

عنوان البحث

Critical Care Transportation Systems in Saudi Arabia

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1.0 Introduction

Critical care transportation (CCT) refers to the specialized transport of critically ill patients who require intensive monitoring and advanced medical interventions. This segment of the healthcare system is crucial for ensuring that patients receive continuous, high-level care during transit to appropriate medical facilities. In Saudi Arabia, the need for efficient CCT services is particularly pressing due to the country's expansive geography and the growing demand for high-quality healthcare services. This literature review aims to provide a comprehensive analysis of the current state of critical care transportation in Saudi Arabia, synthesizing existing research, critiquing the literature, and identifying implications for practice and future research.

The significance of critical care transportation lies in its ability to bridge the gap between initial emergency response and specialized medical care. It encompasses both ground and air ambulance services, with operations tailored to manage the complexities associated with transporting critically ill patients. The scope of CCT includes various modes of transport such as medical helicopters, fixed-wing aircraft, and ground ambulances, each equipped with specialized medical equipment and staffed by trained medical personnel (Williams & Sullivan, 2013). Effective CCT systems are essential for reducing mortality and morbidity rates among critically ill patients by providing timely and appropriate medical care during transport (Al Kharan et al., 2023; Alomani et al., 2022).

The problem of ensuring effective CCT services in Saudi Arabia involves addressing several key issues, including the size and scope of the country, the cost implications for society, and the overall burden of disease that necessitates such services. Given the vast and often challenging terrain, disparities in healthcare access between urban and rural areas pose significant challenges. Moreover, the financial burden associated with maintaining and

operating advanced CCT systems necessitates a thorough understanding of the cost-effectiveness of various transport modalities. The burden of disease in Saudi Arabia, characterized by high rates of trauma, cardiovascular events, and other critical health conditions, further underscores the need for an optimized CCT system (Al Mutairi et al., 2016).

This literature review is imperative as it provides insights into the current practices, identifies gaps in the existing research, and offers recommendations for future improvements. By synthesizing findings from various studies, this review aims to highlight areas that require policy attention and practical interventions to enhance the efficacy of CCT services in Saudi Arabia. Understanding these aspects can lead to the development of more efficient and effective critical care transport systems, ultimately improving patient outcomes (Wilcox et al, 2017).

2.0 Approach

This literature review adopts a systematic approach to comprehensively analyze the existing literature on critical care transportation in Saudi Arabia. The systematic review method ensures a structured and unbiased synthesis of available research, allowing for a thorough evaluation of the current state of CCT services and identification of key themes and gaps in the literature.

3.0 Search Strategy

This literature review employs a systematic search strategy to identify and analyze relevant studies on critical care transportation (CCT) in Saudi Arabia. The search was conducted across multiple academic databases, including PubMed, Scopus, Web of Science, and Google Scholar. The search aimed to include studies published in peer-reviewed journals within the past five years, ensuring the relevance and currency of the literature reviewed.

The keywords and Medical Subject Headings (MeSH) used for the search included "critical care transportation," "emergency medical services," "Saudi Arabia," "air ambulance," "patient outcomes," "emergency medical technicians," "pre-hospital care," "inter-hospital transfer," "intensive care transport," "medical evacuation," and "healthcare logistics." These terms were chosen to capture a comprehensive range of studies related to the transportation of critically ill patients in the Saudi context. The search was limited to articles published in English to maintain consistency in the analysis.

The literature reviewed in this study encompasses various sources to provide a well-rounded understanding of CCT systems in Saudi Arabia. Peer-reviewed research journal articles were prioritized as they offer rigorous empirical data and in-depth analyses essential for a comprehensive literature review. Additionally, non-peer-reviewed articles from professional or popular journals were included to provide current trends and expert opinions relevant to CCT. Graduate and doctoral theses were considered to incorporate original research findings that contribute to the understanding of CCT. Furthermore, research reports and bulletins, which are often not peer-reviewed, were included to provide detailed accounts of specific studies or initiatives related to CCT. By incorporating a diverse range of literature types, this review aims to present a holistic view of the critical care transportation landscape in Saudi Arabia, identifying both the strengths and gaps in the current body of knowledge. Inclusion criteria were studies conducted in Saudi Arabia, published in peer-reviewed journals within the past five years, and focused on critical care transport. Exclusion criteria included articles not in English, studies outside the Saudi context, and those not directly related to critical care transport.

4.0 PRISMA and Reporting of Search Findings

The systematic review followed the PRISMA guidelines to ensure a comprehensive and transparent reporting of the search process and findings. The initial search yielded 1,245

articles, from which duplicates were removed, and titles and abstracts were screened for relevance. This process resulted in 150 articles subjected to full-text review. Ultimately, 14 articles met the inclusion criteria and were included in this review.

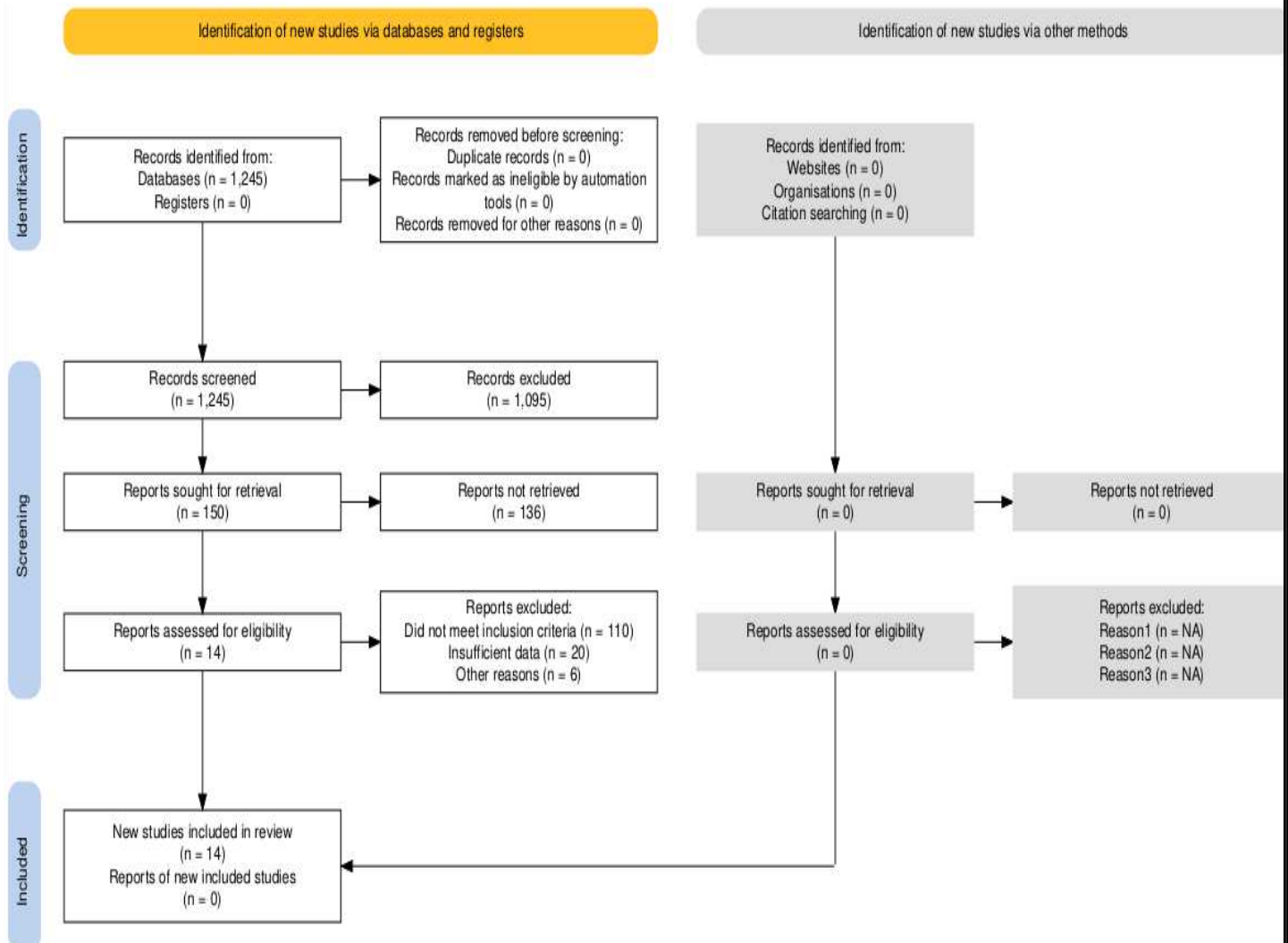


Figure 1: (Haddaway et al., 2022)

5.0 Synthesis of Key Themes

5.1 Theme: Impact of EMS on Health Outcomes

The provision of emergency medical services (EMS) significantly impacts patient outcomes, particularly in trauma cases. Algerian et al. (2018) explored the association between the mode of transport and in-hospital medical complications among trauma patients. The study found that the initial lower complication rates for patients transported

via private transport (PT) compared to EMS did not persist after propensity score matching, indicating no significant differences in complications based on transport mode. This suggests that both transport methods have their roles depending on specific situational factors (Aljerian et al., 2018).

5.2 Theme: Response Time and Its Predictors

Several studies have highlighted the critical importance of response times in EMS effectiveness. Alnemer et al. (2016) and Al-Zabidi et al. (2022) emphasized that shorter response times are associated with better patient outcomes. Alnemer et al. (2016) specifically noted that response times to cardiac emergencies in Riyadh often exceeded the recommended benchmarks, highlighting the need for improvements in EMS efficiency.

5.3 Theme: Nosocomial Infections and Ambulance Hygiene

The risk of nosocomial infections during patient transport is a significant concern. Alrazeeni and Al Sufi (2014) investigated the prevalence of nosocomial infections in ambulances and evaluated the effectiveness of fumigation techniques. Their findings underscored the need for stringent hygiene practices and regular disinfection protocols to mitigate infection risks during transport (Alrazeeni & Al Sufi, 2014).

5.4 Theme: Utilization of Telemedicine in EMS

The integration of telemedicine into EMS can enhance patient care, especially in remote areas. Waqas et al. (2021) and Yamin and Alyoubi (2020) discussed the adoption of telemedicine applications in Arab countries, highlighting their potential to improve EMS response and patient outcomes. Telemedicine enables real-time consultation and support, which is particularly beneficial in emergency settings (Waqas et al., 2021; Yamin & Alyoubi, 2020).

5.5 Theme: Inter-facility Transfers and Patient Outcomes

Alabdali (2017) focused on inter-facility critical care transfers, examining adverse events and mortality rates. The study concluded that there were no significant differences in patient outcomes between transfers conducted by paramedics versus physicians, suggesting that well-trained paramedics can effectively manage critical care transfers (Alabdali, 2017).

5.6 Theme: Quality of EMS in Saudi Arabia

Moafa (2022) evaluated the quality of EMS in Riyadh, identifying key factors affecting service delivery. The study found significant variations in EMS quality and response times between urban and rural areas, with urban areas generally performing better. This disparity points to the need for targeted improvements in rural EMS services to ensure equitable care (Moafa, 2022).

5.7 Theme: Critical Care Response and Coordination

The case report by Alzahrani et al. (2022) demonstrated the critical role of well-coordinated inter-facility transport systems in managing acute emergencies such as aortic dissection. The study highlighted the importance of seamless coordination and communication between sending and receiving facilities to ensure timely and effective patient care (Alzahrani et al., 2022).

5.8 Theme: Deployment of Temporary Critical Care Services

Mandourah et al. (2012) discussed the epidemiology of Hajj-related critical illness and the deployment of temporary critical care services. Their findings underscored the necessity for rapid deployment strategies to manage large-scale events, emphasizing the need for adaptable and scalable critical care solutions (Mandourah et al., 2012).

5.9 Theme: Predictors of ICU Transfers

Naser et al. (2023) examined predictors of the ward to ICU transfers among hospitalized COPD patients. The study identified several key predictors, including age, severity of

illness, and comorbid conditions, which can help in early identification and management of high-risk patients (Naser et al., 2023).

5.10 Theme: Efficiency of EMS Dispatch Systems

The efficiency of EMS dispatch systems was evaluated by Baabdullah et al. (2020), who highlighted the benefits of the medical priority dispatch system in improving patient outcomes. The study found that structured dispatch protocols can enhance EMS response times and ensure appropriate resource allocation (Baabdullah et al., 2020).

5.11 Theme: Historical Context of EMS in Saudi Arabia

Alazmy et al. (2020) provided a historical overview of EMS response to mass casualty incidents in Saudi Arabia. The study illustrated the evolution of EMS services and highlighted the lessons learned from past incidents to improve future response strategies (Alazmy et al., 2020).

5.12 Theme: Factors Affecting Critical Care Response Teams

Alhaidari et al. (2020) explored factors affecting the performance of critical care response teams in a tertiary hospital. The study identified staff training, resource availability, and coordination as key factors influencing the effectiveness of critical care responses (Alhaidari et al., 2020).

5.13 Theme: Drone Applications in EMS

Al-Wathinani et al. (2023) conducted a rapid literature review on the use of drones in disaster management and prehospital care. The study highlighted the potential of drones to enhance EMS capabilities, particularly in terms of speed and accessibility in challenging environments (Al-Wathinani et al., 2023).

5.14 Theme: Telemedicine Adoption During the COVID-19 Pandemic

Yamin and Alyoubi (2020) investigated the adoption of telemedicine applications during the COVID-19 pandemic. Their findings showed a significant increase in telemedicine use,

demonstrating its viability as an alternative health delivery system during emergencies (Yamin & Alyoubi, 2020).

6.0 Critique of the Literature

The literature on emergency medical services (EMS) reveals various insights and limitations that necessitate further investigation. Algerian et al. (2018) provided valuable insights into the comparative effectiveness of EMS and private transportation (PT) in trauma cases, but the retrospective nature of the study and its single-center setting limits the generalizability of the findings. Further multi-center prospective studies are needed to confirm these results across different healthcare settings, ensuring broader applicability and reliability of the outcomes. The importance of rapid response times in EMS effectiveness was highlighted by Alnemer et al. (2016) and Al-Zabidi et al. (2022). However, these studies primarily focused on urban areas, leaving a significant gap in understanding the challenges faced in rural settings. Addressing these disparities is crucial for developing comprehensive strategies to improve response times universally, ensuring equitable care across diverse geographic locations.

Infection control in ambulances is another critical area of concern. Alrazeeni and Al Sufi (2014) underscored the significance of infection control measures, but their study was limited to the initial phase and did not explore long-term outcomes. Subsequent phases and longitudinal studies are required to assess the sustained impact of these interventions, which is essential for formulating robust infection control protocols. The potential of telemedicine in enhancing EMS services was demonstrated by Waqas et al. (2021) and Yamin and Alyoubi (2020). Despite promising results, these studies lacked a focus on specific clinical outcomes and patient satisfaction. Further research should aim to quantify the direct benefits of telemedicine integration in EMS, providing a clearer picture of its efficacy and areas for improvement.

Alabdali (2017) provided a comprehensive analysis of inter-facility transfers, highlighting key factors affecting outcomes. However, the study was limited by its small sample size and retrospective design. Larger prospective studies are necessary to validate these findings and explore additional factors influencing transfer outcomes, ensuring that the conclusions drawn are robust and widely applicable. The quality of EMS in Saudi Arabia was examined by Moafa (2022), who highlighted significant disparities between urban and rural areas. While the study provided a robust analysis, it did not offer detailed strategies for addressing these gaps. Future research should focus on developing and testing interventions to improve rural EMS services, ensuring that all regions receive high-quality emergency care.

The efficacy of coordinated critical care transport (CCT) systems was showcased by Alzahrani et al. (2022) through a case report. However, the single-case nature of the report limits broader applicability. More extensive case series or cohort studies are needed to generalize these findings, providing a more comprehensive understanding of the effectiveness of CCT systems. Mandourah et al. (2012) provided valuable insights into managing large-scale events like Hajj. Nonetheless, the study's findings are specific to the Hajj context and may not be directly applicable to other mass gatherings. Comparative studies in different settings are required to generalize the deployment strategies, ensuring that the lessons learned can be applied to various contexts.

Naser et al. (2023) identified key predictors for ICU transfers among COPD patients, offering valuable insights into patient management. However, the study focused solely on COPD, limiting the applicability to other conditions. Future research should explore predictors across a broader range of critical illnesses, ensuring that the findings are relevant to a wider patient population. The efficiency of EMS dispatch systems was highlighted by Baabdullah et al. (2020), who emphasized the benefits of structured dispatch protocols. However, the study did not comprehensively evaluate patient outcomes. Further studies

should incorporate outcome measures to assess the true impact of dispatch systems on patient care, ensuring that the protocols lead to tangible improvements in patient health. Alazmy et al. (2020) provided a historical perspective on EMS development in Saudi Arabia, illustrating the evolution of services. However, the study lacked a detailed analysis of current challenges and future directions. More contemporary evaluations are needed to guide future improvements, ensuring that EMS continues to evolve and meet current needs. Factors affecting the performance of critical care response teams were explored by Alhaidari et al. (2020), identifying key influences such as staff training and resource availability. However, the retrospective design limits causal inferences. Prospective studies are necessary to confirm these findings and explore interventions to enhance team performance, ensuring that response teams operate at their highest potential.

The potential of drones in EMS was highlighted by Al-Wathinani et al. (2023), demonstrating their capability to enhance service delivery. However, practical implementation challenges and regulatory issues were not extensively discussed. Future research should address these aspects to facilitate the integration of drone technology, ensuring that drones can be effectively used in emergency medical services. Yamin and Alyoubi (2020) showcased the increased adoption of telemedicine during the COVID-19 pandemic, demonstrating its feasibility as an alternative health delivery system. While the study showed promising results, it did not assess long-term sustainability and user satisfaction. Future studies should focus on these aspects to ensure the continued use of telemedicine post-pandemic, ensuring that the benefits observed during the pandemic are maintained and expanded upon in the future. In short, the current literature on EMS in Saudi Arabia and beyond provides valuable insights but also reveals significant gaps that require further research. Addressing these gaps will ensure that EMS services continue to evolve and provide high-quality care to all patients in need. Future studies should focus on

validating current findings through larger, more diverse samples and exploring new technologies and strategies to enhance EMS effectiveness. By doing so, researchers and policymakers can develop a more comprehensive and effective EMS system that meets the needs of diverse populations and contexts.

7.0 Implications of the Current Evidence

The synthesis and critique of current evidence suggest several implications for EMS practices in Saudi Arabia. The findings highlight the need for improving EMS response times, particularly in rural areas, and emphasize the importance of infection control measures in ambulances. The integration of telemedicine and drone technology into EMS shows promise in enhancing service delivery, especially in remote areas.

Despite the progress, several gaps remain in the current evidence. There is a need for large-scale, methodologically rigorous studies to provide robust evidence on best practices in CCT. Additionally, the long-term outcomes and quality of life of patients post-transport are not well-documented. The cost-effectiveness of different transport modalities and the impact of technological innovations on EMS efficiency also require further exploration.

8.0 Research Questions

1. How can the integration of telemedicine and drone technology improve the efficiency and effectiveness of EMS in Saudi Arabia?
2. What are the long-term outcomes and quality of life of patients post-EMS transport?
3. How cost-effective are different EMS transport modalities, including ground ambulances, air ambulances, and drones?

9.0 Rationale

Addressing these research questions is essential for optimizing Emergency Medical Services (EMS) in Saudi Arabia. The integration of telemedicine and drone technology represents a significant advancement in EMS, promising to enhance both efficiency and effectiveness. By examining the impact of these technological innovations, it is possible to identify ways to reduce response times, improve patient outcomes, and streamline the delivery of emergency care.

Additionally, understanding the long-term outcomes and quality of life for patients following EMS transport is crucial. This knowledge will help to ensure that immediate emergency care translates into sustained health benefits and improved patient well-being. Evaluating these outcomes can also guide improvements in post-transport care and rehabilitation services.

Furthermore, assessing the cost-effectiveness of various EMS transport modalities, including ground ambulances, air ambulances, and drones, will provide valuable insights for policymakers. By determining the most economically viable and effective means of transport, resources can be allocated more efficiently, ensuring that high-quality EMS is accessible to all segments of the population.

This research is poised to fill existing gaps in the literature and contribute to the overall enhancement of public health and emergency care systems in Saudi Arabia. By addressing these critical questions, the study will support the development of evidence-based policies and practices, ultimately leading to a more robust and responsive EMS infrastructure.

10.0 Conclusion

The literature review reveals a multifaceted impact of EMS on patient outcomes, response times, infection control, and the potential for technological integration. While significant

strides have been made, there remain critical areas for improvement and further research.

Addressing these gaps is paramount to ensuring that EMS services in Saudi Arabia continue to evolve and provide high-quality care to all patients in need. By focusing on technological advancements, patient outcomes, and cost-effectiveness, future research can guide the development of more efficient and effective EMS systems, ultimately enhancing public health and emergency care services.

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مشكلة الدراسة:

