Impact of Teamwork and Communication Training Interventions on Safety Culture and Patient Safety in Emergency Departments: A Systematic Review

Mohamed Alsabri, MD,* Zoubir Boudi, MD,† Dominique Laquée, MD, PhD,** Roger Daglius Dias, MD, PhD,‡ Julia S. Whelan, MD,¶ Linda Östlundh, MLIS,¶ Guillaume Alinier, PhD, MPhys, PGCert,**†††† Churchill Onyeji, MD, MPH,** Philippe Michel, MD, MSc, PhD,**‡‡‡‡ Shan W. Liu, MD, MPH,**‡‡‡‡ Carlos A. Jr Camargo, MD, DrPH,**‡‡‡‡ Tobias Lindner, MD,** Anna Slagman, MD,** David W. Bates, MD, PhD,**‡‡‡‡ Karim Tazarourte, MD, MSc, PhD,**‡‡‡‡ Sara J. Singer, MD,**‡‡‡‡ Anita Toussi, MD,**‡‡‡‡ Shamai Grossman, MD, MPH,** and Abdelouahab Bellou, MD, MSc, PhD****

**From the Department of *Emergency Medicine, Beth Israel Deaconess Medical Center, Teaching Hospital of Harvard Medical School, Harvard Medical School, School of Health Sciences, UAE University, Al Ain, United Arab Emirates; †Department of Medicine, Brigham and Women’s Hospital, Boston, Massachusetts; ‡Department of Emergency Medicine, Perpignan Hospital and Toulouse III University, Toulouse, France; ‡‡STRATATUS Center for Medical Simulation, Department of Emergency Medicine, Brigham and Women’s Hospital, Harvard Medical School; ‡‡‡Knowledge Services, Beth Israel Deaconess Medical Center, Boston, Massachusetts; ‡‡‡‡The National Medical Library, College of Medicine and Health Sciences, UAE University, Al Ain, United Arab Emirates; **Hamad Medical Corporation Ambulance Service, Doha, Qatar; ††School of Health and Social Work, University of Hertfordshire, Hatfield, United Kingdom; †††Weil Cornell Medicine-Qatar, Doha, Qatar; §§Department of Health Quality, University Hospital, Hospices Civils; §§‡‡Health Services and Performance Research Laboratory, EA 7425, University Lyon 1, Lyon, France; §§§Department of Emergency Medicine, Massachusetts General Hospital, Harvard Medical School, Boston, Massachusetts; §§§‡Division of Emergency and Acute Medicine (CVK, CCM), Charité University Medicine, Berlin, Germany; §§§***Department of Healthcare Quality, Brigham and Women’s Hospital, Harvard Medical School, Boston, Massachusetts; §§§‡‡Emergency Medicine Department, University Hospital, Hospices Civils, Lyon, University Lyon 1, Lyon, France; §§§‡‡‡Department of Medicine, Division of Primary Care, Stanford University School of Medicine, Stanford, California; §§§‡‡‡‡Department of Emergency Medicine, Union Hospital Terre Haute and Clinton IN, Simulation Center for Health Care Education, Indiana State University, Terre Haute, Indiana; and §§§Research Innovation Department, Global Health Care Network and Research Innovation Institute LLC, Brookline, MA, Massachusetts. Correspondence: Abdelouahab Bellou, MD, MSc, PhD, PO-BOX 157, Brookline, 02446 MA (e-mail: abellou402@gmail.com); Shamai Grossman, MD, MPH, Department of Emergency Medicine, Beth Israel Deaconess Medical Center, Teaching Hospital of Harvard Medical School, Harvard Medical School, Boston, 02215 MA (e-mail: sgrossma@bidmc.harvard.edu).

There was no funding for this systematic review.

The authors disclose no conflict of interest.

Systematic Review Registration: PROSPERO (CRD42016052544).

Data Sharing Statement: The data generated by our systematic review will be available in a public, open-access repository.

Supplemental digital contents are available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal’s Web site (www.journalpatientsafety.com). Copyright © 2020 Wolters Kluwer Health, Inc. All rights reserved.

Objectives: This study aimed to narratively summarize the literature reporting on the effect of teamwork and communication training interventions on culture and patient safety in emergency department (ED) settings.

Methods: We searched PubMed, EMBASE, Psych Info CINAHL, Cochrane, Science Citation Inc, the Web of Science, and Educational Resources Information Centre for peer-reviewed journal articles published from January 1, 1988, to June 8, 2018, that assessed teamwork and communication interventions focusing on how they influence patient safety in the ED. One additional search update was performed in July 2019.

Results: Sixteen studies were included from 8700 screened publications. The studies’ design, interventions, and evaluation methods varied widely. The most impactful ED training interventions were End-of-Course Critique, Team Strategies and Tools to Enhance Performance and Patient Safety (TeamSTEPPS), and crisis resource management (CRM)–based training. Crisis resource management and TeamSTEPPS CRM-based training curriculum were used in most of the studies. Multiple tools, including the Kirkpatrick evaluation model, the Agency for Healthcare Research and Quality Hospital Survey on Patient Safety Culture, the TeamSTEPPS Teamwork Attitudes Questionnaire, the Safety Attitudes Questionnaire, and the Communication and Teamwork Skills Assessment, were used to assess the impact of such interventions. Improvements in one of the domains of safety culture and related domains were found in all studies. Four empirical studies established improvements in patient health outcomes that occurred after simulation CRM training (Kirkpatrick 4), but there was no effect on mortality.

Conclusions: Overall, teamwork and communication training interventions improve the safety culture in ED settings and may positively affect patient outcome. The implementation of safety culture programs may be considered to reduce incidence of medical errors and adverse events.

Key Words: patient safety, safety culture, emergency department, communication

Health care system is facing an increase of medical errors that are ranked as the third main cause of mortality in the United States.1-4 Reports have highlighted that medical errors result from human errors related to poor communication and teamwork.1,5 Importantly, most of these errors that are associated with communication problems are preventable.3 Safety culture entails as outcomes linked to people’s attitudes, values, behavior patterns, perceptions, and competencies that define the individual or group commitment and style of proficiency toward health and safety management within the organization.5 Teamwork is a combination of thoughts, behaviors, and feelings that help health providers work as one team and continuously improve the quality of care.6 Its 5 components are referred to as the “big five,” and they are the following: team orientation, backup behavior, mutual performance, team leadership, and adaptability.7 Patient outcomes are correlated with patient safety, which is impacted by teamwork.10 Implementing team development interventions is one of the most significant ways to improve teamwork.11 Four types of teamwork interventions have been identified: team building, leadership training, team training, and team debriefing.12 For many years, the aviation industry used crew resource management (CRM) as a team-based training approach for pilots. The aims of CRM are to promote safety, improve teamwork behaviors, and reduce errors.13 Emergency care and other clinical specialties, such as...
anesthesiology and surgery, have similar characteristics including high-risk and complex working environments.\textsuperscript{14,15} Studies have shown that successful application of aviation-based teamwork, communication interventions such as CRM, simulation, and checklists to dynamic or rapidly changing health care, specialties have led to improved outcomes.\textsuperscript{14,15} Emergency departments (EDs) are unique and dynamic health care units that are particularly prone to communication and teamwork mishaps.\textsuperscript{16,17} Thus, one of the major ED challenges is achieving effective communication among the medical teams both within and outside the ED to guarantee patient safety.\textsuperscript{16,17}

There are several published systematic reviews that have investigated team training communication interventions within clinical care settings.\textsuperscript{9,11,18–25} These reviews suggest a significant benefit of training interventions in improving teamwork among health care providers. In the ED, the impact of these interventions on patient safety is currently underinvestigated.\textsuperscript{18,23} This systematic review narratively summarizes the literature reporting on the effect of teamwork and communication training interventions on culture and patient safety in ED settings.

**METHODS**

This review was conducted as recommended by Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.\textsuperscript{26}

**Protocol**

Based on PRISMA guidelines, investigators (M.S., D.L., J.L.W., A.B.) created the review protocol and a search strategy. The research question of the study was developed in accordance with the key elements of PICO framework: Participants (P), Interventions (I), Comparison (C), and Outcomes (O).\textsuperscript{27} The protocol was registered in PROSPERO (CRD42016052544).

**Selection Criteria for Eligibility**

All studies included in this review met the predetermined eligibility criteria.

**Inclusion Criteria**

Peer-reviewed studies that were carried out in the ED setting and described teamwork and communication interventions in an ED, pre-post intervention studies, randomized clinical trials, and observational studies were included. Clinical staff like physicians and assistant physicians, respiratory therapists, nurses, technicians, and paramedics were selected as the best subjects of the study. All interventions to improve teamwork and communication, safety culture, and safety outcomes in an ED were included.

**Exclusion Criteria**

Studies that lacked information on interventions, studies reporting interventions in non-ED settings, review studies not focused on improving teamwork, studies not related to safety culture, studies found in the gray literature, and studies written in non-English languages were not included.

**Sources of Data and Strategy for Literature Search**

The literature search was performed in June 2018 and included studies published from January 1, 1988, to June 8, 2018, in the following bibliographic databases: EMBASE, PubMed, Psych Info CINAHL, Science Citation Inc, and Cochrane Central Register of Controlled Trials. All references were transferred to the reference manager software F1000 Workspace.\textsuperscript{28} References of eligible articles were manually reviewed for supplementary citations. The search details are shown in Supplementary Online Appendix 1, http://links.lww.com/JPS/A356. The list of studies that met inclusion criteria is available in Supplementary Online Appendix 2, http://links.lww.com/JPS/A357. Finally, a manual search on already published systematic reviews of team-based training and communication was done to check for appropriate references in the selected articles (Fig. 1).\textsuperscript{28} In addition, an updated search in PubMed for the period of June 7, 2018, to July 5, 2019, was conducted to ensure inclusion of eventual new studies published since the last search date before submitting the article (Fig. 1).

**Selection Process**

Two reviewers (M.A., A.B.), specialists in emergency medicine, independently screened the titles and abstracts. The selection was focused only on peer-reviewed published studies. The reviewers read the full-text articles obtained and selected those that met all inclusion criteria. A third author (D.L.) assisted in resolving any issues of disagreements through consensus agreement.

**Data Extraction**

Study characteristics were extracted: authors, publication year of the study, country, objectives, research design, setting, study sample, features or attributes of the intervention, evaluation instrument, response rate, statistical test, findings, effect, outcomes/conclusions, and follow-up strategy. We reported whether studies showed a continuous improvement with a sustained strategy of teamwork and communication after the implementation of the interventions. Patient safety outcomes were collected by assessing adverse events like mortality and incidence of clinical errors.

**Quality Assessment of Studies**

Two assessors (M.A. and A.B.) independently rated the quality of the studies using the Newcastle-Ottawa Scale (NOS).\textsuperscript{30} A star rating system was used to review the studies.\textsuperscript{30} The definition of “high quality” for the studies was settled as any study with a ranking equal or superior (≥2) to 7 stars. In addition, if discrepancies presented, these were resolved through discussion and consensus between the analysts.

**Data Synthesis**

A qualitative narrative synthesis was performed. It was structured around the different strategies used by the studies for teamwork and communication improvements in the ED unit.

**RESULTS**

**Overview**

The search included 8700 citations (Fig. 1). Sixteen studies were selected by the assessors based on the review criteria.\textsuperscript{31–46} Of which 15 were performed in the United States\textsuperscript{31–45} and 1 was performed in Denmark.\textsuperscript{46} Fourteen studies were performed in adult EDs.\textsuperscript{31–43,46} 2 studies were performed in pediatric EDs,\textsuperscript{44,45} and 4 studies focused on ED trauma cases.\textsuperscript{32,33,44,45} Six studies were observational survey studies,\textsuperscript{32,37,38,41,43,45} 5 studies were designed as pretest and poststudy surveys,\textsuperscript{31,33,36,39,40,44,46} and 1 study was a randomized controlled trial.\textsuperscript{45} Details of the included studies’ characteristics are shown in Table 1.

For a better understanding, we divided our findings into different sections, including assessment tools, training interventions, safety culture improvement, and teamwork intervention outcomes.
Assessment Tools Used for the Evaluation of Teamwork and Communication Training Interventions

The results of the assessment tools used in the selected studies are shown in Table 1.

The Safety Attitudes Questionnaire

The Safety Attitudes Questionnaire (SAQ) was adapted based on the Flight Management Attitudes Questionnaire used in commercial aviation. It is composed of 60 items, and responses were presented in the 5-point Likert scale. One study reported results on the 6 categories of the SAQ. The study findings showed significant benefits of teamwork training in the ED (interstaff communication, staff-patient communication, staff’s comfort with providing feedback). There was no significant increase reported among other categories after the implementation of the training program.

A Survey to Determine the Safety Culture of Patients in the Hospital

The survey tool known as the Agency for Healthcare Research and Quality (AHRQ) Hospital Survey on Patient Safety Culture (HSOPS) is a 42-item tool used to address the elements of safety culture. The AHRQ HSOPS was used in 4 studies. Knowledge, attitudes, and other communication styles had increased 45 days after baseline ($P < 0.05$) and had been sustained by day 90. The frequency about event reporting, transitions or handoffs, and teamwork in hospital units also have improved significantly.

Team Strategies and Tools to Enhance Performance and Patient Safety Teamwork Attitudes Questionnaire

The TeamSTEPPS (Team Strategies and Tools to Enhance Performance and Patient Safety) Teamwork Attitudes Questionnaire (T-TAQ) is a self-reporting instrument mainly developed to assist in measuring attitudes of a person regarding the key components of teamwork in a unit or department, captured within TeamSTEPPS. The aims of using the TeamSTEPPS curriculum was to improve teamwork skills and communication skills and to promote the safety of patients and the safety culture. The T-TAQ was used in 4 studies. A study by Wong et al showed statistically significant improvements in 4 of the 5 T-TAQ constructs: situation monitoring, team structure, mutual
### Table 1. Characteristics of the Selected Studies

| Study                  | Country          | Study Design                  | Sample Size | Department               | Intervention          | Evaluation Instrument                                      |
|-----------------------|------------------|-------------------------------|-------------|--------------------------|-----------------------|-----------------------------------------------------------|
| Hefner et al<sup>38</sup> | United States    | Observational survey study    | 784         | Multidepartmental        | CRM training          | AHRQ Hospital Survey                                     |
| Roberts et al<sup>41</sup> | United States    | Observational longitudinal study | 57 trauma teams | ED and surgery | Simulation | Changes in individual and team behaviors               |
| Patterson et al<sup>45</sup> | United States    | Observational survey study    | 218         | Pediatric ED             | Simulation            | Number and type of LSTs; ANTS scale                      |
| Morey et al<sup>40</sup> | United States    | Before-and-after observational survey study | 1058 | ED | Teamwork training | Staff Attitude and Opinion Survey Patient Satisfaction Survey |
| Jones et al<sup>31</sup> | United States    | Before-and-after observational survey study | 70 | ED | TeamSTEPPS Essentials | AHRQ Hospital Survey |
| Lisbon et al<sup>39</sup> | United States    | Before-and-after observational survey study | Full staff | ED | TeamSTEPPS Fundamentals | Kirkpatrick’s 4 levels of evaluation TeamSTEPPS Knowledge Test AHRQ Hospital Survey |
| Hughes et al<sup>36</sup> | United States    | Before-and-after observational survey study | Not reported | ED | CRM training | HFAS |
| Grogan et al<sup>13</sup> | United States    | Before-and-after observational survey study | 489 | Multidepartmental including ED | Teamwork training | ECC HFAS |
| Auerbach et al<sup>44</sup> | United States    | Before-and-after observational survey study | 398 | ED | Simulation | Trauma simulation evaluation tool |
| Miller et al<sup>52</sup> | United States    | Observational interrupted time series study | 39 | ED | Teamwork training | CTS |
| Wong et al<sup>37</sup> | United States    | Observational survey study    | 62          | ED                        | Simulation            | TAQ HSOPS                                                  |
| Capella et al<sup>35</sup> | United States    | Before-and-after observational survey study | 114 | ED and surgery | TeamSTEPPS simulation | + Trauma Team Performance Observation Tool |
| Sweeney et al<sup>43</sup> | United States    | Observational survey study    | 203         | ED                        | CRM training          | Custom 12-item survey                                     |
| Shapiro et al<sup>42</sup> | United States    | Randomized controlled trial   | 20          | ED                        | CRM training + simulation | Team Dimensions Rating Form |
| Palved et al<sup>36</sup> | Denmark          | Before-and-after observational survey study | 39 | ED | Simulation | SAQ Trainee Reactions Score |
| Obenrader et al<sup>34</sup> | United States    | Before-and-after observational survey study | 57 | ED | TeamSTEPPS | TeamSTEPPS TAQ TeamSTEPPS Teamwork Perceptions Questionnaire Nursing Culture Assessment Tool |

### (Continued next page)
| Study                  | Effect of the Intervention | Group          | Pretreatment* | Posttreatment* | P   | Posttreatment 2*: Sustainment of the Effect | P | Qualitative Assessment |
|-----------------------|----------------------------|----------------|---------------|---------------|-----|---------------------------------------------|---|-------------------------------------------|
| Roberts et al⁴¹       | Leadership                 | Whole sample   | 3.72 (0.36)   | 4.22 (0.67)   | NS  | NR                                         |   | NR                                        |
|                       | Leader clearly identifiable|                | 3.78 (0.51)   | 3.83 (0.35)   | NS  | NR                                         |   | NR                                        |
|                       | Cooperation                |                | 2.89 (0.65)   | 3.94 (0.92)   | 0.01| NR                                         |   | NR                                        |
|                       | Communication              |                | 2.56 (0.46)   | 3.50 (0.97)   | 0.015| NR                                         |   | NR                                        |
|                       | Decision making            |                | 3.67 (0.71)   | 4.17 (0.97)   | NS  | NR                                         |   | NR                                        |
| Patterson et al⁴⁵      | Task management            | Whole sample   | NR            | 2.7 (1.1)     | NR  | NR                                         |   | NR                                        |
|                       | Teamwork                   |                | NR            | 2.6 (1.1)     | NR  | NR                                         |   | NR                                        |
|                       | Situation awareness        |                | NR            | 2.5 (1.2)     | NR  | NR                                         |   | NR                                        |
|                       | Decision making            |                | NR            | 2.4 (1.2)     | NR  | NR                                         |   | NR                                        |
| Morey et al⁴⁰          | Clinical error rate        | Experimental   | 30.9%         | 4.4%          | 0.039| NR                                         |   | NR                                        |
|                       |                            | Control        | 16.8%         | 12.1%         | 0.081| NR                                         |   | NR                                        |
|                       | Staff attitudes            | Experimental   | 75.0%         | 78.5%         | 0.047| NR                                         |   | NR                                        |
|                       |                            | Control        | NR            | NR            | NR  | NR                                         |   | NR                                        |
|                       | Staff assessment of        | Experimental   | NR            | NR            | 0.04| NR                                         |   | NR                                        |
|                       | institutional support      | Control        | NR            | NR            | NR  | NR                                         |   | NR                                        |
| Jones et al³¹          | Frequency of events        | Whole sample   | 60%           | 70%           | 0.24| NR                                         |   | NR                                        |
|                       | Teamwork                   |                | 64%           | 70%           | 0.36| NR                                         |   | NR                                        |
|                       | Handoffs and transitions   |                | 43%           | 55%           | NR  | NR                                         |   | NR                                        |
| Lisbon et al³⁹         | Knowledge                  | Whole sample   | NR            | NR            | <0.05| NR                                         |   | NR                                        |
|                       | Attitudes                  |                | NR            | NR            | <0.05| NR                                         |   | NR                                        |
|                       | Communication              |                | NR            | NR            | <0.05| NR                                         |   | NR                                        |
| Hughes et al³⁶         | HFAS                       | Whole sample   | NR            | NR            | <0.005| NR                                         |   | NR                                        |
| Grogan et al³³         | ECC                        | Whole sample   | NR            | NR            | NR  | NR                                         |   | NR                                        |
|                       | HFAS                       |                | NR            | NR            | NR  | NR                                         |   | NR                                        |
|                       |                           | Didactic       | NR            | 6.3 (1.6)     | 0.147| NR                                         |   | NR                                        |
|                       |                           | ISS            | NR            | 7.8 (0.4)     | 0.003| NR                                         |   | NR                                        |
|                       |                           | Decay          | NR            | 6.0 (1.9)     | 0.407| NR                                         |   | NR                                        |

(Continued next page)
support, and leadership ($P < 0.05$). A significant improvement in communication was also observed.38

**The Anesthetists’ Non-Technical Skills System**

The Anesthetists’ Non-Technical Skills (ANTS) system was designed to assist in assessing nontechnical skills, mainly in anesthesia. Such skills include teamwork, decision making, task management, and situation awareness.51 Behaviors are evaluated using a 4-point Likert style rating scale (0–4).32 Patterson et al55 showed high scores of 3 or 4 in improving behaviors during specific clinical situations. Most teams scored 3 or 4 in task management (73%), teamwork (64%), situation awareness (58%), and decision making (58%).

**The End-of-Course Critique**

The End-of-Course Critique (ECC) is a tool measuring participants’ reaction to guidance or training, their perceived training needs, and their alleged value of the newly developed skills, and it explains the expected training opportunities in the future.33 In a study by Grogan et al,33 it was found that 95% of the respondents

---

**TABLE 1. (Continued)**

| Study          | Effect of the Intervention | Group          | Pretreatment* | Posttreatment* | $P$   | Posttreatment 2*; Sustainment of the Effect | $P$   | Qualitative Assessment                                           |
|---------------|---------------------------|----------------|---------------|----------------|-------|------------------------------------------|-------|---------------------------------------------------------------|
| **Wong et al37** | HSPSC                      | Whole sample   | 40.6%         | 40.6%          | 0.028 | NR                                       | NR    | Simulation enhanced curriculum improved attitudes toward teamwork and safety culture |
|               | Event reporting frequency  |                |               |                |       |                                          |       |                                                                |
|               | Teamwork                  |                |               |                |       |                                          |       |                                                                |
|               | Handoffs and transitions TAQ‡ |                |               |                |       |                                          |       |                                                                |
|               | Team structure             |                |               |                |       |                                          |       |                                                                |
|               | Leadership                 |                |               |                |       |                                          |       |                                                                |
|               | Situation monitoring       |                |               |                |       |                                          |       |                                                                |
| **Capella et al35** | Leadership               | Whole sample   | 2.87          | 3.46           | 0.003 | NR                                       | NR    | Team training via simulation improves performance            |
|               | Situation monitoring       |                | 3.3           | 3.9            | 0.009 | NR                                       | NR    |                                                                |
|               | Mutual support             |                |               |                |       |                                          |       |                                                                |
|               | Leadership                 |                | 2.87          | 3.46           | 0.003 | NR                                       | NR    |                                                                |
|               | Communication              |                | 3.3           | 3.9            | 0.009 | NR                                       | NR    |                                                                |
|               | Overall ratings            |                | 3.12          | 3.7            | <0.001| NR                                       | NR    |                                                                |
| **Sweeney et al43** | Interstaff communication | Whole sample   | 4.84 (1.99)   | 5.96 (1.9)     | 0.001 | NR                                       | NR    | CRM simulation improves communication                         |
|               | Staff-patient communication|                | 5.29 (1.81)   | 6.22 (1.66)    | 0.001 | NR                                       | NR    |                                                                |
|               | Staff comfort providing feedback |                | 4.65 (2.40)   | 5.24 (2.39)    | 0.001 | NR                                       | NR    |                                                                |
| **Shapiro et al42** | Teamwork behavior       | Experimental   | NR            | NR             | 0.07  | NR                                       | NR    | Simulation improves CRM team behaviors                          |
|               | Control                    |                | NR            | NR             | 0.55  | NR                                       | NR    |                                                                |
| **Paltved et al36** | Safety climate            | Whole sample   | 25.74 (4.41)  | 26.59 (4.23)   | <0.001| NR                                       | NR    | ISS improves safety culture and teamwork                         |
|               | Teamwork climate           |                | 19.9          | 20.6           | <0.05 | NR                                       | NR    |                                                                |
| **Obenrader et al44** | Communication  | Whole sample   | 3.77 (0.03)   | 3.91 (0.07)    | 0.03  | 3.91 (0.07)                              | 0.001 | Intervention improved teamwork and communication                |
|               | T-TAQ                     |                | 4.09 (0.01)   | 3.92 (0.02)    | ≤0.001| 4.58 (0.02)                              | ≤0.001|                                                                |
|               | TTPQ                      |                | 6.273 (0.188) | 6.364 (0.168)  | 0.54  | 7.500 (0.158)                            | ≤0.001|                                                                |
|               | NCAT Teamwork             |                | 23.67 (0.732) | 23.5 (0.471)   | 0.86  | 23.5 (0.245)                             | 0.84  |                                                                |
|               | T-TAQ                     |                | 3.21 (0.13)   | 3.40 (0.115)   | 0.005 | 3.77 (0.78)                             | ≤0.001|                                                                |
|               | TTPQ                      |                | 15.90 (0.534) | 15.864 (0.385) | 0.89  | 17 (0.406)                             | 0.02  |                                                                |

*Data are presented as mean (SD) or percentage.
†Data are presented as percent improvement.
‡Values are regression coefficients.
NR, not reported; HSPSC, Hospital Survey on Patient Safety Culture; NCA T, Nursing Culture Assessment Tool; TTPQ, TeamSTEPPS Teamwork Perceptions Questionnaire; LST, Latent Safety Threat.
agreed or strongly agreed with the statements that ECC training could minimize the incidence of clinical medical errors during patient care.

Human Factors Attitude Survey
The Human Factors Attitude Survey (HFAS) is a pretraining and posttraining survey tool designed by the University of Texas and the National Aeronautics and Space Administration based on other surveys used in the aviation industry. It uses a standard 5-point Likert scale from strongly agree to strongly disagree.22,53 Grogan et al33 showed that a training intervention (CRM training emphasizing on 6 key areas: managing fatigue, creating and managing teams, recognizing adverse situations, cross-checking and communication, decision making, and performance feedback) significantly impacts the 20 items among 23 rated items of the HFAS ($P < 0.01$).

Hughes et al36 showed improvement in 15 questions among 23 questions used in the post-HFAS survey scores ($P < 0.005$).

Communication and Teamwork Skills Assessment
The Communication and Teamwork Skills Assessment was designed to measure the communication and team skills of health care providers on site. Specifically, the tool uses specific behavior makers to measure situational awareness.24 Hughes et al36 used the Communication and Teamwork Skills Assessment to evaluate the effect of CRM training on various skills required of the members of a team. The findings of the study by Hughes et al showed significant improvement in briefing by communicating the plan of care, selecting the potential team leader, and allocating roles to members of the team. Cross-checking and updating members of the team through face-to-face communication and sharing pertinent information showed statistically significant improvements.36 Briefing team members led to improved understanding of patients’ needs ($P < 0.05$).36

Clinical Teamwork Scale
The Clinical Teamwork Scale (CTS) is used to measure skills directly related to teamwork and communications.55 Miller et al35 used the CTS to evaluate in situ simulation (ISTS), which showed significant improvement in briefing by communicating the plan of care, selecting the potential team leader, and allocating roles to members of the team. Cross-checking and updating members of the team through face-to-face communication and sharing pertinent information showed statistically significant improvements. Briefing team members led to improved understanding of patients’ needs ($P < 0.05$).56

Trauma Team Performance Observation Tool
The Trauma Team Performance Observation Tool includes 21 items that are graded on the Likert scale, which consists of 1 to 5 dimensions, where 1 represents very poor and 5 represents excellent.56 Capella et al35 found that across teamwork domain ratings and overall ratings, there was a significant improvement from pretraining to posttraining in leadership, situation monitoring, mutual support, and communication ($P < 0.005$).

Others Assessment Tools
Specific survey questionnaires were used for the interventions in a study by Sweeney et al.43 Their findings showed that simulation-based training programs that emphasized CRM and standardization of patient encounters contributed to improved communication within the ED setting. This improved communication was found between staff members and with patients.43 Morey et al40 and Shapiro et al47 used the Team Dimensions Rating Form.55 Morey et al40 showed a statistically significant improvement after clinicians’ participation in the Emergency Team Coordination Course (ETCC) as indicated by teamwork quality, enhanced attitudes toward teamwork among health care staff in ED, and reduced rates of clinical error rate, pointing its effectiveness in reducing errors and improving attitudes regarding hospital team members.48 In a study by Shapiro et al,42 there was no statistically significant improvement in the quality of team behavior in the simulation group ($P = 0.07$) and no change in team behavior in the control group during the 2 observation periods ($P = 0.55$).

Training Interventions
Most of the training interventions focused on improving teamwork, communication, and leadership. All studies used simulation training approaches, and 9 studies showed that the results followed the principles of CRM. Although there were significant variations in their definitions and descriptions of CRM and how simulation was implemented, interventions showed that CRM principles taught with simulation increased interprofessional education.31,33,36,38,40,43

Safety Culture Measurement and Improvement
The HSOPS, which is the most applicable tool used for safety culture measurement, was used in 4 studies.31,37–39 Other questionnaires, such as the SAQ, T-TAQ, and ANTS, were also applicable and were used to measure the impacts of teamwork intervention on safety culture. All studies showed improvement in one of the safety culture domain or safety culture-related improvements (leadership, communication, teamwork climate). Wong et al37 found positive improvement in scores for all dimensions except for continuous improvement or organizational learning, and management support for patient safety in hospitals. Jones et al36 also showed a 9% increase in the average score for positive replies after the implementation of training interventions. Nonpunitive error response showed a decline in the percentage of positive scores. On the other hand, Hefner et al36 found a statistically significant increase in all HSOPS dimensions ($P < 0.05$) except for staffing. In contrast, Lisbon et al39 showed a significant increase in all HSOPS dimensions related to communication compared with baseline and reported no negative response. Interestingly, Jones et al36 and Hefner et al36 found that after the TeamSTEPPS Fundamentals Course Training on teamwork skills that covered communication, mutual support, team structure, leadership, and situation monitoring, course participants had an average increase of 9% in positive responses for 11 of 12 safety culture survey components. In regard to nonpunitive response to medical error, the results demonstrated that the percentage of correct response decreased, with 28% response after training compared with the 30% before training. However, the study found no statistically significant difference in both pretraining and posttraining scores.31,38

In addition, Wong et al37 showed that the simulation in the TeamSTEPPS curriculum enhanced interprofessional education and that the interventions were sustained within 1 year in 3 of the 6 safety culture survey dimensions related to teamwork and communication.37 Conversely, Hefner et al38 found an increase in 11 of 12 dimensions, whereas staffing scored 34% after training compared with 36% before training.38 Crisis resource management was found to have the potential of supporting a safety culture and in minimizing errors that affect patient safety in all the respondents.38 In this instance, CRM training seems to have significant impacts on teamwork and the communication domains of safety culture in comparison to the supervisor and management dimensions.38
Teamwork Intervention Effects and Outcomes

Kirkpatrick Evaluation Model

The Kirkpatrick (KP) analysis and evaluation model is a tool composed of 12 learning outcomes classified in 4 different levels.\(^5^7\) It has been designed to assess the effectiveness of training programs based on 4 levels.\(^5^7\)

All studies demonstrated that simulation-based training has a positive impact in terms of KP 3 and 4. Ten studies\(^3^1\)–\(^3^3\),\(^3^7\)–\(^4^1\),\(^4^4\)–\(^4^6\) showed an effect of simulation-based training on CRM TeamSTEPPS and the ETCC on KP 3 in ED settings. In 4 of the reviewed studies, there was at least some improvements in patient health outcomes in KP 4 after the implementation of simulation CRM training but no effect on mortality.\(^3^2\),\(^3^5\),\(^3^9\),\(^4^4\)

TeamSTEPPS Teamwork Attitudes Questionnaire

Five studies showed statistically significant improvement in scores for the 5 constructs of the T-TAQ, demonstrating that using simulation not only significantly enhances health care workers’ attitude toward effective teamwork and communication behaviors but also directly impacts teamwork processes and potentially affects patient safety outcome parameters.\(^3^1\),\(^3^5\),\(^3^7\),\(^3^9\) In comparison with the control EDs, the experimental study showed an improved quality of teamwork, better staff attitudes toward teamwork, and a reduction in the clinical error rates.\(^4^0\)

CRM Training

The study by Grogan et al\(^3^3\) showed comparable positive feedback from the staff. Eighty-six percent reported that the CRM training program improved the safety and quality of health, and 95% believed that it decreased the risk of medical errors.\(^3^3\) Morey et al\(^3^0\) presented a proportional relationship between teamwork integration in the work environment and leaders’ level of involvement. Shapiro et al\(^3^2\) illustrated that adding educational curricula based on CRM and the ETCC in the ED setting had a significant influence on the improvement of communication among healthcare workers.\(^4^1\) Roberts et al\(^3^1\) showed individual or team changes in behaviors (KP 3), demonstrating that team training enhanced situation awareness, care efficiency, patient safety, team functioning, and mutual support.\(^4^1\) Paltved et al\(^3^6\) used the SAQ to evaluate the impact of ISTS training and noted an increase in teamwork and in providers’ attitudes concerning safety.\(^4^7\) The study showed that the safety climate is directly correlated with patient safety.\(^4^6\) Hughes et al\(^3^6\) showed that CRM training significantly improved team dynamics, communication, and patient safety.

Simulation-Based Training Program

Similarly, a training program based on simulation and designed to embed CRM principles and techniques enabled significant perceived improvements reported by participants (KP 1) with regard to communication between staff members. However, this rating increase showed no evidence of a specific effect or improvement in clinical outcomes or safety parameters when these were measured.\(^4^3\) Patterson et al\(^4^5\) showed that in situ, multifaceted simulation-based training could improve clinical care as well as the discovery of threats to patient safety and system issues in clinical environment that are considered to be at higher risks of errors. Capella et al\(^1^5\) found improved patient care after CRM simulation training. In addition, Miller et al\(^4^2\) and Auerbach et al\(^4^4\) showed that airway management, determination of pelvic fracture, and application of cervical spine precautions in patients with real trauma after adult ISTS were improved.

Auerbach et al\(^3^4\) demonstrated as well improved teamwork, higher detection of latent safety threats, and higher levels of satisfaction among participants. Finally, Miller et al\(^3^2\) also demonstrated that in ISTS program, there were significant associated improvements in overall communication and teamwork in clinical settings; however, the improvement was not maintained when ISTS was discontinued.\(^3^2\)

In some studies, conflicting results among studies were found in skill maintenance. In the study by Miller et al,\(^3^2\) sharing of CRM skills in the clinical working environment showed no evidence of sustainability after 1 month, whereas the transfer was retained up to a year in the study by Wong et al.\(^3^7\) Lisbon et al\(^3^9\) found that there was an improvement on attitudes and knowledge during 45 days after baseline (\(P < 0.05\)), maintaining this improvement 90 days after training.

Quality of the Studies

Table 2 presents the quality of the studies according to the NOS marking criteria.\(^3^0\) The scores obtained on the NOS range from 6 to 9. According to this evaluation, the quality of the studies is intermediate to high. The overall average NOS score was 6.9, so we consider the quality of the studies to be intermediate.

DISCUSSION

The principal aim of our systematic review was to explore the effects of evidence-based team training interventions on patient safety culture and outcomes within the ED setting. Sixteen studies that were overall rated as intermediate quality were found. All studies showed improvements in at least one level of the KP framework, often levels 3 or 4.\(^3^6\),\(^4^6\)

We found that participants’ reactions to trainings across studies were positive, with improved professional behavior, knowledge, engagement, and attitudes. Moreover, the overall objectives of the trainings were met. Participants reported enjoying the trainings and believed them to be relevant and valuable in the improvement of teamwork, communication, and patient safety.\(^3^1\),\(^3^6\),\(^3^8\),\(^3^9\),\(^4^1\)–\(^4^3\),\(^4^5\) Our findings agree with previous systematic reviews exploring other health care settings in which the implementation of a safety culture with interventions like teamwork and leadership training was crucial in improving patient safety outcomes.\(^1^8\)–\(^2^4\) Crisis resource management training emphasizes behaviors and requires specific interventions that focus on teamwork, communication, workload management, stress and fatigue management, leadership, and decision making, and recognizes adverse situations.\(^3^2\),\(^3^5\),\(^4^0\),\(^4^3\),\(^6^2\)

It is suggested that CRM simulation-based training could have a significant influence on the improvement of communication among staff and with patients, and staff satisfaction while reducing clinical errors in the ED setting.\(^3^2\),\(^3^5\),\(^4^0\),\(^4^3\) However, evidence concerning CRM training and its impacts on patient safety outcomes and mortality over the long term was lacking. Most of the studies focused on improving nontechnical skills, leadership, and teamwork rather than safety culture or patient safety outcomes. We found heterogeneity in the outcomes described in the selected studies using the KP framework. It is possible that the KP model did not meet all outcomes after simulation training programs in the ED setting.\(^3^6\),\(^6^0\),\(^6^1\),\(^6^3\) We found that in all studies, the authors used approaches that were similar to real-life situations. Safety culture is a subcomponent of organizational culture, and it reveals common behaviors, attitudes, beliefs, and values toward goals, which differ among individuals. The safety culture can be influenced by different types of interventions to enhance teamwork.\(^5^2\),\(^6^4\) The most successful programs that show evidence of positive impact of team training interventions in the ED setting are ECC and TeamSTEPPS CRM-based training. A multicenter prospective study that involved ETCC training in 9 ED
settings showed that team attitudes and perceptions about communication was improved.41 Also, there was an increase in questionnaires scores in TeamSTEPPS implementation in an academic ED improved knowledge, attitudes, behavior, and patient outcomes in levels 3 and 4 of the KP model.31,35,37,39 However, these studies did not determine which specific intervention was the most successful in improving safety culture and patient safety.

Our findings suggest that noticeable changes in culture can result from team improvement strategies that combine several intervention methods. These need to be adapted not only to the participants’ learning styles but also to the actual issues that are being addressed and resources available.65,66

Because any intervention, including an evidence-based validated and standardized intervention, cannot be considered to be also successful in all each health care settings, it may be appropriate to propose actions based on a particular domain within the organization, including teamwork, communication, and safety culture, where performance suggests a broad gap. Crisis resource management simulation-based training for ED teams may result in a significant reduction in clinical errors, without an increase in caregiver workload, and improve the safety culture behavior in ED settings.50–55,67–69 Descriptions of needs assessments, planning, trainings, outcomes, and follow-ups are brief in most studies, which can be a challenge in comparing or synthesizing them. Furthermore, a significant number of factors must be taken into consideration when recommending the type of training that should be implemented and how.

Limitations

We extensively reviewed studies that reported interventions and their impacts on patient safety and safety culture within ED settings. We found that training interventions on teamwork and communication may improve patient safety and safety culture. Nevertheless, our systematic review had several limitations. The variety of interventions and evaluation methods prohibited meta-analysis. The studies published in English only were included and the gray literature was excluded, which may have limited the strength of our review.

### TABLE 2. Quality Assessment of the Studies

| Authors          | Representativeness of the Exposed Cohort | Selection of the Nonexposed Cohort | Ascertainment of Exposure | Outcome of Interest Not Present at Study Start | Comparability of Cohorts | Assessment | Length of Follow-up | Adequacy of Follow-up of Cohorts | Total Score |
|------------------|------------------------------------------|-----------------------------------|---------------------------|-----------------------------------------------|--------------------------|------------|---------------------|----------------------------------|-------------|
| Hefner et al,38  | *                                        | *                                 | *                         | *                                             | *                        | *          | *                   | *                                 | 8           |
| Roberts et al,41 | *                                        | *                                 | *                         | *                                             | *                        | *          | *                   | *                                 | 7           |
| Patterson et al,45| *                                        | *                                 | *                         | *                                             | *                        | *          | *                   | *                                 | 6           |
| Morey et al,43   | **                                       | *                                 | *                         | *                                             | *                        | *          | *                   | *                                 | 9           |
| Jones et al,31   | *                                        | *                                 | *                         | *                                             | *                        | *          | *                   | *                                 | 6           |
| Lisbon et al,39  | *                                        | *                                 | *                         | *                                             | *                        | *          | *                   | *                                 | 6           |
| Hughes et al,36  | *                                        | *                                 | *                         | *                                             | *                        | *          | *                   | *                                 | 8           |
| Grogan et al,33  | *                                        | *                                 | *                         | *                                             | *                        | *          | *                   | *                                 | 6           |
| Auerbach et al,44| *                                        | *                                 | *                         | *                                             | *                        | *          | *                   | *                                 | 7           |
| Miller et al,32  | *                                        | *                                 | *                         | *                                             | *                        | *          | *                   | *                                 | 6           |
| Wong et al,37    | *                                        | *                                 | *                         | *                                             | *                        | *          | *                   | *                                 | 8           |
| Capella et al,35 | *                                        | *                                 | *                         | *                                             | *                        | *          | *                   | *                                 | 7           |
| Sweeney et al,43 | *                                        | *                                 | *                         | *                                             | *                        | *          | *                   | *                                 | 6           |
| Shapiro et al,42 | *                                        | *                                 | *                         | **                                            | *                        | *          | *                   | *                                 | 8           |
| Palvand et al,36 | *                                        | *                                 | *                         | *                                             | *                        | *          | *                   | *                                 | 6           |
| Obenrader et al,44| *                                       | *                                 | *                         | *                                             | *                        | *          | *                   | *                                 | 6           |

The Newcastle-Ottawa Quality Assessment Scale consists of 4 items on study selection, 1 item on comparability, and 3 items on study outcomes. According to this scale, studies can be awarded one star for each of the 4 items on selection and for each of the 3 items on outcomes and a maximum of 2 stars for comparability. Stars are awarded such that the highest-quality studies are awarded up to 9 stars.
We narratively summarize peer-reviewed studies to gather scientific evidence on how team and communication training impacts patients and safety culture. Furthermore, 15 of 16 studies were conducted in the United States, which could limit the generalization of the results.

CONCLUSIONS

Overall, our systematic review suggests that training interventions on teamwork and communication may improve the culture of safety and patient safety in the ED setting. The adoption of safety culture programs in the EDs must be considered to reduce medical errors and adverse events. There is a need for further research focused on assessing multiprofessional teamwork and communication skills to ensure a better understanding of team performance and propose relevant solutions that would improve patient safety in the ED setting.

ACKNOWLEDGMENTS

We are grateful to Margo Coletti, Director of Information Systems—Knowledge Services, Beth Israel Deaconess Medical Center, Boston, Massachusetts, to have updated the databases search.

REFERENCES

1. Kohn LT, Corrigan JM, Donaldson MS. To Err Is Human: Building a Safer Health System. Washington, DC: National Academies Press; 2000.
2. Leape LL, Brennan TA, Laird N, et al. The nature of adverse events in hospitalized patients. Results of the Harvard medical: practice study II. N Engl J Med. 1991;324:377–384.
3. National Patient Safety Foundation. Free from Harm: Accelerating Patient Safety Improvement Fifteen Years After to Err Is Human. Boston, MA: National Patient Safety Foundation; 2015.
4. Makary MA, Daniel M. Medical error—the third leading cause of death in the US. BMJ. 2016;353:i2139.
5. Joint Commission on Accreditation of Healthcare Organizations. The Joint Commission Guide to Improving Staff Communication. Oakbrook Terrace, IL: Joint Commission Resources; 2005.
6. Health and Safety Commission. ACNI Study Group on Human Factors. 3rd Report: Organizing for Safety. London: HMSO; 1993.
7. Salas E, DiazGranados D, Weaver SJ, et al. Does team training work? Principles for health care. Acad Emerg Med. 2008;15:1002–1009.
8. Hackman JR. The design of work teams. In: Lorsch JW, ed. Handbook of Organizational Behavior. Englewood Cliffs, NJ: Prentice Hall; 1987:315–342.
9. Salas E, Reyes DL, McDaniel SH. The science of teamwork: progress, reflections, and the road ahead. Am Psychol. 2018;73:593–600.
10. Sorbero ME, Farley DO, Mattke S, et al. Outcome Measures for Effective Teamwork in Inpatient Care (RAND Technical Report TR-462 AHRQ). Arlington, VA: RAND Corporation; 2008.
11. Shuffler ML, DiazGranados D, Salas E. There’a science for that: team development interventions in organizations. Curr Dir Psychol Sci. 2011;20:365–372.
12. Lacerenza CN, Marlow SL, Tannenbaum SI, et al. Team development interventions: evidence-based approaches for improving teamwork. Am Psychol. 2018;73:517–531.
13. Muñoz-Marrón D. Factores Humanos En Aviación: Crm (Crew Resource Management Gestión De Recursos De La Tripulación). Pap Psicolí. 2018; 39. doi:10.23923/pap.psicol2018.2870.
14. Howard SK, Gaba DM, Fish KJ, et al. Anesthesia crisis resource management training: teaching anesthesiologists to handle critical incidents. Aviat Space Environ Med. 1992;63:763–770.
15. Risser DT, Rice MM, Salisbury ML, et al. The potential for improved teamwork to reduce medical errors in the emergency department. The MedTeams Research Consortium. Ann Emerg Med. 1999;34:373–383.
16. Eisenberg EM, Murphy AG, Sutcliffe K, et al. Communication in emergency medicine: implications for patient safety. Commun Monogr. 2005;72:390–413.
17. Ramakrishnan S, Qayyum H, Burke D, et al. The safety of emergency medicine. Emerg Med J. 2015;33:293–299.
18. McCulloch P, Rathbone J, Catchpole K. Interventions to improve teamwork and communications among healthcare staff. Br J Surg. 2011;98:469–479.
19. Weaver SJ, Dy SM, Rosen MA. Team-training in healthcare: a narrative synthesis of the literature. BMJ Qual Saf. 2014;23:359–372.
20. Hughes AM, Gregory ME, Joseph DL, et al. Saving lives: a meta-analysis of team training in healthcare. J Appl Psychol. 2016;101:1266–1304.
21. Weaver SJ, Lyons R, DiazGranados D, et al. The anatomy of health care team training and the state of practice: a critical review. Acad Med. 2010; 85:1746–1760.
22. Marlow SL, Hughes AM, Sonesh SC, et al. A systematic review of team training in health care: ten questions. Jt Comm J Qual Patient Saf. 2017; 43:197–204.
23. O’Dea A, O’Connor P, Keogh I. A meta-analysis of the effectiveness of crew resource management training in acute care domains. Postgrad Med J. 2014;90:699–708.
24. Weaver SJ, Lubomksi LH, Wilson RF, et al. Promoting a culture of safety as a patient safety strategy: a systematic review. Ann Intern Med. 2013; 158:369–374.
25. Husebo SE, Akerjordet K. Quantitative systematic review of multi-professional teamwork and leadership training to optimize patient outcomes in acute hospital settings. J Adv Nurs. 2016;72:2980–3000.
26. Moher D, Liberati A, Tetzlaff J, et al. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med. 2009;6:e1000097.
27. Schardt C, Adams MB, Owens T, et al. Utilization of the PICO framework to improve searching PubMed for clinical questions. BMC Med Inform Decis Mak. 2007;7:16.
28. F1000Workspace. F1000Workspace (v35). Computer Software. London, UK: Faculty of 1000 Ltd; Available at: https://www.f1000workspace.com/.
29. Khan KS, Kunz R, Kleijnen J, et al. Five steps to conducting a systematic review. J R Soc Med. 2003;96:118–121.
30. Wells GA, Shea B, O’Connell D, et al. The Newcastle-Ottawa Scale (NOS) for Assessing the Quality of Non-randomized Studies in Meta-analysis. Rockville, MD: Agency for Healthcare Research and Quality; 2013.
31. Jones F, Podila P, Powers C. Creating a culture of safety in the emergency department. J Nurs Adm. 2013;43:194–200.
32. Miller D, Crandall C, Washington C, et al. Improving teamwork and communication in trauma care through in situ simulations. Acad Emerg Med. 2012;19:608–612.
33. Grogan EL, Stiles RA, France DJ, et al. The impact of aviation-based teamwork training on the attitudes of health-care professionals. J Am Coll Surg. 2004;199:843–848.
34. Obenrader C, Broome ME, Yap TL, et al. Changing team member perceptions by implementing TeamSTEPPS in an emergency department. J Emerg Nurs. 2019;45:31–37.
35. Capella J, Smith S, Philp A, et al. Teamwork training improves the clinical care of trauma patients. J Surg Educ. 2010;67:439–443.
36. Hughes KM, Benenson RS, Krichtien AE, et al. A crew resource management program tailored to trauma resuscitation improves team behavior and communication. J Am Coll Surg. 2014;219:545–551.
37. Wong AH, Gang M, Szylud D, et al. Making an “attitude adjustment”: using a simulation-enhanced interprofessional education strategy to improve
attitudes toward teamwork and communication. Simul Healthc. 2016;11:117–125.
38. Hefner JL, Hillgoss B, Knupp A, et al. Cultural transformation after implementation of crew resource management: is it really possible? Am J Med Qual. 2016;32:384–390.
39. Lisbon D, Allin D, Cleek C, et al. Improved knowledge, attitudes, and behaviors after implementation of teamstepps training in an academic emergency department. Am J Med Qual. 2014;31:86–90.
40. Morey JC, Simon R, Jay GD, et al. Error reduction and performance improvement in the emergency department through formal teamwork training: evaluation results of the medteams project. Health Serv Res. 2002;37:1553–1581.
41. Roberts NK, Williams RG, Schwind CJ, et al. The impact of brief team communication, leadership and team behavior training on ad hoc team performance in trauma care settings. Am J Surg. 2014;207:170–178.
42. Shapiro MJ, Morey JC, Small SD, et al. Simulation based teamwork training for emergency department staff: does it improve clinical team performance when added to an existing didactic teamwork curriculum? Qual Saf Health Care. 2004;13:417–421.
43. Sweeney LA, Warren O, Gardner L, et al. A simulation-based training program improves emergency department staff communication. Am J Med Qual. 2013;29:115–123.
44. Auerbach M, Roney L, Aysseh A, et al. In situ pediatric trauma simulation. Pediatr Emerg Care. 2014;30:884–891.
45. Patterson MD, Geis GL, Falcone RA, et al. In situ simulation: detection of safety threats and teamwork training in a high risk emergency department. BMJ Qual Saf. 2013;22:468–477.
46. Paltved C, Bjerggaard AT, Krogh K, et al. Designing in situ simulation in the emergency department: evaluating safety attitudes amongst physicians and nurses. Adv Simul. 2017;2:4.
47. Helmreich RL, Merritt AC, Sherman PJ, et al. The Flight Management Attitudes Questionnaire (FMAQ). NASA/UT/FAA Technical Report 93-4. Austin, TX: The University of Texas; 1993.
48. Helmreich RL, Merritt AC. Culture at Work in Aviation and Medicine: National, Organizational, and Professional Influences. Aldershot, UK: Ashgate Publishing Limited; 1998.
49. Agency for Healthcare Research and Quality. Surveys on Patient Safety Culture™. Available at: http://www.ahrq.gov/professionals/quality-patient-safety/patientsafetyculture/index.html. Accessed August 2017.
50. Agency for Healthcare Research and Quality. Internet Citation: TeamSTEPPS Fundamentals Course: Module 1. Introduction. Available at: http://www.ahrq.gov/teamstepps/instructor/fundamentals/module1/slintro.html. Accessed March 2018.
51. Finl R, Glavin R, Maran R, et al. ANTS System—Observation and Rating Sheet 2004. Available at: https://www.abdn.ac.uk/iprc/documents/ANTS%20Handbook%202012.pdf. Accessed June 30, 2018.
52. Helmreich RL, Wilhelm JA, Gregorich SE, et al. Preliminary results from the evaluation of cockpit resource management training: performance ratings of flightcrews. Aviat Space Environ Med. 1990;61:576–579.
53. Helmreich RL, Wilhelm JA, Kelle JO, et al. Reinforcing and Evaluating Crew Resource Management: Evaluator/LOS Instructor Reference Manual. Austin, TX: NASA–University of Texas at Austin; 1990.
54. Frankel A, Gardner R, Maynard L, et al. Using the Communication and Teamwork Skills (CATS) assessment to measure health care team performance. Jr Comm J Qual Patient Saf. 2007;33:549–558.
55. Guise J-M, Deering S, Kanki B, et al. Validation of a tool to measure and promote clinical teamwork. Simul Healthc. 2008;3:217–223.
56. Team Performance Observation Tool. TeamSTEPPS 2.0 Available at: https://www.ahrq.gov/sites/default/files/wysiwyg/professionals/education/culture-tools/teamstepps/instructor/reference/tmpot.pdf.
57. Kirkpatrick DL, Kirkpatrick JD. Evaluating Training Programs: The Four Levels. San Francisco, CA: Berrett-Koehler Publishers; 2006.
58. Sitzmann T, Brown KG, Casper WJ, et al. A review and meta-analysis of the nomological network of trainee reactions. J Appl Psychol. 2008;93:280–295.
59. Weaver SJ, Rosen MA, DiazGranados D, et al. Does teamwork improve performance in the operating room? A multilevel evaluation. Jr Comm J Qual Patient Saf. 2010;36:133–142.
60. Jones KJ, Skinner AM, High R, et al. A theory-driven, longitudinal evaluation of the impact of team training on safety culture in 24 hospitals. BMJ Qual Saf. 2013;22:394–404.
61. Kirkpatrick D. Great ideas revisited: revisiting Kirkpatrick’s four-level model. Train Dev. 1996;50:54–57.
62. Salas E, Wilson KA, Burke CS, et al. Does crew resource management training work? An update, an extension, and some critical needs. Hum Factors. 2006;48:392–412.
63. Kirkpatrick D. The Four Levels of Evaluation (No. 701). Pewaukee, WI: American Society for Training and Development; 2007.
64. Sorra JS, Nieva VF. Hospital Survey on Patient Safety Culture. The Agency for Healthcare Research and Quality: Rockville, MD: 2004. Prepared by Westat, under Contract No. 290-96-0004. AHRQ Publication No. 04-0041.
65. Der Sahakian G, Buléon C, Alinier G. Educational Foundations of Instructional Design Applied to Simulation-Based Education. In: Chiniara G, ed. Clinical Simulation: Education, Operations, and Engineering. 2nd ed. Cambridge: Academic Press; 2019:185–206.
66. Alinier G, Hssain I. Creating Effective Learning Environments: The Educator’s Perspective. In: Chiniara G, ed. Clinical Simulation: Education, Operations, and Engineering. 2nd ed. Cambridge: Academic Press; 2019:217–227.
67. Cooper MD. Towards a model of safety culture. Saf Sci. 2000;36:111–136.
68. Kapur N, Parand A, Soukup T, et al. Aviation and healthcare: a comparative review with implications for patient safety. JRSM Open. 2016;7:205427041561654.
69. Clarke S, Horeczko T, Carlisle M, et al. Emergency medicine resident crisis resource management ability: a simulation-based longitudinal study. Med Educ Online. 2014;19:25771.