Team training: implications for emergency and critical care pediatrics

Walter J. Eppich\textsuperscript{a}, Melissa Brannen\textsuperscript{b} and Elizabeth A. Hunt\textsuperscript{c}

\textsuperscript{a}Division of Emergency Medicine, \textsuperscript{b}Division of Critical Care, Department of Pediatrics, Children’s Memorial Hospital, Chicago, Illinois, USA and \textsuperscript{c}Johns Hopkins School of Medicine, Division of Pediatric Critical Care, Department of Anesthesiology, Baltimore, Maryland, USA

Correspondence to Walter J. Eppich, MD, Division of Emergency Medicine, Department of Pediatrics, Children’s Memorial Hospital, Chicago, IL, USA
Tel: +1-773-975-8617; e-mail: weppich@childrensmemorial.org


\textbf{Purpose of review}

The field of team training is quickly evolving and data are emerging to support the close relationship between effective teamwork and patient safety in medicine. This paper provides a review of the literature on team training with specific emphasis on the perspectives of emergency and critical care pediatricians.

\textbf{Recent findings}

Errors in medicine are most frequently due to an interaction of human factors like poor teamwork and poor communication rather than individual mistakes. Critical care settings and those in which patients are at the extremes of age are particularly high-risk, making emergency and critical care pediatrics a special area of concern. Team training is one approach for reducing error and enhancing patient safety. Currently, there is no single standard for team training in medicine, but multiple disciplines, including anesthesiology, emergency medicine and neonatology, have adapted key principles from other high-reliability industries such as aviation into crisis resource management training.

\textbf{Summary}

Team training holds promise to improve patient safety in pediatric emergency departments and critical care settings. We must carefully delineate the optimal instructional strategies to improve team behaviors and combine these with rigorous outcomes assessment to diagnose team problems and prescribe targeted solutions, and determine their long-term impact on patient safety.

\textbf{Keywords}

crisis resource management, emergency medicine, patient safety, pediatric, team training

Introduction

Highly educated, experienced and motivated clinicians work every day in the complex environment of modern medicine. Despite the best intentions of these individuals, life-threatening errors are not uncommon. Indeed, the oft-cited Institute of Medicine (IOM) Report ‘To Err is Human’ \cite{1} drew attention to the impact of medical error in the United States’ healthcare system, with up to 98 000 deaths per year. This landmark study identifies certain clinical contexts as particularly high-risk, including emergency and critical care settings and at the extremes of age, such as pediatric emergency departments and critical care units. For example, multiple studies \cite{2–4,5,6–8} highlight deficiencies of pediatric practitioners in providing appropriate care during actual and simulated medical and trauma resuscitations.

The IOM Report \cite{1} highlights that 60–80\% of medical errors are primarily a result of human errors such as ineffective communication and teamwork. The report specifically recommends that healthcare organizations implement interdisciplinary team training programs for critical care areas, including the emergency department, intensive care unit and operating room. High-reliability organizations in nonmedical industries have not only recognized the importance of teamwork and communication training, but they have also developed methods to assess competency within these domains \cite{9–11}.

While the role of effective teamwork and communication in today’s complex healthcare landscape is garnering more attention \cite{12}, the medical field is clearly behind our industry colleagues. This exciting field is quickly evolving, however, and data are emerging to support the close relationship between effective teamwork and patient...
Teams and teamwork

In their exhaustive literature review, entitled ‘Medical Teamwork and Patient Safety: The Evidence-based Relation’, Baker et al. [9] defined a team as two or more individuals with specialized knowledge and skills who perform specific roles, and complete interdependent tasks to achieve a common goal or outcome. Medical team members must often function with a high workload of critical tasks that are frequently evolving, and thus the team must adapt dynamically to achieve its goals [9].

The constantly changing membership of medical teams, however, complicates team processes. Risser et al. [13] note that emergency department ‘teams’ include ad hoc members from other departments (e.g. surgery, orthopedics, diagnostic imaging, laboratory) and thus differ from airline cockpit crews, which have been described as ‘tightly coordinated, mission-focused, technically-skilled small groups’ (p. 375).

Within these ad hoc teams, separate hierarchies of power and training add additional layers of complexity. These ad hoc groups in the ED have been described as ‘extreme action teams’, as team members ‘1) cooperate to perform urgent, highly consequential tasks while simultaneously 2) coping with frequent changes in team composition and 3) training and developing novice team members whose services may be required at any time’ (p. 592) [14]. Rapidly changing team composition makes it difficult for the team members to anticipate each other’s skills, knowledge, strengths and habits [14]. Teamwork skills are therefore even more critical in these dynamic, complex teams.

Teamwork comprises those behaviors that promote effective team member interaction, including team leadership, mutual performance monitoring, backup behavior, adaptability and team orientation [15,16]. Team members must possess team interaction competencies to function effectively, namely teamwork-related knowledge, skills and attitudes. Representative examples of each type of competency include knowledge (shared understanding of the situation, familiarity with teammates’ abilities); skills (how to communicate effectively, such as ‘closing the loop’, how to monitor teammates’ performance); and attitudes (team cohesion and mutual trust) [9]. Baker et al. [17] report on the role of teamwork in the professional education of physicians and provide recommendations for specialty-focused assessment and training of team-related knowledge, skills and attitudes across the stages of one’s career.

Finally, team members have individual knowledge structures (including mental models) that interact with environmental cues and are modified through team processes such as communication and coordination to yield the multilevel phenomenon known as team cognition [18]. Salas et al. [18] illustrate the importance of team cognition in sports through the example of the ‘blind pass’ in basketball. In this example, both passing and receiving basketball players have a similar mental picture of the game and translate the shared understanding of each other and the situation into dynamic coordinated action. For an in-depth discussion of human factors and team psychology in high-stakes medical environments, see St Pierre et al. [19]. Team behaviors that promote shared mental models [20] and team cognition can be taught using team training.

Teams and communication

Recent literature [21,22] identifies poor teamwork and communication as factors that threaten the safety of pediatric patients in the emergency department. It has become clear that in addition to pediatric-specific knowledge, skills and attitudes, healthcare workers must possess key team and communication competencies for the provision of safe, effective healthcare. In fact, the American Academy of Pediatrics Committee on Pediatric Emergency Medicine [22] specifically recommends teamwork and communication training for all healthcare workers in pediatric emergency settings.

Central to effective teamwork is communicating in a manner that allows the development of a common understanding about the situation at hand, namely a shared mental model [20], and the ability for the mental model to evolve as clinical circumstances dictate. A standard format for presenting clinical information is one example of how communication can promote a shared mental model. A widely advocated approach to standardizing and enhancing communication, particularly between disciplines, is the ‘SBAR’ method (situation, background, assessment, recommendation) [23]. When team leaders promote an atmosphere in which team members are encouraged to clarify key information or question apparent errors, these examples of enhanced knowledge sharing and cross-checking through improved communication also support a shared mental model. In one study [24], openness to communication among team members in an intensive care unit was associated with the degree to which they understood patient care goals. Risk-adjusted morbidity in teaching hospitals correlates with reported levels of communication and collaboration on surgical teams [25]. For example, handover protocols adapted from Formula-1 pitstops reduced the number of technical errors and information omissions during handovers from surgical to critical care unit teams [26].
A Medical Team Training questionnaire [27] identified hidden problems in communication and provided targets for training interventions. In order to ensure an accurate common understanding, especially in dynamic situations, team members must speak up when they have patient safety concerns. In fact, they are obligated to continue to speak up until the other team members acknowledge their concern. This can be achieved by using previously assigned critical language that is essentially a code word for calling a time out, such as ‘I’m uncomfortable’ or ‘I’m concerned’ [12]. Indeed, it is the use of such critical language that often triggers the utilization of multidisciplinary medical emergency or rapid response teams to evaluate patients with acute deterioration independently of the chain of command. Recent studies [28–30,31**] suggest that developing mechanisms for identifying children who are decompensating on the wards early and accessing multidisciplinary teams may reduce the risk of in-hospital respiratory and cardiopulmonary arrest outside of the intensive care settings. A rapid response system is essentially a large safety net for hospitalized children, which hinges on appropriate communication between medical teams.

**Learning from other industries: team training and crisis resource management**

Team training has been used extensively by the military and aviation industries for many years to improve team performance. Several authors have reported on the challenges of team training and provide guidelines for translating the lessons from aviation to medicine [32] and turning teams of experts into expert medical teams [33]. These lessons include the need for management to address cross-cultural training; integration of team training throughout a professional’s career; curricula driven by task analysis; and interdisciplinary simulations that combine technical and team skills.

One form of team training is crew resource management training, which is defined as ‘instructional strategies designed to improve teamwork [in the cockpit] by applying well tested training tools (e.g., performance measures, exercises, feedback mechanisms) and appropriate training methods (e.g., simulators, lectures, videos) targeted at specific content (i.e., teamwork knowledge, skills, and attitudes)’ [34]. David Gaba, MD, adapted the principles of team and crew resource management training from aviation to create anesthesiology crisis resource management (ACRM) [35–37]. ACRM is a team-training program that emphasizes several individual and team behaviors (see Table 1) [38]. Indeed, they have found widespread acceptance in CRM training courses in other disciplines. In simulation-based CRM courses, teams of healthcare providers manage multiple simulated critical events such as respiratory failure or shock in mocked-up clinical environments (operating room, emergency departments, intensive care units). Video-recordings can be used to help facilitate the debriefing session that follows, in which learners are guided to the key concepts of medical management and CRM principles through the use of various debriefing techniques [39**,40**]. Tools to assess nontechnical skills (including teamwork, task management, situation awareness and decision making) have been developed [41–43,44**]. Murray and Foster [45] provide a concise overview of CRM principles for organizing a multidisciplinary healthcare team.

### Table 1 Key principles of anesthesia crisis resource management

<table>
<thead>
<tr>
<th>Key principle</th>
<th>Action</th>
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<tbody>
<tr>
<td>Know the environment</td>
<td>Prevent and manage</td>
</tr>
<tr>
<td>Anticipate and plan</td>
<td>Fixation errors</td>
</tr>
<tr>
<td>Call for help early</td>
<td>Cross (double) check</td>
</tr>
<tr>
<td>Exercise leadership and followership</td>
<td>Use cognitive aids</td>
</tr>
<tr>
<td>Distribute the workload</td>
<td>Re-evaluate repeatedly</td>
</tr>
<tr>
<td>Mobilize all available resources</td>
<td>Use good teamwork</td>
</tr>
<tr>
<td>Communicate effectively</td>
<td>Allocate attention wisely</td>
</tr>
<tr>
<td>Use all available information</td>
<td>Set priorities dynamically</td>
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**Team training in emergency medicine**

Multiple investigators have targeted team training in the emergency department, which is a unique healthcare setting. Many contextual factors characterize the emergency department and affect how healthcare providers make decisions.

These include [43,46]:

1. ill-structured problems,
2. incomplete or conflicting information,
3. dynamic situations,
4. multiple competing goals,
5. intense time pressure,
6. serious consequences of error.

Three additional CRM principles take these factors into account: triage/prioritization; efficient management of multiple patients; and effective coping with disruptions/distractions [47]. The MedTeams project was specifically conceived to adapt CRM principles from aviation to emergency medicine. Risser et al. [13] initially published the MedTeams teamwork behavior matrix, which included five key team dimensions: maintain team structure and climate; apply problem-solving strategies; communicate with the team; execute plans and manage workload; and improve team skills. In a prospective multicenter trial, the MedTeams investigators [48] evaluated the effects of an Emergency Team Coordination Course.
(ETCC). Using validated behaviorally anchored rating scales, they found that didactic sessions and workplace training improved team behaviors, reduced error and improved staff attitudes at those hospitals in which the training took place. An extension of prior work [49], Shapiro et al. [50] subsequently included team simulation sessions to the existing didactic teamwork training of ETCC. The addition of simulation demonstrated promise to augment team performance, but the incremental benefit of simulation was not clear from this work. Wallin et al. [51] found improvement in targeted team skills (assumption of roles, communication, call for help) after a simulation-based intervention with five full-scale simulations of a trauma patient. Rather than focusing on many team behaviors, these investigators focused their training on selected team skills; they also found improvements in skills that were not explicitly trained (e.g., anticipation and planning, workload distribution, allocating attention). The Society for Academic Emergency Medicine [52] encourages further research to determine which variables affect team performance in emergency settings and what strategies maximize team functioning.

**Team training in pediatrics**

In a landmark paper, Halamek et al. [53] called for a paradigm shift in pediatric medical education after developing a well-received neonatal resuscitation course that integrated technical and behavioral-based team skills. In a series of cumulative papers, Thomas and colleagues also focus on team training in neonatal resuscitation. Neonatal resuscitation has many similarities to medical crises in the ICU or ED. Neonatal resuscitations are often unannounced (e.g., crash Caeserian section or precipitous preterm delivery) and teams from multiple departments must coordinate their at times competing efforts (obstetrics, pediatrics/neonatology, anesthesiology) with little or no preparation. Such ad hoc multidisciplinary teams also form in emergency departments during trauma resuscitations and on the wards when providers respond to patients with cardiopulmonary arrest.

Thomas et al. [54] translated existing behavioral markers from aviation and created a scoring system for teamwork during neonatal resuscitations.

These specific, observable teamwork behaviors included

1. Sharing information,
2. Inquiry,
3. Assertion,
4. Sharing intentions,
5. Teaching,
6. Evaluating plans,
7. Managing workload,
8. Maintaining vigilance/environmental awareness,
9. Overall teamwork,
10. Leadership.

Thomas and colleagues [55] then observed these team behaviors in neonatal resuscitations and found a weak but significant correlation between teamwork behavior and adherence to neonatal resuscitation program (NRP) guidelines and quality of care. Finally, Thomas et al. [56] randomized pediatric interns to standard NRP courses or NRP courses that also included team training. Blinded observers rated video recordings of simulated resuscitation events using the behaviors previously defined. The interns who participated in the NRP class with team training showed more frequent information sharing, inquiry and assertion, vigilance and workload management. The long-term impact of this teaching intervention remains unclear.

Jankouskas et al. [57] studied the performance of a multidisciplinary team of providers, including pediatric residents and nurses, in simulated resuscitation scenarios. They found enhanced perceived team collaboration and significantly improved ratings of team skills after simulation-based CRM training. The American Heart Association has recently placed increased emphasis on the importance of teamwork in critical situations. The current iteration of the Pediatric Advanced Life Support [58] integrates a ‘Resuscitation Team Concept’ video and specifically emphasizes eight elements of effective team dynamics (see Table 2).

**Multidisciplinary teams**

Emergency and critical care pediatrics involves the coordination of many subspecialties, multiple clinicians and trainees at various levels. For example, the management of a hemodynamically unstable trauma patient or a child in cardiopulmonary arrest demands rapid decision making and mobilization of significant resources. In such a complex environment, it is difficult to know which elements of teamwork to emphasize during team training and which clinical outcomes to assess as measures of effectiveness. While the literature regarding the benefit of team training in terms of improved patient outcomes is evolving, promising data are emerging. For example,

<table>
<thead>
<tr>
<th>Table 2 Eight elements of effective team dynamics</th>
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<tbody>
<tr>
<td>1. Closed-loop communication</td>
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<td>2. Clear messages</td>
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<tr>
<td>3. Clear roles and responsibilities</td>
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<tr>
<td>4. Knowing one’s limitations</td>
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<tr>
<td>5. Knowledge sharing</td>
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<tr>
<td>6. Constructive intervention (constructive feedback about performance in real time)</td>
</tr>
<tr>
<td>7. Re-evaluation and summarizing</td>
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<td>8. Mutual respect</td>
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Reproduced with permission from [58].
Nielsen et al. [59] studied the effect of a standardized teamwork training curriculum on labor and delivery teams among 15 hospitals. While the investigators found no significant improvement in adverse maternal or neonatal outcomes, there was a significant decrease in the time elapsed between decisions to perform a Caesarian section to the actual incision in the operating room (by an average of 12 min) for teams that had received the team training compared with those who had not. This example of an emergent, high-stakes procedure that requires efficient coordination across multiple disciplines provides a surrogate marker of quality improvement until more clinical outcome data are available.

Conclusion
Successful teamwork, including good communication, lays essential foundations for well tolerated, effective care in the dynamic, high-stakes and often ill-defined environments of emergency and critical care pediatrics. Further integration of team training and crisis resource management into routine care models holds promise to improve patient safety and, ultimately, outcomes of sick and injured children. Team training curricula and assessment tools have been developed, but further refinement is needed. We must carefully delineate the optimal instructional strategies to improve team behaviors and combine these with rigorous outcomes assessment to diagnose team problems. Only then can we prescribe targeted solutions for meaningful improvement and retention of team competencies and determine the long-term impact on patient safety.

References and recommended reading
Papers of particular interest, published within the annual period of review, have been highlighted as:

* of special interest
** of outstanding interest

Additional references related to this topic can also be found in the Current World Literature section in this issue (pp. 350–351).


19. A theoretical discussion of team cognition and how simulation-based training can be used to diagnose team performance. The authors also propose markers of team cognition, which are described in detail.


21. An outstanding overview of literature from multiple domains, including psychology, aviation and medicine. This resource provides concise descriptions of human factors and team psychology issues as they relate to acute medical emergencies, without being overly theoretical.


24. This paper reviews issues related to patient safety in pediatric emergency care.


26. A policy statement from the American Academy of Pediatrics Committee on Pediatric Emergency Medicine that explores the cause of errors and threats to patient safety in pediatric emergency care settings. This report also makes clear recommendations for improving patient safety, including team and communication training for emergency care providers.


29. The authors surveyed physicians and nurses in the intensive care unit setting and found that perceptions about communication openness among caregivers was related to their understanding of patient care goals.


31. Authors analyzed 6083 surveys from 55 medical centers and found that reported levels of communication/collaboration with attending and resident doctors correlated with risk-adjusted morbidity, linking perceptions about communication with patient-related outcome data.
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The authors prospectively studied the change in performance after implementing a new handover protocol developed with Formula 1 racing and aviation industries. The clinical handovers occurred for pediatric heart surgery patients from cardiothoracic surgery teams to critical care teams. There were significant reductions in technical errors and omissions of key information, demonstrating the benefit from a relatively simple intervention.


The authors present a novel categorization of cardiopulmonary arrest in pediatric patients outside of the ICU setting. This categorization, based on preceding signs and symptoms and initial cardiac rhythms, may identify targets for education of in-hospital first responders and code teams responding to pediatric cardiopulmonary arrests.

32 Hamman WR. The complexity of team training: what we have learned from aviation and its applications to medicine. Qual Saf Healthcare 2004; 13 (Suppl 1):72–79.


Excellent review of the debriefing strategies that facilitate effective discussion after simulations, particularly the advocacy-inquiry approach. This technique allows the debriefer to make his/her thinking transparent while promoting learners’ deep understanding of their performance during the simulation.


The authors developed a teamwork performance scale to assess CRM skills during simulation-based training sessions. A detailed discussion of psychometric properties of the instrument is provided, such as validity and reliability, which are essential for rigorous outcomes assessment.


In contrast to many similar papers in the medical simulation literature, these authors provide a thorough discussion of their methods and processes.


This study provides priorities for simulation-based research in emergency medicine. The authors discuss CRM and team training and suggest priorities for research in the field.


Thomas et al. present a study in a program of research that applies teamwork behavioral markers to determine learning benefits of an educational intervention. Only pediatric interns participated; future research will likely look at the impact on training on multidisciplinary teams.


The researchers used previously validated performance tools (see [41] and [42]) to assess outcomes of their multidisciplinary team training program.


The authors examined the impact of team training on outcome markers in the delivery room. There were seven intervention and eight control hospitals in their cluster randomized controlled trials. While there was no difference in adverse maternal or neonatal outcomes, the time from ‘decision to incision’ for emergency Cesarean delivery was significantly less (12 min) in intervention hospitals. This notable study examined actual patient care outcomes rather than attitudes or simulated performance.