Examining non-technical skills for ad hoc resuscitation teams: a scoping review and taxonomy of team-related concepts

J. Colin Evans1*, M. Blair Evans2, Meagan Slack3, Michael Peddle1 and Lorelei Lingard4

Abstract

Background: Non-technical skills (NTS) concepts from high-risk industries such as aviation have been enthusiastically applied to medical teams for decades. Yet it remains unclear whether—and how—these concepts impact resuscitation team performance. In the context of ad hoc teams in prehospital, emergency department, and trauma domains, even less is known about their relevance and impact.

Methods: This scoping review, guided by PRISMA-ScR and Arksey & O'Malley’s framework, included a systematic search across five databases, followed by article selection and extracting and synthesizing data. Articles were eligible for inclusion if they pertained to NTS for resuscitation teams performing in prehospital, emergency department, or trauma settings. Articles were subjected to descriptive analysis, coherence analysis, and citation network analysis.

Results: Sixty-one articles were included. Descriptive analysis identified fourteen unique non-technical skills. Coherence analysis revealed inconsistencies in both definition and measurement of various NTS constructs, while citation network analysis suggests parallel, disconnected scholarly conversations that foster discordance in their operationalization across domains. To reconcile these inconsistencies, we offer a taxonomy of non-technical skills for ad hoc resuscitation teams.

Conclusion: This scoping review presents a vigorous investigation into the literature pertaining to how NTS influence optimal resuscitation performance for ad hoc prehospital, emergency department, and trauma teams. Our proposed taxonomy offers a coherent foundation and shared vocabulary for future research and education efforts. Finally, we identify important limitations regarding the traditional measurement of NTS, which constrain our understanding of how and why these concepts support optimal performance in team resuscitation.

Keywords: Resuscitation, Non-technical skills, Ad Hoc team, Scoping review, Prehospital, Emergency medicine, Trauma

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EXAMINING NON-TECHNICAL SKILLS FOR AD HOC RESUSCITATION TEAMS: A SCOPING REVIEW AND TAXONOMY OF TEAM-RELATED CONCEPTS

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BACKGROUND

Non-technical skills (NTS) concepts from high-risk industries such as aviation have been enthusiastically applied to medical teams for decades. Yet it remains unclear whether – and how – these concepts impact resuscitation team performance. In the context of ad hoc teams in prehospital, emergency department, and trauma domains, even less is known about their relevance and impact.

SELECTED RESULTS

- 61 ARTICLES WITH DATA EXTRACTED VIA DESCRIPTIVE ANALYSIS, COHERENCE ANALYSIS, AND CITATION NETWORK ANALYSIS.
- INCONSISTENT DEFINITION AND APPLICATION ACROSS 14 NON-TECHNICAL CONSTRUCTS.
- LITERATURE BASE THAT IS DISTRIBUTED ACROSS NUMEROUS DOMAINS, RESULTING IN DISCONNECTED AND PARALLEL DISCUSSION.
- MEASUREMENT TECHNIQUES THAT FAIL TO CAPTURE ALL ASPECTS OF THE CONSTRUCT BEING INVESTIGATED.
- EMERGENCE OF SHARED MENTAL MODELS AND TEAM SITUATIONAL AWARENESS AS TWO CONSTRUCTS THAT ARE OFTEN CONFLATED AND WHICH MAY BE ESSENTIAL TO OUR UNDERSTANDING OF HOW AD HOC RESUSCITATION TEAMS FUNCTION.

KEY FINDINGS

This scoping review presents a vigorous investigation into the literature pertaining to how NTS influence optimal resuscitation performance for ad hoc prehospital, emergency department, and trauma teams. Our proposed taxonomy offers a coherent foundation and shared vocabulary for future research and education efforts. Finally, we identify important limitations regarding the traditional measurement of NTS, which constrain our understanding of how and why these concepts support optimal performance in team resuscitation.
Introduction
Despite establishing the significance of teammate collaboration for resuscitation performance, resuscitation literature has yet to achieve a consensus regarding how non-technical skills (NTS) work and which constructs are most relevant to resuscitation teams. Interpersonal constructs like leadership, teamwork, and communication, and cognitive constructs such as decision-making and situational awareness have been studied in many settings and are now included within resuscitation guidelines around the world [1, 2]. Prehospital, emergency department, and trauma resuscitation teams perform in dynamic domains [3], experience frequent team membership turnover and integrate different professional cultures [4] all while expressing a high degree of interdependence [5]. The composition of these teams varies by region, but what these teams hold in common is their shared tasking as specialists in resuscitation and the necessity to unite members who are available to respond at the time of the patient’s critical event on an ad hoc basis. While there is now an extensive literature regarding relevant terms and concepts, there is still a need for a common language for NTS, particularly as they pertain to ad hoc prehospital, emergency department, and trauma resuscitation teams.

Methods
We selected scoping review as the most appropriate methodology to map the state of the literature pertaining to NTS in ad hoc team resuscitation. This approach allows us to describe the breadth of the literary landscape and account for its contours, unrestricted to methodology and setting or by a narrowly predefined research question [14]. Our search was guided by both PRISMA scoping review guidelines [15], and Arksey & O’Malley’s five step framework [14, 16] (see Table 1).

Identifying the research question and search strategy
Leveraging the research question specified above, a preliminary list of keywords was first generated by brainstorming among members of the authorship team (which includes experts in medical teams and clinical aspects of resuscitation) regarding relevant terms and concepts. This keyword list was refined by reviewing concepts described in relevant studies using a database and Google Scholar search of the terms “non-technical skills” and “resuscitation”, and by cross-referencing all terms with the taxonomy applied to surgeons by Yule et al. [17]. This taxonomy was selected because our team regarded it as the most comprehensive and representative of the non-technical constructs identified in our preliminary search. This taxonomy distinguishes constructs as interpersonal skills (communication, leadership, teamwork, briefing/planning/preparation, resource management, seeking advice and feedback, coping with pressure/stress/fatigue) and cognitive skills (situation awareness, mental readiness, decision making, adaptive strategies/flexibility, workload distribution). With this keyword list, a

| Phase/stage | Goal of phase/stage |
|-------------|---------------------|
| Stage 1     | Identifying the research question |
| Stage 2     | Identifying relevant studies |
| Stage 3     | Study selection |
| Stage 4     | Charting the data |
| Stage 5     | Collating, summarizing and reporting the results |

Table 1 Key phases in scoping review methods (adapted from Arksey and O’Malley 2005)
A research librarian assisted in selecting MeSH terms, database selection, and designing search queries. Our team chose to emphasize medical literature and selected four databases [EMBASE (Ovid), CINAHL (Ebsco), MEDLINE (Ovid), and PsychINFO (Ovid)]. The database search combined three groups of terms: 1. activity (e.g., resuscitation, ATLS, ACLS), 2. setting (e.g., prehospital, paramedic, emergency department), and 3. non-technical skills. An example of our CINAHL search query is available in online supplemental materials.

Study selection as well as inclusion and exclusion criteria were informed in an iterative fashion as our familiarity with the literature evolved. We primarily sought literature that specified a focus on prehospital or emergency department teams. Teams including other descriptions were included (e.g., trauma teams) in cases where our research team determined that teams described in the papers included emergency or prehospital members or when the clinical tasks took place in an emergency department context. Our final criteria are listed in the online supplemental materials and sought to identify manuscripts featuring original empirical studies as well as literature reviews that overtly measured or described NTS in the prehospital, emergency, and trauma settings.
The inclusion of review articles in this dataset aligns with our configurative approach and speaks to our research question, which focuses on patterns regarding how relevant concepts were used in the literature.

**Data collection, charting and analysis**

The PRISMA flowchart illustrating the progress of the search is available in Fig. 1. We performed our initial search in June, 2017 and a final update on October 12, 2021. The search identified numerous domains where resuscitation teams research was published and therefore supplemental search strategies (i.e., hand search of selected titles; grey literature search) were not integrated into this review. The database search results were combined with articles identified in our preliminary search and uploaded into the Covidence software platform [16] for duplicate removal, title & abstract screening, and full text eligibility screening. Two reviewers independently conducted title and abstract screening for all sources as well as subsequent screening for full text eligibility, with discrepancies resolved through discussion.

Our team performed three analyses of articles selected for data charting [14]: (a) traditional extraction of descriptive information, (b) coherence analysis to critically consider a study’s capacity to inform the literature, and (c) citation network analysis of articles included in this review.

Data extraction was performed by a single author using a Microsoft Excel (2018) spreadsheet. This analysis included categorizing broad themes (e.g., publication date, study type) as well as those more pertinent to our review (e.g., setting, team type, non-technical skills studied).

The heterogeneity of manuscript types and topics across the resulting articles in our dataset led us to employ ‘Coherence Analysis’ to explore how knowledge is being mobilized across this literature and situate each article by its influence on emerging theory. Traditional quality appraisals that entail a focus on methodological characteristics (e.g., risk of bias assessment) are ill-suited for scoping reviews. Instead, our coherence analysis aims to provide insight into how an article contributes to the scholarly conversation and uses an approach akin to those used by existing narrative reviews [17] and qualitative meta-syntheses [18, 19].

The coherence analysis involved three binary (Yes/No) items addressing: (1) Whether concepts related to non-technical skills team aspects were defined and operationalized (e.g., operational definition in main text), (2) Whether the article was situated within the broader literature by citing and appropriately characterizing relevant seminal works, and (3) Whether the article presents findings that contribute to our knowledge of non-technical skills. To assess intercoder reliability, our primary analyst and another author completed coherence analysis for ten articles. Across the 30 decision points, raters agreed on 26 decisions (87% agreement). The resulting Cohen's Kappa value (K = 0.59; CI = 0.21–0.96) was acceptable.

Because the coherence analysis suggested that several articles were not well situated within the broader literature, we performed a citation network analysis to illustrate and explore relationships between articles. We examined the reference lists of included articles and cross-referencing citations for other articles in our dataset, producing a social network matrix identifying which articles were cited by those published later. The network matrix was visualized using Gephi software (v. 0.9.2), whereby the resulting network was descriptively analyzed alongside indicators of each article’s position within the network.

**Results**

**Descriptive summary**

The search query produced 9595 independent records screened by reviewers, from which 205 articles were reviewed at the level of full text. Sixty-one articles were included in the final analysis, which spanned 1992 to 2021 with forty-six (75%) articles involving original empirical data. Among the twenty (33%) intervention-based articles, six were randomized clinical trials or controlled experiments and fourteen described interventions delivered to a single group of participants (e.g., pre/post cohort study; descriptions of feasibility). Articles reporting on interventions used one of two approaches: either examining the implementation of specific policies or processes (e.g., team debriefing) or the implementation of targeted group interventions (e.g., TeamSTEPPS). Among the twenty-six nonintervention articles (43%), nine were qualitative articles involving interviews and/or observation, thirteen were quantitative articles using data drawn from clinical/training tasks (e.g., use of electronic health records, quantitative coding of video), two performed mixed methods analysis using both qualitative and quantitative assessments, and two were survey articles assessing staff perceptions of the salience of NTS. The analyzed articles also included thirteen (21%) narrative reviews and two comment articles.

In terms of the nature of the teams being investigated in these articles, thirty-eight (62%) articles referred to multidisciplinary teams with members from more than one discipline of medicine (e.g., surgical resident and emergency medicine resident), and forty-five (74%) had an interprofessional scope (e.g., physician, nurse, paramedic, respiratory therapist). With regard to our specific focus on ad hoc teams, twenty-eight (46%) articles addressed ad hoc team resuscitation, eleven (18%) articles examined
Table 2  Characterizing included articles regarding approach, coherence, and NTS included

| Author, Year | Description | Interpersonal Skills | Cognitive Skills |
|--------------|-------------|----------------------|------------------|
| Driscoll & Vincent, 1992 | Quantitative, observational [2] | * | * |
| Xiao et al., 1996 | Quantitative, observational [3] | * | * |
| Stohler, 1998 | Qualitative, interviews [2] | * | * |
| Cooper & Wakelam, 1999 | Quantitative, observational [3] | * | * |
| Meeraudeau, 1999 | Review [3] | * | * |
| Williams et al., 1999 | Quantitative, observational [3] | * | * |
| Bergs et al., 2005 | Quantitative and qualitative, observational [2] | * | * |
| Cole & Crichton, 2006 | Qualitative, interviews and observation [3] | * | * |
| Hunt et al., 2007 | Review [3] | * | * |
| Campeau, 2008 | Qualitative, interviews [2] | * | * |
prehospital responders, and five (8%) articles explored intersectoral teams (i.e., identifying members from multiple agencies such as paramedics and police) but none explicitly labelled these teams as intersectoral.

Among the non-technical skills for which we performed descriptive analysis, interpersonal skills were represented in fifty-eight articles (95%), while thirty-five (57%) explicitly examined cognitive skills. One observation from this review involves contrasting the attention directed toward interpersonal and cognitive skills over time. As evident in Table 2[4, 6, 8, 10, 20–76], interpersonal skills were the exclusive focus of analyzed articles until 2007—after which articles increasingly focused on both interpersonal and cognitive skills. This expansion of focus coincides with the 2006 release of the Yule et al. taxonomy [77]; however, our citation analysis found that only 5 (8%) articles [4, 46, 51, 62, 70] cited this taxonomy directly.

**Taxonomy**

Framed around Yule et al’s NTS taxonomy for surgeons [77] and informed by our descriptive analysis, we created the Proposed Taxonomy of Non-Technical Skills and Team Constructs for Ad Hoc Team Resuscitation (Table 3) [4–7, 10, 20–42, 44–53, 57–66, 78–80]. This taxonomy represents our collective interpretation of definitions and applications presented in the literature integrated within this review, whereby we adapted the original Yule et al. taxonomy [17] and generated definitions regarding each construct that emerged from articles examining prehospital and ad hoc teams. As one key advance relative to the original taxonomy, the range of constructs has been broadened to include additional constructs identified in our review (i.e., debriefing, followership, and shared mental models). The novel taxonomy also identified a shift regarding the underpinning operationalization and classification of constructs. Whereas original perspectives of this taxonomy focused on skills with an ‘individual’ focus on training and preparation for individuals to contribute to teams, our revised taxonomy defines these constructs fundamentally as team processes (i.e., actions or behaviours observed when members combine their resources, knowledge, and skills as a team). Finally, the definitions and applications of these constructs that have emerged in this taxonomy confound classification as either interpersonal or cognitive and thus these categories have been removed.

**Coherence analysis**

Through the coherence analysis, we identified that thirty-nine (64%) articles explicitly defined key terms. For example, in one article [10] the authors described contrasting leadership definitions based on the context of “stable teams” or “action teams”, which were characterized using references to describe both types of teams and leadership tasks associated with each. Twenty-two (34%) articles did not provide definitions for key terms and demonstrated inconsistency in their interpretation and application of key constructs. As an illustrative example, the concept of a shared/team mental model is one construct for which researchers held contrasting definitions and operationalizations.

The second coherence analysis component found that forty-six (75%) of the articles in our dataset were well-situated. In one article that achieved a “yes” rating, the authors used their introduction to extensively detail the history of non-technical skills rating systems [51]. We characterized the remaining fifteen articles (25%) as poorly situated because the articles did not introduce seminal works to situate key concepts, or because they misinterpreted the evidence base when situating their work.

The third coherence analysis component found that forty-nine articles (80%) used their discussion to contribute back to the understanding of how NTS influences team performance. For instance, a 2017 observational study by Calder et al. conducted interviews and in vivo observation to disentangle the conceptual overlaps in previous literature regarding team situational awareness, shared mental models, and team communication. In their discussion, they identified that their “findings contrast with previous work since we found that team members did in fact have a shared mental model” and that their work represented “the first comprehensive mixed method investigation of how inter-professional teams communicate during ED resuscitation” [57]. These findings contribute explicitly to the body of literature and move forward our understanding of resuscitation team performance. The twelve (20%) articles that received a “no” rating in this category failed to advance the scholarly conversation largely due to their presentation of non-specific claims that NTS interventions can improve team performance.

**Network analysis**

Figure 2 is an illustration of the network comprised of articles included in this review. An arrow (tie) from one article to another reflects a citation. This network is limited to only the papers in this review, but it nevertheless characterizes the scholarly communities from which the field has emerged. The network was sparse, in that nine papers were both uncited and had not cited other papers in this review and only eight papers received more than five citations from others.

The network also provides an opportunity to reflect on the extent to which earlier publications received
| Author, Year | Description | Interpersonal Skills | Cognitive Skills |
|--------------|-------------|----------------------|------------------|
|              | [Coherence score] | Communication | Leadership | Teamwork | Briefing & Planning | Resource Management | Advice seeking | Stress or Fatigue Management | Followupship | Debriefing | Decision-making | Situational Awareness | Mental Readiness | Adaptation | Shared Mental Model |
| Hicks et al., 2008 | Quantitative survey, importance of NTS [3] | * | * | * | * | | | | | | | |
| Hoyer et al., 2009 | Quantitative, observational [3] | * | * | | * | | | | | | | |
| Manser, 2009 | Review [3] | * | * | * | | | | | | | | |
| Andersen et al., 2010 | Qualitative interviews [3] | * | * | | | | | | | | | |
| Capellà et al., 2010 | Pre/post intervention, clinical setting [3] | * | * | * | | | | | | | | |
| Hunziker et al., 2010 | Controlled trial, simulation setting [2] | * | | | | | | | | | | |
| Westli et al., 2010 | Quantitative, observational [3] | * | | | | | | | | | | |
| Sacevic et al., 2011 | Qualitative, interview [3] | | * | | | | | | | | | |
| Høyer et al., 2011 | Controlled trial, clinical setting [3] | * | * | * | * | | | | | | | |
| Hunziker et al., 2011 | Review [3] | * | * | | | | | | | | |
| Author Year          | Description | Interpersonal Skills | Cognitive Skills |
|----------------------|-------------|----------------------|------------------|
|                      |             | Coherence score      | Communication | Leadership | Teamwork | Briefing & Planning | Resource Management | Advice seeking | Stress or Fatigue Management | Followship | Debriefing | Decision-making | Situational Awareness | Mental Readiness | Adaptation | Shared Mental Model |
| Steine-mann et al., 2011 | Pre/post intervention, clinical setting | [1] | * | * | * | * | * | * | * | * | * | * |
| Jankouskas et al., 2011 | Pre/post intervention, simulation setting | [0] | * | * | * | * | * | * | * | * | * | * |
| Miller et al., 2011 | Description of intervention delivery | [0] | * | * | * | * | * | * | * | * | * | * |
| Norris & Lockey, 2012 | Review | [3] | * | * | * | * | * | * | * | * | * | * |
| Sarcevic et al., 2012 | Qualitative, observational | [3] | * | * | * | * | * | * | * | * | * | * |
| Cooper et al., 2013 | Review | [3] | * | * | * | * | * | * | * | * | * | * |
| Castelao et al., 2013 | Review | [3] | * | * | * | * | * | * | * | * | * | * |
| Petrosniack & Hicks, 2013 | Review | [3] | * | * | * | * | * | * | * | * | * | * |
| Shields & Flin, 2013 | Review | [3] | * | * | * | * | * | * | * | * | * | * |
| Clarke et al., 2014 | Description of intervention delivery | [1] | * | * | * | * | * | * | * | * | * | * |
| Gjeraa et al., 2014 | Review | [3] | * | * | * | * | * | * | * | * | * | * |
| Author, Year     | Description of Intervention | Interpersonal Skills [Coherence score] | Cognitive Skills |
|----------------|----------------------------|--------------------------------------|-----------------|
| Rasmussen et al., 2014 | Quantitative survey, team experiences [3] | * | * |
| Clements et al., 2015 | Pre/post intervention, clinical setting [2] | * | * |
| Gillman et al., 2016 | Description of intervention delivery [1] | * | * |
| Lorello et al., 2016 | Experimental design, simulation setting [3] | * | * |
| Maluso et al., 2016 | Quantitative, observational [0] | * | * |
| Holly et al., 2016 | Review [3] | * | * |
| Steinmann et al., 2016 | Pre/post intervention, clinical setting [3] | * | * |
| Steinmann et al., 2017 | Controlled trial, simulation setting [3] | * | * |
| Calder et al., 2017 | Qualitative interviews and observation [3] | * | * |
| Author, Year | Description | Interpersonal Skills | Cognitive Skills |
|--------------|-------------|----------------------|-----------------|
|              |             | Communication | Leadership | Teamwork | Briefing & Planning | Resource Management | Advice seeking | Stress or Fatigue Management | Followership | Debriefing | Decision-making | Situational Awareness | Mental Readiness | Adaptation | Shared Mental Model |
| Johnson et al., 2017 | Quantitative, observational [3] | * | * | | | | | | | | | |
| Myers et al., 2017 | Experimental design, simulation setting [2] | | | | | | | | | | | |
| El Shafy et al., 2018 | Quantitative, observational [3] | * | * | | | | | | | | | |
| Ghazali et al., 2018 | Quantitative, observational [3] | * | * | * | | | | | | | | |
| Hicks & Petrosoniak, 2018 | Review [3] | * | * | * | * | | | | | | | |
| O’Neill et al., 2018 | Review [2] | * | * | * | * | | | | | | | |
| Sullivan et al., 2018 | Pre/post intervention, simulation setting [0] | * | * | * | * | | | | | | | |
| Herzberg et al., 2019 | Quantitative, observational [1] | * | * | * | | | | | | | | |
| Lazzara et al., 2019 | Review [3] | * | * | * | * | | | | | | | |
| Murphy et al., 2019 | Qualitative interviews [1] | * | * | * | | | | | | | | |
| Author, Year | Description | Interpersonal Skills | Communication | Leadership | Teamwork | Briefing & Planning | Resource Management | Advice seeking | Stress or Fatigue Management | Followership | Debriefing | Decision-making |
|-------------|-------------|----------------------|---------------|------------|----------|---------------------|---------------------|----------------|-----------------------------|--------------|-------------|------------------|
| Coggins et al., 2020 | Quantitative, observational and survey | * | * | * | * | * | * | | | | |
| Cormack et al., 2020 | Review | * | * | * | * | * | * | | | | |
| Dagnell, 2020 | Commentary | * | * | * | * | * | * | | | | |
| Dumas et al., 2020 | Quantitative, observational | * | * | * | * | * | * | | | | |
| Fernandez et al., 2020 | Controlled trial, simulation and live resuscitation | * | * | * | * | * | * | | | | |
| Gilmartin et al., 2020 | Quality improvement report | * | * | * | * | * | * | | | | |
| Kristiansen et al., 2020 | Pre/Post intervention, live resuscitation | * | * | * | * | * | * | | | | |
| Lapierre et al., 2020 | Review | * | * | * | * | * | * | | | | |
| Sherman et al., 2020 | Qualitative, observational | * | * | * | * | * | * | | | | |
| Armstrong et al., 2021 | Pre/Post intervention, simulation | * | * | * | * | * | * | | | | |
| Petrosinaki et al., 2021 | Quantitative, observational | * | * | * | * | * | * | | | | |
| | | | | | | | | | | | |
Discussion

Our scoping review has identified the heterogenous nature of the disciplines, methodologies, and scope of articles pertaining to NTS for team resuscitation. While this diversity opens opportunities for growth and novelty, it also creates conditions for disconnected conversations that do not share a language and fail to accumulate into a refined model for how teams work during resuscitation. This discussion reflects on the nature and implications of such disconnected conversations within this field of inquiry. We also reflect on how our revised NTS taxonomy can redefine resuscitation teams research by facilitating consistent use of team-based concepts and by identifying emerging constructs that warrant exploration.

A key observation that has emerged from our coherence analysis and the supporting network analysis is that there are many disconnected, parallel scholarly conversations in the literature. Of particular note is the disconnect between articles published in clinical medicine journals and those published in non-medical domains such as human factors or applied ergonomics. Our coherence analysis revealed that specific non-technical skills were inconsistently defined across such domains, and the network analysis showed minimal cross-referencing occurring both within and between these two domains. These disconnects have profound implications for what we know about NTS for team resuscitation: insights already obtained in one field are ‘rediscovered’ in another; inconsistencies in terminology impede a cumulative refinement of knowledge; and the unique diversity of insight that might accompany interdisciplinary inquiry fails to materialize.

While NTS for individual practitioners [77] was the model around which this review was based and represents the conventional framing of this topic, the emerging discourse incorporates a wider spectrum of team processes. The Proposed Taxonomy of Non-Technical Skills and Team Constructs for Ad Hoc Team Resuscitation represents our effort mark this transition and bridge the disconnects that we identified within the literature base. Although scoping reviews are often used to aggregate and describe an evidence base, they are also a powerful tool to (re)configure the evidence base and advance theory [81]. Our taxonomy aims to identify and resolve inconsistencies in terminology that may limit future research and educational progress in this domain. It presents and defines NTS and team constructs that were targeted in studies within this field to-date, synthesizing definitions from the dominant approaches within the literature. Further, it includes examples of how these constructs have been applied in ad hoc teams and is informed by key insights from past empirical research.

This taxonomy could bridge the parallel discussions in this rich literature so that future scholars can contribute more coherently and purposefully to a shared knowledge base; however, the definitive nature of some constructs included in this taxonomy are limited by the quality and breadth of work to date. For instance, constructs of stress and fatigue management were included in our taxonomy because they were included in the initial taxonomy and reflected upon by 10 sources in our review but were often not positioned as a clear team process. Just as our review identified constructs like followership or shared mental models that weren’t integrated in earlier taxonomies, we present this as an evolving taxonomy with an expectation of future empirical investigation and refinement.

A particular area where the taxonomy can build coherence in the field relates to the popular constructs of shared mental models and team situational awareness. Whereas shared mental models refer to a situation in which “team members hold common or overlapping cognitive representations of task requirements, procedures, and role responsibilities” [79] pp. 222, situational awareness is “the perception of elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of their status in the near future.” [81] pp. 36. Situationally-aware teams are those where members develop and maintain a collective understanding of a specific situation or patient presentation; as an acute ‘state’ of being situationally aware. Team members with shared mental models tend to enter a situation knowing their own (and others) roles as well as the goals of the group when they face given situations. Inconsistency in the use of these terms was a key finding of our coherence analysis. These two terms are often conflated across the studies [26, 56, 62, 66] or omitted insofar as
| Nontechnical Skill/Construct        | Considerations for Prehospital Ad Hoc Resuscitation Teams                                                                                       | Selected citations                                                                                     |
|-----------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|
| **Leadership**                    | Leadership is a subcategory of teamwork and central to team's success. Members should maintain congruent and shared beliefs about which               | [4–6, 10, 20, 24, 28, 32, 34, 41, 44, 45, 51, 58, 65, 66]                                           |
|                                   | members are leaders. Leadership may be fluid, transitioning between team members or distributed across numerous team members as task demands change or       |                                                                                                       |
|                                   | as team composition evolves. Leaders often play a key role in team stress management, trust, and psychological safety, and maintaining a positive atmosphere. |                                                                                                       |
|                                   | Threats: 1. Ambiguous leader identity. 2. Leader performing technical interventions resulting in task fixation/loss of situational awareness             |                                                                                                       |
|                                   | Literature supports closed-loop communication (e.g., direction-verification-confirmation-acknowledgement, follow up once task complete)              |                                                                                                       |
|                                   | Leader communication is directed at maintaining situational awareness and task delegation, follower communication is directed at closing loop and       |                                                                                                       |
|                                   | volunteering information that will foster team situational awareness. Communication effectiveness is increased when team member names are used and      |                                                                                                       |
|                                   | through direct delegation. Graded assertiveness (e.g., Concern-Uncomfortable-Safety) model for patient safety is a means to overcome hierarchical barriers.|                                                                                                       |
|                                   | Threats: 1. Excessive/redundant information exchange. 2. Failure to use common language. 3. Cultural or hierarchical barriers resulting in indirect      |                                                                                                       |
|                                   | language and incomplete or inaccurate information sharing. 4. Environmental barriers and distractions. Patient safety literature in resuscitation has       |                                                                                                       |
|                                   | supported a transition from vertical integration, to a more horizontal structure that favours team input. Resuscitation teams feature characteristics of       |                                                                                                       |
|                                   | distributed cognition whereby working memory and pattern matching are greater than that of any individual member. Resuscitation team composition is          |                                                                                                       |
|                                   | often fluid, with dynamic team member turnover, changes in or distributed leadership, and the presence of sub-teams with specialized tasks (e.g., airway     |                                                                                                       |
|                                   | team, compression team) Threats: 1. Ad hoc teams must unite under immense time pressure in conditions of significant complexity, as such team behaviours and    |                                                                                                       |
|                                   | structure are vulnerable to failure. 2. Vertical integration and hierarchy have oppressive impact on follower performance.                            |                                                                                                       |
| **Communication**                 | Verbal and non-verbal exchange of information. May occur within the team and between team and environment (e.g., patient, bystanders). Whereas        | [5, 6, 20, 24, 28, 29, 32, 35, 42, 44–46, 50, 51, 57, 66, 75]                                           |
|                                   | communication may be task oriented or social in nature, communication is often studied in relation to the extent it develops situational awareness, performing      |                                                                                                       |
|                                   | mutual performance monitoring, and task delegation.                                                                                               |                                                                                                       |
| **Teamwork**                      | Teamwork is a complex set of interactions amongst individuals who work adaptively and interdependently to achieve a common goal. Classically considered a   | [4–6, 29, 32, 34, 35, 42, 58, 65, 66]                                                                   |
|                                   | broad construct and inclusive of other constructs such as leadership, followership, mutual performance monitoring, backup behaviour, adaptability, and      |                                                                                                       |
|                                   | team orientation.                                                                                                                                |                                                                                                       |
Table 3 (continued)

| Nontechnical Skill/Construct Definition | Considerations for Prehospital Ad Hoc Resuscitation Teams | Selected citations |
|----------------------------------------|----------------------------------------------------------|-------------------|
| **Briefing/Planning**                  | Briefing is attributed to enhanced team mental models, decreased role ambiguity, and is associated with error reduction. A four-step model is proposed to facilitate rapid prebriefing, these roles include: 1) what do we know?, 2) what do we expect? (plan A), 3) what will we change? (plan B), 4) role assignment. Planning behaviours include updating of the initial briefing through regular "pauses" or "situation reports" and facilitates improved situational awareness and adaptive behaviours. Threats: 1. Ad hoc resuscitation teams often assemble while the event is ongoing, eliminating the opportunity for prebriefing. | [6, 28, 29, 36, 44, 56, 65] |
| **Resource Management**                | Responsive to fluctuating resource support and demands (e.g., conflicting priorities, fatigue). Requires clear, direct, and specific task assignment. Threats: Mass casualty response and prehospital resuscitation often modifies resource management requirements and situates individual patient resuscitation within a larger team environment. The construct applied to this circumstance is that of a multi-team system. In a multi-team system, team composition is highly reactive to fluctuating demands of broader incident priorities. | [6, 20, 29, 31, 32, 51, 62, 65] |
| **Stress/Fatigue Management**          | Maladaptive stress response is associated with dysfunctions including degraded shared mental models, decreased performance in decision making, altered situational awareness, and impaired team function. Fatigue is associated with deficits in resource management, teamwork, situational awareness, and decision making. Leadership, mutual performance monitoring, backup behaviour, communication, are suggested as mechanisms to foster optimal team orientation, which can combat the detrimental effects of acute stress and fatigue. | [6, 20, 41, 45, 51, 61] |
| **Followership**                       | Refers to traits of resuscitation team members not assigned or fulfilling a leadership position. The corollary to leadership, an acknowledgement that most team members are not leaders but nevertheless exhibit characteristics that have the capacity to significantly impact team performance. Followership research in resuscitation is limited, but there is increasing recognition that the earlier focus on hierarchical teams – with the resulting focus on leader behaviour – contrasts with recognition for the role of follower behaviours. | [66, 87] |
Table 3 (continued)

| Nontechnical Skill/Construct | Definition | Considerations for Prehospital Ad Hoc Resuscitation Teams | Selected citations |
|-----------------------------|------------|----------------------------------------------------------|-------------------|
| **Debriefing**              | A facilitated reflective process performed upon conclusion of team resuscitation efforts for the purpose of examining elements of optimal and suboptimal performance | Debriefing allows opportunity for immediate feedback and fosters a culture of trust and support, facilitating improved team behaviours | [4, 29, 41, 45, 55, 68] |
|                             | [7/11%]    | Threats: 1. The migration of the resuscitation environment from prehospital scene to emergency department functions as a barrier to effective whole-team debriefing. 2. Vertical team structure, lack of trust, and lack of psychological safety are all identified to negatively affect team member contribution to debriefing. |                    |
| **Decision Making**         | A dynamic team process of interpreting data collected from the patient and environment to develop a working diagnosis and determine a course of action | Resuscitation decision making is often recognition-primed, with little space for deliberative decision making. The concept of “distributed cognition” is proposed as a mechanism to describe team decision-making or “team mind” whereby the leader functions as the central executive and team members as evidence gatherers and treatment agents. Studies identify that working memory and pattern matching are improved when decisions are made as a collective in resuscitation teams (e.g., collectives have a larger library of past experiences to contrast with the current situation). | [10, 42] |
|                             | [19/31%]   |                                      |                    |
| **Situational Awareness/Team Situational Awareness** | Process of observing and interpreting ongoing clinical events and environments. Three steps: (1) perception of elements within a dynamic environment or system (e.g., patient), (2) comprehending the meaning associated with these observations; and (3) projecting these findings to support anticipation and response to future events. Evident at the individual level and at the team level. | Situational awareness is foundational to decision-making and guides team coordination, communication, and behaviours. Pre-briefings and intra-response situation reports (“Here’s what I see, this is what I think it means, and this is where I think we’re headed”) supports accurate team situational awareness and provides opportunity for correction. Optimized by: (1) orientation at the beginning of the task; (2) maintenance during task and after disruption/change in environment; (3) recovery and reorientation after degradation. Follower push communication (providing salient information without being asked) and communication of situational awareness is highly correlated with optimal team performance. Threats: Task fixation, scene complexity, entrenched hierarchy/interagency silos, and stressful team environment can limit individual situational awareness while also limiting or eliminating voluntary team member contribution and thus diminish accuracy of team situational awareness. | [6, 35, 46, 50, 51, 57, 58, 62, 66, 78, 80] |
|                             | [28/46%]   |                                      |                    |
| **Mental Readiness**        | Developing psychological skills for individuals and teams to regulate their mental state during performance. Attaining optimal arousal state during moments when demand nears or exceeds resources. | Behaviours associated with the maintenance of an ideal performance state of arousal include: controlled or “tactical” breathing, self-talk, mental rehearsal, and activities that foster optimal team orientation such as prebriefings and maintaining mutual trust. Stress inoculation training, mental practice, and overlearning are three training techniques that are associated with enhanced psychological skills for optimizing performance in acute stress environments. An important foundational component of stress management. | [6, 45, 53] |
**Table 3** (continued)

| Nontechnical Skill/Construct | Considerations for Prehospital Ad Hoc Resuscitation Teams | Selected citations |
|------------------------------|----------------------------------------------------------|---------------------|
| **Adaptive Behaviours**     | Based upon 4 adaptation phases: (1) situation assessment; (2) plan formulation; (3) plan execution; (4) team learning | [6, 20, 29, 51, 65] |
| A team's ability to anticipate and modify their structure and behaviours in response to dynamic changes in their patient's clinical presentation and the environment. These behaviours are highly integrated with other NTS constructs including shared mental models, situational awareness, decision making, and debriefing | By virtue of understanding each team member's role in relation to one another, teams with a strong team mental model have the greatest capacity for adaptive behaviour. Optimizing team situational awareness through regular situation reports allows teams to more accurately and proactively predict dynamic changes resulting in more effective adaptive behaviours. | |
| **Shared Mental Model**      | Associated with higher frequency of communicating and updating situational awareness. | [5, 6, 35, 45, 57, 58, 75, 79, 82] |
| Mental models reflect team members' understanding of the team objectives, structures, and members' roles within the team. Sharedness reflects the extent that members' models are similar across the group | Threats: Ad hoc and intersectoral teams may have a limited shared understanding of their team and tasks | |

[6/10%] | [13/23%] |
findings allude to a construct while failing to explicitly reference it [23–25, 61].

An example of confounded definitions arises when articles indicate that situation reports develop a shared mental model. Whereas situation reports ‘can’ establish mental models when designed for this goal, the value of such reports is watered-down without considering how such reports also shape situational awareness and other group processes like leadership. The problem of omission is less conspicuous but arises when authors refer to
generalized descriptions of effective teams as opposed to tangible and mutually exclusive concepts. For instance, one article argued that teams are optimal when they “have regular training, roles are well defined, and each can make safe assumptions about the level of preparation of others” [25] pp. 38. This claim lacks the precision that is gained when researchers use established concepts like shared mental models, role communication, or teamwork training. In contrast to the above examples, our dataset contains five recent articles wherein team situational

Fig. 2 Citation network analysis. This network was created using Gephi and depicts the 61 articles in this review (nodes) and citations from a given source to another within this review represented by a directed arrow (ties). The size and orientation of each node was based on the number of citations an article received, whereas node colours distinguish articles by year of publication. Circles added to the figure denote papers with the highest number of citations, including a Cooper (1994) (11 citations), b Capella and colleagues (2011) (9 citations), and c Hunt (2007) (7 citations). Note that this network figure only depicts 52 papers because nine papers included in this review had not cited other papers in this review, nor had they been cited by other papers in this review.
awareness and team/shared mental models are described
with the requisite nuance to capture their relationship
[4, 6, 35, 57, 58]. These articles discuss these concepts as
being essential for resuscitation team performance with
one study finding that indicators of shared mental models
explained as much as 23% of the variance in team perfor-
ance outcomes [42].

It is critical for practitioners, researchers, and educa-
tors to distinguish between shared mental models and
situational awareness because each involves differing
challenges within ad hoc settings. Shared mental mod-
els are particularly elusive to promote in intersectoral
prehospital ad hoc teams because they depend on enter-
ing situations with a collective understanding of how the
team will ‘work.’ Research is needed to examine whether
strategies to promote shared mental models from other
contexts (e.g., clinical leaders complete a training module
on how to develop mental models) should be adapted in
the context of ad hoc resuscitation teams. An additional
area of focus lies in examining how these teams adapt in
settings where a shared mental model does not exist or is
not feasible. Ad hoc resuscitation teams clearly constitute
a fertile setting to extend what we know about mental
models and situational awareness from teams with more
stable membership.

With improved clarity and consistency of the con-
structs associated with NTS in team resuscitation, we
might also advance how we measure these constructs.
While our descriptive analysis did not include a for-
mal quality assessment, we observed that quantitative
studies tended to examine key constructs by coding
team interactions that could be observed during clinical
experiences and simulations, or by intervening upon
non-technical skills and measuring clinical outcomes
like patient progress or procedural success. Measure-
ment tools utilized in the studies included in our data-
set focused almost exclusively on behavioral aspects of
nontechnical skills while failing to evaluate the affective
and cognitive components. This observation is mirrored
in Cooper et al.’s systematic review examining measure-
ment of situational awareness in emergency settings
[48] as well as Lapierre et al.’s systematic review of stud-
ies examining simulation to improve trauma team per-
formance [74]. These failings have also been identified
in reviews involving other clinical contexts, which have
recognized that studies examining teams rely on obser-
vational methods and are often inconsistent regarding
how researchers define and measure group processes
[83, 84]. The hazard in this approach is evident in the
measurement of a team’s shared mental model through
observation alone. Observation is a powerful tool for
evaluating actions that might promote shared mental
models (e.g., frequent communication) or observing the
results (e.g., reduced conflict). Yet, observation is only a
proxy for a team’s cognition. With observation alone we
cannot directly estimate the extent that members share
representations. In contrast, validated psychological
measures of shared mental models often involve tools to
identify critical aspects of teamwork in context, measure
members’ individual perceptions of those aspects, and/
or evaluate a group based on the degree to which mem-
bers share representations [85]. Resuscitation researchers
might adapt such tools to support both comprehensive
evaluations of healthcare teams and specific measures
of identified group processes and emergent states [86].

With valid measures for these constructs, we can deline-
ate the nature of small group phenomena in resuscitation
team performance and identify the active ingredients of
interventions.

Limitations

The selected databases focused on clinical medicine jour-
nals. While the few articles that we identified from non-
clinical medicine journals have given us an indication of
the divide that may exist between clinical and non-clin-
cal journals, our search strategy did not capture the full
breadth of investigations outside of the clinical medicine
literature. Another limitation arises due to the inherent
nature of the scoping review as an iterative process that
redefines its inclusion and exclusion criteria as it trav-
erses diverse territory. When applied to a heterogenous
dataset such as this, the scoping review has the potential
to leave those more accustomed to the rigid structure
of systematic reviews and meta-analyses discomfited
about what may have been left on the cutting room floor.
Finally, citation network analysis constitutes an emerg-
ing analysis technique not usually included in scoping
review methods. Constructing a network including only
the studies from this review was useful to document how
NTS definitions or measures have emerged within resus-
citation literature; however, we did not document cita-
tions to sources outside of this review or external papers
citing those included in this review. Researchers could
use more comprehensive citation analyses to explore
connections between resuscitation team literature and
research from other clinical settings or areas of study.

Conclusion

The literature on non-technical skills for ad hoc prehos-
pital, emergency department, and trauma resuscitation
teams is both diverse and disconnected. This review estab-
lishes that ad hoc resuscitation teams, and intersectoral ad
hoc prehospital resuscitation teams, present realms that are
ripe for future inquiry. We also offer a proposed taxonomy
which presents a universal set of definitions for non-tech-
nical skills and team constructs for ad hoc resuscitation
teams. We anticipate that this taxonomy will support the precision needed to incrementally advance understanding of teams in this context, such that insights obtained in one field can be applied in another, knowledge can accumulate across disciplines, and the rich insights of interdisciplinary inquiry can be realized. We also encourage future investigators to look beyond this literature base in search of validated psychological measures which more comprehensively assess the constructs being evaluated, so that the unique group processes responsible for collaboration in ad hoc teams can be more precisely described and enhanced through targeted training efforts.

Abbreviation
NTS: Non-technical skills.

Supplementary Information
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Authors’ contributions
JCE: conception, design, acquisition and analysis, drafting and revision; MBE: design, analysis, drafting and revision; MP: conception, revision, supervision; LL: conception, design, analysis, drafting and revision; MS: acquisition and analysis; revision; NTS: Non-technical skills.

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References
1. Greif R, Lockey A, Breckwoldt J, Carmona F, Conaghan P, Kuzovlev A, et al. European resuscitation council guidelines 2021: education for resuscitation. Resuscitation. 2021;161:388–407. https://doi.org/10.1016/j.resuscitation.2021.02.016.
2. Neumar RW, Shuster M, Callaway CW, Gent LM, Atkins DL, Bhangu R, et al. Part 1: executive summary: 2015 American Heart Association guidelines update for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation. 2015;132(18 suppl 2):S315–67. https://doi.org/10.1161/CIR.0000000000000252.
3. Dinh JV, Schweising EJ, Venkatesh A, Traylor AM, Kilcullen MP, Perez JA, et al. The role of teamwork processes within the dynamic domains of healthcare: a systematic and taxonomic review. Front Commun. 2021;11:6(3). https://doi.org/10.3389/fcomn.2021.617928.
4. Manser T. Teamwork and patient safety in dynamic domains of healthcare: a review of the literature. Acta Anaesthesiol Scand. 2009;53:143–51. https://doi.org/10.1111/j.1399-6576.2008.01717.x.
5. Salas E, Sims DE, Burke CS. Is there a “big five” in teamwork? Small Group Res. 2005;36:555–99. https://doi.org/10.1177/10944015050360040477134.
6. Hicks C, Petrosoniak A. The human factor: optimizing trauma team performance in dynamic clinical environments. Emerg Med Clin North Am. 2018;36:1–17. https://doi.org/10.1016/j.emc.2017.08.003.
7. Brindle P, Cardinal P, editors. Optimizing crisis resource management to improve patient safety and team performance: a handbook for all acute care health professionals. Middletown: Royal College of Physicians and Surgeons of Canada; 2017.
8. Corman S, Scott S, Stedmon A. Non-technical skills in out-of-hospital cardiac arrest management: a scoping review. Australas J Paramed. 2020;13:17. https://doi.org/10.33151/ajp.17.744.
9. Schmutz JB, Lei Z, Eppich WJ, Wiens MC, Tsehaye T, van der Meer M. Reflection in the heat of the moment: the role of in-action team reflexivity in health care emergency teams. J Org Behav. 2018;39:749–65. https://doi.org/10.1002/job.2299.
10. Sarcevic A, Marsic I, Waterhouse LJ, Stockwell DC, Burd RS. Leadership structures in emergency care settings: a study of two trauma centers. Int J Med Inform. 2011;80(4):227–38. https://doi.org/10.1016/j.ijmedinf.2011.01.004.
11. Andreotta PB. A typology for health care teams. Health Care Manag Rev. 2010;35(4):345–54. https://doi.org/10.1097/HCR.0b013e3181e69c6b.
12. Adeluyi OA, Ofili AN. Strengthening intersectoral collaboration for primary health care in developing countries: can the health sector play a broader role? J Environ Public Health. 2010;2010. https://doi.org/10.1155/2010/272896.
13. Gough D, Thomas J, Oliver S. Clarifying differences between review designs and methods. Syst Rev. 2012;1(1):1–9. https://doi.org/10.1186/2046-4053-1-28.
14. Arksey H, O’Malley L. Scoping studies: towards a methodological framework. Int J Soc Res Methodol. 2005;8(1):19–32. https://doi.org/10.1080/13645573200119616.
15. Tricco AC, Liddle E, Zarif W, O’Brien KK, Colquhoun H, Levac D, et al. PRISMA extension for scoping reviews (PRISMA-SCR): checklist and explanation. Ann Intern Med. 2018;169(7):467–73. https://doi.org/10.7326/M18-0850.
16. Pham MT, Rajic A, Greig JD, Sargeant JM, Papadopoulos A, McEvon SA. A scoping review of scoping reviews: advancing the approach and enhancing the consistency. Res Synth Meth. 2014;5:371–85. https://doi.org/10.1002/issm.1123.
17. Yule S, Flin R, Paterson-Brown S, Maran N. Non-technical skills for surgeons in the operating room: a review of the literature. Surgery. 2006;139(2):140–9. https://doi.org/10.1016/j.surg.2005.06.017.
18. Covidence - Better Systematic Review Management. https://www.covidence.org/
19. Mitchell B, Cristancho S, Nyhof BB, Lingard LA. Mobilising or standing still? a narrative review of surgical safety checklist knowledge as developed in 25 high-yield papers from 2009 to 2015. BMJ Qual Saf. 2017;26(10):837-44. https://doi.org/10.1136/bmjqs-2016-006218.
20. Ashtan RA, Morris L, Smith I. A qualitative meta-synthesis of emergency department staff experiences of violence and aggression. Int Emerg Nurs. 2018;1(39):13–9. https://doi.org/10.1016/j.ijen.2017.12.004.
21. Stomski NJ, Morrison P. Participation in mental healthcare: a qualitative meta-synthesis. Int J Ment Health Syst. 2017;11(1):1–11. https://doi.org/10.1186/s11539-017-0174-y.
22. Campeau AG. The space-control theory of paramedic scene-management. Symb Intercar. 2008;31:285–302. https://doi.org/10.1525/si.2008.31.3.285.
23. Driscoll PA, Vincent CA. Organizing an efficient trauma team. Injury. 1992;23:107–10. https://doi.org/10.1016/0020-1383(92)90043-R.
24. Xiao Y, Hunter WA, Mackenzie CF, Jeffries NJ, Horst RL. Task complexity in emergency medical care and its implications for team coordination. Hum Factors. 1996;38(4):636–45. https://doi.org/10.1177/001872059627206.
25. Stohler SA. High performance team interaction in an air medical program. Air Med J. 1998;17(3):116–20. https://doi.org/10.1016/S0149-619X(98)80009-2.
26. Cooper S, Wakeham A. Leadership of resuscitation teams: ’lighthouse leadership’ Resuscitation. 1999;42(1):27-45. https://doi.org/10.1016/S0300-5972(99)00080-5.
27. Meereabeau L, Page S. I'm sorry if I panicked you: nurses' accounts of teamwork in cardiopulmonary resuscitation. J Interprof Care. 1999;13(1):29–40. https://doi.org/10.1080/135618299025533.
28. Williams KA, Rose WD, Simon R. Teamwork in emergency medical services. Air Med J. 1999;18(4):149–53. https://doi.org/10.1016/S0149-619X(99)00028-7.
29. Bergs EA, Rutten LF, Tadros T, Krijnen P, Schipper IB. Communication during trauma resuscitation: do we know what is happening? Injury. 2003;36(8):905–11. https://doi.org/10.1016/j.injury.2004.12.047.
30. Cole E, Crickton N. The culture of a trauma team in relation to human factors. J Clin Nurs. 2006;15(10):1257–66. https://doi.org/10.1111/j.1365-2702.2006.01566.x.
31. Hunt EA, Shikofski NA, Stavroudis TA, Nelson KL. Simulation: translation to improved team performance. Anesthesiol Clin. 2007;25(2):301–19. https://doi.org/10.1016/j.anclin.2007.03.004.
32. Hicks CA, Bandiera GW, Denny CJ. Building a simulation-based crisis resource management course for emergency medicine, phase 1: results to improved team performance. Anesthesiol Clin. 2007;25(2):301–19. https://doi.org/10.1016/j.anclin.2007.03.004.
33. Andersen PO, Jensen MK, Lippert A, Østergaard D. Identifying non-technical skills and barriers for improvement of teamwork in cardiac arrest teams. Resuscitation. 2010;81(6):695–702. https://doi.org/10.1016/j.resuscitation.2010.01.024.
34. Capella J, Smith S, Philip A, Putnam T, Gilbert C, Fry W, et al. Teamwork training improves the clinical care of trauma patients. J Surg Educ. 2016;73(6):493–49. https://doi.org/10.1016/j.jsurg.2016.06.006.
35. Hunziker S, Buhlmann C, Tschann F, Baletzke G, Legeret C, Schumacher C, et al. Brief leadership instructions improve cardiopulmonary resuscitation in a high-fidelity simulation: a randomized controlled trial. Crit Care Med. 2010;38(4):1086–91. https://doi.org/10.1097/CMC.0b013e3181cf7383.
36. Westh H, Johnsen B, Eid J, Rasten I, Brattebo G. Teamwork skills, shared mental models, and performance in simulated trauma teams: an independent group design. Scand J Trauma Resusc Emerg Med. 2010;18(1):47. https://doi.org/10.1186/1757-7241-18-47.
37. Høyer CB, Christensen EF, Eika B. Standards of resuscitation during inter-hospital transportation: the effects of structured team briefing or guideline review - a randomised, controlled simulation study of two micro-interventions. Scand J Trauma Resusc Emerg Med. 2011;19(1):1–11. https://doi.org/10.1186/1757-7241-19-15.
resuscitation: a mixed methods qualitative analysis. Int J Emerg Med. 2017;10(1):1–9. https://doi.org/10.1186/s12245-017-0149-4.

60. Johnsen BH, Westli HK, Espevik R, Wisborg T, Brattebø G. High-performing trauma teams: frequency of behavioral markers of a shared mental model displayed by team leaders and quality of medical performance. Scand J Trauma Resusc and Emerg Med. 2017;25(1):1–6. https://doi.org/10.1186/s13049-017-0452-3.

61. Myers JA, Powell DM, Aldington S, Sim D, Psirides A, Hathaway K, et al. The impact of fatigue on the non-technical skills performance of critical care air ambulance clinicians. Acta Anaesthesiol Scand. 2017;61(10):1305–13. https://doi.org/10.1111/aas.12994.

62. El-Shafy IA, Delgado J, Akerman M, Bularo F, Christopherson NA, Prince JM. Closed-loop communication improves task completion in pediatric trauma resuscitation. J Surg Educ. 2018;75(1):58–64. https://doi.org/10.1016/j.jsurg.2017.06.025.

63. Ghazali DA, Darmian-Rafei I, Ragot S, Orion D. Performance under stress conditions during multidisciplinary team tmmersive pediatric simulations. Pediatr Crit Care Med. 2018;19(6):270–8. https://doi.org/10.1097/ PCC.0000000000001473.

64. O’Neill TA, White J, Delaloye N, Gilfoyle E. A taxonomy and rating system to measure situation awareness in resuscitation teams. PLoS ONE. 2018;13(5):e0196825. https://doi.org/10.1371/journal.pone.0196825.

65. Sullivan S, Campbell K, Ross JC, Thompson R, Underwood A, LeGare A, et al. Identifying non-technical skill deficits in trainees through interdis-
ciplinary trauma simulation. J Surg Educ. 2018;75(4):978–83. https://doi.org/10.1016/j.jsurg.2017.10.007.

66. Herzberg S, Hansen M, Schoonover A, Skarica B, McNulty J, Harrod T, Snowden JM, Lambert W, Guise JM. Association between measured teamwork and medical errors: an observational study of prehospital care in the USA. BMJ Open. 2019;9(10):e025314. https://doi.org/10.1136/bmjopen-2018-025314.

67. Lazzara EH, Keebler JR, Shuffler ML, Patzer B, Smith DC, Misasi P. Considerations for multiteam systems in emergency medical services. J Patient Saf. 2019;15(2):150–3. https://doi.org/10.1097/PTS.0000000000000213.

68. Murphy M, McCloughen A, Curtis K. The impact of simulated multidisci-
plinary trauma team training on team performance: a qualitative study. Australas Emerg Care. 2019;22(1):1–7. https://doi.org/10.1016/j.ajace.2018.11.003.

69. Armstrong P, Peckler B, Plkinton-Ching J, Mcquade D, Rogan A. Effect of simulation training on nurse leadership in a shared leadership model for cardipulmonary resuscitation in the emergency department. Emerg Med Australas. 2021;33(2):255–61. https://doi.org/10.1111/1742-6723.13605.

70. Coggin A, Santos ADL, Zaklama R, Murphy M. Interdisciplinary clinical debriefing in the emergency department: an observational study of learning topics and outcomes. BMC Emerg Med. 2020;20(1):1–10. https://doi.org/10.1186/s12873-020-00370-7.

71. Dagnell AJ. Teamwork and leadership in out-of-hospital cardiac arrest – do these non-technical skills require attention? Australas J Paramedicine. 2020;24:17 https://doi.org/10.33151/ajp.177488.

72. Dumas RP, Vella MA, Cheirimen KC, Smith BP, Subramanian M, Maher Z, et al. Team assessment and decision making is associated with outcomes: a trauma video review analysis. J Surg Research. 2020;1(246):544–9. https://doi.org/10.1016/j.jsr.2019.09.033.

73. Fernandez R, Rosenman ED, Olenick J, Misisco A, Brolliar SM, Chipman AK, et al. Simulation-based team leadership training improves team leadership during actual trauma resuscitations: a randomized controlled trial. Crit Care Med. 2020;48(1):73–82. https://doi.org/10.1097/CCM.0000000000004077.

74. Gilmarín S, Martin L, Kenny S, Callanan I, Salter N. Promoting hot debrief-
ing in an emergency department. BMJ Open Qual. 2020;9(3):e000913. https://doi.org/10.1136/bmjopen-2020-000913.

75. Kristiansen LH, Freund DS, Rolfing JHD, Thoringer R. Trauma team training at a”high risk low incidence hospital” Dan Med J. 2020;67(3):A03190189.

76. Lapierre A, Bourgueneau S, Gauvin-Lepage J, Lavoie P, Arbour C. Effectiveness of interprofessional manikin-based simulation training on teamwork among real teams during trauma resuscitation in adult emergency departments: a systematic review. Simul Healthc. 2020;15(6):409–21. https://doi.org/10.1097/PHC.0000000000004443.

77. Petrocsonak A, Fan M, Hicks CM, White K, McGowan M, Campbell D, et al. Trauma resuscitation using in situ simulation team training (TRUST) study: Latent safety threat evaluation using framework analysis and video review. BMJ Qual Saf. 2021;30(9):739–46. https://doi.org/10.1136/ bmjqs-2020-011363.

78. Sherman JM, Chang TP, Zip N, Nager AL. Barriers to effective teamwork relating to pediatric resuscitations perceptions of pediatric emergency medicine staff. Pediatr Emerg Care. 2020;36(3):146–50. https://doi.org/10.1097/PEC.0000000000002125.

79. Salas E, Prince C, Baker DP, Sheehan L. Situation awareness in team performance: implications for measurement and training. Hum Factors. 1995;37(1):123–36. https://doi.org/10.1177/001872099577904925.

80. Mathieu JE, Goodwin GF, Heffner TS, Salas E, Cannon-Bowers JA. The influence of shared mental models on team process and performance. J Appl Psychol. 2000;85(2):273–83. https://doi.org/10.1037/0021-9010.85.2.273.

81. Endsley MR. Toward a theory of situation awareness in dynamic systems. Hum Factors. 1995;37(1):32–65. https://doi.org/10.1037/0021-9010.85.2.273.

82. Cannon-Bowers JA, Salas E. Converse S. Shared mental models in expert team decision making. In: Castellan Jr NJ, editor. Individual and group decision making: current issues. Hillsdale, New Jersey: Lawrence Erlbaum Associates; 1993. p. 221–46.

83. Kolbe M, Boos M. Laborious but elaborate: the benefits of really studying teamwork and medical errors in health care settings a review of survey instruments. Med Care. 2015;53(4):16–30. https://doi.org/10.1097/ PEC.0000000000000298.

84. Gisick LM, Webster KL, Kleeber JR, Lazzara EH, Fouquet S, Fletcher K, et al. Measuring shared mental models in healthcare. J Patient Saf Res Manag. 2018;28(10):1478. https://doi.org/10.3389/fpsyg.2019.01478.

85. Rosen AA, Diazgranados D, Dietz AS, Benishel LE, Thompson D, Pro-
ovost PL, et al. Teamwork in healthcare: key discoveries enabling safer, high-quality care. Am Psychol. 2018;73(4):433. https://doi.org/10.1037/ ampp000298.

86. Prince C, Baker DP, Sheehan L. Situation awareness in team performance: implications for measurement and training. Hum Factors. 1995;37(1):123–36. https://doi.org/10.1177/001872099577904925.

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