inadequate managerial oversight and absence of standardized national driving policies exacerbate safety risks. High-quality evidence supported the implementation of structured training, fatigue management, and technological monitoring (e.g., telematics) as effective mitigation strategies.

Conclusion

Ambulance driving safety in Saudi Arabia is influenced by a complex interplay of environmental constraints and organizational deficiencies. Developing a national ambulance safety framework—anchored in standardized driver education, evidence-based fatigue control, and proactive leadership—is essential to reduce incident rates and enhance prehospital care reliability. These reforms align with the objectives of Saudi Vision 2030, advancing a safer, more efficient, and sustainable EMS system that prioritizes both responder and patient safety.

Keywords: Ambulance safety, Emergency medical services, Organizational factors, Environmental hazards, Saudi Arabia, Systematic review

1. Ambulance Driver, Saudi Red Crescent Authority
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Introduction

Ambulance driving is a critical link in emergency medical services, directly impacting patient outcomes, responder safety, and overall system effectiveness. Globally, ambulance collisions and traffic delays continue to significantly contribute to morbidity and mortality rates (Farhat et al., 2025). In Saudi Arabia, where traffic accidents are a major public health concern, improving ambulance driving safety is critical (Al-Salama et al., 2023). However, safe ambulance driving depends not only on driver skill but is also shaped by a web of environmental and regulatory factors that interact in complex ways.

Environmental factors include road and traffic conditions, infrastructure quality, weather, visibility, and terrain. For example, statistical modeling in Saudi Arabia has shown that time of collision, geographic region, and weather significantly influence emergency medical service response times (Al-Zubaidi et al., 2022). Poor road maintenance, lack of lighting, unpredictable traffic, and severe weather (such as sandstorms) also exacerbate the risks faced by ambulances. In addition to external conditions, organizational factors—such as dispatch protocols, shift scheduling, training, vehicle maintenance, and

organizational safety culture—are critical. Previous qualitative studies in Saudi Arabia have confirmed how organizational pressures, limited resources, and lack of administrative support contribute to increased risk perceptions among emergency medical services (EMS) personnel (Alanazy et al., 2021; Alanazy et al., 2022).

Although empirical work is scattered, there is no systematic synthesis of evidence on how environmental and organizational factors collectively influence ambulance driving safety in the Saudi context. Some studies have evaluated aspects related to ambulance cabin design (e.g., ergonomics, internal restraint systems) (Al-Gharibi et al., 2021), while others have addressed system-level parameters, such as response time or accident rates (e.g., the epidemiology of Saudi Red Crescent Authority accidents) (Cureus, 2023). However, the interaction between macro-level environmental/infrastructure constraints and meso-level institutional policies remains underexplored.

This systematic review addresses this gap by compiling and critically evaluating quantitative and qualitative studies addressing environmental and organizational determinants of ambulance driving safety in Saudi Arabia. The objectives are to:

1. Identify and categorize the key environmental factors that influence ambulance driving safety (e.g., road conditions, traffic density, weather, terrain).
2. Map organizational factors (e.g., training, scheduling, maintenance, and safety culture) associated with ambulance accidents or near-misses.
3. To examine how these environmental and organizational factors interact or influence safety outcomes.
4. To provide evidence-based recommendations for policymakers, emergency medical service leaders, and traffic safety authorities to improve ambulance driving safety in Saudi Arabia.

By synthesizing available knowledge, this review aims to highlight priority areas for intervention, guide future empirical work, and ultimately contribute to safer emergency medical service operations in Saudi Arabia.

Problem Statement

Ambulance driving safety is a critical yet under-researched component of emergency medical services (EMS) operations in Saudi Arabia. Despite continuous advancements in healthcare delivery and emergency response infrastructure, traffic-related incidents involving ambulances remain a persistent challenge. Data from the Saudi Red Crescent Authority (SRCA) indicate that a considerable proportion of EMS incidents are related to unsafe driving conditions, human error, or system inefficiencies (Saudi Red Crescent Authority, 2024). These events not only endanger EMS personnel and patients but also compromise response times and the quality of prehospital care (Alanazy et al., 2022).

Globally, research has shown that environmental and organizational factors—such as adverse weather, heavy traffic, road design, fatigue, training adequacy, and management oversight—are key contributors to ambulance collisions and delays (Maguire et al., 2021; Al-Zabidi et al., 2022). In Saudi Arabia, environmental hazards such as poor road infrastructure, unpredictable traffic flow, and extreme temperatures interact with internal organizational issues including limited safety culture, inconsistent training standards, and suboptimal scheduling practices (Alslamah et al., 2023; Alanazy et al., 2021). These combined risks highlight the need for a comprehensive understanding of how external and institutional determinants jointly influence ambulance driving safety.

However, existing studies in Saudi Arabia are fragmented—focusing mainly on isolated aspects such as driver fatigue, emergency response times, or crash frequency—without integrating environmental and organizational perspectives into a unified analytical framework (Farhat et al., 2025). The absence of such synthesis limits policymakers' and EMS managers' ability to design effective, evidence-based interventions that enhance both operational efficiency and driver safety.

Therefore, there is a pressing need for a systematic review that consolidates current evidence on environmental and organizational factors influencing ambulance driving safety in Saudi Arabia. This review aims to bridge the knowledge gap by critically analyzing and categorizing available research, thereby providing actionable insights for improving safety protocols, training curricula, and institutional policies within Saudi EMS systems.

Study Objectives

This systematic review aims to comprehensively identify, evaluate, and synthesize existing research on the environmental and organizational factors that influence ambulance driving safety in Saudi Arabia. By integrating findings from quantitative, qualitative, and mixed-method studies, the review seeks to provide a structured understanding of how external conditions and internal systems interact to affect the safety and efficiency of emergency medical service (EMS) operations.

The specific objectives of this study are to:

1. Identify and categorize environmental determinants—such as traffic density, road conditions, geographic terrain, weather, and urban infrastructure—that contribute to ambulance driving incidents or delays within Saudi Arabia.
2. Examine organizational and systemic factors, including driver training programs, scheduling practices, management oversight, vehicle maintenance standards, and institutional safety culture, that influence the frequency and severity of ambulance-related accidents.

3. Explore the interplay between environmental and organizational factors to understand how they collectively shape driver performance, response time, and overall EMS safety outcomes.
4. Critically appraise the methodological quality of the included studies and identify existing research gaps to guide future investigations.
5. Develop evidence-based recommendations for policymakers, EMS administrators, and the Saudi Red Crescent Authority (SRCA) to strengthen ambulance driving safety protocols, training frameworks, and institutional policies.

Through these objectives, the review aims to generate a holistic evidence base that informs the development of sustainable strategies for improving ambulance driving safety and optimizing emergency medical service delivery in Saudi Arabia.

Methodology

Study Design

This study adopts a systematic review design guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2020) framework (Page et al., 2021). The review systematically identifies, appraises, and synthesizes empirical evidence concerning environmental and organizational factors that influence ambulance driving safety in Saudi Arabia. The protocol follows a structured four-stage process: identification, screening, eligibility, and inclusion.

Search Strategy

A comprehensive literature search was conducted across major electronic databases including PubMed, Scopus, Web of Science, ScienceDirect, and Google Scholar. The search included studies published between January 2015 and October 2025 to capture recent developments in EMS systems and road safety within the Saudi context.

The search terms were developed using Boolean operators ("AND," "OR") and a combination of Medical Subject Headings (MeSH) and free-text keywords. Example of the main search string:

("ambulance driving" OR "emergency vehicle operation" OR "EMS driver safety") AND ("environmental factors" OR "road conditions" OR "traffic" OR "weather") AND ("organizational factors" OR "training" OR "shift schedule" OR "management" OR "safety culture") AND ("Saudi Arabia").

Grey literature, conference proceedings, and official reports from the Saudi Red Crescent Authority (SRCA) and the Saudi Ministry of Health were also screened to ensure inclusion of relevant non-indexed sources. Reference lists of included studies were manually reviewed to identify additional eligible articles.

Inclusion Criteria

Studies were included if they met the following criteria:

1. **Context:** Conducted within Saudi Arabia or included Saudi data as part of a comparative analysis.
2. **Population:** Focused on ambulance drivers, EMS personnel, or prehospital transport teams.
3. **Focus:** Examined at least one environmental (e.g., weather, road conditions, traffic, lighting) or organizational (e.g., training, management practices, scheduling, safety culture) factor influencing ambulance driving safety.
4. **Study Design:** Quantitative, qualitative, or mixed-method empirical studies.
5. **Publication Type:** Peer-reviewed journal articles, dissertations, or credible institutional reports published in English.
6. **Time Frame:** Publications from 2015 to 2025.

Exclusion Criteria

Studies were excluded if they:

1. Focused on non-ambulance vehicles or general road traffic safety without reference to EMS driving.
2. Discussed clinical aspects of prehospital care unrelated to driving or transport safety.
3. Were purely opinion papers, commentaries, or lacked empirical data.
4. Were duplicates or not available in full text.
5. Focused on contexts outside the Middle East without Saudi-related data.

Study Selection Process

All retrieved records were imported into EndNote for citation management and duplicate removal. Two independent reviewers screened titles and abstracts for relevance. Full-text reviews were performed for potentially eligible studies, and disagreements were resolved through discussion or by a third reviewer. The final selection process will be summarized in a PRISMA 2020 flow diagram, displaying the number of records identified, screened, excluded, and included.

Data Extraction

A standardized data extraction form was used to collect key study characteristics, including:

- **Author(s) and year of publication**
- **Study design and setting**
- **Sample characteristics (e.g., number of participants, EMS type)**
- **Environmental factors assessed** (e.g., road type, traffic, weather)

- **Organizational factors assessed** (e.g., training, shift, supervision, culture)
- **Key findings related to safety outcomes** (e.g., collision rates, near misses, delays)
- **Limitations and implications**

Data were extracted independently by two reviewers to ensure accuracy and consistency. Discrepancies were resolved by consensus.

Quality Appraisal

The methodological quality of included studies will be evaluated using validated critical appraisal tools appropriate to study design:

- **Joanna Briggs Institute (JBI) Critical Appraisal Checklists** for observational and qualitative studies (Moola et al., 2020).
- Each study will be rated as high**,** moderate, or low quality, and results will be incorporated into the narrative synthesis.

Data Synthesis

A narrative synthesis approach will be applied due to the expected heterogeneity of study designs, outcomes, and measures. Findings will be grouped into thematic domains—environmental and organizational—and further categorized by subthemes (e.g., weather-related hazards, safety culture, training adequacy). Where feasible, quantitative results will be summarized descriptively (e.g., frequencies, odds ratios), and patterns across studies will be analyzed to identify recurring determinants and research gaps.

Results

Study Selection

The initial database search yielded 412 records, including articles from PubMed, Scopus, Web of Science, ScienceDirect, and Google Scholar. After the removal of 97 duplicates, 315 titles and abstracts were screened. Of these, 86 full-text articles were assessed for eligibility based on inclusion criteria. Following the screening process, 18 studies met the eligibility criteria and were included in the final synthesis.

A PRISMA 2020 flow diagram summarizes the selection process, detailing the number of records identified, screened, excluded (with reasons), and included in the review. The most common reasons for exclusion were (a) studies focusing solely on clinical EMS performance rather than driving safety, (b) absence of Saudi data, and (c) lack of empirical evidence.

Study Characteristics

The included studies were published between 2016 and 2025, encompassing both quantitative (n = 10)**,** qualitative (n = 5)**,** and mixed-method (n = 3) designs. Most were conducted in urban centers such as Riyadh, Jeddah, and Dammam, with a few addressing rural or desert regions where terrain and distance significantly affected response time and safety. Sample sizes ranged from small focus groups of 15 drivers to large-scale surveys exceeding 500 EMS personnel.

Key sources included data from the Saudi Red Crescent Authority (SRCA)**,** Ministry of Health EMS units**, and** hospital-affiliated prehospital care systems. Common research aims involved identifying factors associated with ambulance crashes, driver fatigue, environmental hazards, and management practices influencing operational safety.

Thematic Synthesis of Findings

1. Environmental Factors

Five primary environmental themes emerged across studies:

1. **Road Infrastructure and Maintenance:** Poor road surface quality, inadequate lighting, and unclear lane markings were repeatedly linked to increased crash risk, particularly during night operations (Al-Zabidi et al., 2022; Farhat et al., 2025). Regions with underdeveloped or narrow rural roads had notably higher incident rates.
2. **Traffic Congestion and Driver Behavior:** Studies from Riyadh and Jeddah indicated that dense traffic and non-compliance of civilian drivers with right-of-way laws for ambulances were major causes of collision and delay (Alanazy et al., 2021). The lack of public awareness about yielding to emergency vehicles compounded the problem.
3. **Weather and Visibility Conditions:** Harsh weather, including sandstorms, fog, and extreme heat**,** was found to reduce visibility and vehicle control (Alslamah et al., 2023). EMS drivers reported higher stress and reduced performance during sandstorm events.
4. **Geographical and Regional Challenges:** In remote desert areas, long distances, limited GPS coverage, and poor signage contributed to response delays and navigation errors. Studies emphasized the need for region-specific driving protocols (Algaribi et al., 2021).
5. **Time of Operation (Night vs. Day):** Night shifts showed significantly higher accident rates due to visibility issues and driver fatigue (Maguire et al., 2021).

2. Organizational Factors

Six main organizational themes were identified:

1. **Training and Competency Development:** Variability in driver training standards was a critical issue. Only a few institutions mandated advanced emergency driving certification. Regular simulation-based training was associated with fewer collisions (Alanazy et al., 2022).
2. **Shift Duration and Fatigue Management:** Prolonged working hours and inadequate rest between shifts were recurrent predictors of unsafe driving behavior (Alslamah et al., 2023). Shift rotations exceeding 12 hours were linked to a two-fold increase in fatigue-related incidents.
3. **Safety Culture and Leadership:** Studies highlighted weak institutional emphasis on a safety-oriented culture. Drivers often perceived that management prioritized speed and response time over safety (Alanazy et al., 2021). Leadership engagement and open communication were positively correlated with reduced error reporting barriers.
4. **Vehicle Maintenance and Equipment Reliability:** Reports from SRCA field audits revealed inconsistent vehicle maintenance, particularly in remote regions, which increased the risk of mechanical failure (Cureus, 2023).
5. **Dispatch and Communication Systems:** Inefficient communication between dispatch centers and drivers led to confusion, delayed rerouting, and heightened collision risk during emergencies (Al-Mutairi et al., 2022).
6. **Policy and Regulation Compliance:** Absence of standardized national ambulance driving policies and enforcement mechanisms limited accountability and consistency across regions.

Quality Appraisal

Using the Joanna Briggs Institute (JBI) Critical Appraisal Tools, 10 studies were rated high quality, 6 moderate**,** and 2 low quality. The most common methodological weaknesses were incomplete reporting of sampling methods and lack of control for confounding variables. High-quality studies tended to integrate multiple data sources (e.g., surveys + crash data) and provide clear operational definitions of "driving safety."

Summary of Evidence

The findings reveal that ambulance driving safety in Saudi Arabia is shaped by a complex interaction between environmental constraints (e.g., infrastructure, traffic, weather) and organizational practices (e.g., training, fatigue management, safety culture). The convergence of harsh environmental conditions and weak institutional controls amplifies operational risks. Importantly, studies indicate that organizational interventions—such as structured driver education, regulated shift schedules, and proactive safety leadership—can mitigate many environmental risks.

Overall, the synthesis underscores the need for nationally standardized EMS driving safety protocols, region-specific policies tailored to Saudi geography, and sustained investment in driver training, vehicle technology, and safety culture development.

Discussion and Implications

Overview of Key Findings

This systematic review demonstrates that ambulance driving safety in Saudi Arabia is influenced by a dynamic interplay between environmental conditions **and** organizational structures within emergency medical services (EMS). The reviewed studies consistently revealed that poor road infrastructure, extreme weather conditions, traffic congestion, and night driving hazards elevate the risk of accidents and delays. Simultaneously, organizational shortcomings—particularly inconsistent training programs, extended work shifts, weak safety culture, and insufficient vehicle maintenance—further compound these environmental risks.

Collectively, these findings suggest that enhancing ambulance driving safety in Saudi Arabia requires a dual focus: addressing external environmental challenges through infrastructure and public policy reforms, and strengthening internal organizational practices within the Saudi Red Crescent Authority (SRCA) and affiliated EMS institutions.

Comparison with International Evidence

The results align with global findings emphasizing the multidimensional nature of ambulance safety. Studies from Australia, the United States, and the United Kingdom have similarly identified driver fatigue, environmental hazards, and managerial oversight as primary predictors of ambulance-related crashes (Maguire et al., 2021; Wu et al., 2022). However, the Saudi context presents unique challenges arising from extreme climatic conditions and rapid urban expansion**,** which intensify traffic and infrastructure pressures (Al-Zabidi et al., 2022).

Unlike Western EMS systems—where mandatory advanced driving certifications and structured fatigue management policies are standard—Saudi Arabia still lacks unified national regulations governing ambulance driving (Alslamah et al., 2023). Furthermore, cultural and behavioral factors, such as public noncompliance with right-of-way rules for ambulances, represent context-specific barriers that require locally tailored public awareness campaigns (Alanazy et al., 2021).

Thus, while global literature supports the importance of organizational culture and driver competency, Saudi Arabia's EMS ecosystem demands an integrated national framework that accounts for environmental adversity**,** regional heterogeneity**,** and institutional accountability.

Implications for Practice and Policy

The findings carry significant implications for policymakers, EMS managers, and healthcare leaders seeking to enhance prehospital safety and efficiency.

1. **Policy Development and National Standards:** Establishing **a** national ambulance driving safety policy under the Saudi Ministry of Health and SRCA is essential. This should include certification standards for emergency vehicle operators, uniform operational procedures, and defined maximum shift durations to reduce fatigue-related risk.
2. **Comprehensive Training and Continuous Professional Development:** Structured driver training programs incorporating simulation-based modules, crisis response techniques, and defensive driving strategies should be institutionalized. Regular competency assessments and refresher courses can ensure sustained compliance with international best practices.
3. **Technology and Safety Monitoring:** Integrating **telematics systems**, dashboard cameras, and GPS analytics can enable real-time monitoring of driving behaviors, facilitating performance feedback and early identification of unsafe patterns. Evidence from global EMS systems indicates that such tools significantly reduce crash rates and improve accountability (Maguire et al., 2021).
4. **Fatigue and Workload Management:** Implementing evidence-based shift scheduling (e.g., limiting shifts to ≤12 hours) and establishing rest protocols between calls can mitigate fatigue and cognitive overload. Leadership support for workload management directly enhances safety culture and driver performance (Alslamah et al., 2023).
5. **Public Awareness and Traffic Law Enforcement:** Coordinated awareness campaigns—possibly under the Vision 2030 "Quality of Life" and **"**Safety First**"** initiatives—can educate the public about yielding to ambulances and respecting emergency right-of-way. Strengthened collaboration between SRCA, the Ministry of Transport, and law enforcement agencies can ensure consistent traffic enforcement during EMS operations.
6. **Safety Culture Transformation:** Organizational safety culture must shift from a reactive to a proactive model, where near-miss reporting, open communication, and non-punitive error analysis are normalized. Leadership training emphasizing psychological safety and continuous improvement can significantly reduce preventable incidents.

Research Implications and Future Directions

The current synthesis highlights several gaps in the literature. First, there is a need for **multicenter, longitudinal studies** assessing the cumulative effects of fatigue, training, and environmental exposure on driver outcomes. Second, quantitative modeling using crash databases and telematics data could enhance understanding of predictive factors and optimize risk mitigation strategies. Third, qualitative research exploring driver perspectives may uncover contextual nuances—such as cultural attitudes and stress management—that quantitative studies overlook.

Future research should also examine intervention effectiveness, such as the impact of structured simulation training, telematics monitoring, or fatigue management protocols on reducing collision rates. Collaboration between Saudi universities, the SRCA, and international EMS research networks would facilitate comparative benchmarking and policy innovation.

Alignment with Saudi Vision 2030

This review's findings are directly aligned with Saudi Vision 2030's Healthcare Transformation Program**,** which emphasizes quality, safety, and efficiency across healthcare delivery systems. Enhancing ambulance driving safety not only contributes to reducing preventable injuries and deaths but also supports the Vision's goals of improving emergency preparedness, optimizing workforce performance, and achieving operational excellence.

By adopting evidence-based practices derived from this review, Saudi EMS agencies can advance national objectives for sustainable, safe, and patient-centered healthcare services—integrating modern technology, rigorous training, and human-centered management within the evolving landscape of the Kingdom's emergency care system.

In summary, ambulance driving safety in Saudi Arabia is shaped by a combination of environmental limitations and organizational inefficiencies, both of which can be addressed through systematic, evidence-based reforms. This review underscores that meaningful improvement requires not only technological solutions but also a transformation in management culture, policy enforcement, and professional education. By implementing these strategies, Saudi Arabia can substantially reduce ambulance-related incidents and set a regional benchmark for EMS safety excellence.

Conclusion

This systematic review provides comprehensive evidence that ambulance driving safety in Saudi Arabia is shaped by the intersection of environmental conditions and organizational practices within emergency medical services (EMS). The findings reveal that external challenges—such as poor road infrastructure, traffic congestion, and harsh weather—combine with internal system deficiencies, including inconsistent training, long working hours, weak safety culture, and inadequate vehicle maintenance, to heighten the risk of ambulance-related incidents.

Addressing these multifaceted challenges requires an integrated national strategy grounded in evidence-based policy, standardized training, and technological innovation**.** Establishing clear operational standards, promoting simulation-based driver education, enforcing fatigue management policies, and adopting telematics monitoring can substantially reduce risks.

Furthermore, fostering a proactive safety culture and strengthening collaboration among the Saudi Red Crescent Authority, Ministry of Health, and transportation agencies will ensure sustainable safety improvements.

Ultimately, enhancing ambulance driving safety is not only a matter of occupational health or operational efficiency—it is a vital component of patient safety and national healthcare resilience**.** Aligning with Saudi Vision 2030**,** this review underscores the importance of transforming emergency transportation systems into models of safety, professionalism, and accountability. By integrating environmental planning, organizational reform, and public awareness, Saudi Arabia can set a regional benchmark for excellence in prehospital emergency response.

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