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Team-training in healthcare: a narrative synthesis of the literature

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ABSTRACT

Background Patients are safer and receive higher quality care when providers work as a highly effective team. Investment in optimising healthcare teamwork has swelled in the last 10 years. Consequently, evidence regarding the effectiveness for these interventions has also grown rapidly. We provide an updated review concerning the current state of team-training science and practice in acute care settings.

Methods A PubMed search for review articles examining team-training interventions in acute care settings published between 2000 and 2012 was conducted. Following identification of relevant reviews with searches terminating in 2008 and 2010, PubMed and PSNet were searched for additional primary studies published in 2011 and 2012. Primary outcomes included patient outcomes and quality indices. Secondary outcomes included teamwork behaviours, knowledge and attitudes.

Results Both simulation and classroom-based team-training interventions can improve teamwork processes (eg, communication, coordination and cooperation), and implementation has been associated with improvements in patient safety outcomes. Thirteen studies published between 2011 and 2012 reported statistically significant changes in teamwork behaviours, processes or emergent states and 10 reported significant improvement in clinical care processes or patient outcomes, including mortality and morbidity. Effects were reported across a range of clinical contexts. Larger effect sizes were reported for bundled team-training interventions that included tools and organisational changes to support sustainment and transfer of teamwork competencies into daily practice.

Conclusions Overall, moderate-to-high-quality evidence suggests team-training can positively impact healthcare team processes and patient outcomes. Additionally, toolkits are available to support intervention development and implementation. Evidence suggests bundled team-training interventions and implementation strategies that embed effective teamwork as a foundation for other improvement efforts may offer greatest impact on patient outcomes.

INTRODUCTION

> …It has become necessary to develop medicine as a cooperative science; the clinician, the specialist, and the laboratory workers uniting for the good of the patient, each assisting in elucidation of the problem at hand, and each dependent upon the other for support. – William J. Mayo, Commencement speech at Rush Medical College, 1910

Deficiencies in communication and teamwork have long been cited as a frequent contributor to adverse events. Precise estimates of the extent of the problem are difficult to make, given definitional, reporting and measurement inconsistencies. However, a variety of studies support the notion that teamwork and communication are critical components of safe healthcare systems. Previous reviews report linkages between various aspects of teamwork (eg, situational monitoring, communication, leadership, trust, shared mental models) and clinical performance.[1–3] Meta-analytic results suggest the relationship between team processes and clinical performance indicators has generally been characterised by medium to large effect sizes.[4 5] For example, studies in surgery have shown increased odds of complications and death (OR 4.82; 95% CI 1.30 to 17.87) when surgical teams exhibit less frequent teamwork behaviours (eg, less information sharing during intraoperative and handoff phases, and less briefing).[6] Reviews of malpractice claims further underscore that communication problems are major contributing factors in 24% of cases.[7] Other studies found teamwork and communication issues cited as root causes in 52–70% of adverse events.[8 9] Additionally, teamwork and communication dimensions of safety

culture have been significantly related to adverse clinical events.[10 11]

The 2001 Making Health Care Safer report[12] provided one of the early reviews concerning the topic of healthcare team-training in a chapter entitled 'Crew Resource Management and Its Application in Medicine'. This review discussed early conceptualisations of team-training in other high-reliability industries such as aviation and summarised early studies attempting to translate team-training principles developed elsewhere into healthcare settings. The development and implementation of team-training programmes in acute care settings has grown dramatically in the last decade with improvements in content, methods and evaluation desgins.[13–15] Advances in training content, implementation and evaluation have increasingly drawn on over 30 years of evidence examining team performance processes and team-training across a wide variety of high-risk environments.[16] While previous reviews described the state of team-training in healthcare through 2009,[13 14] the prevalence of peer-reviewed literature evaluating team-training interventions continues to grow. Publication trends suggest that in the last 5 years, over 448 papers examining teamwork topics in a variety of languages, across a variety of care settings, have appeared in PubMed (see figure 1). Additionally, team-training was formally identified in 2013 as a top patient safety strategy encouraged for adoption in acute care settings.[17] Therefore, our objective is to provide an updated narrative synthesis of the body of evidence evaluating team-training in acute care settings, including implementation trends, evidence for effectiveness and potential boundary conditions (ie, factors that may enhance or inhibit effectiveness). In providing this updated review, we hope to also highlight fruitful areas for future research and innovative practice.

Types of team-training strategies

Team-training is defined as a constellation of content (ie, the specific knowledge, skills and attitudes that underlie targeted teamwork competencies), tools (ie, team task analysis, performance measures) and delivery methods (ie, information, demonstration and practice-based learning methods) that together form an instructional strategy.[18] In this sense, team-training is a systematic methodology for optimising the communication, coordination and collaboration of healthcare teams that combines specific content with opportunities for practice, formative feedback and tools to support transfer of training to the daily care environment.

As described by the National Quality Forum[19]:

> Health care organizations must establish a proactive, systematic, organization-wide approach to developing team-based care through teamwork training, skill building, and team-led performance improvement interventions that reduce preventable harm to patients…training programs should systematically address and apply the principles of effective team leadership, team formation [and team processes].

Borrowing from other high-reliability communities, team-training in healthcare originated largely in the form of Crew Resource Management (CRM), a specific team-training strategy focused on developing a subset of teamwork competencies including hazard identification, assertive communication and collective management of available resources.[20–23] However, the practice of team-training is much broader. Today, team-training is an overarching term that encompasses a broad range of learning and development strategies, methods and teamwork competencies. Table 1 outlines several types of team-training strategies.

The critical element defining team-training is that the learning activity focuses on developing, refining and reinforcing knowledge, skills or attitudes that underlie effective teamwork behaviours such as communication, coordination and collaboration. Prior reviews found that the most commonly targeted teamwork competencies include communication, situational awareness, leadership, role clarity and coordination.[14 24–27] To this end team-training activities are often designed to develop generalisable, transportable teamwork competencies that learners can apply across different settings and teams. This differentiates team-training from learning activities focused on technical clinical skills (eg, differential diagnosis and procedural skills), as well as team building exercises focused on developing emergent states such as trust or cohesion among members of an intact team.

METHODS

A PubMed search for key review articles examining team-training interventions in acute care settings published between January 2000 and December 2012 was conducted. Key search terms included 'team-training', 'teamwork training', 'teamwork training interventions', 'crew resource management', 'TeamSTEPPS' and related terms. Following identification of relevant reviews with searches terminating in 2008,[13] 2009[12 21] and 2010,[24 25] a search of PubMed and PSNet was completed to identify additional primary studies published between 1 January 2011 and 31 December 2012. Studies were excluded if they were only descriptive in nature, if conducted in non-English-speaking populations or if primarily targeting students or trainees. Narrative summaries of individual studies and shared themes are presented. This review was supported by Agency for Healthcare Research and Quality (AHRQ), which had no role in the selection or review of the evidence or the decision to submit this manuscript for publication.

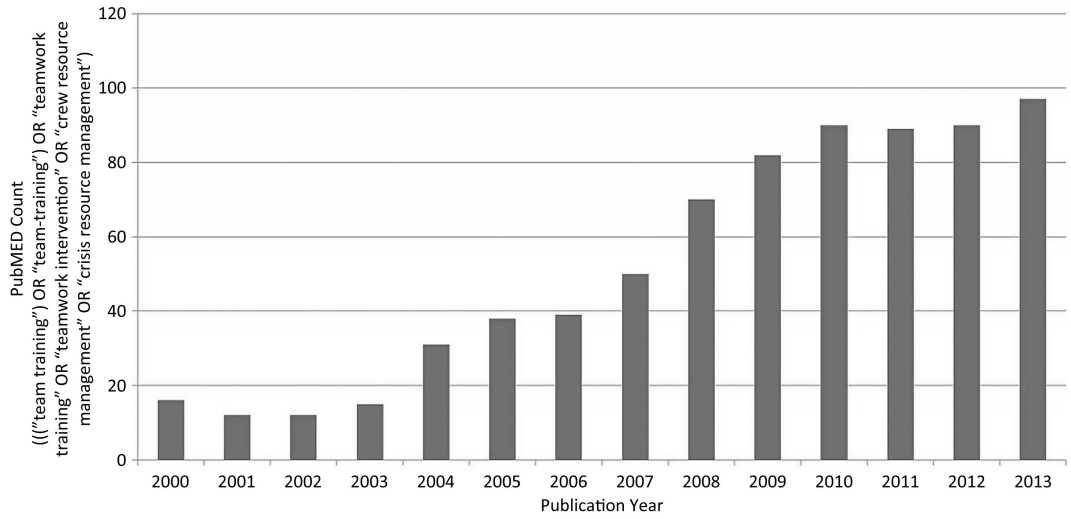

Figure 1 PubMed publication trends from 2000 through October 2013 for team-training and related concepts.

RESULTS

Several previous reviews have examined the effectiveness and implementation of healthcare team-training.[2 13–15 23–33] For example, one systematic review of interventions to improve team effectiveness in healthcare found that the majority involved some form of team-training (42 of 48 reviewed studies).[13] Other reviews investigated the effectiveness of team-training for obstetric emergencies,[33] for enhancing communication in surgery and anaesthesia,[20 25 31] classroom-based interventions[27] and simulation-based interventions.[15 24 30] Additionally, several reviews investigated the content, design and delivery of team-training and the impact of team processes on clinical processes and outcomes.[2 14 24 26 29 31 32 34] We draw on results from these reviews and 26 articles published since their searches terminated in order to describe the current body of evidence regarding the effectiveness of team-training in acute care settings, the contexts in which it has been evaluated and effects of different design and delivery methods. Findings from 26 studies published after previous reviews concluded their searches are summarised in table 2 and discussed in greater detail in subsequent sections (see online supplementary appendix for detailed evidence summary).

What is the context for team-training?

Previous reviews highlight that team-training has been implemented across a broad range of acute care contexts.[2 13 14 27 30] This includes academic hospitals[35] and community-based hospitals,[36 37] as well as medical centres affiliated with the Veterans Administration (VA) and the Military Health System.[38–40] Though our focus is on current practitioners,[41–44] team-training programmes have focused on a variety of audiences including students and clinical trainees.[45 46] The majority of studies have focused on evaluating team-training efforts among frontline clinicians working in obstetric or perioperative care areas; however, studies have also been conducted in emergency and critical care, procedural areas (eg, endoscopy) and administration. For example, table 2 demonstrates that 9 studies of the 26 published between 2011 and 2012 were conducted in surgical work areas, 5 were conducted in critical care or inpatient nursing units and 4 were conducted in obstetrical or emergency/trauma settings, respectively. Four studies were conducted in other areas, including procedural areas or administration, or were conducted across multiple types of care areas.

Team-training programmes for hospital leaders have also demonstrated positive effects. Individual executive leadership development programmes fall outside the scope of traditional team-training initiatives; however, team-training programmes for executive leaders is an area ripe for further research as many healthcare organisations move towards enterprise affiliations and Accountable Care Organization (ACO) models. In this way administrators, service line leaders, division leaders and frontline providers increasingly manage and work not only in teams, but as part of teams-of-teams, or multiteam systems (MTS).[47 48] MTSs are defined as two or more teams that work interdependently towards at least one common goal.[49] Initial work has begun to examine the leadership competencies that matter most in these contexts and to test interventions to cultivate them.[50 51] However, further development and evaluation of team-training interventions targeting MTSs within the healthcare context are needed.

Team type

Teamwork in healthcare is often characterised by highly dynamic team membership, participation on multiple teams and rapid team formation. As opposed to intact teams who have a history and future working together, some types of healthcare teams, particularly in acute care settings, may not have ever worked together before, form under stressful conditions (eg, a

Table 1 Team-training strategies

Team-training strategy	Definition	Primary teamwork competencies targeted	Best practices
Assertiveness training	Dedicated to developing communication strategies that support task-relevant and team-performance relevant assertiveness	▶ Backup behaviour ▶ Closed-loop communication ▶ Conflict management ▶ Mutual trust ▶ Psychological safety ▶ Team leadership	▶ Clearly define training objectives around task-relevant and team performance assertiveness rather than general assertive behaviours and differentiate from aggressive behaviours. ▶ Compare and contrast effective and ineffective assertive behaviours ▶ Provide opportunities to practice appropriate assertiveness that include feedback. Practice should also strive to include realistic time pressures or other stressors to allow practice using and reacting to appropriate assertiveness under such conditions.
Cross -training	Team members learn the roles that comprise the team, as well as the tasks, duties, and responsibilities fulfilled by fellow team members.	▶ Accurate and shared mental models (SMMs) of team roles and responsibilities	▶ Include information about the roles and responsibilities of other team members and how they operate to achieve these. ▶ Explain the *why*— clarify who members depend on for information. ▶ Provide opportunities to shadow another role if possible. ▶ Provide feedback during cross-training that facilitates the formation of reasonable expectations of one another.
Error management training	Participants are encouraged to make errors during training scenarios, analyse these errors and practice error recognition and management skills.	▶ Collective efficacy ▶ Cue-strategy associations ▶ SMMs ▶ Team adaptation	▶ Ensure trainees understand the purpose of this training strategy is to encounter errors and to have the opportunity to practice managing them in a safe environment. ▶ Frame errors as positive opportunities for learning. ▶ Embed the opportunity to make errors into training scenarios by providing minimal guidance during the scenario. ▶ Follow the scenario with immediate feedback and discussion to facilitate learning.
Guided team self-correction	Strategy designed around a cycle of facilitated briefings and debriefings that occur around a training scenario or live event.	▶ Backup behaviour ▶ Collective orientation ▶ Closed-loop communication ▶ Cue-strategy associations ▶ Mission analysis ▶ Mutual trust ▶ SMMs ▶ Team adaptation ▶ Team leadership	▶ Define the team self-correction skills to be trained prior to team self-correction training. ▶ Record positive and negative examples of teamwork dimensions during team performance episode. ▶ Classify and prioritise observations, diagnose strengths and weaknesses, and identify goals for improvement before beginning debrief. ▶ Set the stage for team participation and solicit examples of teamwork behaviour during debrief.

Continued

Table 1 Continued

Team-training strategy	Definition	Primary teamwork competencies targeted	Best practices
Metacognition training	Focuses on developing cognitive aspects of team performance by teaching strategies dedicated to analysing, updating and aligning mental models of the s task, coordination strategy, and contingencies.	Cue-strategy associations Mission analysis SMMs Team adaptation	Develop training objectives around cognitive processes such as planning, monitoring and re-analysis. Structure metacognitive practice tasks around a subject that trainees have pre-existing knowledge about.
Team adaptation and coordination training	Focuses on how to effectively use all available resources (ie, people, information, etc.) through effective team communication, coordination and cooperation. Crew or Crisis Resource Management is a form of TACT.	▶ Backup behaviour ▶ Closed-loop communication ▶ Cue-strategy associations ▶ Mission analysis ▶ Mutual performance monitoring ▶ Leadership ▶ Shared mental models	▶ Develop training objectives that address around transportable teamwork competencies for ad-hoc teams (no history or future). ▶ Training team-specific competencies can also be incorporated for intact teams. ▶ Train intact teams together if possible. ▶ Create opportunities for both guided and unguided practice. ▶ Develop feedback mechanisms that engage self-reflection and team self-correction following practice opportunities. ▶ Develop tools that support effective teamwork, but recognise that tools alone (eg, checklists) cannot optimise team performance (and alone may negatively impact performance).

Adapted from Salas *et al*.[32]

code) and may not have great likelihood of working together closely in the future. Such teams are known as ad hoc teams or action teams and are defined by rapid formation, an abbreviated lifespan and often limited experience working together previously. Given this context, can team-training be effective for such ad hoc teams? Previous reviews indicate that healthcare team-training has been conducted with intact (ie, teams who work together currently or on a regular basis) and ad hoc teams (ie, teams formed quickly for brief periods of performance or for training purposes only). For example, Weaver[14] found eight studies that reported training intact teams and five studies that reported training in ad hoc teams. One meta-analysis that examined team-training effectiveness across a variety of industries including healthcare found similar effect sizes for teams who worked together on a regular basis (intact teams $\rho=0.48$) and teams who did not (ad hoc teams $\rho=0.44$).[4] A second meta-analysis that also examined the effects of team-training on overall team performance across a range of settings found that team-training had a greater positive impact on the performance of ad hoc teams ($d_{Intact}=0.62$; $d_{Adhoc}=0.92$); however, the difference was not statistically significant.[52] Within healthcare, several of the most robust studies have used training strategies allowing teams to train together (eg, closing the operating room for 1 day so that team members could attend training together); however, this is not a boundary condition for training effectiveness.

What have we learned about team-training design and delivery?

Several reviews of team-training and team processes in healthcare have also examined training design and delivery.[13 14 24 27 31] These reviews find variation among programmes in the teamwork competencies targeted, curriculum used, how much time learners spend in training, how often clinicians and staff are participating, and other details regarding content, delivery strategies and evaluation efforts.

Training content

As described earlier, many different types of training strategies fall under the umbrella of team-training. Previous reviews found communication, situational awareness, leadership and situation monitoring as the most common teamwork competencies targeted.[14 27] Table 2 emphasises that similar competencies have also been the focus of more recent primary studies, particularly as the adoption of teamwork training curriculums built around these competencies (eg, TeamSTEPPS, CRM, VA Medical Team Training (VA MTT)) has grown. For example, 9 of the 26 studies reviewed used some form of CRM, 7 reported using components of the TeamSTEPPS curriculum and 3

Table 2 Studies examining team-training effects on clinical process or patient outcomes

	Study characteristics			
	Curriculum	**Setting**	**Design**	**Clinical processes or patient outcomes**
Andreatta 2011[41]	OBEMAN	OB	Descriptive	▶ Five types of incongruent hospital policies or procedures governing clinical practice identified
Armour 2011[42]	TS	OR	Time series	▶ Significant reduction in surgical morbidity (20.2% vs 11% *) and mortality (2.7% vs 1%*) ▶ Significant improvement in 4 of 6 SQIP measures* ▶ Room turnover time decreased significantly (43 vs 35.5 min*), percentage of on-time first case starts improved (69% to 81%+) ▶ Patient willingness to recommend significantly improved (77% to 89.3%*) ▶ Evidence of some decay over 1 year post-training follow-up for mortality, morbidity, on-time starts and patient satisfaction, while SQIP remained improved
Carney 2011[69]	VA MTT	OR	Pre-post	
Castner 2012[85]	TS	Multiple	NCGPT	
Cooper 2011[53]	Leadership TT	Hospital management	Post only	
Deering 2011[39]	TS	Combat support hospital	Pre-post	▶ Decreased number of adverse events (22.2 vs 18.2 events^{+}) ▶ 83% decrease in medication and transfusion errors (7.1 vs 1.2*), 70% decrease in needlestick injury and exposures (4.0 vs 1.2*), 65% decrease communication incidents (5.2 vs 1.8*) ▶ No significant decrease in incidents related to three other teamwork competencies
Figueroa 2012[65]	TS	ICU	Time series	
Fransen 2012[43]	Multidisciplinary	OB	Cluster RCT	▶ Trained teams adhered to predefined obstetric procedures more frequently than non-trained teams (83% vs 46%*)
Frengley 2011[86]	CRM	ICU	NCGPPT	▶ Regardless of modality that clinical management skills were also taught, all participating teams improved clinical management scores*
Heard 2011[87]	CRM	Endoscopy	Time series	
Kirschbaum 2012[88]	Multidisciplinary	OR	Pre-post	
Maxson 2011[89]	TS	Surgery	Time series	
Mayer 2011[35]	TS	PICU SICU	Longitudinal with non-equivalent control	▶ Nosocomial infections decreased slightly^{+} ▶ Average time for placing patients on extracorporeal membrane oxygenation (ECMO) decreased (23 vs 14 min*) ▶ No significant change in length of rapid response team events
McLaughlin 2011[44]	Trauma TT	Trauma	Post-only	
Neily 2011[38]	VA MTT	OR	RCC	▶ 50% greater reduction in risk-adjusted surgical mortality for MTT group versus control (RR=1.49)* ▶ Reduction of 0.5 deaths per 1000 procedures associated with every quarter that teamwork intervention was in place* ▶ Qualitative interviews suggested improvements in overall perioperative efficiency, reduced length of procedures, improved first case on-time start times and equipment use

Continued

Table 2 Continued

	Study characteristics			
	Curriculum	**Setting**	**Design**	**Clinical processes or patient outcomes**
Patterson 2013 (online 2012)[66]	Multidisciplinary TT	Paediatric ED	Time series	▶ Patient safety event rate decreased (2–3 annually vs 1000 days since safety event, 12 m post)
Phipps 2012[70]	CRM	L&D	Pre-post	▶ Decrease in adverse outcome index (AOI) (0.052 pre vs 0.043 post) ▶ No significant change in patient satisfaction
Riley 2011[36]	TS	L&D	NCGPPT	▶ Weighted adverse outcome score (WAOS)—an index of perinatal harm—decreased 37% for full intervention group only (1.15 pre vs 0.72 post*) ▶ Variability in WAOS scores was decreased post-training for full intervention group only
Singer 2011[54]	Leadership TT	Hospital mgmt.	Qual. Longitudinal	
Steinemann 2011[90]	CRM	Trauma	Prospective cohort	▶ 16% reduction in ED resuscitation time*, 76% increase in completeness of clinical tasks* ▶ No significant changes in mean hospital length of stay, ICU days or deaths
Stevens 2012[71]	CRM	Cardiac surgery	Pre-post	
Stocker 2012[91]	CRM	PICU	Time series	
Tapson 2011[80]	CRM	Surgery	Longitudinal	▶ Significantly more post-training than pretraining charts met guideline recommendations and standards of care for timing, inpatient duration and prophylaxis use beyond discharge*
van Schaik 2011[92]	CRM	PICU	Cross-sectional	
Volk 2011[93]	CRM	OR	Post-only	
Young-Xu 2011[58]	VA MTT	OR	RCC	▶ 20% greater reduction in risk-adjusted surgical morbidity in the MTT group versus control (RR=1.20)*

+, improvement, but not statistically significant; CBT, case based learning; CRM, Crew or Crisis Resource Management; L&D, labor and delivery; NCGPT, non-equivalent comparison group post-test only; NCGPPT, non-equivalent comparison groups pre-test/post-test; OB, obstetrics; OBEMAN, obstetrics, emergency medicine, anesthesiology, and neonatology program; OR, operating room; Peds, pediatrics; PICU, pediatric intensive care unit; RCC, retrospective controlled cohort study; SBT, simulation based training; SICU, surgical intensive care unit; TS, TeamSTEPPS; VA MTT, VA Medical Team Training. *p<0.05.

studies used VA MTT. Seven studies reported using other team-training curriculums.

More narrowly defined programmes targeting deep development of specific teamwork skills (eg, leadership) in the healthcare context have also been evaluated. Two[53 54] of the twenty-six studies reviewed specifically evaluated an intervention designed to develop teamwork competencies among hospital leaders and administrators. Such programmes may differ from those focused on frontline providers in the level of emphasis on certain teamwork competencies (eg, transformational leadership, conflict management and mediation, broader internal and external environment awareness, boundary spanning activities that facilitate coordination with other internal or external teams, etc., may be of greater emphasis),[55 56] as well as design (eg, greater use of table-top simulations or game-based approaches).[57]

Training modality and methods

The evidence to date demonstrates that healthcare team-training programmes vary in the instructional modalities and methods used. Instructional methods can be conceptualised in terms of three broad categories: (1) information-based methods (eg, didactic lecture), (2) demonstration-based methods (eg, behavioural modelling, videos) and (3) practice-based methods (eg, simulation, role playing). Previous reviews found that the majority (83%) of team-training programmes integrated both information and practice-based methods, while only 35% reported incorporated demonstration-based activities.[14]

Simulation-based versus *classroom-based training.* Simulation is a broad training modality that may include physical simulation of clinical care environments, standardised patients, cognitive simulations and role play. It includes both centre-based learning activities and in situ activities that occur in the actual environment where care is provided.

Simulation is a common modality for team-training in healthcare. Previous reviews found 68% of programmes using simulation-based activities.[14] Several reviews have examined simulation-based team-training exclusively.[15 24 30] In terms of outcomes, previous

reviews examining simulation-based team-training[15 24 30] and classroom-based team-training[27] separately reported similar positive effects on learner reactions, knowledge or skills, and clinical practices. In terms of patient outcomes, both simulation studies and classroom-based studies have shown a positive impact on patient outcomes. Though simulation is powerful learning activity, particularly for teamwork competencies, some of the most robust studies published since these previous reviews were completed did not use elaborate simulation methods, but still achieved significant reductions in both mortality and morbidity.[38 58] Direct comparison studies also provide insight. Riley[36] compared perinatal work areas in three different hospitals; one participated in a didactic team-training programme, one participated in an in situ simulation programme and one served as a control. Results indicated that significantly greater reductions in patient harm were achieved by the group that participated in the in situ simulation programme compared with both the didactic and control groups (37% reduction vs 1% reduction vs 43% increase in harm, respectively).

Training duration. Programme duration is an area in which team-training programmes in healthcare vary. A review of 18 studies evaluating classroom-based team-training interventions found course duration varied from 4 h to 3 days with several studies describing longer train-the-trainer programmes.[27] Another review found that 53% of 40 reviewed team-training programmes were designed to last less than 1 day.[14]

Intervention design and implementation strategy

Overall, no comprehensive meta-analysis to date has directly examined variations in design or implementation strategy as boundary conditions influencing the effectiveness of healthcare team-training programmes. However, current evidence supports the notion that the most effective team-training programmes leverage a bundled intervention design that pairs learning activities and practice, with tools designed to support effective teamwork during daily clinical care (eg, checklists, reminders, peer coaches). This bundled design aligns with a systems-based approach to training that emphasises a comprehensive strategy for developing and sustaining expert team performance.[32] These strategies view training as one piece of the puzzle that will support effective team performance under stressful conditions over time. For example, Buljac-Samardzic's[13] descriptive systematic review of strategies to optimise team effectiveness found that the majority involved some form of team-training; however, other interventions also included tools to support team performance during care (eg, checklists, goal lists; 8 studies), as well as broader organisational interventions (eg, redesign of care processes or team structures, 8 studies).

Implementation strategy. In terms of implementation strategy, both train-the-trainer and direct train-the-staff strategies have been used. For example, a train-the-trainer model formed the foundation for the National Implementation of TeamSTEPPS Project,[59] a collaborative effort by the U.S. Department of Defense (DoD), the AHRQ and the American Institute for Research (AIR) designed to create a national training and support infrastructure for healthcare entities implementing team-training. Through a national network of team resource centres, individuals interested in leading the implementation of team-training within their organisation could become TeamSTEPPS Master Trainers by participating in an intensive 3-day training session. Master Trainers then return to train administrators and frontline personnel within their own organisation using the customisable TeamSTEPPS curriculum. A slightly different approach was used in the large-scale implementation of team-training throughout the VA. As part of the VA National Center for Patient Safety Medical Team-training (MTT) Programme, learning sessions for participating VA medical centres were facilitated directly by an interdisciplinary team of dedicated MTT faculty.[38] Both strategies, however, include local facility change teams, implementation of on-the-job tools (eg, process checklists, scripts) to support training transfer, as well as measurement and evaluation processes as integral implementation components.

Transfer of training. Overall, systems-based models of team-training share an implementation approach that strategically considers what happens before, during and after training in order to facilitate transfer of effective teamwork into daily care processes. These models are rooted in classic transfer of training models, which stipulate that transfer, generalisation of teamwork skills developed in training and maintenance of these skills over time is the product of the work environment (ie, support for using teamwork skills, opportunities to use these skills in practice), training design and individual trainee characteristics.[60] This suggests that the most effective team-training efforts include readiness assessment and preparation, learning activities that bring together multidisciplinary practitioners, deployment of performance support tools (eg, checklists or structured communication tools) and post-training support through coaching, reinforcement and recognition for improved teamwork, and ongoing measurement paired with constructive feedback concerning teamwork processes.[61] For example, the VA MTT programme was led by a national coordinating entity (the VA National Center for Patient Safety) who worked with local implementation teams through 2 months of preplanning and readiness preparation prior to implementation.[38] Transfer of training was also supported by structured communication tools and quarterly follow-up coaching. The TeamSTEPPS programme similarly offers readiness assessment and evaluation planning, and facilitator training as part of the TeamSTEPPS Master

Trainer curriculum, as well as coaching and deployment support.

Organisational policies and procedures have also been changed to facilitate transfer of trained teamwork skills. For example, one study of team-training in surgery found significant improvements in on-time first case starts and operating room turnover times following training.[42] To sustain these improvements, the organisation implemented policy changes and incentives around these two processes. The combination of team-training and these organisational changes resulted in continued improvement in both processes over the 4 years following training implementation. Specifically, on-time starts increased 42% across the total 5-year period reported (69–98%) and there was a 38% decrease in OR turnover time ($mean_{2006}$=43 min to $mean_{2010}$=27 min). Such examples reinforce the notion that effective team-training initiatives go beyond training alone to proactively address aspects of the organisational work environment that support team members in sustaining effective teamwork practices over time, as well as generalisation of skills to new teams and new situations.[62]

What have we learned about team-training effectiveness?

Team-training has demonstrated the capacity to improve both how teams do their work and resulting outcomes across a wide variety of industries. For example, one meta-analysis of team-training that included 93 effect sizes across a broad range of industries found that participation in team-training can account for nearly 20% of the variance in team processes (ρ=0.44) and outcomes (ρ=0.39).[4]

Several reviews also support the notion that team-training can meaningfully improve participant knowledge or attitudes, teamwork processes, clinical care processes and even patient outcomes.[5 13 14 27 31] Though local customisation of team-training curriculum is common and evaluation metrics are heterogeneous, we attempt to summarise findings in the remainder of this section in terms of participant reactions, changes in knowledge, attitudes or skill, teamwork processes or behaviours in clinical environments, and clinical processes or patient outcomes. This organising structure is based upon Kirkpatrick's framework for training evaluation that organises training outcomes across the four levels described below.[63]

Level 1: learner reactions to training

Previous reviews demonstrate that learner reactions are one of the more common, yet least robust, evaluation metrics reported. One review found that 60% of 40 reviewed articles reported learner reactions to training (eg, perceptions of training utility, applicability and general satisfaction with training).[14] The sample of 26 studies summarised in table 2 demonstrates a shift towards more comprehensive evaluation of team-training programmes, however. Ten studies explicitly reported trainee reactions; while 7 studies examined trainee knowledge, attitudes or self-efficacy; 16 studies evaluated team behaviours, processes or emergent states (eg, teamwork climate, safety climate, trust); and 13 studies evaluated clinical processes or patient outcomes (see online supplementary appendix).

Overall, learner reactions to team-training have been shown to be positive, often with 80% or more of training participants, indicating that the topics covered during training were applicable to their work setting (see online supplementary appendix). Reactions can be important factors in shaping learner motivation to use effective teamwork strategies on the job and should be considered for that reason; however, they are not highly correlated with other training outcomes[64] and are not generally considered strong indicators of training effectiveness. Increasingly evaluation efforts have moved away from reporting participant reactions as primary outcomes, focusing instead on evaluating effects on provider behaviours and patient outcomes.

Level 2: learner knowledge, self-efficacy and attitudes

This second level of evaluation examines the impact of training on learner knowledge, self-efficacy and attitudes. Previous reviews indicate that such outcomes were reported in 50%[13] to 78%[27] of studies. Self-efficacy or confidence in one's ability to engage in effective teamwork behaviours during future clinical events was the most commonly reported outcome at this level among the studies reviewed in table 2. Self-efficacy is an important antecedent that shapes intentions to use effective teamwork skills during clinical practice and has been related to increased use of effective teamwork behaviours.[65] Overall, previous reviews and the additional seven primary articles that evaluated these outcomes provide evidence that team-training can positively impact these types of outcomes (see online supplementary appendix). Of the seven articles, five reported significant improvements in teamwork attitudes, self-efficacy or knowledge following training and the majority of these used CRM or TeamSTEPPS training curriculums. Several studies have also investigated the duration of these effects over time or differential effects among various types of clinicians. For example, Figueroa[65] found that increases in leadership and clinical skills confidence achieved immediately post-training were sustained at a 3-month post-training evaluation. Similarly Patterson[66] found gains in teamwork knowledge sustained at follow-up conducted 8–10 months post-training.

Level 3: teamwork behaviours, processes and emergent states

Changes in teamwork behaviours and processes are arguably the primary criteria by which the effectiveness of team-training programmes in healthcare has been evaluated. Previous reviews found that 44%[28] to

63%[14] of studies reported evaluating the impact of team-training on team behaviour or performance. Sixteen of the twenty-six studies (62%) reviewed (see online supplementary appendix) evaluated the impact of team-training at this level, of which 12 reported significant improvements (ie, statistically significant improvement on one or more process measures or at least one dimension of safety culture/climate, or statistically significant differences between participating teams and controls). The methods used to assess team performance range from team self-ratings to blinded observational ratings using validated measurement tools. A number of observational tools and behavioural marker systems have been developed to evaluate teamwork in both simulated and live practice environments (eg, the Oxford Non-Technical Skills (NOTECHS) scale,[67] the Anesthetists' Non-Technical Skills (ANTS) system[68]), which have greatly improved the strength and validity of findings in studies that have used them. For example, one high-quality study that used a modified version of the NOTECHS adapted for the trauma care setting found significant improvements in observed teamwork processes both during simulated cases and live cases following an in situ simulation-based team-training programme that included both a brief web-based didactic learning session and multidisciplinary clinical simulations.

In addition to team behaviours, evaluations of team-training have also often included measures of emergent, affective aspects of team performance such as teamwork climate or safety climate. Teamwork climate and safety climate reflect shared perceptions regarding communication openness, mutual support and other aspects of team functioning. Previous reviews also indicate that such measures may be used as part of pretraining needs analysis.[27]They are often measured with a safety culture or climate survey; however, reporting of results is highly heterogeneous. Some studies report composite scores that aggregate several survey items into one domain or dimension (eg, Carney,[69] Phipps[70]) while others report item-level results (eg, Stevens[71]). Overall, there is some moderate evidence that team-training may positively impact teamwork climate or safety climate outcomes; however, conclusions are limited by variation in reporting.

Level 4: clinical processes and patient outcomes

More recently, studies demonstrate the impact of team-training programmes on clinical processes, as well as indices of care safety and quality. Previous reviews found that only a few studies had attempted to evaluate the impact of team-training on such outcomes.[5 13 14 27 72] However, effect sizes have tended to fall in the medium to large range (eg, $d=0.63$,[73] as cited in[5]), indicating that team-training has been related to meaningful improvements in clinical process and patient outcomes. Thirteen of the twenty-six studies summarised in table 2 evaluated the impact of team-training at this level, of which ten reported statistically significant improvement. Additionally, several robust studies offer high-quality evidence that comprehensive team-training programmes can improve both clinical processes and patient outcomes. For example, an evaluation of the VA MTT programme demonstrated significant and sustained decreases in preoperative delays (from 16% to 7% of cases, $p=0.004$), increased antibiotic prophylaxis compliance (from 85% to 97%, $p<0.0001$), decreases in equipment issues/case delays (from 24% to 7% of cases, $p<0.0001$), decreased handoff issues (from 5.4% to 0.3% of cases, $p<0.0001$) and most notably significantly greater reductions in both mortality (RR=1.49) and morbidity (RR=1.20) for facilities that implemented team-training.[38 58] Furthermore, a dose–response relationship was established such that for each quarter the programme was in place at a facility, a decrease of 0.5 deaths per 1000 procedures ($p=0.001$) was observed. Implementation of TeamSTEPPS has been associated with increased efficiency in clinical processes for multidisciplinary trauma teams (eg, decreased times from arrival to surgery from 130.1 to 94.5 min ($p<0.05$), endotracheal intubation from 10.1 to 6.6 min (n.s.) and CT scan from 26.4 to 22.1 min ($p<0.01$),[74] as well as an 83% reduction in medication and transfusion errors ($p<0.001$) and a 70% reduction in needlestick injuries and exposures ($p<0.05$) in a U.S. Combat Support Hospital deployed in Iraq.[39] Other studies have also reported significant reductions in clinical decision time ($p<0.05$)[40] associated with team-training, as well as one study showing a reduction in adverse clinical events and a 50% reduction in high-severity malpractice claims (pretraining 11 high-severity claims, post-training 5 high-severity claims, no statistics reported).[75]

Strength of evidence

Overall, the body of evidence concerning the effectiveness of team-training in healthcare spans the continuum of low-quality, medium-quality and high-quality studies. The majority of previous reviews did not systematically rate study quality. However, Buljac-Samardzic[13] concluded that the majority of studies reviewed were of low-level to moderate-level quality even though eight of the reviewed team-training studies were categorised as high or moderate quality (ie, RCT or high-quality pre-post study). Similar conclusions were drawn by McCulloch.[28] Significant homogeneity among studies, both in training content and strategy, as well as reported outcomes limited conclusions. In the review by Rabøl[27] of classroom-based team-training interventions, 15 of the 18 reviewed studies were uncontrolled and 17 studies were rated at a moderate or high risk for bias.

A number of high-quality primary studies have been published since these reviews were completed. These

include the VA studies[38 58 69] and several studies of the TeamSTEPPS curriculum.[35 39 42] These studies used high-quality retrospective controlled designs or high-quality pre-post designs that examined the effects of training across multiple outcomes including teamwork processes and patient outcomes. Several very recent studies published after our search window ended have also employed strong quasi-experimental designs, larger sample sizes, robust analytical methods (eg, multilevel analyses) and different outcomes (eg, care coordination practices across teams, communication with patients and families) to further strengthen conclusions regarding team-training effectiveness.[76–79]

Are the effects of team-training sustained over time?

Sustainability of team-training effects over time is a common question among both improvement scientists and practitioners. Many early evaluations of team-training limited follow-up evaluations to 6 months post-training or less.[27 28] Recent studies have included longer follow-up evaluation periods with multiple measurement points. Of the 26 papers summarised in table 2, 11 included follow-up evaluations examining at least one of the Kirkpatrick levels more than 6 months after the training activity. For example, Mayer and colleagues[35] found significant improvements in observed team processes 1 month post-training that were sustained at 6 months and 12 months post-training in a sample of critical care providers. Findings regarding changes in survey measures of patient safety culture over time were mixed, however. In studies examining the implementation of the VA's team-training programme, results indicated both significant improvements in perceptions of teamwork climate 9–11 months following implementation[69] and statistically significant reductions in surgical mortality 1 year post.[38 58] Several studies also demonstrated that variability in aggregate indices of patient harm were reduced following implementation of a team-training programme delivered using a combination of both didactic learning activities and in situ simulation.[36 70] Overall, there is evidence for improvements in teamwork knowledge, attitudes and team processes during shorter term evaluation windows (eg, less than 6 months) and increasingly more robust evidence for longer term impact on aggregate indices of real or potential patient harm. There are also indications of skill decay over time, however, with several studies demonstrating that all short-term improvements in knowledge, skills and practices were not maintained over longer time periods.[66 80] While a great deal of work has been dedicated to examining optimal refresher training intervals for clinical procedural skills (eg, resuscitation or intubation skills[81 82]), relatively minimal work has been done to understand optimal refresher intervals for teamwork competencies.

DISCUSSION

In summary, previous reviews of team-training in healthcare and recent studies have found that these programmes can improve teamwork processes and patient outcomes (eg, reductions in adverse events, reductions in mortality and morbidity). Current evidence also offers detailed insight into team-training design and implementation strategies relevant for researchers and practitioners alike.[13 14 24 27–32] Additionally, over three decades of research examining team-training in a wide variety of contexts exists that both researchers and practitioners can draw from.

In terms of the strength of evidence, previous systematic reviews included several studies that used RCT or controlled pre-post designs. Several robust studies examining team-training strategies have been published since previous reviews concluded. However, it is important to note that previous reviews and recent studies reflect a wide range in quality of evidence—with several studies limited by small sample sizes, weak study design and limited detail regarding the team-training curriculum or implementation strategy. Overall, our synthesis suggests that there is moderate to high-quality evidence that team-training can positively impact healthcare team processes and, in turn, clinical processes and patient outcomes. These effects have been demonstrated across a variety of acute care areas, including critical care, surgery and emergency care. A key finding is that the studies demonstrating the most robust evidence for effectiveness[35 38 58] have implemented team-training as a bundled intervention that includes preplanning, readiness assessment, interdisciplinary learning activities and tools to support active transfer and sustained use of effective teamwork practices into daily care. Additionally, evaluation efforts undertaken in the most robust studies leveraged large care systems and strong quasi-experimental evaluation designs. This is not to say that every attempt to implement team-training should be compelled to follow similar evaluation efforts. These findings do underscore the value of implementing bundled interventions that match learning activities with activities to actively practice effective teamwork strategies and tools to support effective teamwork in daily practice. This underscores that team-training is most effective when paired with other methods to improve teamwork and also that team-training is one of several interventions that has proven effective at reducing patient harm and improving patient safety.[62 83]

Additionally, our synthesis underscores that there is meaningful heterogeneity and local adaptation in both training design and implementation across studies. While the studies reviewed used similar general training strategies (eg, CRM), the details of specific competency areas targeted and delivery methods were highly heterogeneous. As noted in previous reviews[13 14 28] and in the more recent work reviewed here, training programmes varied in duration, activities and modality.

The importance of local customisation is also reflected in the toolkits available to support team-training implementation. For example, a customisable version of the TeamSTEPPS curriculum is available publically through AHRQ (http://teamstepps.ahrq.gov/). Additionally, the VA MTT programme is available to VA Medical Centers through the National Center for Patient Safety (http://www.patientsafety.gov/mtt/). Both programmes provide customisable content while emphasising local adaptation of learning materials and implementation strategies. Best practices for team-training development and evaluation[61 84] can also provide guiderails for implementation and evaluation design.

To continue building this evidence base, future work should continue to evaluate team-training efforts across time and outcomes. This includes continuing to examine the impact on patient safety outcomes using robust implementation designs, evaluating team-training effects in multiteam system contexts (eg, chronic disease management, comprehensive cancer care), examining the comparative effectiveness of different methods of training implementation and examining implementation methods to support sustainment of behaviour changes achieved through training. For example, there is currently limited evidence that provides insight into the frequency of retraining or dedicated practice needed to develop and maintain effective teamwork skills. Additionally, there is a need to examine how dynamic team composition (ie, changes in team membership) moderate team processes and the effects of team-training. Methodologically, robust validation studies can continue to strengthen the evidence regarding team-training effectiveness and the factors or conditions that influence effectiveness. Finally, longitudinal studies and studies addressing the integration of team-training concepts throughout the career development of healthcare professionals are needed to continue building our understanding of team-training in healthcare.

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