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REVIEW ARTICLE

Review article: Use of the Team Emergency Assessment Measure in the rating of emergency teams' non-technical skills: A mapping review

Simon COOPER [1], Clifford CONNELL [2] and Robyn CANT [1]

[1]Institute of Health and Wellbeing, Federation University Australia, Melbourne, Victoria, Australia, and [2]Nursing and Midwifery, Monash University, Melbourne, Victoria, Australia

Abstract

The present study aims to explore the utility of the Team Emergency Assessment Measure (TEAM) in relation to the enhancement of emergency team non-technical skills based on research conducted over the last decade. In this mapping review, a citation mining process identified 22 primary studies for inclusion, published between 2012 and 2022. It provides outcome data on emergency teams' non-technical skills following team training and/or real-life patient emergencies. Emergency team studies related to resuscitation teams (adult, paediatric, newborn and obstetric cases) and medical emergency team (MET) management of patient deterioration. Team performance ratings varied, ranging from approximately 90% for experienced clinical teams down to 38% for students. Statistically significant improvements in performance were notable following training and/or repeated practice. Validity evidence, across 11 studies that provided change data described positive learning outcomes and moderate intervention effects. However, according to Kirkpatrick's model of educational evaluation the studies were limited to professional development phases of learning and immediate post-training assessments rather than care quality improvement. The review highlights a lack of studies evidencing quality improvement or clinical impact such as change of patient care practice or health service performance. There is a need to conduct well-designed studies that explore both technical and non-technical skills of resuscitation teams and METs. Currently, non-technical skills training and repeated performance evaluations using the TEAM contribute immensely to the proficiency of emergency teams.

Key words: *continuing professional development, medical emergency team, non-technical skill, patient safety, training and assessment.*

Key findings

- NTS are the human factors within clinical teamwork skills that contribute to safe and efficient task performance: leadership, teamwork, situtation awareness and task performance.
- We confirmed the TEAM as a valid instrument for assessing medical emergency team NTS performance across hospital clinical teams (adult, paediatric, obstetrics) and in student training.
- In 22 studies, staff training via repeated simulated scenarios or participation in live emergency events revealed that NTS performance improves with training; the benefits of teamwork and a suggested performance benchmark are documented.

Introduction

Teamwork and effective communication skills within medical emergency teams are essential for the provision of safe patient care.[1–3] These skills are recommended as part of clinical training and can be supported and maintained through simulation-based training.[4,5] An increased focus on patient safety, aiming to mitigate medical errors, has led to the development of non-technical skills and related research.

Non-technical skills (NTS) are defined by Flowerdew *et al.* as: 'the cognitive, social and personal resource skills that complement technical skills and contribute to safe and efficient task performance'.[6] In the current context, NTS include leadership, teamwork and communication together with the cognitive competencies of situation awareness and decision-making.[7] These are often described as 'human factors'.[8]

Correspondence: Adjunct Associate Professor Robyn Cant, Institute of Health and Wellbeing, Federation University Australia, Berwick Campus, Clyde Road, Berwick, VIC 3806, Australia. Email: r.cant@federation.edu.au

Simon Cooper, PhD, MEd, BA (Hons), FHEA, Professor; Clifford Connell, PhD, GradCertCritCare (ED), BN (Hons), RN, Senior Lecturer; Robyn Cant, PhD, MHthSc, Adjunct Associate Professor.

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These skills apply across healthcare teams, whether it be, for example, in surgical teams,[9,10] emergency teams[5,11] or healthcare students training in interprofessional settings.[12] Numerous studies have focused on the training of disciplinary and interprofessional medical and nursing teams. For example, a review of 38 studies of simulation programmes concluded that training improved team performance and interpersonal team dynamics.[13] Additionally, the leadership skills of medical residents significantly improved with regular paediatric resuscitation mock events.[11] An interview study of operating room clinicians concluded that interpersonal behaviours such as clear and open communication, task management and information sharing were key to effective teamwork.[9]

There is therefore a need to map our understanding of how non-technical skills measures are used and what effect their use may have on training and development outcomes.

The evaluation tool: TEAM

The Team Emergency Assessment Measure (TEAM)[14] is recognised as a valid and reliable tool[5,15] that has accrued a body of evaluation data and over 250 citations. The tool was initially developed for the assessment of adult resuscitation team performance, but its use has been expanded to the assessment of emergency team performance in a variety of settings, including medical emergency teams management of acute events and paediatric, obstetric and neonatal resuscitation teams. A team is generally considered to be three or more individuals working together at an acute event.

The TEAM includes 11 specific items and one global rating of NTS performance using a 5-point scale rated from '0' (never) to '4' (always). The tool is typically completed by a trained observer (or peers), at the conclusion of an event. Three categories of 'Leadership', 'Teamwork' and 'Task management' are assessed, together forming one factor that measures overall NTS performance. The single page tool is easy to use (see the scale in Appendix S1) and has been widely adopted to assess NTS. A dedicated website offers further information (Emergency Teamwork Assessment [The TEAM Tool]: http://medicalemergencyteam.com/).

Although the validity of NTS instruments including the TEAM instrument has been endorsed in several studies,[5,7,8] it is important to capture the breadth of current research and research settings. The aim of the present study is to explore the use of the TEAM and how measurement feedback may help to enhance NTS.

Methods

A mapping review of literature was conducted. This review method was chosen as it addresses a defined practice-related issue and helps to identify gaps in larger volumes of evidence that may inform future studies.[16,17] We followed the guidance of Grant and Booth[16] and Sutton *et al.*[17] in conducting a mapping review. A mapping review can be completed within a restricted timeline, to provide an overview of a topic but, nevertheless, uses a systematic search of literature. The results are presented as a visual synthesis (mapping) of included studies rather than a topic synthesis[17] and study appraisals are not generally required.

Literature search strategy

The literature search was founded on citations accrued by the TEAM using a snowball citation-mining process. A second-generation search of literature was conducted to identify the citations of three key TEAM studies published during the instrument's development and validation phases.

The database Scopus was chosen as the source of literature as it claims to index the widest range of scholarly journals and it tracks citations (https://www.elsevier.com/en-au/solutions/scopus). Advances in machine learning have facilitated systematic searches of literature and reduced protracted tasks involved in a traditional literature search.[18(section 2.1)] The use of a snowball mining technique outlines the scope of related studies and considers current research trends.

Three citation searches were conducted in Scopus in February 2022, for the primary studies Cooper *et al.* (2010, 2013, 2016) to ensure full coverage of citation data. Snowballing identified 184 citations of the original article (2010) and 272 citations in total (Table 1). A cross-check using Google Scholar identified three further citing articles in journals that were not tracked by Scopus; these were added.

Article selection and synthesis

The article titles and abstracts were downloaded to a single library database (Endnote) and 26 duplicates were removed. From a scan of the titles and abstracts, it was identified that a number of articles did not meet the inclusion criteria (e.g. did not cite the whole TEAM scale). Two authors (RC, CC) independently screened the list of articles to

TABLE 1. *Citation numbers mined from three key Team Emergency Assessment Measure (TEAM) development/validation studies*

TEAM article	Participant sample/setting	No. of citations in Scopus
Cooper *et al.*[14]	Medical and nursing students (simulation laboratory evaluations)	184
Cooper *et al.*[19]	Trained hospital nurses (simulation 'ward', adult evaluations)	42
Cooper *et al.*[20]	Interprofessional emergency team, clinicians in hospital emergency unit (real-life adult patient resuscitation codes)	46

identify suitable papers based on the inclusion criteria, using the article screening software Covidence[21] for full text review. A total of 22 studies were selected for inclusion.

Inclusion criteria

All studies were required to include a 'non-technical skills' evaluation using simulated or real-life medical emergency teamwork events, with performances rated either by individual trained observers, peers, or a clinical team. Inclusion criteria were:

- Peer reviewed primary studies that report the use of or evaluated the 'Team Emergency Assessment Measure'.
- Studies with participant samples that include medical or nursing professionals, other healthcare disciplines, or students.
- Uni-professional and inter-professional studies in any clinical domain. For example, adults, paediatrics and obstetrics care.
- Studies in any setting such as hospital, acute care, community, or simulation laboratory.

Excluded were qualitative studies and those that applied self-reported ratings or used other tools/checklists.

In the next phase, data reporting the use and impact of the TEAM were extracted from the selected studies and mapped in tabular form. The mapping review focused upon each study's characteristics, such as where the activity took place and where and how results were reported, but without requiring an in-depth analysis.[17,18]

Studies were mapped to (i) levels of evidence in the designs; (ii) the patient-specific setting and disciplines involved; and (iii) training outcomes, including assessments and an evaluation based on Kirkpatrick's Four Levels of Training Evaluation.[22] The four levels of evaluation are reaction, learning, behaviour and results, with the latter focusing upon training impacts on patient management. These levels are described more fully in a following section.

Results

The original TEAM development study was published in 2010[14] and the citing studies were published over the following decade (2012–2021). Half were recent, published within the last 5 years (2017–2021) (Table 2).

All studies comprised a team of at least three clinicians or healthcare students whose performance was rated 'as one' by a trained observer or peers.

Six development/validation studies by Cooper *et al.* reporting NTS assessments with Australian participants, were included.[14,19,20,22–24,31] These study designs comprised quasi-experimental single group post-test, or pretest/post-test designs and one single group mixed methods design. The samples ranged across pre-professional nursing and medicine students, qualified nurses and interprofessional medicine/nursing emergency teams. Table S1 presents the characteristics of all the included studies.

International research was well represented with studies originating in 10 countries. These were led by Australia ($n = 7$), USA ($n = 4$), UK ($n = 2$) and Sweden ($n = 2$), followed by Brazil, Finland, France, Germany, India and Italy that reported a single study (Table 2).

Patient-specific settings and disciplines

The TEAM was used to evaluate NTS performance in various hospital-based healthcare settings including emergency units, in obstetrics and neonatal care, paediatric units, and hospital wards. The studies evaluated both 'live' emergency events and simulated 'mock' training.

Interprofessional teams were common among the studies. The study samples included a range of healthcare disciplines: pre-professional medicine and nursing students, qualified nurses, qualified midwives, physicians and interprofessional medical/nursing/other teams.

Levels of evidence

The studies included educational evaluations that utilised research designs at the lower end of levels of research evidence.[32] One study was an experimental controlled study (Level 1.c) and the remainder were quasi-experimental designs at Level 2 (2.d: pretest–post-test) or Level 3 Observational-analytic designs without a control group. We noted there were an insufficient number of studies with a similar approach to reporting outcome metrics to enable a meta-synthesis.

TEAM performance ratings

The TEAM total score (sum of 11 items, rated out of a possible 44 points) was a key outcome. Just over half the studies (13 of 22) described the TEAM total score. The remainder chose to report only the single item 'Global' score, or subsection ratings.

The TEAM total scores extracted from the five interprofessional clinician studies (not students) (Table S1) ranged from means of 71.6% to 89.0% and averaged 79%. In the simulation-based studies of professional teams ($n = 2$) the mean TEAM total scores were 57.0% and 73.4%. Across all studies the settings could be grouped into acute care medical emergency teams, paediatric and obstetric categories, or student training. Some examples of outcomes were:

- Hospital emergency team live events where, in two longitudinal studies the TEAM total mean scores were 34.6 (79%)[20] over 106 events, and 39.2 (89%) across 80 events.[23]
- Obstetric newborn emergency team simulations: in 15 teams across two groups, the observed TEAM total mean scores were 35.0 (79.5%).[29]
- Paediatric emergency team simulations: the mean TEAM total score over 132 simulated scenarios in three venues was 31.53 (71.7%).[33]
- Medical residents' repeated team simulations: in 23 teams, the mean TEAM total score was 25.3 (57.5%).[34]
- Nursing student simulations: in 32 teams, the mean TEAM total score was 16.72 (38%).[24]

Other studies reported statistically significant improvements in the total TEAM scores post-training interventions, as described below.

TABLE 2. *Validity evidence of non-technical skills training outcomes from experimental and quasi-experimental comparison studies*

Study/country of origin	Topic/design	Disciplines/ sample	Training outcome: level of evaluation/ ratings/effect
Cant *et al.*[23]/Australia	Improving the non-technical skills of hospital medical emergency teams: the Team Emergency Assessment Measure (TEAM) Quasi-experimental longitudinal educational evaluation	Interprofessional hospital medical/nurse teams Longitudinal observational study of 80 actual hospital emergency team's performance over 10 months – early and late periods tested	Level 1 (Reaction), Level 2 (Learning), Level 3 (Behaviour) • TEAM total mean score was 89% in 80 real-world episodes (283 clinician assessments) The tool was reliable with Cronbach's alpha 0.78, high uni-dimensional validity and mean inter-item correlation of 0.45. There was a trend of performance improvement over time. Staff reflection and debriefing discussions addressed performance improvement. TEAM is a valid, reliable and easy to use tool for use clinical and training settings
Cooper *et al.*[19]/Australia	Managing patient deterioration: assessing teamwork and individual performance Quasi-experimental pretest–post-test educational evaluation	44 hospital registered nurses in teams of 3 in a ward setting completed 3 patient deterioration simulations with a patient actor and MCQ before/after	Level 1 (Reaction), Level 2 Learning (as knowledge) • TEAM total mean score was 57% Knowledge (via MCQ) improved significantly after training to $M = 64\%$ ($P = <0.001$). Significant associations were seen between Leadership, Teamwork and Task Management ($P < 0.006$) and the Global score. TEAM is a valid measure of team performance in patient deterioration scenarios
Cooper *et al.*[20]/Australia	Measuring teamwork performance: validity testing of the TEAM with clinical resuscitation teams Quasi-experimental longitudinal educational evaluation	Interprofessional hospital medical/nurse teams 106 videos of actual hospital emergencies (collected over 10 months): early and late periods were explored	Level 2 (Learning), Level 3 (Behaviour) • TEAM total mean score was 79% (34.6/44) Overall discriminant validity and internal consistency was good (Cronbach's alpha of 0.94). A non-significant improvement in scores was seen between the first 3 months and final 3 months, indicating that repeated practice enabled improved behaviours in the latter period. The TEAM is a feasible, valid and reliable non-technical assessment measure in real clinical settings
Doymaz *et al.*[11]/USA	Improving the performance of residents in paediatric resuscitation with frequent simulated emergencies Quasi-experimental pretest–post-test educational evaluation	43 senior paediatric medical residents completed weekly mock events with focus on assessment of team leadership, post-test at 6 months	Level 2 (Learning) • TEAM total mean scores were initially 71.93% ±18.50, and final $M = 81.44\% \pm 11.84$, significantly improved ($P = 0.01$). This indicates a large training effect size (Cohen's $d = 0.61$, $r = 0.29$) Medical residents' team leadership/performance was significantly improved by increasing the frequency of mock events during residency to improve team leadership performance in paediatric senior residents
Endacott *et al.*[24]/Australia	Simulated patient deterioration scenarios in ward-like setting in teams of three (3 scenarios with patient actor) Quasi-experimental two-group design	Nursing students ($n = 97$) and 44 registered nurses (32 student, 15 registered nurse teams)	Level 1 (Reaction), Level 2 (Learning) • TEAM total mean scores differed significantly between groups (nurses 57% *vs* students 38%, $t = 6.841$, $P < 0.01$) Objective structured clinical examination performance was similar across registered nurses ($M = 54\%$) and students ($M = 49\%$). All staff should work to develop teamwork skills for medical emergencies

TABLE 2. *Continued*

Study/country of origin	Topic/design	Disciplines/ sample	Training outcome: level of evaluation/ ratings/effect
Innocenti *et al.*[25]/Italy	Teamwork evaluation during emergency medicine residents' high-fidelity simulation Quasi-experimental single group longitudinal evaluation	Medical residents $n = 27$ (novice and senior) in a bi-monthly programme of 18 repeated medical emergency simulations during residency were evaluated using video records	Level 2 (Learning) • Average ratings 37, 36 (P = NS) in senior/ juniors (83%) • Teamwork performances improved over time. 0.18 sessions showed good internal consistency and good to fair inter-rater reliability for three scales. The TEAM Cronbach's α 0.954; Intraclass Correlation Coefficients (ICC) 0.921
Mahramus *et al.*[26]/ USA	Emergency care clinicians; teamwork in simulated cardiopulmonary arrest events Quasi-experimental single group design	Interprofessional clinicians $n = 73$ (resident physicians [25%], registered nurses [32%] and respiratory therapists [41%]) completed two scenarios with debriefing after each	Level 1 (Reaction), Level 2 (Learning) • Teamwork scores for first simulation (3.2 ± 0.5) and second simulation: (3.7 ± 0.4) improved significantly ($P < 0.001$) (this indicates a large effect size based on repeated practice: Cohen's $d = 1.10$, $r = 0.48$) (Baseline Teamwork scores from TEAM were 2.57 to 2.72). The mean (SD) dual observer Teamwork ratings were $M = 3.0$ (0.5) and $M = 3.7$ (0.3) respectively ($P < 0.001$) confirming above data. Participants' evaluations were positive, with improved perceptions of teamwork behaviours
Morse *et al.*[27]/UK	Randomised study of simulated ALS following an IPL course (IG) or UPL course (CG) using Global score Randomised controlled post-test design	Final year students, $n = 48$ medical and $n = 48$ nursing (8 interdisciplinary teams of 6) ALS training	Level 1 (Reaction), Level 2 (Learning) • Global TEAM score of $M = 8.38/10$ was significantly higher for IPL course IG *versus* UPL course CG, $M = 6.25/10$ ($P = 0.03$) (this indicates a large intervention effect size: Cohen's $d = 1.21$, $r = 0.52$) Survey: reactions were positive. Performance can change and improve in the short-term; further studies are required to assess long-term effects of IPL interventions
Pennington *et al.*[28]/ USA	Remote digital (video) simulations at 9 training sites in 8 countries Quasi-experimental pretest–post-test design	Interprofessional clinician teams ($n = 9$) completed 2–3 simulation scenarios of acute crises before and after training with a checklist	Level 2 (Learning) • Global score mean rating was significantly improved from 5.8 to 6.9/10 after training ($P = 0.04$) Six of 9 teams showed an overall improvement in global performance after training with the CERTAIN checklist (range 7–52%). For 11 TEAM items an improvement trend was noted, but no sections were improved overall. The greatest improvement in scores was the 'team's ability to complete tasks in a timely manner' and in the 'team leader's communication'
Rovamo *et al.*[29]/Finland	Simulation-based workshop on multidisciplinary teamwork of newborn emergencies Quasi-experimental two group design	Obstetrics and neonatal/ paediatric professionals: 99 staff of two delivery units: non-matched intervention (IG) and control groups (CG)	Level 2 (Learning) • TEAM total mean scores were similar in both IGs and CGs (35/44, 79.5%) Non-technical skills CRM instruction before simulation training did not enhance acquisition of teamwork skills of IGs over CGs. Team leadership skills made the difference in this un-matched two-group study

(*Continues*)

TABLE 2. *Continued*

Study/country of origin	Topic/design	Disciplines/ sample	Training outcome: level of evaluation/ ratings/effect
Siems *et al.*[30]/USA	Paediatric rapid response team training through crew resource management training of team leaders, then observations of events Quasi-experimental pre-post-test design	Paediatrics interprofessionals; in situ observations of RRT activations were performed pre and post a leader training intervention	Level 2 (Learning), Level 3 (Behaviour) • TEAM total mean scores $M = 11/44$ (25%) were significantly higher ($P = <0.001$) and Global score improved $M = 6.0$ to 9.0 ($P = <0.001$) after the intervention. Leadership was significantly improved ($P = 0.004$) All three categories of TEAM improved after leader training: Leadership 2.5–3.5; Teamwork 2.7–3.7; Task management 2.9–3.8, Targeted CRM training of the team leader resulted in improved overall team performance and team dynamics that correlated with paediatric patients requiring transfer to the ICU (other RRT team members were not involved in training, limiting the overall training outcome)

The TEAM is rated out of a possible 44 points for 10 items and the Global score is rated out of 10 points. Level of training outcome is based on Kirkpatrick Model, described in a following section. CG, control group; IG, intervention group.

Validity evidence of training outcomes

Eleven of the 22 studies reported experimental or quasi experimental studies that presented two-group comparisons, pretest–post-test data or sequential training data. These offered validity evidence of training outcomes through reports of an increase in performance scores. The sequential studies reported longitudinal data based on initial (early) and late assessments. In Table 2, we report the patient settings, disciplines involved and the evidence.

High NTS scores were evident. Differing approaches to reporting the study outcomes precluded an overall summary, but we highlight exemplar outcomes. An observational study of 'live' hospital medical emergency team events reported a mean TEAM total score of 89%.[20] Professional clinician teams commonly performed better than student teams. A simulation study of 15 trained nurse teams and 32 nursing student teams in disciplinary teams of three, reported a TEAM total mean score of 57% for nurses and 38% for students when managing deteriorating patients.[24] A programme of frequent mock events enabled senior medical residents to improve their NTS and achieve a mean TEAM total score of 81.4% in the final event.[11] However, not all training interventions showed improved NTS performance. A multidisciplinary newborn emergencies workshop did not improve NTS performance in the intervention group over the control group, with mean TEAM total scores the same in both groups (35/44, 79.5%).[29]

The Global score (assessed out of a possible 10 points) was often the main focus of reporting. Mahramus *et al.*[26] found that interprofessional emergency teams' global scores improved significantly after simulation training ($P < 0.001$), and we computed a large effect of training (Cohen's $d = 1.10$). Similarly, Siems *et al.*[30] who assessed paediatric rapid response teams after team leader crew resource management training, found global scores improved from $M = 6.0$ to $M = 9.0$ ($M = 90\%$, $P = <0.001$) but final TEAM total mean scores of 79.5% in intervention and control groups did not differ. Interprofessional training of student medical/nursing teams reported by Morse *et al.*[27] showed a significantly improved mean global score (8.38/10) in the intervention group, also showing a large training effect (Cohen's $d = 1.21$).

These comparisons verify that NTS teamwork performance can be enhanced by practice. We also noted that longitudinal studies that involved recurring medical emergencies demonstrated performance improvement trends in professional disciplines[20,23] and significant NTS improvements in medical resident teams.[11,25]

Training impact, evaluated using Kirkpatrick Model

We applied the Kirkpatrick Model[35] of training evaluation to studies of the TEAM to determine the likely impact of each study design on clinical care. This four-level hierarchy of educational impact ranks training outcomes as: (i) reaction (e.g. training is engaging, relevant); (ii) learning (knowledge, skills or confidence acquired); (iii) behaviour (learnings are applied in practice); (iv) results (clinical improvement occurs as a result of training).

We classified each study according to the level of outcome (documented in Table S1). An assumption was made that NTS practice through simulated 'training' or through participation in real-life emergencies is related to participants' experiential learning. We then produced a visual

map of training impacts (Fig. 1). As a single study often involved dual levels of evaluation, each level was individually documented, signified by a diamond symbol.

As shown in Figure 1, interprofessional medical/nursing teams were the most common TEAM training examples. Across the various settings there was a strong focus on Level 2 (Learning). Few studies surveyed participants regarding their Reaction (Level 1) but those that did so[19,23,24,30,33,36] generally described positive themes confirming code events as beneficial, and training as relevant to participants.

There was a scarcity of training or practice designed to evaluate the impact on clinical practice (Level 3: Behaviour change) or Level 4 (Results: impact on patients or on healthcare services). No study reported training impact at Level 4.

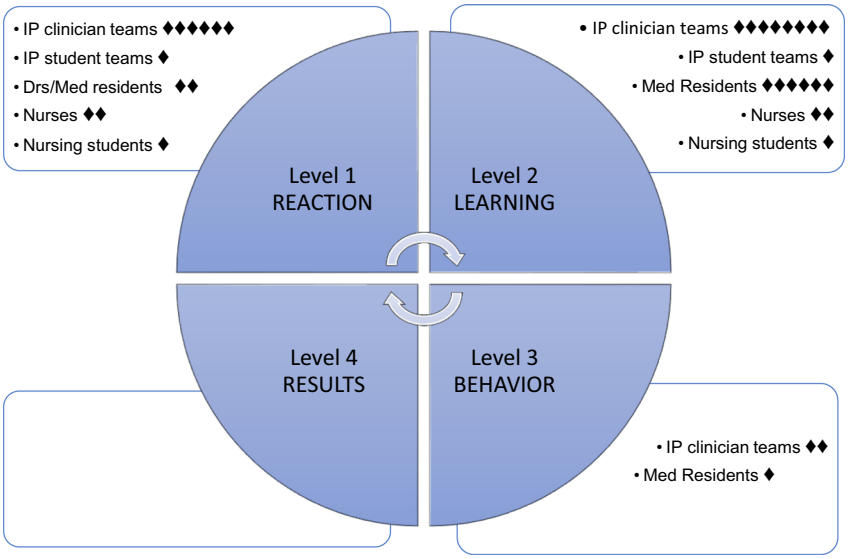

Figure 1. *Training impact: four levels of training evaluation in Team Emergency Assessment Measure studies by samples. Each ♦ symbol represents one study; IP, interprofessional; med, medicine.*

Discussion

The benefits of using a valid and reliable NTS assessment tool clearly emerged from the 22 included primary studies. As seen in Table 2, the TEAM demonstrated reliability and validity across a range of studies and was found to be feasible for trained observers, peers and students from 10 countries across the world, incorporating nurses, midwives, medical staff and students. Clinical settings included 'live' evaluations and simulated events conducted in emergency units, obstetrics, neonatal care, paediatrics and general hospital wards.

Team performance varied with ratings ranging from approximately 90% for experienced clinical teams down to 38% for students, with notable performance improvements following training interventions and repeated practice. There was a particular focus on leadership skills training which improved overall NTS ratings, consistent with the required role of the team leader to orchestrate the team's activities.[11,30] This clearly indicates that leadership and teamwork skills can be developed and perhaps debunks the argument that leaders are born rather than made.[37]

Training impact was demonstrated at Levels 1–3 on Kirkpatrick's hierarchy but with no outcomes at Level 4. This should be the focus of future research to demonstrate the translational impact on patient care; for example, an increase in resuscitation survival following NTS training.

Of note, however, is that the studies tended to utilise research designs at lower evidence levels with only one experimental controlled study. Well controlled longitudinal studies would be of benefit here as the rating of NTS at a single point in time has substantially less benefits than measures that assess changes over time (i.e. involving skill development and decline).

Non-technical skills are a core competency standard for emergency teams, but international training and education providers continue to focus primarily on technical skills development. This is an issue that needs to be addressed as there is clear evidence, for example, that both the non-technical and technical skills of individual rescuers effect the outcomes of CPR.[38] Hence, as shown by Kim and Lee[38] both should be an integral part of resuscitation training. Nevertheless, the last few years has seen a greater focus on teamwork skills especially following incidents that reflect failures in patient safety.[39] The incorporation of important programmes such as TeamSTEPPS[40] is enhancing teamwork development and patient safety and should be adopted globally.

Additionally, there is a need to consider benchmarks for proficiency in relation to NTS skills, for example with the TEAM. Cooper *et al.*[23] suggest that a score of 33 or less out of 44 (≤75%) equates to a 'poor' performance, 34–39 (77–88%) 'good', ≥40 (≥91%) excellent. Of course, this can only ever be a rough guide as situations and contexts vary within and between emergency teams, so measurement of performance over time would be more beneficial.

There were several limitations to this review. Firstly, we decided to map the use of only one teamwork assessment tool – the TEAM. This was primarily because of the volume of published work with this particular tool. The reader should note that there are other NTS measures and that systematic reviews have been published that compare their efficacy. Notably, a review by the American Heart Association[5] recommends TEAM as a pre-eminent instrument to measure NTS, and TEAM was lauded in another review as a valid and easy to use tool.[41]

Secondly, a risk of publication bias cannot be excluded as it is possible that studies are only submitted for publication where there has been a positive outcome/effect. Further to this, we detected a balance in reporting as two of the included studies in this mapping review report no differences between control and intervention groups after training.[29,30]

Conclusions

The TEAM is endorsed as a valid assessment tool for rating the NTS of medical emergency teams, in both 'live' events and simulated training. The tool is widely cited in over 270 studies internationally and has also been validated in primary studies of French, German and Swedish translations.

In this paper, we mapped validity evidence across 11 studies that provided change data and describe positive learning outcomes across the majority of studies. However, research in the field has yet to mature beyond the impact of staff professional development and immediate post-training assessments. The review highlights a lack of studies that provide evidence for quality improvements, for example, the transfer of NTS competencies into clinical practice changes (Kirkpatrick Level 3: Behaviour) and NTS performance related to patient outcomes or health service performance (Level 4: Results). In the meantime, NTS training and repeated performance evaluations using the TEAM contribute immensely to the proficiency of medical emergency teams.

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Author contributions

All three authors met all of the following conditions: (i) substantial contributions to conception and design of the study, acquisition of data, or analysis and interpretation of data; (ii) drafting the article or revising it critically for important intellectual content; and (iii) final approval of the version to be published.

Competing interests

None declared.

Data availability statement

Data derived from public domain resources.

References

1. Agency for Healthcare Research and Quality. *About TEAMSTEPPS*. 2020. [Cited 20 Feb 2023.] Available from URL: https://www.ahrq.gov/teamstepps/about-teamstepps/index.html
2. Australian Commission on Safety and Quality in Health Care. *National Quality and Healthcarre Standards: Recognising and Responding to Acute Deterioration Standard*. Canberra: ACSQHC, 2022.
3. Weller J, Boyd M, Cumin D. Teams, tribes and patient safety: overcoming barriers to effective teamwork in healthcare. *Postgrad. Med. J.* 2014; **90**: 149–54.
4. Orique SB, Phillips LJ. The effectiveness of simulation on recognizing and managing clinical deterioration: meta-analyses. *West. J. Nurs. Res.* 2018; **40**: 582–609.
5. Cheng A, Nadkarni VM, Mancini MB *et al*. Resuscitation education science: educational strategies to improve outcomes from cardiac arrest: a scientific statement from the American Heart Association. *Circulation* 2018; **138**: e82–e122.
6. Flowerdew L, Brown R, Vincent C, Woloshynowych M. Development and validation of a tool to assess emergency physicians' non-technical skills. *Ann. Emerg. Med.* 2012; **59**: 376–85.
7. Allard MA, Blanie A, Brouquet A *et al*. Learning non-technical skills in surgery. *J. Visc. Surg.* 2020; **157**: S131–6.
8. Savoldelli GL, Brindley PG, Jaffrelot M, Cardinal P. Crisis resource management and non-technical skills: from individuals to teams, from danger to safety. In: Chiniara G, ed. *Clinical Simulation*. Amsterdam: Elsevier, 2019; 347–72.
9. Aveling E-L, Stone J, Sundt T, Wright C, Gino F, Singer S. Factors influencing team behaviors in surgery: a qualitative study to inform teamwork interventions. *Ann. Thorac. Surg.* 2018; **106**: 115–20.
10. Shafiei SB, Hussein AA, Guru KA. Cognitive learning and its future in urology: surgical skills teaching and assessment. *Curr. Opin. Urol.* 2017; **27**: 342–7.
11. Doymaz S, Rizvi M, Giambruno C. Improving the performance of residents in pediatric resuscitation with frequent simulated codes. *Glob. Pediatr. Health* 2020; **7**: 2333794X20970010.
12. Andersen P, Coverdale S, Kelly M, Forster S. Interprofessional simulation: developing teamwork using a two-tiered debriefing approach. *Clin. Simul. Nurs.* 2018; **20**: 15–23.
13. Schmidt E, Goldhaber-Fiebert SN, Ho LA, McDonald KM. Simulation exercises as a patient safety strategy: a systematic review. *Ann. Intern. Med.* 2013; **158**: 426–32.
14. Cooper S, Cant R, Porter J *et al*. Rating medical emergency teamwork performance: development of the Team Emergency Assessment Measure (TEAM). *Resuscitation* 2010; **81**: 446–52.
15. Boet S, Etherington N, Larrigan S *et al*. Measuring the teamwork performance of teams in crisis situations: a systematic review of assessment tools and their measurement properties. *BMJ Qual. Saf.* 2019; **28**: 327–37.
16. Grant M, Booth A. A typology of reviews: an analysis of 14 review types and associated methodologies. *Health Info. Libr. J.* 2009; **12**: 91–108.
17. Sutton A, Clows M, Preston L, Booth A. Meeting the review family: exploring review types and associated information retrieval requirements. *Health Info. Libr. J.* 2019; **36**: 202–22.

18. van Haastrecht M, Sarhan I, Yigit Ozkan B, Brinkhuis M, Spruit M. SYMBALS: a systematic review methodology blending active learning and snowballing. *Front. Res. Metr. Anal.* 2021; **6**: 685591.
19. Cooper S, Cant R, Porter J *et al.* Managing patient deterioration: assessing teamwork and individual performance. *Emerg. Med. J.* 2013; **30**: 377–81.
20. Cooper S, Cant R, Connell C *et al.* Measuring teamwork performance: validity testing of the Team Emergency Assessment Measure (TEAM) with clinical resuscitation teams. *Resuscitation* 2016; **101**: 97–101.
21. Veritas Health Innovation. Covidence Systematic Review software. 2020. [Cited 20 Feb 2023.] Available from URL: www.covidence.org
22. Cooper S, McConnell-Henry T, Cant R *et al.* Managing deteriorating patients: registered nurses' performance in a simulated setting. *Open Nurs. J.* 2011; **5**: 120–6.
23. Cant RP, Porter JE, Cooper SJ, Roberts K, Wilson I, Gartside C. Improving the non-technical skills of hospital medical emergency teams: the Team Emergency Assessment Measure (TEAM™). *Emerg. Med. Australas.* 2016; **28**: 641–6.
24. Endacott R, Bogossian FE, Cooper SJ *et al.* Leadership and teamwork in medical emergencies: performance of nursing students and registered nurses in simulated patient scenarios. *J. Clin. Nurs.* 2015; **24**: 90–100.
25. Innocenti F, Angeli E, Alesi A, Scorpiniti M, Pini R. Teamwork evaluation during emergency medicine residents' high-fidelity simulation. *BMJ Simul. Technol. Enhanc. Learn* 2016; **2**: 12–8.
26. Mahramus TL, Penoyer DA, Waterval EME, Sole ML, Bowe EM. Two hours of teamwork training improves teamwork in simulated cardiopulmonary arrest events. *Clin. Nurse Spec.* 2016; **30**: 284–91.
27. Morse JC, Brown CW, Morrison I, Wood C. Interprofessional learning in immediate life support training does effect TEAM performance during simulated resuscitation. *BMJ Simul. Technol. Enhanc. Learn* 2019; **5**: 204–9.
28. Pennington KM, Dong Y, Coville HH, Wang B, Gajic O, Kelm DJ. Evaluation of TEAM dynamics before and after remote simulation training utilizing CERTAIN platform. *Med. Educ. Online* 2018; **23**: 1485431.
29. Rovamo L, Nurmi E, Mattila MM, Suominen P, Silvennoinen M. Effect of a simulation-based workshop on multidisplinary teamwork of newborn emergencies: an intervention study. *BMC. Res. Notes* 2015; **8**: 671.
30. Siems A, Cartron A, Watson A, McCarter R Jr, Levin A. Improving pediatric rapid response team performance through crew resource management training of team leaders. *Hosp. Pediatr.* 2017; **7**: 88–95.
31. Bogossian F, Cooper S, Cant R *et al.* Undergraduate nursing students' performance in recognising and responding to sudden patient deterioration in high psychological fidelity simulated environments: an Australian multi-centre study. *Nurse Educ. Today* 2014; **34**: 691–6.
32. Johanna Briggs Institute. *JBI Levels of Evidence*, 2014. [Cited 20 Feb 2023.] Available from URL: https://jbi.global/sites/default/files/2019-05/JBI-Levels-of-evidence_2014_0.pdf
33. Couto TB, Kerrey BT, Taylor RG, FitzGerald M, Geis GL. Teamwork skills in actual, in situ, and in-center pediatric emergencies: performance levels across settings and perceptions of comparative educational impact. *Simul. Healthc.* 2015; **10**: 76–84.
34. Hultin M, Jonsson K, Härgestam M, Lindkvist M, Brulin C. Reliability of instruments that measure situation awareness, team performance and task performance in a simulation setting with medical students. *BMJ Open* 2019; **9**: e029412.
35. Kirkpatrick Partners. *The Kirkpatrick Model 2022*. [Cited 20 Feb 2023.] Available from URL: https://kirkpatrickpartners.com/the-kirkpatrick-model/
36. Saunders R, Wood E, Coleman A, Gullick K, Graham R, Seaman K. Emergencies within hospital wards: an observational study of the non-technical skills of medical emergency teams. *Australas. Emerg. Care* 2021; **24**: 89–95.
37. Boerma M, Coyle EA, Dietrich MA *et al.* Point/counterpoint: are outstanding leaders born or made? *Am. J. Pharm. Educ.* 2017; **81**: 58.
38. Kim EJ, Lee KR. Relationship between non-technical skills and resuscitation performance of nurses' team in in-situ simulated cardiac arrest. *Korean J. Adult Nurs.* 2015; **27**: 146–55.
39. Ockenden D. *Findings, Conclusions and Essential Actions from the Independent Review of Maternity Services at the Shrewsbury and Telford Hospital NHS Trust: Our Final Report*. London: NHS, 2022.
40. Agency for Healthcare Research and Quality. *TeamSTEPPS 2.0. Agency for Healthcare Research and Quality*. 2019. [Cited 20 Feb 2023.] Available from URL: https://www.ahrq.gov/teamstepps/instructor/index.html
41. McKay A, Walker ST, Brett SJ, Vincent C, Sevdalis N. Team performance in resuscitation teams: comparison and critique of two recently developed scoring tools. *Resuscitation* 2012; **83**: 1478–83.

Supporting information

Additional supporting information may be found in the online version of this article at the publisher's web site:

Table S1. Characteristics of included quantitative studies of Team Emergency Assessment Measure with level of evaluation.
Appendix S1. Team Emergency Assessment Measure.