Featured Article

Impact of Advanced Nurse Teamwork Training on Trauma Team Performance

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Abstract
Background: Prior studies suggest interprofessional teamwork training improves trauma resuscitation team performance and outcomes. This study explores whether additional improvements are observed with advanced trauma nurse training in comparison with prior interprofessional teamwork studies conducted in the same setting.
Methods: This is a prospective, quasiexperimental preintervention and postintervention study incorporating TeamSTEPPS® with interprofessional simulations.
Results: Trauma nurses' self-confidence in skills increased significantly in all areas after training ($p < .05$). Trauma resuscitation team performance improved significantly after training but degraded between 6 and 12 months after training. The greatest decline in performance over time was seen in the leadership domain ($p < .05$).
Conclusions: Study findings support prior studies, suggesting teamwork training improves team attitudes and performance. Interprofessional trauma resuscitation team training provided every 6 months may support sustained improvement gains over time.

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> **Key Points**
> - Trauma teamwork training including the TeamSTEPPS® model has a positive effect on nursing confidence and trauma team performance.
> - However, performance degrades 6 to 12 months after the initial training, suggesting the need for semiannual reinforcement.
> - Recurrent training may be an effective strategy to maintain nursing confidence and sustain trauma team performance improvements.

Ineffective teamwork and communication account for more than two-thirds of preventable patient harm events (PSNet, 2018). The negative impact of poor team performance is particularly evident in high-risk environments, including the trauma resuscitation setting. The trauma resuscitation setting is characterized by complex clinical care provided by dynamic interprofessional teams with little time for deliberate planning (Courtenay, Nancarrow, & Dawson, 2013). The role of the trauma registered nurse (RN) as an essential member in trauma resuscitations is well recognized, but little is known regarding optimal methods for RN training and the impact of advanced training on trauma team attitudes and performance in the practice setting (Clements, Curtis, Horvat, & Shaban, 2015).

Background

Growing evidence suggests teamwork training improves clinician confidence, attitudes toward safety, team performance, and patient outcomes (Hughes et al., 2016; Shin, Park, & Kim, 2015; Weaver, Dy, & Rosen, 2014), with superiority found in programs incorporating simulation-based training (SBT) (Cook et al., 2012). Several studies suggest structured interprofessional teamwork training, with and without SBT, improve trauma resuscitation team attitudes and performance (Amiel, Simon, Merin, & Ziv, 2016; Miller, Crandall, Washington, & McLaughlin, 2012; Peckler, Prewett, Campbell, & Brannick, 2012; Roberts et al., 2014; Steinemann et al., 2011). Studies incorporating Team Strategies and Tools to Enhance Performance and Patient Safety (TeamSTEPPS®) as a teamwork framework have found model use improves team attitudes and performance in

diverse settings (Capella et al., 2010; Lee et al., 2017; Lisbon et al., 2016). A recent meta-analysis on team training in health care, including studies conducted in trauma care, emphasized that all Kirkpatrick (1998) levels of training evaluation (i.e., reactions, learning, transfer, results) improve with team training (Hughes et al., 2016).

Although the body of evidence suggests trauma teamwork training has a positive effect on team attitudes and performance, there is a dearth of research on the impact of RN training on trauma resuscitation team attitudes and performance in the clinical setting. A few studies (Armstrong, Crouch, Read, & Palfrey, 2013; Rice et al., 2016; Tippett, 2004; Zekonis & Gantt, 2007) have explored RN-only attitudes, learning and performance in simulated settings, thus providing limited insight into trauma teams in clinical practice.

From 2006 to 2011, the study health care system served as a resource training center for roll out of TeamSTEPPS® in health care settings nationwide. Formal TeamSTEPPS® interprofessional team training with its use in the trauma resuscitation setting began in 2008. The impact of team training before, after, 1 year later, with cessation and resumption of Resident Physician training has been explored. This study aims to determine the effect of an advanced trauma nurse core curriculum (ATCC) on trauma resuscitation team quality outcomes in an established TeamSTEPPS® program.

Materials and Methods

Design and Samples

The study used an Institutional Review Board—approved prospective, quasiexperimental pre/post intervention design conducted in a state designated and American College of Surgeons verified, Level I Trauma Center. The following convenience samples were utilized: (a) Nurses attending the ATCC in February 2014, along with General Surgery and Emergency Medicine Resident Physicians practicing during the study periods. All eligible RNs and most Resident Physicians had participated in prior simulation-based trainings; however, this frequency was not evaluated, (b) Trauma clinicians providing care during trauma resuscitation activations including General Surgery and Emergency Medicine Resident Physicians, RNs, respiratory therapists,

pharmacists, attending physicians, and other clinicians that currently comprise such clinical teams, and (c) Trauma registry data queried for patients $\geq$ 18 years of age collected during resuscitation team observation periods. Comparisons to prior trauma team outcomes observed in the same setting were made at 6-months and 12-months postintervention initiation (Figure 1). Each team was treated as a subject and evaluated as a group. Prior calculation at a 90% power estimated a sample of at least 32 observations as sufficient to ascertain whether true differences in team performance could be found (Capella et al., 2010).

Intervention

The ATCC is a 1-day program with didactic content and simulations provided by an interprofessional faculty with trauma and TeamSTEPPS® expertise. Nurses apply to attend the ATCC as part of a Trauma Nurse Academy and must have a minimum of 18 months of emergency nursing experience, prior completion of the hospital 1-day introductory *Trauma Crash Course* (i.e., includes the TeamSTEPPS® Essentials curriculum), and hold a current Emergency Nurses Association Trauma Nurse Core Course© (TNCC) verification. A detailed description of the Trauma Nurse Academy has been published prior (Peters et al., 2018). In February 2014, 39 RNs completed the ATCC intervention, with 10 additional RNs trained in September 2014 (Figure 1).

ATCC Didactic

A 4-hour morning curriculum began with a "Making Good Great" presentation by the trauma medical director to emphasize the essential nature of teamwork,

interprofessional cultural variations, and successful communication for managing high-stakes clinical scenarios. The nurse's role in trauma quality improvement utilizing the electronic health record and conflict resolution using TeamSTEPPS® tools incorporating role-play completes the morning component.

ATCC Simulations

High-Risk Procedure Review

Called "find one, use one, teach one" this session was conducted in the trauma bay in RN groups of 4 to 5. Scenario-based patient presentations were used to establish competency in critical equipment use. Scenarios incorporated the following: open thoracotomy tray, arterial-lines, rapid infuser, external ventricular drains, chest tubes, and pediatric resuscitation with weight-based tape. Cases were randomly selected by RN attendees using a blind draw process. Faculty presented the case to the RN learner who gathered the appropriate supplies, sets up the equipment, and taught the process to the other RN learners. Because of the high-risk/low-volume nature of emergency thoracotomy, this procedure was reviewed as a group to familiarize all RN attendees with tray contents and location, rib-spreader assembly, and safe execution of internal defibrillation.

Intraosseous Catheter Placement

Evidence suggests that patients with limited vascular access, requiring resuscitation, benefit from placement of an intraosseous (IO) device because vascular access is rapid, easy, and reliable. Nurse ATCC participants received both didactic and hands on practice with IO placement and management. An IO vendor-sponsored clinical instructor provided a one-
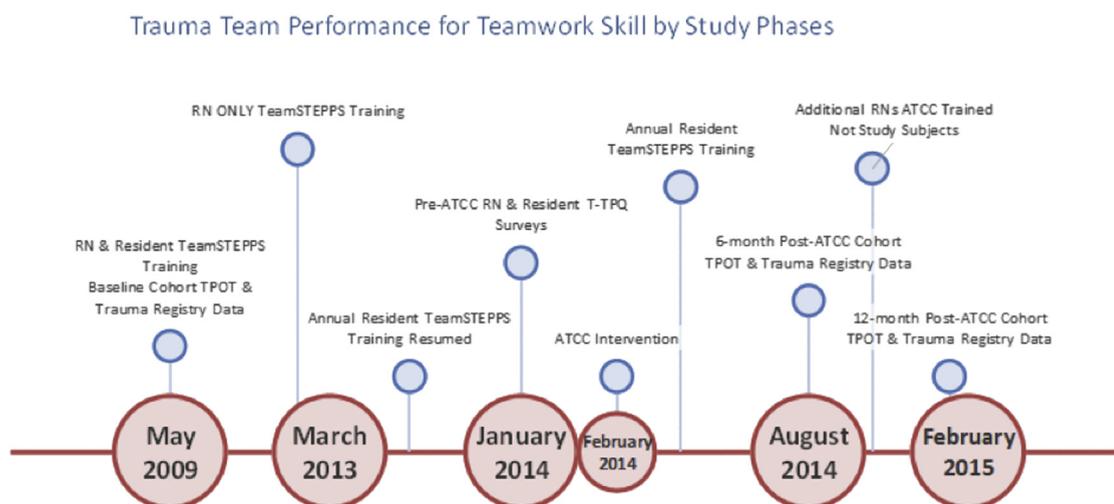

Figure 1 Time line for advanced trauma nurse training impact study. ATCC = advanced trauma core curriculum; RN = registered nurse; Brief T-TPQ = brief TeamSTEPPS teamwork perceptions questionnaire; TPOT = trauma team performance observation tool.

hour presentation on the indications, use, placement, and management of an IO to the entire ATCC RN group. Using simulated bones and raw eggs, hands on experience occurred in groups of four to five RNs during the breakout sessions providing opportunity to use the device. Competency was subsequently verified in the Emergency Department by an Emergency Medicine physician.

Trauma Nurse Process Review

Using with permissions a TNCC gunshot wound scenario, ATCC RN attendees individually completed a primary and secondary survey on a low-fidelity manikin. Following skill demonstration, RN attendees received debriefing on trauma nurse process performance with a TNCC instructor using TNCC guidelines. Sessions lasted 10 to 15 minutes per RN learner.

TeamSTEPPS® Interprofessional Simulation-Based Team Training

A 90-minute interprofessional SBT session was conducted in an Emergency Department patient room comprising two high-stakes trauma scenarios for emergency thoracotomy and surgical airway in RN groups of 4 to 5. Study investigator developed scenarios (e.g., Appendix A) using the Simulation Module for Assessment of Resident Target Event Responses (SMARTER) (Rosen, Salas, Salvatore, Wu, & Lazzara, 2008) model, as recommended in the "Training Guide: Using Simulation in Team-STEPPS Training" (American Institutes for Research, 2011). The SBT scenarios were designed to emphasize clinical acumen in complex trauma cases to trigger use of Team-STEPPS® tools to resolve conflict. Following orientation to learning objectives and the Trauma Performance Observation Tool (TPOT) by a faculty member, learners were oriented to the simulation environment by a simulation education specialist. Nurse attendees participated as either the primary or secondary RN for one simulation scenario and assisted with scenario debriefing using the TPOT for the second scenario. Each scenario lasted approximately 10 minutes using teams that included a trauma surgeon, Emergency Medicine physician, and a respiratory therapist as trained confederates. The advanced human patient simulator Laerdal SimMan® (Laerdal, Wappingers Falls, New York) was utilized during the scenario-based sessions. Changes to the high-fidelity simulator by the simulation education specialist mimicked the physiological state of a trauma patient. Simulator adjunctions allowed for surgical incisions and placement of emergency airways and rib spreaders to enhance fidelity. Debriefing using a plus/delta format lasts approximately 30 minutes after each scenario guided by a faculty team comprised of a TEAMSTEPPS® trained trauma clinical nurse specialist, surgeon, and emergency medicine physician.

Measurements

Trauma and TEAMSTEPPS® Knowledge Test

To assess baseline knowledge before ATCC attendance, RNs completed a 22-item trauma and TEAMSTEPPS® knowledge test (points range 0-100). This test comprised questions from the Society of Trauma Nurses 2012 E-Library, used with permission, and questions from the TeamSTEPPS® test bank, within the public domain. Psychometric evaluation of the test items has not been reported by developers and was not conducted for the Trauma and TEAMSTEPPS® Knowledge Test by the study team.

Trauma Nurse Core Course (TNCC) Trauma Nurse Process (TNP) Skill Assessment

Pass or fail of the TNP skill assessment was determined using TNCC standards and scored by a TNCC instructor. The TNCC-simulated scenario requires systematic completion of the primary and secondary survey assessment and management of an injured trauma patient. The scenario contains 43 skill steps and includes critical elements, which if omitted or completed out of order results in a critical failure of the skills assessment. Critical elements include skills steps such as airway, breathing, and circulation management, which require immediate intervention. All critical assessment steps, or double starred items, must be completed and be done in the correct order. Single starred items are essential skill steps and are expected to be performed, but their sequence is not critical. For successful completion, all double and single starred items had to be completed along with demonstration of 70% of the total points/steps.

Trauma RN Confidence Survey

The Trauma RN Confidence Survey is a course evaluation developed by the research study team that consists of 14 questions (See Appendix B). The survey asks RN subjects to rate their confidence in technical and nontechnical teamwork skills before and after completion of the ATCC training. A 5-point scale rating is used 1 (very low) to 5 (very high). One question on confidence in each of the following skills were assessed: (a) identify life-threatening injuries during primary and secondary surveys, (b) prepare the trauma bay for a patient's anticipated physical and emotional needs, (c) assist with emergent thoracotomy, (d) emergent surgical airway, and (e) massive transfusion protocol, (f) insert an intraosseous catheter, (g) identify appropriate communication techniques to facilitate conflict resolution using TeamSTEPPS® tools, (h) and demonstrate quality trauma electronic health record documentation. The other survey questions ask RN subjects to list three things learned, impact on practice, attainment of

course objectives, simulation and instructor effectiveness, and would they recommend the course to colleagues. Survey psychometric evaluation was not conducted by the study team for this instrument.

Brief TeamSTEPPS® Teamwork Perceptions Questionnaire (Brief T-TPQ)

The 20-item Brief T-TPQ, for use in the public domain, is a valid and reliable survey to measure teamwork relationships, skills, and behaviors using a Likert-type scaled score 1 (strongly disagree) to 5 (strongly agree). Internal consistency is 0.83 to 0.94, with a total survey reliability of 0.93 (Castner, 2012). Subjects voluntarily completed the survey using Qualtrics (Qualtrics, Provo, UT) distributed via e-mail before the ATCC intervention (January 2014), 6-months postintervention (August 2014), and 12-months postintervention (February 2015). To maximize the sample, all available RN and Resident Physician responses were used.

Trauma Performance Observation Tool (TPOT)

A 21-element tool (range 21-105), the TPOT, assesses trauma team performance in the four TeamSTEPPS® domains (i.e., leadership, situational monitoring, mutual support, and communication) with a 5-point scale from 1 (very poor) to 5 (excellent). Cronbach alpha for the subscales have been reported at >0.53 and 0.83 for all TPOT items (Baker, Capella, Hawkes, & Gallo, 2011). A convenience sample of trauma teams was used based on availability of local TeamSTEPPS® Master Trainers/trauma clinical care experts, who typically attend trauma activation events, serving as trained evaluators to observe and score trauma team performance using the TPOT. Using the model for inter-rater agreement, as described by the TPOT originators (Baker et al., 2011) for TPOT rater consistency across all study comparison periods, reliability testing using dry runs of study simulations with confederates was conducted. Intraclass correlations were not determined for the present study. Trauma teams were blinded to the TPOT evaluations and did not receive postobservation feedback to control potential bias. Trauma performance observation scores 6-months postintervention (August 2014) and 12-months postintervention (February 2015) were compared to a prior TPOT evaluation period within the institution (May 2009) when interprofessional TeamSTEPPS® SBT was in place.

Trauma Registry Data

Query of the trauma registry for the two TPOT observation time periods (August 2014 and February 2018) occurred for the following variables: age, gender, injury severity score, time in minutes to focused assessment with sonography for trauma, time to computed tomography, time in the Emergency Department, and trauma-related injury severity score. Changes in the trauma registry from earlier TeamSTEPPS® study cohorts in the institution (e.g., May 2009) required patient efficiency outcome comparisons utilizing the last TeamSTEPPS® study period collected post registry upgrade (August 2013). During the August 2013 period used for pre-ATCC efficiency comparison, the resident physician teamwork training was not occurring, but RN interprofessional SBT continued via the *Trauma Crash Course*.

Data Analysis

Trauma nurse knowledge scores were calculated as means with standard deviations and ranges. Successful TNP skill performance was determined with frequencies. Differences in pre/post trauma RN confidence survey scores were calculated as means and analyzed using paired *t*-tests. Trauma nurse and Resident Physician Brief T-TPQ scores at the three time points were not linked to subject identity; therefore, a repeated measures analysis of these data was not possible. The data were analyzed using a two factor ANOVA with staff type and time period group as the independent variables. Comparisons between the TPOTs were reported as means for each teamwork domain and the overall team performance using ANOVA to assess for the possibility of significant differences between the groups at baseline, preintervention, and postintervention. The effect of rater was not included in the analysis. For missing TPOT data cells, the overall mean of the item was substituted to allow for consistent analysis methodology as used with the baseline comparison data. Descriptive statistics were used to characterize the trauma patient registry data, with chi-square used to compare demographic differences in groups over time. The nonparametric Kruskal—Wallis test was used because of absence of normality in the distribution of the trauma registry data. Analyses were conducted using SAS 9.3 for Windows (SAS, Inc., Cary, NC). Significance was set at $\alpha = .05$.

Results

Trauma and TEAMSTEPPS® Knowledge Test

Prerequisite ATCC trauma RN knowledge scores varied widely ($\bar{x} = 82.74 \pm 8.86$; range 55-95; maximum score 100).

Trauma Nurse Core Course (TNCC) Trauma Nurse Process (TNP) Skill Assessment

For nurse ATCC attendees, 12.8% passed the TNP skill assessment (5/39 RNs). Critical failures were observed in 87.1% of the TNP skill assessments completed.
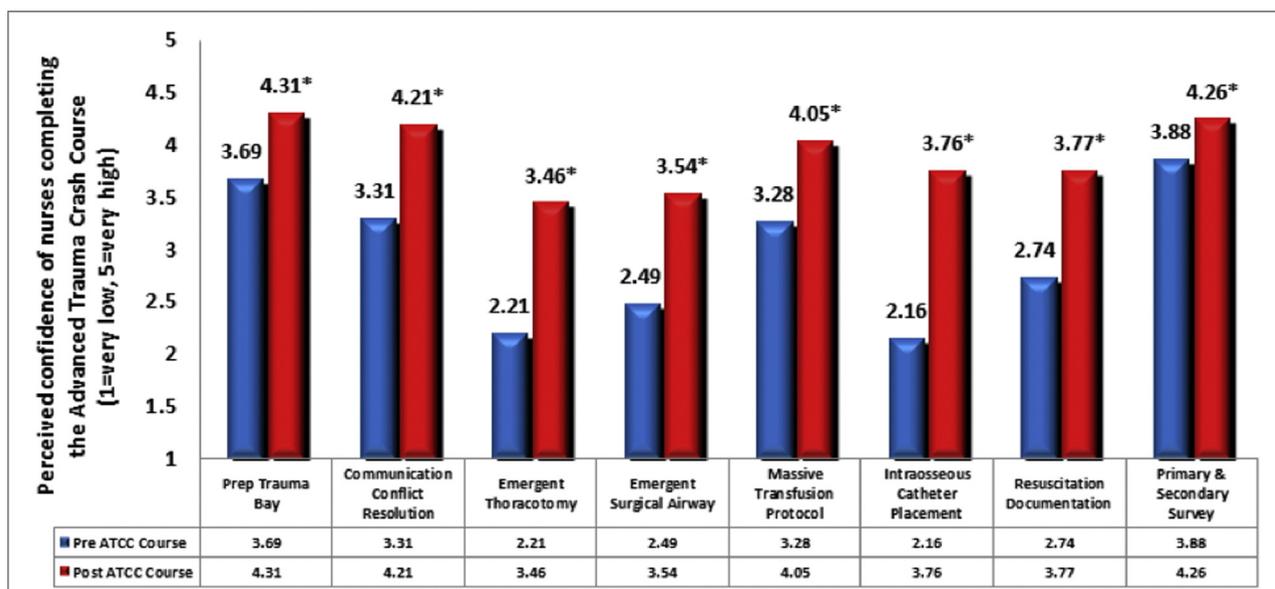
Figure 2   A comparison of nurse confidence with technical and nontechnical skills before and after ATCC Course. *($p = <.001$). ATCC = advanced trauma core curriculum.

Trauma RN Confidence Survey

Trauma nurse confidence scores increased significantly pre- to post-ATCC completion for all technical and nontechnical skills ($p < .001$) and are represented in Figure 2.

Brief TeamSTEPPS® Teamwork Perceptions Questionnaire (Brief T-TPQ)

Safety perceptions (Brief-T-TPQ) did not differ significantly for Resident Physicians versus RNs nor in the three time period groups (pre- vs. 6-months and 12-months post-ATCC).

Trauma Performance Observation Tool (TPOT)

Scores for TPOT over the study time periods are summarized in Table 1. Total TPOT scores at 6-months post-ATCC training were significantly higher than pre-ATCC ($p = .0011$) and 12-months post-ATCC ($p = .0013$). Total TPOT scores decayed to the baseline pre-ATCC level at 12-months postintervention. For the TPOT Leadership Domain (max score = 25), the performance score was greatest at 6-months post-ATCC and declined below the pre-ATCC measure by 12-months post-ATCC. For the Communication Domain (max score = 25) both the 6-months and 12-months postscores were significantly higher than pre-

Table 1   Comparisons of Trauma Team Performance Scores (TPOT) Study Phases

Outcome Measure	Subscale	Pre	6-Month Post	12-Month Post	p-Values
Teamwork Skill	Leadership	16.47	18.43	14.53	*.0016 †.0019 ‡<.0001
	Situation Monitoring	23.80	24.76	24.03	NS
	Mutual Support	15.70	16.41	16.01	NS
	Communication	20.98	23.73	22.42	*.0006 †.04 ‡NS
	Total Score	76.97	82.98	77.00	*.0011 †NS ‡.0013

Note. NS = not significant.
* Pre versus 6-months post.
† Pre versus 12-months post.
‡ 6-months versus 12-months post.

ATCC measure. The Communication Domain score 6-months post-ATCC was higher than the 12-month post-ATCC score, but the difference was not significant ($p > .05$). No differences were noted across time periods for Situational Monitoring and Mutual Support Domains ($p > .05$).

Trauma Registry Data

No statistical differences in trauma patient characteristics for age, gender, injury severity score, or trauma-related injury severity score were noted between study periods (pre-ATCC/n = 260; 6-months post-ATCC/n = 170; 12-months post-ATCC/n = 220; $p > .05$), controlling for potential severity of injury bias on efficiency. Efficiency gains to computed tomography and Emergency Department dwell time seen in prior studies within the institution were not seen post-ATCC ($p > .05$); however, time to ultrasonography 12-months post-ATCC was significantly shorter compared to pre and 6-months post-ATCC (pre = 10.91 vs. 6-months post = 9.54 vs. 12-months post = 8.61; $p = .0071$).

Discussion

This is the first study to explore the impact of advanced nurse training utilizing a TeamSTEPPS® interprofessional SBT model on trauma team attitudes and performance in a Level 1 Trauma Center practice setting. The study findings showed for experienced trauma RNs with prior TeamSTEPPS® training (i.e., completion of the *Trauma Crash Course*), baseline trauma and teamwork knowledge scores varied widely; however, the mean knowledge performance for the sample exceeded the passing score of 80 of 100 points. Most of the ATCC RN attendees failed to demonstrate TNP skill competency in accordance with ENA standards during this skills station. This finding supports existing knowledge regarding poor clinical skill retention seen in health care providers (Alspach, 2012) and emphasizes the need for further research on optimal training intervals (Cook et al., 2012). Consistent with prior SBT literature (Hughes et al., 2016), this study showed RN confidence in technical and nontechnical skills increases significantly with interprofessional teamwork SBT.

Attitudes regarding teamwork relate to safe patient care because it may impact the ability of health care professionals to provide quality care in dynamic care environments, including trauma settings (Manser, 2009). Although several studies have demonstrated interprofessional teamwork training increases perceptions of safety and improves teamwork post-training (Brasaite, Kaunonen, & Suominen, 2015; Wu, et al., 2016), similar findings were not observed in this study. Differences in safety attitudes in this study showed an upward trend over time, but the changes were insignificant, as measured by the Brief T-TPQ. Li (2013)

found teamwork climate to be the major determinant of patient safety attitudes among nurses. Because TeamSTEPPS® concepts are already enculturated in the present study trauma resuscitation setting, ATCC may not provide additional impact on safety attitudes. The small sample size for Resident Physician responses limits conclusions related to this group. Use of a variety of safety perception tools in the literature (Hughes et al., 2016) limits comparisons between studies. Further investigation is needed to identify an optimal perception of safety tool for use in trauma teamwork research.

Overall trauma team performance improved significantly from pre-ATCC to 6-months post-ATCC training but did not sustain over the 12-month study period. Team communication performance, however, improved significantly post-ATCC training and did sustain. This was likely influenced by annual General Surgery and Emergency Medicine Resident Physician TeamSTEPPS® SBT interprofessional training occurring 6-weeks before the 6-month post-ATCC study assessment period (Figure 1). An important study finding is that team performance in the Leadership Domain declined significantly below the baseline despite training of additional trauma ATCC RNs during this study period (i.e., September 2014, see Figure 1). Additional RN training would be expected to provide additional reinforcement of learned team behaviors in the trauma bay. Resident Physicians serve in the team leader role in the present study's trauma resuscitations, but currently receive annual teamwork training versus every 6 months as provided with ongoing RN training. The performance of team leaders is highly correlated with the performance of teams (Briggs et al., 2015). In trauma resuscitation, leadership is a learned skill and improves the process of care (Ford et al., 2016). Leadership behaviors need reinforcement (Lee et al., 2017). Therefore, interprofessional trauma resuscitation team training provided every 6 months for all team members, including Resident Physicians, may support sustained improvement gains over time more effectively than annual training for some.

Recent meta-analyses and systematic reviews, including studies in the trauma resuscitation setting, have reported on the positive effect of interprofessional teamwork training on patient safety and outcomes of care, (Hughes et al., 2016; Shin et al., 2015; Weaver et al., 2014). Time to definitive trauma care (i.e., operating room) is associated with reduced trauma-related mortality (Mowery et al., 2011). Efficiency gains in time to computed tomography and Emergency Department dwell times beyond those seen in prior studies within the institution (Capella et al., 2010) were not seen post-ATCC training. Improved efficiency to focused assessment with sonography at 12-months post-ATCC training may reflect increases in Resident Physician technical skill competency over time. These findings suggest ATCC did not contribute to additional trauma team efficiency, even when the baseline comparison for these efficiency outcomes occurred when Resident Physician

training was not in place in the institution (Figure 1). In a prior study in the same setting conducted during this 2-year Physician Resident training cessation period, all three efficiency measures for time in minutes to computed tomography, focused assessment with sonography, and Emergency Department dwell had decayed back below the pre-interprofessional teamwork training baseline (Harris et al., 2014). This suggests leadership performance may have a greater impact on team efficiency than ATCC. Further research is needed to identify optimal trauma resuscitation measures of efficiency and to determine if these measures impact trauma mortality and morbidity.

Limitations

Convenience sampling, size, single center setting, and use of tools without psychometric data for some measures threaten internal validity and generalizing of findings. Because of the lengthy and ongoing implementation of TeamSTEPPS® in the study institution, it was impossible to employ raters who were naïve to the results of previous studies. Although discontinuing some raters and introducing new ones at different time periods created confound between rater and time, it was necessary to avoid the likely stronger bias of having only raters who were well aware of the benefits of Team-STEPPS®. The significant changes in TPOT scores across the three time periods may have been partially due to an effect of rater that could not be included in the analysis. Facility-based changes in trauma activation policies, Resident Physician rotation patterns, trauma registry upgrades, and high facility census are confounding variables. However, as recommended by the literature, the study strength is found in advancement of knowledge with use of a validated tool to measure interprofessional team performance and a comprehensive approach to program evaluation over a 6-year time frame in a clinical setting.

Conclusions

Use of a TeamSTEPPS® simulation-based model for ATCC may be an effective strategy for increasing nurse confidence and improving trauma teamwork performance in the resuscitation setting. The important role of the Resident Physician team leader in trauma team performance is a notable study finding and suggests bi-annual teamwork training for all team members may be superior to annual training. This innovative model for interprofessional TeamSTEPPS® SBT may serve as an effective platform for future research in a variety of clinical settings.

Acknowledgment

Supplementary Data

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