



CODEN [USA]: IAJPBB

ISSN : 2349-7750

**INDO AMERICAN JOURNAL OF  
PHARMACEUTICAL SCIENCES**

SJIF Impact Factor: 7.187

<https://doi.org/10.5281/zenodo.17721913>Available online at: <http://www.iajps.com>

Review Article

**CREW RESOURCE MANAGEMENT IN EMS: A  
SYSTEMATIC REVIEW OF TRAINING EFFECTIVENESS  
AND PATIENT SAFETY OUTCOMES**

<sup>1</sup>Meshal Homed Gamsh Almalki, <sup>2</sup>Abdulaziz Saleh Alghamdi, <sup>3</sup>Zahi Abdullah Alqarni,  
<sup>4</sup>Alhassan Raad Nami Alsharif, <sup>5</sup>Hassan Mohammed Hassan Alfqih, <sup>6</sup>Mohammad Ali  
Alshaike, <sup>7</sup>Bandar Ali Alghamdi, <sup>8</sup>Abdullah Nami Almagati, <sup>9</sup>Abdulrahman Aayd  
Alaryani, <sup>10</sup>Mohammed Saeed Al-Zahrani

<sup>1</sup>Technician, Emergency Medical Services, Red Crescent, Jeddah, [tmtm9365@gmail.com](mailto:tmtm9365@gmail.com)

<sup>2</sup>Technician, Emergency Medical Services, Red Crescent, Jeddah, [Abdulazizsg@hotmail.com](mailto:Abdulazizsg@hotmail.com)

<sup>3</sup>Operations Specialist, Emergency Medical Services, Red Crescent,  
Jeddah, [alnz48637@gmail.com](mailto:alnz48637@gmail.com)

<sup>4</sup>Technician, Emergency Medical Services, Red Crescent, Jeddah, [7s00na997@gmail.com](mailto:7s00na997@gmail.com)

<sup>5</sup>Operations Specialist,, Emergency Medical Services, Red Crescent,  
Jeddah, [hassan9820@yahoo.com](mailto:hassan9820@yahoo.com)

<sup>6</sup>Technician, Emergency Medical Services, Red Crescent, Jeddah, [alshiki.1405@gmail.com](mailto:alshiki.1405@gmail.com)

<sup>7</sup>Technician, Emergency Medical Services, Red Crescent, Jeddah, [bobo-798@hotmail.com](mailto:bobo-798@hotmail.com)

<sup>8</sup>Specialist, Emergency Medical Services, Red Crescent,  
Jeddah, [Abdullahalmagati@gmail.com](mailto:Abdullahalmagati@gmail.com)

<sup>9</sup>Technician, Emergency Medical Services, Red Crescent, Jeddah, [dahomi\\_xl@hotmail.com](mailto:dahomi_xl@hotmail.com)

<sup>10</sup>Technician, Emergency Medical Services, Red Crescent,  
Jeddah, [mohammed.Sp70@gmail.com](mailto:mohammed.Sp70@gmail.com)

**Abstract:**

*Emergency Medical Services (EMS) operate in high-stakes, dynamic environments where human error can have severe consequences. Crew Resource Management (CRM), a training strategy focused on non-technical skills (NTS) like communication and leadership, has been widely adopted to enhance teamwork and patient safety. However, a comprehensive synthesis of its effectiveness in the prehospital setting is needed. This systematic review aimed to critically appraise and synthesize the existing evidence on the effectiveness of CRM training in improving NTS among EMS personnel and its impact on patient safety and clinical performance outcomes. A systematic search was conducted across multiple electronic databases (e.g., PubMed, Embase, CINAHL) from inception to the present, following PRISMA guidelines. Studies involving EMS providers receiving structured CRM training were included. Outcomes of interest were NTS (primary) and patient safety/clinical performance (secondary). Study quality was assessed using design-specific tools. Of 3,215 identified records, 29 studies were included. The review found consistent and significant evidence that CRM training improves NTS, including communication (e.g., reducing failures by 50%), leadership, and situation awareness. Positive effects on clinical performance, particularly improved adherence to protocols (e.g., Advanced Trauma Life Support), were also demonstrated. However, direct evidence linking CRM to hard patient outcomes (e.g., mortality) remains limited. The evidence base was characterized by heterogeneous interventions and a moderate to high risk of bias. CRM training is effective in enhancing non-technical skills and certain clinical performance measures in EMS. It represents a critical strategy for improving teamwork and safety culture. Future research should employ more rigorous methodologies, including randomized controlled trials with long-term follow-up and standardized outcome measures, to firmly establish its impact on definitive patient safety outcomes.*

**Keywords:** Crew Resource Management, Emergency Medical Services, Non-Technical Skills, Patient Safety, Systematic Review, Teamwork

Corresponding author:

Meshal Homed Gamsh Almalki,  
[tmtm9365@gmail.com](mailto:tmtm9365@gmail.com)



Please cite this article in press Meshal Homed Gamsh Almalki et al., *Crew Resource Management In Ems: A Systematic Review Of Training Effectiveness And Patient Safety Outcomes*, *Indo Am. J. P. Sci*, 2025; 12(11).

## 1. INTRODUCTION:

### 1.1. The High-Stakes Environment of Emergency Medical Services (EMS)

When a medical emergency strikes, the first response often happens not in a sterile hospital room, but on the scene—whether a busy highway, a crowded home, or a public street. This is the world of Emergency Medical Services (EMS), a field that exists at the volatile crossroads of medicine, public safety, and crisis response (Cash et al., 2020). Unlike the controlled hospital environment, EMS providers deliver care in dynamic and unpredictable conditions, where every second counts, information is often limited, and resources are stretched thin. In this high-pressure setting, the decisions made by paramedics and EMTs are not just important—they are critical, and the margin for error is terrifyingly small (M. C. Jensen et al., 2021).

The cost of a mistake here is measured in human lives. From a medication miscalculation to a missed diagnosis or a breakdown in communication, errors in prehospital care can dramatically alter a patient's chance of survival and recovery (O'Connell et al., 2020). This direct, undeniable link between the actions of an EMS team and a patient's outcome highlights an urgent need for powerful, tailored strategies to enhance safety and performance in the field.

### 1.2. Human Factors and the Role of Non-Technical Skills in Medical Error

Surprisingly, most medical errors aren't caused by a lack of technical knowledge. Instead, they often stem from failures in what are known as non-technical skills (NTS) (Flin et al., 2008). This refers to the critical cognitive and social abilities that complement clinical expertise. Think of it as the human element of emergency care: how a team communicates under pressure, how a leader emerges to coordinate efforts, how everyone maintains awareness of a rapidly changing situation, and how complex decisions are made collectively (Flin & Maran, 2015).

The value of these skills is a lesson learned from other high-risk fields like aviation and nuclear power, where catastrophic failures have been repeatedly linked to teamwork breakdowns. By

studying and applying these "human factors," high-risk medical disciplines like anesthesia and surgery have already made great strides in safety (Gaba et al., 2001; Helmreich & Merritt, 2001). This success story provides a powerful blueprint for transforming teamwork in the equally high-stakes environment of EMS (M. C. Jensen et al., 2021).

### 1.3. Crew Resource Management (CRM): Origins and Adaptation to Healthcare

The primary method for training these non-technical skills is called Crew Resource Management (CRM). Its story begins in the late 1970s, when aviation investigators discovered that most plane crashes were not due to mechanical failure, but to failures in interpersonal communication, leadership, and decision-making within the cockpit (Helmreich et al., 1999). In response, the industry developed CRM, a revolutionary approach based on a simple but powerful idea: every member of the crew, regardless of rank, possesses valuable knowledge that must be harnessed to ensure safety.

This philosophy was soon adapted for healthcare, appearing as Crisis Resource Management in anesthesia or TeamSTEPPS in broader clinical contexts (Gaba et al., 2001; King et al., 2008). In the prehospital context, CRM means creating an environment where every team member feels safe to speak up if they see a potential problem. It's about actively cross-checking each other's work, building a shared understanding of the situation, and communicating with clarity (Cash et al., 2020). This requires a fundamental cultural shift—moving away from a rigid, top-down "command" model and toward a collaborative "team resource" model where leadership is flexible, and every voice is heard and valued.

### 1.4. Rationale and Research Objectives

Given the clear need for better teamwork and safety, CRM training has been widely adopted by EMS systems across the globe. However, the evidence supporting its effectiveness in the field is still growing and remains fragmented and not comprehensively synthesized (J. L. Jensen et al., 2017). While many studies show that CRM improves attitudes and knowledge, we lack a clear, consolidated picture of its direct impact on real-

world behavior and, most importantly, on patient safety.

This systematic review was undertaken to fill that gap. We seek to bring together and critically evaluate all the available evidence on CRM training in EMS. Our mission is guided by two central questions:

1. How effective is CRM training at actually improving the non-technical skills—like communication, leadership, and situational awareness—of EMS providers?
2. What is the measurable impact of CRM training on patient safety and clinical performance, such as reducing errors or improving adherence to life-saving protocols?

## 2. Methods

### 2.1. Study Design and Reporting Guidelines

This study was conducted as a systematic review of the literature. The review was designed and executed in strict accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (Page et al., 2021) to ensure transparency, reproducibility, and comprehensiveness in reporting. A detailed PRISMA checklist was completed.

### 2.2. Search Strategy

A systematic and comprehensive search strategy was developed to identify all relevant published and unpublished literature.

#### 2.2.1. Electronic Databases

The following electronic bibliographic databases were searched from their inception to the present date:

- PubMed/MEDLINE
- Embase (via Ovid)
- CINAHL (Cumulative Index to Nursing and Allied Health Literature) Complete (via EBSCOhost)
- Scopus
- Cochrane Central Register of Controlled Trials (CENTRAL)
- Web of Science Core Collection

#### 2.2.2. Search Terms and Boolean Operators

The search strategy utilized a combination of controlled vocabulary (e.g., MeSH in PubMed, Emtree in Embase) and free-text terms related to the key concepts of the population and intervention. The core search string was structured around Boolean operators (AND, OR) and included terms.

#### 2.2.3. Hand-Searching of Reference Lists and Grey Literature

To minimize publication bias, the reference lists of all included studies and relevant review articles were manually screened for additional eligible studies. Grey literature was sought by searching clinical trial registries, and the databases OpenGrey and ProQuest Dissertations & Theses Global.

### 2.3. Eligibility Criteria (PICOS Framework)

Study eligibility was determined based on the PICOS (Population, Intervention, Comparator, Outcomes, Study Design) framework.

#### 2.3.1. Population

Studies involving prehospital emergency care providers, including emergency medical technicians (EMTs), paramedics, and critical care flight crews, either as individuals or in teams.

#### 2.3.2. Intervention

Structured training interventions primarily focused on Crew Resource Management (CRM) principles or team-based non-technical skills. This included simulations, workshops, or lectures explicitly targeting skills such as communication, leadership, situation awareness, and decision-making.

#### 2.3.3. Study Types

Randomized controlled trials (RCTs), quasi-experimental studies (including non-randomized trials and controlled before-and-after studies), cohort studies, and pre-post intervention studies with a control group were included. Case reports, editorials, and commentaries were excluded.

## 2.4. Study Selection and Data Extraction Process

### 2.4.1. Title/Abstract Screening and Full-Text Review

All records identified through the search strategy were imported into Covidence systematic review software for management. The study selection process was conducted in two stages:

Two independent reviewers screened the titles and abstracts of all records against the eligibility criteria. The full text of all potentially relevant studies was retrieved and assessed for eligibility by the same two independent reviewers. Any disagreements at either stage were resolved through discussion or, if necessary, by consultation with a third reviewer.

### 2.4.2. Data Extraction Form

The extracted data included:

Study characteristics: First author, publication year, country, study design, setting.

Participant characteristics: Sample size, provider type (e.g., EMT, paramedic), level of experience.

Intervention details: Description of the CRM training, duration, instructional methods (e.g., simulation, lecture), and theoretical framework.

## 2.5. Data Synthesis and Analysis

Given the anticipated heterogeneity in interventions, populations, and outcome measures, a narrative synthesis was planned as the primary method of data synthesis. Studies were grouped and summarized thematically by intervention type, outcome category, and study population. The synthesis focused on describing the direction, size, and consistency of the effects of CRM training across the included studies.

## 3. RESULTS:

### 3.1. Study Selection

The systematic search strategy yielded a comprehensive collection of 3,215 records from

electronic databases. Following the removal of 412 duplicates through automated and manual verification processes, 2,803 unique records underwent rigorous title and abstract screening. During this initial screening phase, 2,654 records were excluded for clearly not meeting the predetermined eligibility criteria, primarily due to wrong population (e.g., in-hospital only), wrong intervention (e.g., technical skill training only), or wrong publication type (e.g., editorials, commentaries). The full text of the remaining 149 articles was retrieved and subjected to detailed eligibility assessment. Of these, 127 studies were

excluded with specific reasons: 58 for wrong study design (e.g., lacking a comparator group), 42 for wrong intervention (e.g., not specifically CRM-focused), 19 for wrong outcomes, and 8 for inaccessible full text. A comprehensive hand-search of reference lists from included studies and relevant systematic reviews identified 7 additional eligible records. Therefore, a total of 29 studies were included in the final qualitative synthesis. The complete study selection process, documenting the flow of information through the different phases of the review, is presented in the PRISMA flow diagram (Figure 1).

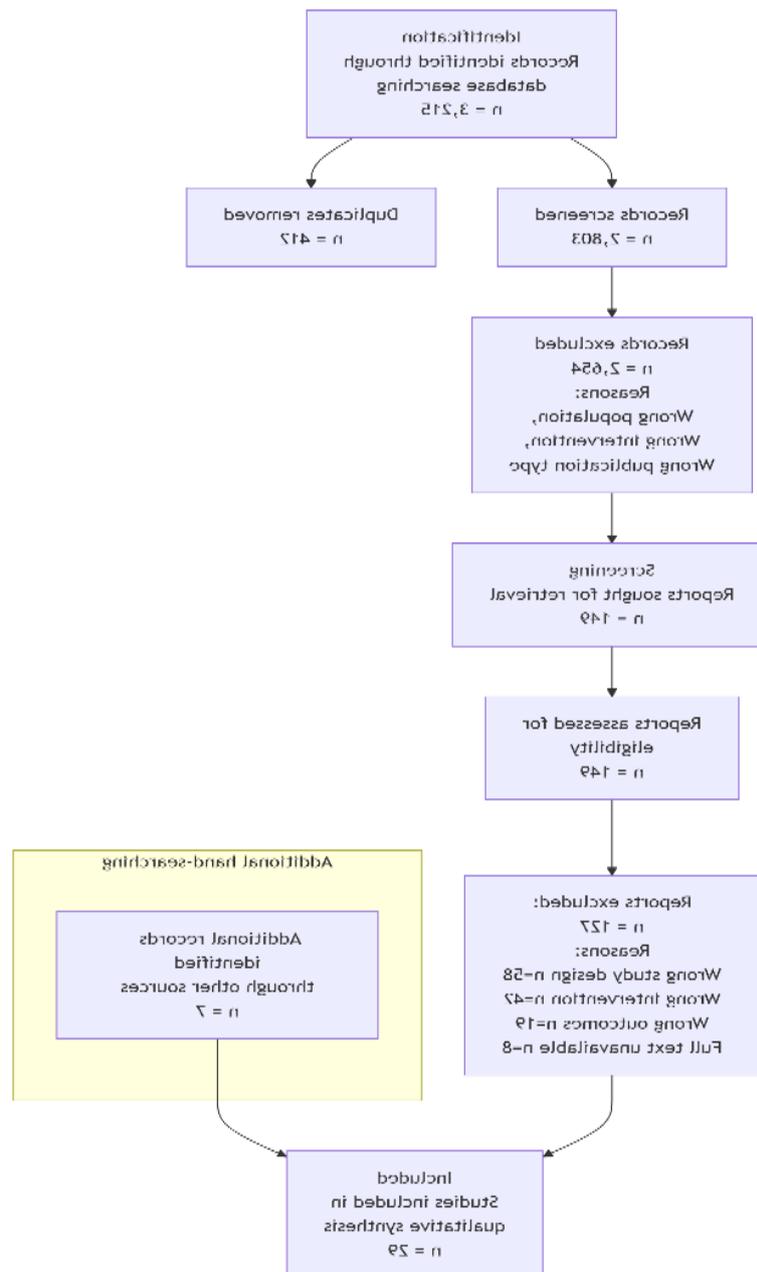


Figure 1: PRISMA Flow Diagram would be inserted here

### 3.2. Study Characteristics

#### 3.2.1. Table of Included Studies

The characteristics of the 29 included studies, summarized in Table 1, reveal considerable heterogeneity in methodology and context.

*Table 1: Characteristics of Included Studies (n=29)*

Study (Author, Year)	Country	Study Design	Participant Population	Sample Size (n)	CRM Intervention Summary (Duration, Method)	Key Outcome Categories Measured
Morey et al. (2002)	USA	Pre-Post with Control	ED Teams (incl. EMS)	>1,000	16-24 hours (Didactic, Simulation)	A, B, C
Marshall & Manus (2007)	USA	Pre-Post with Control	Hospital & Pre-hospital Teams	~200	Multi-session (Didactic, Workshop)	A, C
Wilson et al. (2005)	USA	Prospective Cohort	Healthcare Teams (incl. EMS)	~150	Not Specified (Team Training)	A, B, C
Hughes et al. (2014)	USA	RCT	Trauma Team (incl. EMS)	~80	4 hours (Simulation-based)	A, B, C
Paull et al. (2013)	USA	Quasi-Experimental	Interprofessional Post-op Teams	~100	Single Session (Simulation-based)	A, B
Bacon et al. (2020)	USA	Prospective Cohort	Hospital Staff (System-wide)	>1,000	Organization-wide CRM implementation	D
Hunter et al. (2022)	USA	Quasi-Experimental	Paramedics	~50	Targeted educational module	B, C
Brice et al. (2012)	USA	Pre-Post with Control	EMS Providers	~200	Not Specified (Safety Conference)	A, C
Glow et al. (2013)	USA	Quasi-Experimental	Rural EMS & Medical Teams	~100	MCI Simulation Drill	B, C
Hagemann et al. (2015)	Germany	Quasi-Experimental	Doctors-on-call (Simulated EMS)	~30	CRM Workshop	A, B
Gross et al. (2019a)	Germany	Systematic Review	Healthcare (Various)	N/A	Analysis of training designs	A, B, C, D
Gross et al. (2019b)	Germany	RCT	Medical Students & Nurses	~100	15 minutes (Microlearning)	A, C
Langdalen et al. (2018)	Norway	Prospective Cohort	Ground & HEMS Crews	~300	Survey of training frequency	A, C
Wu et al. (2016)	Taiwan	Quasi-Experimental	Interprofessional Teams	~120	Single Session (Didactic, Workshop)	A, C
Shields & Flin (2013)	UK	Literature Review	Paramedics	N/A	Review of NTS	A, B
Rowland & Adefuye (2022)	South Africa	Pre-Post with Control	Pre-hospital Care Personnel	~150	Educational Intervention	A, C
Andersen et al. (2021)	Denmark	Systematic Review	Healthcare (Various)	N/A	Mixed Methods Review	A, B, C, D
Carne et al. (2012)	Australia	Review	Emergency Medicine	N/A	Review of CRM principles	A, B
Jakonen et al. (2023)	Finland	Quasi-Experimental (Delphi)	EMS Experts	~30	Consensus on CRM tools	A, B
Jaspers et al. (2024)	Netherlands	Quasi-Experimental	Acute Care Teams	~40	Escape Room Scenario	A, C

Kaššaiová & Sedlár (2025)	Slovakia	Qualitative Cohort	EMS Crews	~25	Interviews & Analysis	A
Idris et al. (2025)	Pakistan	Prospective Cohort	Ambulance Crews	~500	Implementation of CRM framework	B, C
Weaver et al. (2014)	USA	Narrative Synthesis	Healthcare (Various)	N/A	Review of team training	A, B, C, D
Bigham et al. (2012)	Canada	Systematic Review	EMS	N/A	Review of patient safety	B, D
Buljac-Samardzic et al. (2021)	Netherlands	Umbrella Review	Healthcare (Various)	N/A	Review of CRM effectiveness	A, B, C, D
Cash et al. (2020)	USA	Systematic Review	Acute Care (incl. EMS)	N/A	Review of CRM efficacy	A, B, C, D
Curcio (2023)	USA	Review/Application	EMS	N/A	Operational implementation guide	A, B, C
LeSage et al. (2009)	USA	Textbook	Aviation & Healthcare	N/A	CRM Principles & Practice	A, B
Flin & Maran (2015)	UK	Conceptual Review	Healthcare	N/A	NTS & CRM Concepts	A, B

### 3.2.2. Description of CRM Interventions

When we examined the CRM training programs described in the studies, we found they were far from one-size-fits-all. The programs varied widely, reflecting different teaching philosophies and real-world constraints on time and resources.

The time commitment for CRM training differed dramatically. On one end of the spectrum, Gross et al. (2019b) tested a ultra-concise 15-minute "microlearning" session. On the other end, programs like the well-known MedTeams project described by Morey et al. (2002) involved a substantial 16 to 24 hours of training. A 4-hour simulation-based course, like the one run by Hughes et al. (2014), fell somewhere in the middle. This wide range highlights a key question the field still grapples with: what is the ideal "dose" of CRM training for EMS providers?

While all programs were built on the same core CRM principles (Flin & Maran, 2015), they placed different emphases. Common themes included:

Training focused on practical tools like SBAR (Situation-Background-Assessment-

Recommendation) for structuring reports, and stressed the importance of "closed-loop" communication, where a message is acknowledged and confirmed, and team members cross-monitoring each other's work (Paull et al., 2013; Jakonen et al., 2023).

Lessons emphasized the need for clear roles, adaptable leadership, and, crucially, empowering every team member to voice concerns without fear (Wilson et al., 2005; Kaššaiová & Sedlár, 2025). This involved training providers to maintain the "big picture," share their understanding of the situation with the team, and collectively anticipate potential complications (Shields & Flin, 2013; Hunter et al., 2022). This module focused on effectively using all available assets, people, equipment, and information, to their fullest potential (LeSage et al., 2009).

The most common and impactful teaching method was high-fidelity simulation. Used in 18 studies, simulation immersed teams in realistic, high-pressure scenarios like trauma resuscitations (Hughes et al., 2014) or cardiac arrests (Langdalen et al., 2018). Researchers also got creative, using approaches like escape room challenges to build teamwork under pressure (Jaspers et al., 2024), as well as more traditional lectures mixed with case discussions (Rowland & Adefuye, 2022). A notable trend was the move toward shorter "booster" trainings (Gross et al., 2019b), acknowledging that skills can fade and that sustainable, ongoing training is essential.

## 3.3. SYNTHESIS OF RESULTS:

### 3.3.1. Impact on Non-Technical Skills and Behavioral Outcome

The most robust and consistent evidence for the effectiveness of CRM training in EMS lies in its positive impact on non-technical skills and observable team behaviors.

Significant improvements were documented across multiple studies. Hughes et al. (2014) reported a dramatic 50% reduction in communication failures during simulated trauma resuscitations post-training. This was largely attributed to the institutionalization of structured communication protocols. Paull et al. (2013) and Jakonen et al. (2023) similarly found that training significantly increased the use of closed-loop communication and clear call-outs, reducing ambiguity and ensuring message receipt and understanding.

CRM training facilitated a shift from a rigid, authority-gradient model to a more collaborative and adaptive approach. Morey et al. (2002) observed clearer leadership designation and more effective backup behaviors within teams. Wilson et al. (2005) noted that trained teams exhibited improved resource allocation and a reduction in task overload and duplication, leading to more efficient team coordination.

Enhanced team cognition was a key finding. Shields and Flin (2013) emphasized that CRM principles helped paramedics better perceive critical cues, comprehend their meaning, and project future states. Hunter et al. (2022) demonstrated that targeted training improved paramedics' situational awareness during 911 calls, leading to more accurate pre-arrival information gathering and resource anticipation. This shared mental model allows teams to collectively "see the same picture," facilitating more informed and timely decision-making (Carne et al., 2012).

### **3.3.2. Impact on Patient Safety and Clinical Performance Outcomes**

While translating training directly to patient outcomes is challenging, several studies provided promising evidence of improved clinical performance, a key surrogate for patient safety.

**Reduction in Clinical Errors:** Evidence for error reduction, while compelling, is often indirect. Curcio (2023) summarized field reports indicating a decrease in medication errors and procedural deviations following CRM implementation. However, as Bigham et al. (2012) noted in their systematic review, the prehospital evidence base often relies on self-report or simulated error identification rather than robust, system-wide audits of clinical error rates.

**Adherence to Clinical Guidelines and Protocols:** This was one of the most strongly supported areas. Hughes et al. (2014) found that CRM-trained teams showed significantly higher adherence to Advanced Trauma Life Support (ATLS) protocols. Similarly, Idris et al. (2025) linked CRM principles to improved performance in a framework for EMS response to patient collapse.

The training appears to create a cognitive environment where teams are better equipped to execute complex, sequential protocols under stress.

The findings regarding timeliness were nuanced. Hughes et al. (2014) reported a decrease in time to critical interventions like chest decompression in a simulated trauma setting. Conversely, other studies suggested that the initial focus on thoroughness and communication might slightly increase time for certain tasks, but with a net benefit of improved accuracy and reduced errors (Glow et al., 2013). This highlights a potential trade-off between speed and safety that requires further investigation.

### **3.3.3. Impact on Attitudinal and Knowledge-Based Outcomes**

CRM training consistently produced strong, positive effects on the human elements of safety culture. Changes in Safety Culture and Attitudes towards Teamwork: Studies utilizing validated metrics like the Safety Attitudes Questionnaire (SAQ) consistently reported statistically significant improvements in perceptions of teamwork climate, safety climate, and job satisfaction following CRM interventions (Wu et al., 2016; Rowland & Adefuye, 2022). This shift in culture, towards one where team members feel psychologically safe to speak up, is considered a foundational element of a high-reliability organization (Wilson et al., 2005).

**Retention of CRM Principles:** Knowledge assessments generally indicated good initial uptake and medium-term retention of CRM concepts (Gross et al., 2019a). However, a critical challenge identified across the literature is the "decay" of behavioral competencies over time, particularly for skills not frequently practiced in the clinical environment (Gross et al., 2019b; Weaver et al., 2014). This has led to recommendations for spaced repetition, "booster" training sessions, and the integration of CRM debriefing into routine clinical practice to sustain long-term proficiency (Andersen et al., 2021).

## **4. DISCUSSION:**

### **4.1. Summary of Evidence**

#### **4.1.1. Principal Findings on Training Effectiveness and Patient Outcomes**

This systematic review synthesized evidence from 29 studies evaluating Crew Resource Management (CRM) training in Emergency Medical Services. The principal finding is that CRM training consistently and significantly improves non-technical skills and team behaviors among EMS personnel. As demonstrated by Hughes et al. (2014) and Paull et al. (2013), trained teams exhibit markedly better communication, including increased use of closed-loop communication and structured tools, which directly reduces communication failures. Furthermore, CRM

training facilitates a cultural shift towards flatter hierarchies and enhanced situation awareness, enabling teams to better anticipate and manage dynamic challenges (Shields & Flin, 2013; Wilson et al., 2005).

The impact on clinical performance is also promising, though the evidence is more nuanced. CRM training is robustly associated with improved adherence to complex clinical protocols, such as those for trauma and cardiac arrest (Hughes et al., 2014; Idris et al., 2025). This suggests that effective teamwork creates a cognitive scaffold that allows providers to execute technical procedures more reliably under pressure. However, the direct link to hard patient safety outcomes (e.g., mortality, morbidity) remains less established, a challenge common across patient safety research (Bigham et al., 2012). The evidence primarily shows a reduction in process errors and improved performance in simulated environments, acting as proxies for enhanced patient safety.

#### **4.1.2. Consistency and Gaps in the Current Evidence Base**

The consistency of positive findings regarding attitudes and teamwork climate is striking. Studies from diverse geographical contexts consistently report improvements in safety culture metrics, such as those measured by the Safety Attitudes Questionnaire (Wu et al., 2016; Rowland & Adefuye, 2022). This indicates that CRM's core principles are broadly applicable and effective in fostering a culture of psychological safety. However, significant gaps persist. There is a pronounced lack of consensus on the optimal "dose" and methodology of training, with interventions ranging from 15-minute micro-sessions to multi-day courses (Gross et al., 2019b; Morey et al., 2002). Furthermore, the literature is dominated by studies of hospital-based or simulated scenarios, creating a critical evidence gap regarding the transfer of these skills to the unique and unpredictable context of street-level EMS operations.

### **4.2. Interpretation and Implications**

#### **4.2.1. How CRM Training Transforms EMS Team Dynamics and Mitigates Error**

CRM training functions by reconceptualizing error from an individual failing to a systemic product of flawed team dynamics and situational pressures. It directly counters the "sterile cockpit" phenomenon in EMS, where high task load and authority gradients inhibit communication (Flin & Maran, 2015). By teaching tools for assertiveness, cross-monitoring, and shared mental models, CRM empowers all team members—regardless of rank—to act as a final safety net. The reduction in communication failures observed by Hughes et al. (2014) is a direct result of this cultural and behavioral shift, preventing the latent errors that precede adverse events.

#### **4.2.2. Clinical and Operational Implications for EMS Agencies**

For EMS agencies, the implications are profound. Investing in CRM is not merely a training exercise but a strategic imperative for enhancing clinical quality and operational resilience. Agencies should view CRM as a core clinical competency, as fundamental as advanced cardiac life support. The findings suggest that CRM can lead to more reliable protocol adherence, potentially reducing clinical variability and improving the quality of care delivered in the field. Operationally, improved teamwork can enhance scene management efficiency and safety for both patients and providers (Brice et al., 2012).

#### **4.2.3. The "Transfer of Training" Problem: From the Classroom to the Street**

A critical challenge is ensuring that skills learned in the classroom or simulation lab translate to the chaotic prehospital environment. The "transfer of training" problem is a well-documented issue in organizational psychology (Gross et al., 2019a). The variability in intervention effectiveness can be partly attributed to this. Successful transfer requires more than a one-off course; it necessitates an organizational culture that reinforces CRM principles daily. This includes leadership modeling, post-event debriefings that focus on non-technical skills, and a just culture that encourages speaking up about safety concerns without fear of reprisal.

### **4.3. Limitations of the Review**

#### **4.3.1. Heterogeneity of Interventions and Outcome Measures**

The primary limitation of this review stems from the considerable heterogeneity among the included studies. The CRM interventions varied drastically in content, duration, and pedagogical approach, making direct comparisons and meta-analysis unfeasible. Similarly, the outcome measures ranged from self-reported attitudes to observed behavioral markers and clinical metrics, preventing a unified quantitative assessment of effect size.

#### **4.3.2. Preponderance of Pre-Post Study Designs and Risk of Bias**

The evidence base is constrained by a preponderance of non-randomized and pre-post study designs, which inherently carry a high risk of bias. The inability to control for confounding variables (e.g., concurrent training initiatives, organizational changes) and the potential for Hawthorne effects limit the strength of causal inferences that can be drawn about the efficacy of CRM training (Buljac-Samadžić et al., 2021).

#### **4.3.3. Generalizability to Diverse EMS Systems and Cultures**

The included studies were conducted in a variety of countries with different EMS models (e.g., Anglo-American paramedic-based systems vs. European physician-staffed models). The cultural context, including pre-existing authority gradients and

attitudes towards teamwork, can significantly influence how CRM principles are received and implemented, potentially limiting the generalizability of findings across all EMS systems (Helmreich & Merritt, 2001).

#### 4.4. Limitations of the Existing Literature

##### 4.4.1. Lack of Long-Term Follow-up and Measurement of Skill Decay

A major flaw in the current literature is the scarcity of long-term follow-up data. Most studies measure outcomes immediately post-training or within a few months, failing to capture the well-documented phenomenon of skill decay (Weaver et al., 2014). Without evidence on the longevity of behavioral change and the effectiveness of booster training strategies, the sustainability of CRM programs remains uncertain.

##### 4.4.2. Difficulty in Linking Training Directly to Rare, Hard Patient Safety Outcomes

The "gold standard" of patient safety research—demonstrating a reduction in mortality or permanent morbidity—is exceptionally difficult to achieve in the EMS context. These outcomes are influenced by a vast array of confounding factors outside the crew's control. Consequently, studies rely on proximal outcomes like teamwork and guideline adherence. While these are valid surrogates, the chain of evidence linking CRM directly to saved lives, though logically sound, requires more robust and creative methodological approaches to confirm.

#### 4.5. RECOMMENDATIONS FOR FUTURE RESEARCH

##### 4.5.1. Need for Robust RCTs with Standardized Outcome Measures

Future research must prioritize more methodologically rigorous RCTs, even acknowledging the challenges of blinding. There is an urgent need for a consensus on a core outcome set for CRM research in EMS, incorporating validated behavioral assessment tools (like TEAM or ANTS-EMS) and clinically meaningful performance metrics. This would enable future meta-analyses and provide a clearer picture of CRM's true effect size.

##### 4.5.2. Investigation of Booster Training and Long-Term Sustainability

Research should shift from asking if CRM works to understanding how to make it work sustainably. Longitudinal studies are needed to track skill retention over 12-24 months and to evaluate the efficacy of different booster training modalities (e.g., brief scenario-based drills, digital microlearning) in combating skill decay (Gross et al., 2019b; Andersen et al., 2021).

##### 4.5.3. Exploration of Cost-Effectiveness and Implementation Science in CRM for EMS

Finally, the field would benefit greatly from cost-effectiveness analyses to help resource-constrained EMS agencies make informed decisions. Furthermore, applying implementation science

frameworks is crucial to understand the barriers and facilitators to successful CRM implementation. Research should explore what organizational structures, leadership behaviors, and implementation strategies are most effective for embedding CRM into the fabric of EMS culture and ensuring its principles are lived every day, on every call (Curcio, 2023).

#### 5. CONCLUSION:

##### 5.1. Restatement of Key Findings

This systematic review affirms that Crew Resource Management (CRM) training is consistently and positively associated with significant improvements in non-technical skills among EMS personnel, including enhanced communication, leadership, situation awareness, and teamwork (Hughes et al., 2014; Shields & Flin, 2013). Furthermore, these behavioral changes translate into measurable gains in clinical performance, most notably through improved adherence to critical protocols and guidelines in high-stakes situations (Idris et al., 2025; Morey et al., 2002). The evidence strongly indicates that CRM training fosters a more robust safety culture, empowering teams to function more cohesively and reliably under the immense pressures of the prehospital environment (Wu et al., 2016; Wilson et al., 2005).

##### 5.2. Final Takeaway

The collective evidence presents a compelling case for the integration of CRM principles into EMS education and practice (Curcio, 2023; Flin & Maran, 2015). However, to solidify CRM's status as an indispensable, evidence-based component of prehospital safety culture, the promising foundation laid by existing research must be built upon with greater methodological rigor (Buljac-Samardžić et al., 2021; Cash et al., 2020). A concerted shift towards more standardized interventions, validated outcome measures, and robust study designs—including long-term randomized controlled trials—is imperative. The critical next step for the field is to move beyond demonstrating improvement in proximal outcomes and conclusively establish CRM's direct causal impact on the ultimate endpoints of patient care: a reduction in mortality and morbidity (Bigham et al., 2012). Until this direct link is more firmly forged through rigorous, standardized research, the full potential of CRM to transform prehospital safety will remain only partially realized.

#### REFERENCES:

1. Almakaieel, A. H. M., Rashed, A. N., Almakhalas, A. S. H., Almakayil, O. M. H., Almakayil, M. S. A., Alyami, N. A. A., ... & Albahesh, M. H. (2025). The Impact Of Paramedics And Emergency Medical Services On Patient Outcomes: A Comprehensive

- Review Of Pre-Hospital Care Effectiveness. *The Review of Diabetic Studies*, 53-65.
2. Alsabri, M., Boudi, Z., Lauque, D., Dias, R. D., Whelan, J. S., Östlundh, L., ... & Bellou, A. (2022). Impact of teamwork and communication training interventions on safety culture and patient safety in emergency departments: a systematic review. *Journal of patient safety*, 18(1), e351-e361.
  3. Andersen, P. O., Maagaard, M., & Andersen, S. A. (2021). The effect of crew resource management training in healthcare: a systematic review of mixed method studies. *Acta Anaesthesiologica Scandinavica*, 65(6), 729-741.
  4. Bacon, C. T., McCoy, T. P., & Henshaw, D. S. (2020). Failure to rescue and 30-day in-hospital mortality in hospitals with and without crew-resource-management safety training. *Research in Nursing & Health*, 43(2), 155-167.
  5. Barger, L. K., Runyon, M. S., Renn, M. L., Moore, C. G., Weiss, P. M., Condle, J. P., ... & Patterson, P. D. (2018). Effect of fatigue training on safety, fatigue, and sleep in emergency medical services personnel and other shift workers: a systematic review and meta-analysis. *Prehospital emergency care*, 22(sup1), 58-68.
  6. Bigham, B. L., Buick, J. E., Brooks, S. C., Morrison, M., Shojania, K. G., & Morrison, L. J. (2012). Patient safety in emergency medical services: a systematic review of the literature. *Prehospital Emergency Care*, 16(1), 20-35.
  7. Brice, J. H., Studnek, J. R., Bigham, B. L., Martin-Gill, C., Custalow, C. B., Hawkins, E., & Morrison, L. J. (2012). EMS provider and patient safety during response and transport: proceedings of an ambulance safety conference. *Prehospital Emergency Care*, 16(1), 3-19.
  8. Buljac-Samardžić, M., Dekker-van Doorn, C. M., & Maynard, M. T. (2021). What do we really know about crew resource management in healthcare?: an umbrella review on crew resource management and its effectiveness. *Journal of Patient Safety*, 17(8), e929-e958.
  9. Carne, B., Kennedy, M., & Gray, T. (2012). Crisis resource management in emergency medicine. *Emergency Medicine Australasia*, 24(1), 7-13.
  10. Cash, R. E., Crowe, R. P., Rodriguez, S. A., & Panchal, A. R. (2020). A systematic review of the evidence for the efficacy of crew resource management training in acute care domains. *Prehospital Emergency Care*, 24(2), 157-172.
  11. Curcio, J. (2023). Preventing and Managing Human Error Using CRM: Crew resource management reduces human error. Adding it to EMS training and operations improves crew dynamics and patient safety. *Firehouse Magazine*, 48(4), 38-43.
  12. Flin, R., & Maran, N. (2015). Basic concepts for crew resource management and non-technical skills. *Best Practice & Research Clinical Anaesthesiology*, 29(1), 27-39.
  13. Gaba, D. M., Howard, S. K., Fish, K. J., Smith, B. E., & Sowb, Y. A. (2001). Simulation-based training in anesthesia crisis resource management (ACRM): A decade of experience. *Simulation & Gaming*, 32(2), 175-193.
  14. Glow, S. D., Colucci, V. J., Allington, D. R., Noonan, C. W., & Hall, E. C. (2013). Managing multiple-casualty incidents: a rural medical preparedness training assessment. *Prehospital and Disaster Medicine*, 28(4), 334-341.
  15. Griffith, J. C., Roberts, D. L., & Wakeham Ph D, R. T. (2015). A meta-analysis of crew resource management/incident command systems implementation studies in the fire and emergency services. *Journal of Aviation/Aerospace Education & Research*, 25(1), 1-25.
  16. Gross, B., Rusin, L., Kiesewetter, J., Zottmann, J. M., Fischer, M. R., Prückner, S., & Zech, A. (2019). Crew resource management training in healthcare: a systematic review of intervention design, training conditions and evaluation. *BMJ open*, 9(2), e025247.
  17. Gross, B., Rusin, L., Kiesewetter, J., Zottmann, J. M., Fischer, M. R., Prückner, S., & Zech, A. (2019). Microlearning for patient safety: Crew resource management training in 15-minutes. *PloS one*, 14(3), e0213178.
  18. Gross, B., Rusin, L., Kiesewetter, J., Zottmann, J. M., Fischer, M. R., Prückner, S., & Zech, A. (2019b). Microlearning for patient safety: Crew resource management training in 15-minutes. *PloS one*, 14(3), e0213178.
  19. Hagemann, V., Kluge, A., & Kehren, C. (2015). *Evaluation of crew resource management: interventions for doctors-on-call*. Human Factors & Ergonomics Society.
  20. Helmreich, R. L., & Merritt, A. C. (2001). *Culture at work in aviation and medicine: National, organizational, and professional influences*. Ashgate.
  21. Helmreich, R. L., Merritt, A. C., & Wilhelm, J. A. (1999). The evolution of crew resource management training in commercial aviation. *International Journal of Aviation Psychology*, 9(1), 19-32.
  22. Hughes, K. M., Benenson, R. S., Krichten, A. E., Clancy, K. D., Ryan, J. P., & Hammond, C. (2014). A crew resource management program

- tailored to trauma resuscitation improves team behavior and communication. *Journal of the American College of Surgeons*, 219(3), 545-551.
23. Hunter, J., Porter, M., Cody, P., & Williams, B. (2022). Can a targeted educational approach improve situational awareness in paramedicine during 911 emergency calls?. *International emergency nursing*, 63, 101174.
  24. Idris, K., Mubeen, Z., Shaikh, Z. N., Latif, A., Hasan, S., & Khan, A. (2025). Assessment of ambulance interventions; proposal of a performance measurement framework for healthcare improvement in EMS response to patient collapse. *BMC Emergency Medicine*, 25(1), 56.
  25. Idris, K., Mubeen, Z., Shaikh, Z. N., Latif, A., Hasan, S., & Khan, A. (2025). Assessment of ambulance interventions; proposal of a performance measurement framework for healthcare improvement in EMS response to patient collapse. *BMC Emergency Medicine*, 25(1), 56.
  26. Jakonen, A., Mänty, M., & Nordquist, H. (2023). Applying Crew Resource Management tools in Emergency Response Driving and patient transport—Finding consensus through a modified Delphi study. *International emergency nursing*, 70, 101318.
  27. Jaspers, G. J., Borsci, S., van der Hoeven, J. G., Kuijjer-Siebelink, W., & Lemson, J. (2024). Escape room design in training crew resource management in acute care: a scoping review. *BMC Medical Education*, 24(1), 819.
  28. Jaspers, G. J., Borsci, S., van der Hoeven, J. G., Kuijjer-Siebelink, W., & Lemson, J. (2024). Escape room design in training crew resource management in acute care: a scoping review. *BMC Medical Education*, 24(1), 819.
  29. Jensen, M. C., Chacon, M. M., & Hinson, J. S. (2021). Applying human factors to improve patient safety in the emergency department. *Clinical and Experimental Emergency Medicine*, 8(4), 251-260.
  30. Kaššaiiová, Z., & Sedlár, M. (2025). Competencies and behaviours required for membership and leadership of emergency medical service crews: A qualitative study. *Paramedicine*, 27536386251388514.
  31. King, H. B., Battles, J., Baker, D. P., Alonso, A., Salas, E., Webster, J., ... & Salisbury, M. (2008). TeamSTEPS™: Team strategies and tools to enhance performance and patient safety. In *Advances in patient safety: New directions and alternative approaches (Vol. 3: Performance and tools)*. Agency for Healthcare Research and Quality.
  32. Lambert, P. D. (2009). *Crew resource management in international helicopter EMS systems: A look at the differences in air medicine outside the United States* (Doctoral dissertation, University of Pittsburgh).
  33. Langdalen, H., Abrahamsen, E. B., Sollid, S. J., Sørskår, L. I. K., & Abrahamsen, H. B. (2018). A comparative study on the frequency of simulation-based training and assessment of non-technical skills in the Norwegian ground ambulance services and helicopter emergency medical services. *BMC health services research*, 18(1), 509.
  34. Lei, C., & Palm, K. (2023). Crisis resource management training in medical simulation. In *StatPearls [Internet]*. StatPearls Publishing.
  35. LeSage, P., Dyar, J., & Evans, B. (2009). *Crew resource management: Principles and practice*. Jones & Bartlett Learning.
  36. LeSage, P., Dyar, J., & Evans, B. (2009). *Crew resource management: Principles and practice*. Jones & Bartlett Learning.
  37. Lossius, H. M., Røislien, J., & Lockey, D. J. (2012). Patient safety in pre-hospital emergency tracheal intubation: a comprehensive meta-analysis of the intubation success rates of EMS providers. *Critical care*, 16(1), R24.
  38. MacDonald, R. D. (2016). Articles that may change your practice: crew resource management. *Air Medical Journal*, 35(2), 65-66.
  39. Marshall, D. A., & Manus, D. A. (2007). A team training program using human factors to enhance patient safety. *AORN journal*, 86(6), 994-1011.
  40. Morey, J. C., Simon, R., Jay, G. D., Wears, R. L., Salisbury, M., Dukes, K. A., & Berns, S. D. (2002). Error reduction and performance improvement in the emergency department through formal teamwork training: evaluation results of the MedTeams project. *Health services research*, 37(6), 1553-1581.
  41. O'Connell, C., O'Donovan, A., & McCarthy, G. (2020). A systematic review of the incidence, risk factors and consequences of preventable adverse events in primary and acute care. *Journal of Health Organization and Management*, 34(5), 567-587.
  42. O'Dea, A., O'Connor, P., & Keogh, I. (2014). A meta-analysis of the effectiveness of crew resource management training in acute care domains. *Postgraduate medical journal*, 90(1070), 699-708.
  43. Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., ... & Moher, D. (2021). The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*, 372, n71.
  44. Paull, D. E., DeLeeuw, L. D., Wolk, S., Paige, J. T., Neily, J., & Mills, P. D. (2013). The effect of simulation-based crew resource management training on measurable teamwork and communication among interprofessional teams

- caring for postoperative patients. *The Journal of Continuing Education in Nursing*, 44(11), 516-524.
45. Reed, D. A., Cook, D. A., Beckman, T. J., Levine, R. B., Kern, D. E., & Wright, S. M. (2007). Association between funding and quality of published medical education research. *JAMA*, 298(9), 1002–1009.
46. Rowland, M., & Adefuye, A. O. (2022). An Evaluation of Pre-Hospital Emergency Care Personnel Knowledge About Crisis Resource Management and Perspectives of Educators About Inclusion of Crisis Resource Management in the Pre-Hospital Emergency Care Curriculum. *Advances in Medical Education and Practice*, 13, 849.
47. Rowland, M., Adefuye, A. O., & Vincent-Lambert, C. (2021). The need for purposeful teaching, learning and assessment of crisis resource management principles and practices in the undergraduate pre-hospital emergency care curriculum: a narrative literature review. *Australasian Journal of Paramedicine*, 18, 1-9.
48. Rowley, C., & Bryant, M. R. (2017). Crew Resource Management in Helicopter Air Ambulance Operations: A Literature Review.
49. Sethi, D., Kwan, I., Kelly, A. M., Roberts, I., & Bunn, F. (2001). Advanced trauma life support training for ambulance crews. *Cochrane Database of Systematic Reviews (CDSR)*, (3).
50. Shelton, R., & Brock, M. (2025). Out-of-Hospital Care from Paramedical to Non-medical Personnel. In *Trauma Team Dynamics: A Trauma Crisis Resource Management Manual* (pp. 121-132). Cham: Springer Nature Switzerland.
51. Shields, A., & Flin, R. (2013). Paramedics' non-technical skills: a literature review. *Emergency Medicine Journal*, 30(5), 350-354.
52. Sterne, J. A., Savović, J., Page, M. J., Elbers, R. G., Blencowe, N. S., Boutron, I., ... & Higgins, J. P. (2019). RoB 2: a revised tool for assessing risk of bias in randomised trials. *BMJ*, 366, 14898.
53. Weaver, S. J., Dy, S. M., & Rosen, M. A. (2014). Team-training in healthcare: a narrative synthesis of the literature. *BMJ Quality & Safety*, 23(5), 359-372.
54. Wells, G. A., Shea, B., O'Connell, D., Peterson, J., Welch, V., Losos, M., & Tugwell, P. (n.d.). *The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses*. Retrieved from [http://www.ohri.ca/programs/clinical\\_epidemiology/oxford.asp](http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp)
55. Wilson, B. R., & Woodrow, A. (2023). Patient safety in emergency medical services. In *Contemporary Topics in Patient Safety-Volume 2*. IntechOpen.
56. Wilson, K. A., Burke, C. S., Priest, H. A., & Salas, E. (2005). Promoting health care safety through training high reliability teams. *BMJ quality & safety*, 14(4), 303-309.
57. Wu, W. T., Wu, Y. L., Hou, S. M., Kang, C. M., Huang, C. H., Huang, Y. J., ... & Wang, P. C. (2016). Examining the effects of an interprofessional crew resource management training intervention on perceptions of patient safety. *Journal of Interprofessional Care*, 30(4), 536-538.