Do Interprofessional Simulations Promote Knowledge Retention and Enhance Perceptions of Teamwork Skills in a Surgical-Trauma-Burn ICU Setting?

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A Capstone Presented to the Graduate Faculty
Of the University of Virginia in Candidacy for the
Degree of Doctor of Nursing Practice

School of Nursing
University of Virginia
June 2016

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Acknowledgements

I would like express my very great appreciation for the guidance and support of my Capstone Committee, without whom this work would not have been possible. I am especially grateful to Dr. Beth Quatrara for her wisdom, expertise, and mentorship, and for inspiring me more than she will ever know. I would like to thank Dr. Tina Brashers for her significant contributions that have shaped this capstone, and for her humbling support. An incredible amount of thanks to Jon Howard for the selfless contributions of time and effort provided to make this capstone feasible. To Dr. Rob Sawyer, thank you for embodying true interprofessional practice, for answering countless questions, and for the years of support that have culminated with this capstone. I would also like to express my gratitude to the STBICU team members whom have believed in me, and made this capstone a success.

Most importantly I would like to thank my best friend and Husband, Joe. Thank you for the innumerable sacrifices you have made without question, for your tireless encouragement and support, and for your love.

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Abstract

Background: The ability to function proficiently in critical care relies on knowledge, technical skills, and interprofessional (IP) teamwork. Integration of these factors can improve patient outcomes. Simulation provides "hands-on" practice and allows for the integration of teamwork into knowledge/skill training. However, simulation requires a significant investment of time, effort, and financial resources.

Purpose: To 1) evaluate knowledge retention and analyze changes in perceptions of teamwork amongst nurses and resident physicians (RPs) in a STBICU setting after completion of an interprofessional critical event simulation, and 2) provide insight for future interprofessional simulations, including the ideal frequency of such training.

Design: A comparison-cohort pilot study was developed to evaluate knowledge retention, and analyze changes in perceptions of teamwork.

Methods: A one-hour critical event interprofessional simulation was held for nurses and RPs in a STBICU setting. The simulation required the team to employ interventions to reduce elevated ICPs, and then perform cardiac resuscitation according to ACLS guidelines. A semi-structured debriefing guided by the TENTS tool, highlighted important aspects of teamwork. Participants took knowledge and TSS pretests, posttests, and one-month posttests. Mean scores were calculated for each time point (pre, post, and one-month post) and paired t-tests were used evaluate changes.

Results: Mean knowledge test and TSS scores both significantly elevated after the simulation, and remained significantly elevated at one-month follow-up.

Conclusion: Significant improvements on both knowledge test, and TSS scores, demonstrate the effectiveness of this intervention, and retention of the improvements. Participants valued the intervention and recommended to increase the frequency of such training.

Keywords: Interprofessional, simulation, teamwork, knowledge, critical care

Interprofessional Simulations Promote Knowledge Retention and Enhance Perception of Teamwork in a Surgical-Trauma-Burn ICU Setting

The current state of healthcare is one filled with highly acute, complex patients, managed with ever-changing technology. Healthcare team members are expected to be expert critical thinkers, aware of the most recent evidence, and function effectively in emergency situations. Healthcare leaders struggle with the challenging task of keeping staff up to date on so many fronts. (Lucas, 2014) This challenge is intensified in the intensive care unit (ICU) setting.

To function safely in critical care, nurses and physicians need to collaborate effectively and maintain a high level of clinical knowledge & skills. This is especially true during patient care emergencies, such as cardiopulmonary arrest situations, in which discrete teamwork behaviors can improve patient outcomes (Mahramus, Frewin, Penoyer, & Sole, 2013). The term “critical event” has been used to describe situations where patients deteriorate rapidly and require a coordinated team to intervene swiftly (Lighthall et al., 2003). Such emergencies are low in frequency, which limits clinician exposure and emphasizes the importance of proper training. Turnover in critical care is the highest amongst all fields of nursing. The concept that patient outcomes suffer as experienced nurses leave the bedside, is well supported in the literature (Hauck, Quinn Griffen, & Fitzpatrick, 2011). This further highlights the need to ensure clinicians are well prepared for the complexity and high-acuity nature present in the ICU setting.

Simulation learning is a primary component of education for nursing and medical students (Delac, Blazier, Daniel, & N-Wilfong, 2013). Yet the concept of simulation is integrating much more slowly into the practical arena (Institute of Medicine [IOM], 2015 & Lucas, 2014). The recent emphasis on patient outcomes is forcing hospitals to evaluate their existing systems, including educational methods. Simulation learning holds promise as an exciting and effective tool for education of staff (Delac et al., 2013), yet few studies demonstrate clinical efficacy.

In a Surgical-Trauma-Burn ICU (STBICU) at a level-one trauma center, a "mock code" program specific to the unit's patient population was implemented for new nurses. The feedback was very positive. According to post-training surveys, the participants appreciated the "hands-on" experience and the chance to take care of a cardiac arrest patient in a safe environment. Many of the participants requested this training more frequently. However, this training consisted solely of nurses.

Continued examination of patient outcomes reveals the importance of teamwork, which is now accepted as an essential component of patient care (Figueroa MI, Sepanski R, Goldberg SP, & Shah S, 2013). Multiple studies show a relationship between poorly functioning teams and increased medical errors, which may lead to suboptimal patient outcomes (Acero et al., 2012; Figueroa MI et al., 2013; Patterson, Geis, LeMaster, & Wears, 2013). Recommendations made by the 2015 Institute Of Medicine (IOM) report *Measuring the Impact of Interprofessional Education (IPE) on Collaborative Practice and Patient Outcomes,* include "strengthening the evidence base for IPE" and "linking IPE with changes in collaborative behavior" (p. 2).

The high acuity of the patients in the STBICU also requires the resident physicians (RPs) to be astutely trained to respond to clinical emergencies. Previously, no training specific to the STBICU patient population existed to prepare resident physicians for their rotations through the unit. Additionally, there was no training that allowed nurses and RPs to learn together, forging teamwork skills. A report in 2002 "emphasized that for healthcare providers to work collaboratively, the education and training they receive should prepare them to work together and share expertise" (Grymonpre et al., 2010).

Therefore a pilot study was developed to 1) evaluate knowledge retention and analyze changes in perceptions of teamwork amongst nurses and RPs in a STBICU setting after completion of an interprofessional critical event simulation, and 2) provide insight for future interprofessional simulations (IPS), including the ideal frequency of such training.

Review of Literature

Theoretical Framework

It is generally well accepted that adult learners prefer interactive teaching methodologies to classical didactic instruction, as supported by the concept of andragogy (Russel, 2006). Andragogy is defined as "the art and science of helping adults learn" (Teaching Excellence in Adult Literacy [TEAL], 2011, p.1). In 1970 Malcolm Knowles popularized this concept with the publication *The Modern Practice of Adult Education: From pedagogy to andragogy*. Knowles identifies several assumptions about the characteristics of adult learners, to be considered by the adult educator. The concepts of experience, motivation, and orientation to learning (Russell, 2006) are emphasized within this review.

The adult learner utilizes past experiences to help process new information and make it more meaningful (Knowles, 1980). Simulation allows adult learners to draw upon their existing knowledge base to guide their decision-making. Knowles (1980) identifies that "…people attach more meaning to learnings they gain from experience than those they acquire passively" (p. 44). By way of this concept, simulation is an ideal method of teaching as it allows for experimentation, problem solving, and discussion. Knowles also asserts that the rich depth of experience possessed by adult learners makes them a valuable resource for others. This idea is key in understanding the importance of interprofessional education (IPE). Interprofessional simulation allows the clinicians to understand the strengths that various professions have to offer.

Conversely, the learners realize their own strengths, and how their contributions make them a valuable member of the team.

Adults also desire respect, and they respond better when they perceive their opinion is valued (Knowles, 1980). Teamwork instills respect through understanding of, and appreciation for, other team members. Effective collaboration is an essential component of teamwork and increases morale and retention of nursing staff (Maxson PM et al., 2011).

The motivation to learn is influenced by the learner's perception of how valuable the knowledge is. This is often influenced by an experience the adult learner has that forces them to realize the importance of the knowledge or skill (Knowles, 1980). Such situations arise in cardiac arrests, where a lack of knowledge causes distress amongst the team. Simulation is the perfect environment for this exact sort of scenario, as it allows for practice with the low frequency, high-risk scenarios that clinicians need experience with to build expertise.

Orientation of learning is a concept that correlates closely with motivation to learn. In describing this concept Knowles (1980) states "Learners see education as a process of developing increased competence to achieve their full potential in life. They want to be able to apply whatever knowledge and skill they gain today to living more effectively tomorrow" (p. 44). Again, IPS is an ideal emulation this concept. As in the previously mentioned scenario, simulation affords the team hands-on experience with cardiac arrest, as opposed to merely reading or being told how to respond. IPS allows the learner to immediately apply the new knowledge, as well as providing an opportunity for guidance in a safe setting.

Andragogy provides ample support for both the simulation and interprofessional pieces that formulate IPS. National organizations such as the American Association Colleges of Nursing and The National Advisory Council on Nurse Education and Practice, are calling for more interactive, adult methods for the education of nurses (McKee & Billman, 2011, p. 1). Interprofessional simulations are the logical answer to this call.

Methods of Review

A systematic literature search was performed using the databases of Ovid Medline, the Joanna Briggs Institute, CINHAL, and EBSCOhost in June of 2015. Inclusion criteria were as follows: 1) primary research articles in the English language 2) published in the past ten years 3) focused on interprofessional simulation in the management of high-acuity patients, and 4) measured knowledge and/or teamwork. For the purposes of this review, concepts directly relating to teamwork, such as collaboration, communication, etc., were included. Studies were excluded if they 1) focused on students 2) focused primarily on professions other than nursing and medicine 3) if virtual simulation was the primary intervention and 4) if the full text version was not available.

A title search was completed using combinations of the words “interdisciplinary” “simulation” and “teamwork”. Fifty total articles were revealed, 11 remained after a title screening, of which, seven met inclusion criteria. A keyword search for “mock code” “simulation” “interdisciplinary” and “interprofessional teamwork” elicited 38 articles, 10 remained after title review, and subsequently six met inclusion criteria after abstract review. A final total of 13 studies were included for analysis of this literature review.

Data Summary

The studies elicited by this search used assorted research methodologies, measurement tools, and varied greatly in the delivery of interventions (see Appendix A for table of study details). The Johns Hopkins Nursing Evidence-Based Practice Appendix E: Research Evidence Appraisal Tool was used to evaluate the studies. All study designs were Level II (quasi experimental) with the exception of one randomized controlled trial. For the majority of studies, quality appraisal revealed good to high quality ratings (B to A). Single center studies compromised the vast majority of the literature.

Six of the studies elicited focused on the pediatric population, three on the obstetric population, three on the emergency department/intensive care unit (ICU) population, three on acute care populations and one on the OR population (with some overlap for pediatric ICUs). Simulations were completed during dayshift for all but one of the studies. Almost all of the studies concentrated their efforts on low frequency, high-acuity situations such as cardiac arrests or exsanguination events.

The majority of simulations were of the mid to high-fidelity type. Almost all of the studies included debriefing, some more structured than others. Seven studies used videotaping to enhance the debriefing experience or for observational purposes. The interventions differed significantly in total time (from one 30 minute session to several full day sessions throughout the year), and in the extent of simulation used. Some studies supplemented existing training programs with simulation, whereas in other studies simulation was the main composing factor. Seven of the studies conducted simulations in a dedicated simulation center, in four studies the simulations occurred in situ, and three studies did not specifically mention where the simulations took place.

Most of the studies involved more nurses than physicians, and it was more likely that participants were female. When measured, it was more common for physicians to have previously experienced simulation training compared to nurses. Clinical experience levels of participants ranged anywhere from 6 months to 30 years.

Teamwork. Validated teamwork tools included the TNOTCHES scale, Team Strategies and Tools to Enhance Performance and Patient Safety (TeamSTEPPS) Teamwork Attitudes Questionnaire, TeamSTEPPS Team performance Observation Tool, the Mayo High Performance Teamwork Scale, Collaboration and Satisfaction About Care Decisions (CSACD), and the Safety Attitudes Questionnaire (SAQ) Teamwork and Safety Climate version. Other measurement methods included a checklist for observation of best communication practices, and qualitative surveys.

Patterson and colleagues (2013) sought to reduce patient safety events in the emergency department with the implementation of an IPS program. Significant increases in teamwork scores were found for the SAQ; 73.2, 78.6 & 76.8 for baseline, post-intervention, and re-evaluation ($p < 0.05$). Another emergency department based study used a prospective cohort, pre-test post-test design, to implement a four-hour interprofessional in situ simulation-based training and found significant improvement in mean T-NOTCHES scores for teamwork from first to last scenarios; 16.7 to 17.7 ($p<0.05$) (Steinemann et al., 2011).

The use of TeamSTEPPS training course supplemented with simulation was evaluated in another study in the neonatal ICU at an army hospital in Hawaii. Attitudes toward teamwork and teamwork knowledge were both significantly increased. Significant improvements were also noted in the teamwork skills of team structure, leadership, situation monitoring, mutual support and communication ($p < 0.001$) (Sawyer, Laubach, Hudak, Yamamura, & Pocrnich, 2013). Figueroa and colleagues (2013) also used TeamSTEPPS in a comparison cohort study involving a nine-hour simulation based training course specific to the pediatric ICU setting. Results revealed a significant increase in closed-loop communication, perception of mutual respect, and a sense of empowerment ($p < 0.05$) in their study involving simulations of pediatric cardiac arrests.

Similarly, Klipfel and colleagues (2014) implemented in situ simulations on a general surgical unit and found an increase in mean scores of the Mayo High Performance Teamwork Scale of ≥ 0.7 (on a 3-point rating system) for 3/16 items. Maxson and colleagues (2011) used the CSACD to show that nurse-physician collaboration was significantly enhanced both at two-week, and two-month post simulation ($p < 0.002$). Another study looked at using IPS to improve communication during high-risk deliveries, and found significant improvements in team communication in both obstetric and pediatric teams ($p < 0.005$ and $p < 0.0001$, respectively) (Dadiz et al., 2013).

Sweeney and colleagues (2011) implemented a unique program in which senior pediatric resident physicians were responsible for designing and facilitating a mock code curriculum. Nursing survey results from the study revealed that 62% felt the curriculum encouraged team communication. In another study, qualitative analysis of nurses' responses regarding simulations with the rapid response team identified themes of "teamwork and interprofessional team training" "role clarity" and "communication" (Wehbe-Janek et al., 2012). A recent study by Kotsakis, Mercer, Mohseni-Bod, Gaiterio & Agbeko (2015) found similar results with implementation of an interprofessional, simulation-based acute care course. Themes identified included "improved communication skills" and "increased understanding of roles and teamwork".

Knowledge. In the literature, knowledge is assessed through mixed methodologies consisting of multiple-choice questions, performance evaluations, and through qualitative means. Qualitative analysis from Andreatta and colleagues (2011) reveals key-learning outcomes identified by participants include "clinical techniques" "team factors" and "code management". Similarly, "increased knowledge and skills" is one of the main themes identified by unit nurses in other qualitative analysis regarding rapid response teams (Wehbe-Janek et al., 2012).

After completion of the mock code curriculum in a study by Sweeney and Colleagues (2011) 100% of resident physicians reported that the knowledge gained would improve the quality of future actual resuscitations. Resident physicians had significant improvements in confidence in multiple areas of resuscitation ($p < .05$). The majority of nurses also felt better prepared for an emergency and felt that critical thinking skills had been developed. ((Sweeney, Stephany, Whicker, Bookman, & Turner, 2011)

Figueroa and colleagues (2012) found similar results. Participants felt significantly more equipped to participate in, and lead an actual code ($p <0.05$), manage an advanced airway, and perform cardioversion/defibrillation ($p <0.05$) (Figueroa MI et al., 2013). Results from another IPS intervention revealed knowledge test scores for baseline, post-intervention and re-evaluation of 86%, 96%, and 93%, respectively (Patterson et al., 2013).

Dadiz et al. (2013) used a 20-point checklist to evaluate performance and found a significant increase from 6 to 11 in median checklist scores from year one to year three ($p <0.001$). In 2011, Steinmann et al. reported improvement in the number of teams that completed ≥ 7 of 8 key trauma resuscitation tasks; from 32% to 84% ($p <0.05$), as well as faster time to completion of three common resuscitation tasks; from 460 seconds to 353 seconds ($p <0.01$), after their in situ simulations.

One randomized controlled trial looked at changes in knowledge of midwives and obstetricians after IPS on obstetric emergencies. Participants were randomized to one of four simulation interventions that varied in location (hospital versus simulation center) and length (one day versus two). Mean multiple choice questionnaire (MCQ) scores increased by 20.6 points (95% CI [18.1-23.1]; $p <0.001$) (Crofts et al., 2007). Another study used a "cold simulation" followed by training and a "warm simulation" approach. Participants managed an exsanguination and cardiac arrest simulation without any prior training (cold simulation), then underwent training and ended with their "warm simulation" of the same scenario. All tasks were performed at least 40% faster during the warm simulation ($p < 0.001$), the number of key steps completed significantly increased ($p < 0.001$), and post-intervention knowledge scores were significantly higher (Acero et al., 2012).

Additional Outcomes. This literature review did not seek to identify a relationship between IPS and improved patient outcomes; such research is very limited. However, it is important to note that Andreatta and colleagues (2011) demonstrated a positive correlation between pediatric cardio-pulmonary arrest survival rates, and the inception of their mock code curriculum. The survival rate significantly increased from 33% to approximately 50% within one year of the formal mock code program's implementation ($p=0.000$). Survival rates continued to increase as the number of mock codes increased ($r=.87$) (Andreatta, Saxton, Thompson, & Annich, 2011).

Additionally, Patterson et al. (2013) reported that as of March 2012 the emergency department had sustained more than 2.5 years without a patient safety event, after the implementation of their IPS program. Previous safety events were reported to be 2-3 per year (Patterson et al., 2013). Although the influence of confounding factors is unknown, these studies are of the few that link patient outcomes and IPS.

Discussion

The literature elicited through this review supports the hypothesis that IPS for the management of high acuity patients promotes knowledge acquisition and enhances teamwork. The ranking of this evidence is level II on the Johns Hopkins Nursing Evidence-Based Practice

Appendix H: Synthesis and Recommendations Tool.

Several of the studies examined communication, an essential component of teamwork. One ED found that in nine out of twelve patient safety events, communication issues were a causative factor (Patterson et al., 2013). Similarly, Acero et al. (2012) reported that a systematic review cited communication failures as a frequent cause of surgical errors. Effective communication improves team functioning and ultimately enhances patient safety (Acero et al., 2012).

Patterson and colleagues (2013) highlight the importance of sharing knowledge and collaborative teamwork. Team members increase their comfort with using each other as resources, instead of feeling expected to "know it all". Collaborative knowledge sharing reduces errors, as team members feel comfortable in questioning or consulting another colleague when necessary (Patterson et al., 2013). The concept that more errors occur when clinicians are afraid to speak up is well supported in the literature (Patterson et al., 2013). IPS has the potential to empower clinicians and foster an environment in which they feel safe and supported.

A safe, non-judgmental environment for learning is essential. IPS is ideal for training on low-volume, high-acuity events and situations of rapid patient deterioration. During such events there is a heightened sense of urgency and lack of tolerance for mistakes. Trying to learn under such conditions is challenging and can lead to feelings of inadequacy. IPS can replicate these real-life situations to evoke similar emotional responses, yet allow for mistakes to be made in a safe environment that promotes learning. Such training incorporates the learning of skills and knowledge, while fostering teamwork, all of which are reinforced through debriefing.

"As an education and training strategy, the use of simulation has proven to be effective and superior to other training delivery modalities for a broad range of skills including teamwork and technical skills" (Rosen, Hunt, Pronovost, Federowicz, & Weaver, 2012). However, the feasibility of implementing a simulation program is complex due to financial constraints, physical space to conduct simulations, and the time and effort required to create effective, engaging scenarios. An additional barrier is often the scheduling of health care providers in such a way that does not result in inadequate staffing or create a work-life imbalance.

Limitations of Review

There are several limitations of this review. The research designs, patient populations, and tools used varied greatly. This makes it difficult to compare study findings to each other. The combinations of search terms used in the selected databases may not have uncovered all the pertinent IPS literature available. The review included literature over the past ten years. With the rapidly advancing technologies of simulation, it may have been more prudent to limit studies to a more recent timeframe.

In regards to bias, several of the studies used videotaping which may have altered the participants' responses via the Hawthorne effect. Also, many of these studies were of the pre-test, post-test design. Although some involved repeated measurements later in time, the majority did not. Demonstrating the retention of knowledge and changes in behavior will strengthen the body of evidence supporting IPS. It will also dictate how often IPS should be repeated.

It is important to acknowledge that the majority of these studies evaluated changes in knowledge via written test, or perception of improved knowledge or teamwork. Perception of change does not equal actual change in clinician behavior. Likewise, written knowledge does not necessarily equate to competence at the bedside. A few studies concretely measured changes in response times for certain technical skills or used checklists to appraise teamwork. This is stronger evidence than perceptions of improvement. Yet a gap in the literature exists between

IPS implementation and actual changes in bedside practice, and furthermore, changes in patient outcomes.

Recommendations

As stated above, the vast variety among interventions and study designs, make comparison difficult at best. As discussed by the IOM (2015) report, having a conceptual framework for IPE would allow for consistency, more meaningful results and greater generalizability. Combining IPE and simulation increases the amount of variability, further strengthening the need for such a framework.

The ultimate goal of any healthcare training is to positively impact patient outcomes. The vast majority of the literature, as demonstrated in this review, links IPS with perception of behaviors or improved post-test scores. Ideally future studies will be rigorously designed to evaluate correlations with patient outcomes. This is of course difficult due to multiple confounding factors that are difficult to control for, such as evolving safety climates within organizations. Regardless of the lack of correlations to patient outcomes, "… national organizations have challenged institutions to … implement interdisciplinary team training through the use of simulation and debriefing" (Dadiz et al., 2013).

Methods

Study Design

A quasi-experimental comparison-cohort pilot study was developed to evaluate knowledge retention, and analyze changes in perceptions of teamwork, amongst nurses and RPs in a STBICU setting after completion of an interprofessional critical event simulation. For the purposes of this study, "knowledge" will encompass the clinical awareness and comprehension of intracranial pressure (ICP) management, as well as the ability to correctly apply ACLS algorithms. "Teamwork" will be defined as "an identifiable set of behaviors, cognitions, and attitudes that contribute to the team's overall functioning" (Ilias et al., 2012, p. 388). A secondary outcome of this study was to provide insight for future IPS, including the ideal frequency of such training.

Participants

The primary focus of this pilot study was the affect of IPS among nurses and physicians. It was predicted that less experienced RPs and nurses would have the most to gain from this intervention. Therefore they were the primary targets for participation. To meet inclusion criteria participants were either 1) a nurse in the STBICU or 2) a first through fourth year surgical, emergency, or anesthesiology RP. Nurses that had not completed orientation, or, had greater than five years of STBICU experience, and fellow and attending physicians were not eligible for participation. With consideration for the availability of the institutional Life Support Learning Center (LSLC), and unit staffing, the goal was to recruit twelve physicians and twenty-four nurses, for a total of thirty-six participants. Four, twenty-dollar gift certificates to a local restaurant were raffled off as incentive to participate in the study. As this was a component of STBICU training, the nurses were financially compensated for their time.

Setting

A fifteen-bed STBICU at a 600 bed, level I trauma, tertiary, academic medical facility in the southeastern United States, was the setting for this study. On average, the health system sees 1830 trauma patients and 113 severe TBI patients (GCS <8) on a yearly basis (University of Virginia Health System's Trauma Registry, 2016). The actual simulations occurred in the unoccupied burn hydrotherapy room.

Intervention

All participants provided verbal consent to participate in the study. A brief discussion of the study purpose and introduction to the simulation patient manikin were provided prior to consent. Participants then completed the Knowledge Pretest (Appendix B), the Teamwork Skills Scale (TSS) Pretest (Appendix C), and answered basic demographic questions via paper handouts.

The one-hour simulation was conducted five times. The initial goal was to have two RPs and four nurses per session. All sessions included at least one RP and three nurses. One session involved a first year RP that was scheduled for educational time. The additional three sessions utilized RPs that were on the STBICU service for the day. A sign up sheet was posted for nurses to volunteer. When volunteer numbers were insufficient, and when staffing allowed, nurses on the unit were permitted to participate. Participants were asked to fill out the Simulation Survey immediately following the intervention. The intervention was not adjusted based on feedback until the conclusion of the study. Approximately one month after completion of the simulation session, participants completed the TSS and knowledge test again via online format. Pretest, posttest, and one-month posttest scores were compared.

Simulation Scenario

One of the many patient populations that can deteriorate rapidly is the neurotrauma population. As with any patient population, the care of neurotrauma patients should be based on current evidence-based guidelines. Lack of adherence to guidelines is well established (Bayley et al., 2014).

Therefore, a traumatic brain injury (TBI) patient with high intracranial pressures (ICPs) was selected for the scenario. The management of TBI patients is highly complex and dynamic, and requires a multidisciplinary team (Haddad & Arabi, 2012). The team employed interventions to reduce ICPs based off of the institution's Trauma Handbook (Young & Calland, 2015). Although all interventions may have been correct, the severity of the TBI resulted in brainstem herniation and subsequent cardiac arrest. The team then ran through advanced cardiac life support (ACLS) code management in real-time. (See Appendix D for scenario)

The simulation was followed by a semi-structured debriefing session. The TENTS tool assesses the four components of teamwork; communication, leadership, situation monitoring, and mutual support (Hohenhaus, Powell, & Haskins, 2008) (see Appendix E) and was used to guide the session. The debriefing also answered participants' questions about ICP management and ACLS code management, and reinforced key concepts.

Measures

To assess knowledge acquisition, a nine-question knowledge test was created for use. Content included goals of ICP management, ACLS concepts covered in the scenario, and teamwork knowledge. Clinical nurses specialists of the neurotrauma patient population and an ACLS instructor reviewed the test for content validity (see Appendix C for knowledge test).

To measure perceptions of teamwork the TSS was utilized. The TSS is a self-reported, validated, reliable tool that measures clinicians' perceptions of their teamwork skills (Grymonpre et al., 2010) (see Appendix D for TSS). There are eighteen, five-point Likert scale items, that range from "1" equating to "poor" to "5" equating to "excellent". Possible scores range from 18 to 90, where the higher the score, the more positive the perception of teamwork (Grymonpre et al., 2010).

Data Analysis

Quantitative data was entered into Microsoft Excel and then transferred to the Statistical Package for Social Sciences (SPSS) software (version 23) for data analysis. Descriptive frequencies were run to determine average test scores on each test. Parametric tests indicated that data was normally distributed. A one-tailed paired t-test was used to compare the pretest to posttest, and pretest to one-month knowledge posttest. This was also completed for TSS scores. A p value of <0.05 was considered significant.

Protection of Human Subjects

Approval to conduct this study was obtained from the institution's Social Behavioral Sciences Institutional Review Board (Appendix F). Informed consent was obtained prior to the start of the simulation. The participants' responses and tests were not linked to individuals or to participation group. The only identifying data collected was role (nurse or RP), experience with patient population, and time in the STBICU. Participation was voluntary and there was no penalty for not participating. Participants were notified of the option to participate via email, flyer and verbal recruitment efforts. Participants were entered to win one of four twenty-dollar gift certificates to a local restaurant to encourage participation.

To reduce any risk of social or psychological harm, it was emphasized that participant's individual performance was not the concern of this study, and an individual's performance would not be discussed outside of the simulation. No one with supervisory authority reviewed individual surveys. The participants were aware that the patient's deterioration was not a result of any incorrect actions. The patient was designed to deteriorate to provide the desired exposure. Any risk to the participant was determined to be minimal, and this was not a risk-sensitive participant population.

Results

Participants

Volunteer participants were recruited during the month of February 2016. A total of 22 clinicians, including 16 nurses and six resident physicians participated in this study. Two nurses and one resident did not complete the one-month post-test (13.6% dropout rate). Of the nurses that participated, 93.8% had completed the unit's mock code program during orientation. Length of time working in the unit was from less than one year to nearly four years, with the majority of nurses working in the unit for one to two years (68.9%). Fifty percent had less than two years of experience with the neuro-trauma population, with two nurses having greater than four years of neuro-trauma experience. Of the resident physicians, 83.3% had less than two years of experience with the neuro-trauma population, and 66.7% had completed a prior STBICU rotation.

Knowledge

Testing was completed immediately prior to the simulation, immediately after, and at approximately one-month post-simulation. The mean knowledge pre-test score for all participants was 6.41(SD 1.37) out of a total of 9 possible points (a score of 71.2%). Paired T-tests demonstrate that mean post-test and one-month post-test scores were significantly higher at 8.23(SD 1.02) (91.4%) and 7.5(SD .95) (83.3%) respectively (p<.000) (Appendix H) Comparing roles, the nurses had a higher mean knowledge pre-test score of 73.7% compared to 64.8% for resident physicians, however one-month post-test scores were similar at 82.7% and 85.2%, respectively.

Team Skills Scale

Mean TSS for pre, post, and one-month post-tests were 66.86 (SD 5.68), 69.23 (SD 8.31), and 71.53 (SD 9.05), respectively, out of a total possible score of 90 (Appendix I). Paired T-tests revealed statistically significant improvements between each measurement (p<.000). When compared by role, nurses' mean scores were 67.94, 70.88, and 69.93 respectively. RP's TSS scores increased the most at one-month follow up, with scores of 64, 64.83, and 76 respectively.

Simulation Survey

One hundred percent of participants felt this training would assist them in caring for critically ill TBI patients, and 96% felt this training would assist them with ACLS certification/renewal. Aspects of the training perceived to be valuable included interprofessional teamwork, reality of the scenario, hand-on exposure, instability of the patient, debriefing, and the efficient use of time (see Appendix G). Fifty percent felt this type of training should be offered quarterly, 41% requested training every six months, with the remainder of participant responses ranging from every shift to once per year. One respondent also suggested that simulation training occur once per month during orientation, then decrease to quarterly sessions. The most common theme in response to “suggestions for improvement of future training” was to increase the frequency of team-based simulation training.

Discussion

These results support the use of IPS as an effective way to improve knowledge retention and enhance perceptions of teamwork amongst nurses and RPs in an ICU setting. This is supported by significant increases in knowledge test and TSS scores post intervention, which persisted at one-month evaluations. At one-month follow-up, knowledge test scores decreased slightly, but remained significantly higher than pre-test values. This agrees with the existing literature that validates simulation as an effective teaching modality. This study supplements the existing literature that evaluates knowledge retention post simulation, which is less often evaluated. Many studies demonstrate an increase in immediate posttest scores, however it is the retention of that knowledge that is more meaningful.

On the knowledge pretest, nurses scored higher than the RPs, which may be reflective of the increased exposure the nurses have to this patient population. A TBI patient was specifically selected for this simulation because of the interventions that are often implemented automatically by the bedside nurse, that the RP may or may not be aware of. Such interventions include maintaining neutral positioning of the head, reducing stimulation, and loosening a c-collar, and are recommended in the TBI literature to reduce ICPs (Haddad & Arabi, 2012). There is potential for mismanagement of care if a newer nurse does not know to implement the non-invasive interventions, and an inexperienced RP does not know to ask. This could result in a patient receiving unnecessary invasive interventions. This is an example of how learning the intricacies of other professions can improve patient care.

In regards to teamwork, nurses started with higher TSS scores, indicating that nurses perceived themselves to be more skilled at teamwork than RPs did. Interestingly, RP's TSS scores increased significantly at the one-month follow up, while the nurses' scores remained relatively stable. Perhaps this is because after this intervention the RP's were more comfortable interacting with the nurses on the unit, and were able to better understand their role in the patient's care. It is also possible that the RP's reflected on how teamwork influences their practice, and the quality of care the patients receive. This finding is inline with the recommendation made by the IOM report (2015), which challenges future IP research to demonstrate changes in collaborative behavior. Although we cannot infer that behavior changed, we do know that the participants perceived improvements in their teamwork skills.

The TENTS tool was used to add teamwork structure to the debriefing sessions. One of the most common foci of the debriefings was closed loop communication. On multiple occasions, confusion ensued amongst team members when closed loop communication was not used. Anecdotally, those teams that had good closed loop communication tended to function more effectively. This is supported by a systematic review that found the most common source of errors during code situations is miscommunication (Flannery & Parli, 2016). Closed loop communication is recommended to reduce such errors.

The simulation used in this study was not specifically designed to promote teamwork; rather its primary purpose was to encourage knowledge retention. By working together in a learning environment, and having key teamwork aspects highlighted during debriefing, the participants improved their perceptions of teamwork. This may in part be due to the sense of camaraderie that develops between coworkers when caring for an extremely ill patient, such as after a cardiac resuscitation. To the author's knowledge, this concept has not been specifically explored in the teamwork literature.

A secondary outcome was to provide insight for future IPS. Significant challenges encountered when implementing an educational program include maintenance of a work-life balance, and RP hour restrictions. One respondent commented, "I definitely appreciated having this training on a work day". In-situ training has the benefit of reducing total work hours by conducting education when clinicians are scheduled for work.

In-situ training also presents unique challenges such as ensuring adequate staffing, and balancing patient care needs, while ensuring a robust educational experience. When participants include clinicians assigned to patient care, it is likely that if a patient-care emergency arises, the training will be cancelled. This can result in a significant waste of time and energy resources, and can ultimately result in an unsustainable program. The benefits of this intervention include its brevity (one hour) and its ability to teach clinical knowledge and enhance teamwork simultaneously. This not only reduces the time a clinician needs to be away from patient care, but also may enhance the perceived value of the training. One participant conveyed a favorable view of this training, compared to previous simulations, based on the high clinical applicability of the knowledge. Therefore if high-quality clinical content can be delivered while teamwork is enhanced, the intervention may be more likely to be appreciated, and will be an effective use of resources.

The ideal frequency of re-training was also explored in this study. The majority of participants felt training should occur quarterly to biannually, and cover a variety of patient scenarios. It is difficult to speculate which frequency option is ideal from the learning perspective; since this study did not evaluate knowledge retention or TSS scores beyond one month. Ultimately, the frequency will be determined by the experience of the staff, the amount of knowledge required for the patient populations served, the ability to sustain such a program, and the institution's support for education.

Strengths & Limitations

Much of the simulation literature tests changes with pre and posttest designs, which often show a change in scores immediately following simulation. Less known, is how long participants retain the knowledge or change in behavior. The one-month posttest score evaluation in this study indicated a persistence of improvements in knowledge and perceptions of teamwork.

The vast majority of interprofessional simulation literature involves medical or nursing students, not actual practitioners. It is recommended that health professionals receive team training post-licensure (Curran et al., 2012). Additionally, only a few of the team-based simulation studies focus on critical care. The ICU is an ideal practice setting to implement simulation-based team-training interventions. Multiple procedures and equipment can be integrated into such scenarios, which assist in maintaining competency of ICU physicians and staff. Additionally, this type of training had not previously been implemented in this SBTICU setting at our institution.

In this study, perceptions of teamwork were measured using the TSS. The TSS is designed to detect changes in self-reported teamwork skills of health care professions after implementation of a team-based intervention. This tool is reliable, with a Cronbach's alpha of .94 (Hepburn, Tsukuda, Fasser, 2002) and has been implemented in a number of studies on various populations (Curran, Mugford, Law & Macdonald, 2005, Grymonpre et al., 2010 & Robben et al., 2012).

An additional benefit of this study that enhances its meaningfulness is the structured teamwork debriefing using the TENTS tool. In the literature, the level of structured debriefing varies from study to study. Using the TENTS tool provides a guide for discussion points and allows this debriefing to be replicated more accurately in future studies.

There are several limitations of this pilot study. Foremost, it is important to acknowledge that change in perceptions of teamwork skills does not necessarily equate to changes in teamwork behavior. The same concept applies to the knowledge component of this study. Although the knowledge test was designed to achieve higher levels of comprehension than simple regurgitation of material, improved knowledge test scores do not mean that the knowledge is being integrated into practice. Additionally, the knowledge test was created by the author and limited to content validity. It is also possible that the number of questions is too small to accurately reflect changes in knowledge.

In order to maintain a work-life balance, and consider unit staffing, the intervention was limited to one hour in length. To additionally increase feasibility, the simulations were conducted on day shift and focused only on nurses and RPs. The interprofessional team does not consist solely of dayshift nurses and physicians. Other professional team members (such as respiratory therapists, physical therapists, occupational therapists, etc.) significantly contribute to patient care, but were not included in this study.

Since the aim of this study was to evaluate the effectiveness of an IPS, there was no control group. This limits this study's ability to state that IPS is superior to other training methods. The nurse participants in this study were primarily volunteers, whom knew the author. It is possible that nurses whom volunteered for this study, may have more highly valued teamwork and education than their non-volunteer colleagues. Although individuals were not analyzed for their individual performance, it is possible that the participants were subject to the Hawthorn effect.

The final limitations concern the TSS tool. The TSS was designed for use in the geriatric patient population (Heinemann & Zeiss, 2002), and has not been validated in the ICU setting. There are components of this tool such as "participate actively in team meetings" that were not specific to this type of emergency scenario.

Practice Implications

The results of this study indicate that a relatively short IPS is feasible, and can increase perceptions of teamwork and knowledge retention in nurses and RPs in an ICU setting. Factors to consider when planning such an intervention include the participants' baseline knowledge, amount of content to cover, scheduling of participants, appropriate simulation length, and ideal time for re-training. The open-ended Simulation Survey indicates that the participants found the training valuable and enjoyable.

It is also important to consider the potential unmeasured effects that may occur as a result of this study. As a result of increased awareness of teamwork, participants may integrate teamwork behaviors into practice, and increase collaboration with other professions. It is also possible that the knowledge component will highlight knowledge gaps specific to each individual. This may encourage participants to actively enhance their knowledge base and prepare for future patient care emergencies. It is through these unmeasured potential effects, that patient care, and subsequently, patient outcomes, would be improved.

Future Recommendations

Future research should evaluate knowledge retention and TSS at further lengths of time, such as six months, and one year post-simulation. Replacing self-reporting scales with observation checklists for technical and teamwork skills would strengthen the meaningfulness of future studies. Observing changes during actual patient care would be ideal, and would demonstrate the application of learned knowledge and skills. Quality improvement research that provides insight on how to sustain an IPS program with frequent (every 3-6 months) simulations would be valuable.

Randomized controlled trials that compare IPS to more traditional types of training, and seek to determine the benefits of interprofessional training as opposed to single profession training, would strengthen the existing body of IPS research. Some relationships that could be explored include the effect of IPS on nursing retention, RP performance, and the rate of patient care errors. A cost-benefit analysis that accounts for possible improvements in such outcomes, would be valuable when seeking institutional support for an IPS program. The ultimate goal of future IPS research should be to demonstrate a relationship with patient outcomes.

Conclusion

This pilot study demonstrates the successful implementation of an IPS in a critical care setting. The statistically significant improvements on both knowledge test, and TSS scores, demonstrate the effectiveness of this intervention, and retention of the improvements. Additionally, open-ended questions revealed that participants valued the intervention and would recommend increasing the frequency of such training. This simulation format can be adapted to virtually any type of practice setting. Future research should continue to strengthen the body of literature supporting IPS by exploring relationships between IPS and actual changes in practice, and ultimately associating IPS with changes in patient outcomes.

The recent national focus on enhancing patient safety requires that health care professionals collaborate effectively as a team. Remaining clinically competent and integrating evidence based practice at the bedside is essential given the highly acute nature of hospitalized patients. IPS has the ability to conquer each of these requirements as it promotes knowledge and skill refinement simultaneously while fostering teamwork. This study demonstrated that IPS is an effective method for promoting knowledge acquisition and increasing teamwork in the management of high acuity patients. Future studies should attempt to develop a framework for "best practice" IPS, measure changes in actual bedside practice, and ultimately seek correlations between IPS and improved patient outcomes.

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Appendix A

Studies Analyzed in Literature Review

Study	Participants & Setting	Design	Intervention	Outcomes	Limitations	Level of Evidence*
Acero, et al. (2012)	Participants: 171 OR staff members Setting: Penn Medicine Clinical Simulation Center in Philadelphia, Pennsylvania.	Comparison Cohort with a pre-test, post-test design	Groups responded to a pregnant patient that was hemorrhaging. Participants went through a "cold" simulation, followed by debriefing and didactic education. Participants then repeated the same simulation; referred to as a "warm" simulation.	All teams increased the number of key steps completed (p<0.001). All tasks were performed at least 40% faster during "warm" simulation (p<0.001). The percentage of participants that either agreed or strongly agreed that they understood their role increased from 50% to 98% (p<0.001). The percentage of participants that either agreed or strongly agreed that they knew how to activate the exsanguination protocol increased from 50% to 98% (p<0.004). There were significant increases in knowledge scores post training.	This was a single center study with a convenience sample. Demographic information about participants was not reported. There was no discussion of limitations. The knowledge questionnaire was only composed of three basic questions. There was no discussion of the validity or reliability of the knowledge test. It appears the participants had to pay $75 for the simulations, which could introduce bias. Only one moderator reviewed the videos for scoring and timing.	IIA
Andreatta et al. (2011)	Participants: Pediatric ICU nurses, medical students, the pediatric ward team, pediatric RPs, and pediatric pharmacists. Responses were collected from 228 RPs. Location: The Children's Hospital at the University of Michigan; a tertiary care academic medical center	Longitudinal, mixed-methods design	Monthly, random, mock codes were held. The scenarios were designed to represent common conditions and emergencies seen in the pediatric population. Video recordings were used for immediate debriefing. The comparison intervention was ten informal mock codes held prior to initiation	The residents ranked their ability to lead a code as above average, after completing the mock codes. (4.20 +/- 0.91, scale of 1-6). Key learning outcomes identified by participants included: 547 responses reported under "clinical techniques" 199 responses for "team factors" and 393 responses under "code management" Additional outcomes: Cardiac arrest survival rate increased from 33% prior to formal	This was a single center study. Demographic information about participants was not reported. There was no pre-evaluation of self-confidence taken before the intervention. The ability to compare the two sets of data, and demonstrate an increase in confidence would be more meaningful. Mock codes were only held during day shift on weekdays. Responses were only collected from RPs. The discussion states that the mock codes resulted in increased patient survival rates. However, this is a	IIA

			of the formal mock code program.	mock codes, to approximately 50% within a year of the mock code program implementation. The survival rate increasingly correlated with the number of mock code events (*r* =0.87).	correlation, which does not equal causation.	
Crofts, et al. (2007)	Participants: 140 total; 22 junior doctors, 23 senior doctors, 47 junior midwives, and 48 senior midwives. Setting: Six hospitals in the South West of England, UK and at the Bristol Medical Simulation Centre, UK.	Prospective, randomized controlled trial	Participants were randomized to one of four OB emergency training interventions: a one-day course at local hospital, a one-day course at simulation center, a two-day course with teamwork training at local hospital, or a two-day course with teamwork training at simulation center.	Mean MCQ scores increased by 20.6 points (95% CI 18.1-23.1; $p<0.001$). There was no significant effect on the MCQ score of either the location of training ($p= 0.785$) or the inclusion of teamwork ($p= 0.965$).	Did not meet desired response rate of 144. The MCQ had a true/false format, which allows the participants a 50% to guess correctly. Testing cognitive knowledge does not equal competence. The participants were not randomized to receive training. Participants sought out training on their own, which may have introduced bias.	IB
(Dadiz et al., 2013)	Participants: 228 medical and nursing providers from the obstetric and pediatric departments Setting: The University of Rochester Medical Center; a tertiary medical center with a 60 bed level IV neonatal intensive care unit. Simulations occurred at the Center for Obstetric and Gynecology Simulation.	Prospective, longitudinal, observational study	Annual simulation based training sessions of high-risk deliveries were conducted. Sessions were 90 minutes long, followed by debriefing. Sessions were videotaped for review with checklist. The scenario changed annually to focus on high priority learning needs as identified by the institution's risk management group.	Significant improvements in team communication were seen in both obstetric and pediatric teams ($p<0.005$ and $p<0.0001$, respectively). There was a significant increase from 6 to 11 (out of total possible score of 20) in median checklist scores from year one to year three ($p<0.001$). Additional findings: Pediatric communication was rated significantly higher over time ($p<0.05$).	This was a single center study. Years two and three included team members that had participated previously, and may have positively influenced results. Improved checklist scores do not equal improved patient care. Interprofessional debriefings after actual patient events began during the study period and may have introduced bias.	IIB
(Figueroa MI et	Participants:	Comparison	A nine-hour	Three-month post-	This was a single center	IIB

al., 2013)	Total of 37 (23 nurses, 5 cardiology/critical care trainees, 5 respiratory therapists, & 4 non-categorized) Setting: University of Tennessee Health Science Center/Le Bonheur Children's hospital. Simulations occurred at an off-site simulation center.	cohort; pre & post test design	simulation based training course was developed for the pediatric ICU based on common complications post-cardiac surgery that result in arrest. Didactic session was included. Debriefings followed simulations. Surveys were taken before, after, and three months after, simulations.	simulation survey revealed that participants felt they were more equipped to participate in, and lead, an actual code ($p<0.05$). There was a mean change in reported confidence and skill for advanced airway management and cardioversion/defibrillation ($p<0.05$) at both the immediate post-simulation survey and the three-month follow-up. There was a significant increase in closed-loop communication, use of huddles, perception of mutual respect, and a sense of empowerment ($p<0.05$).	study. Four of the participants are listed as "non-categorized". Course instructors worked with, and evaluated, participants, which may have introduced bias. Data was not sufficient to describe any effect on patient outcomes. Results were not objectively measured.	
Klipfel, et al. (2014)	Participants: 23 staff total; 18 RNs and 5 urology RPs. Setting: General surgical unit at the Mayo Clinic in Rochester, MN.	Comparison cohort; pre-test post-test design.	A quality improvement project implemented in situ simulations consisting of three RNs and a urology RPs. Participants were briefed regarding TeamSTEPPS teamwork principles and encouraged to practice these skills. Two scenarios were presented: one uroseptic patient and another in cardiac arrest.	The mean score of the Mayo High Performance Teamwork Scale increased by ≥ 0.7 (on a 3-point rating system) for 3/16 items. There was an improvement in mean scores for 10/16 questions. Additional outcomes: The participants found the simulations to be useful, prompted realistic responses, improved confidence in a code situation, and provided SBAR practice.	This is a single center study. A convenience sample of limited size was used. There is no discussion of significant improvement, and no *p* values are provided. Videotaping may have altered the participants' behavior. Participants evaluated teamwork of the scenario they participated in. This is a perception of change in teamwork. The tapes were not reviewed for inter-rater reliability, which would strengthen the meaningfulness of the results. Improvement in post-test scores does not ensure change in clinical behavior outside of the study setting.	IIA
Kotsakis et al. (2014)	Participants: 38 physicians and 51 nurses Setting: The	Mixed method evaluative approach	A one-day course consisting of six, ten-minute simulations	Themes identified included: Improved communication skills and increased understanding of roles	This was a single center study. There was a low level of study structure. No discussion of the validity or reliability of the	IIB

	hospital for Sick Children, Toronto, Canada		focusing on crisis resource management, SBAR, BLS skills, and medical knowledge.	and teamwork. Additional outcomes: 100% of respondents rated the day as excellent/very good. Respondents reported improved confidence. Respondents valued the simulations and requested repeated sessions.	tools used. The study measured perception of improved skills and teamwork.	
Maxson et al. (2011)	Participants: 28 total; 19 nurses and 9 physicians from a surgical ward at Mayo Clinic in Rochester, MN. Setting: Simulations were conducted at the Mayo Clinic Multidisciplinary Simulation Center in Rochester, MN.	Comparison cohort; Pre-test post-test design	Three clinical scenarios designed to simulate common post-operative complications. Scenarios lasted about twenty minutes each, and were videotaped for use during debriefings. Team principles were introduced after the first simulation. Debriefing occurred after each scenario with a focus on communication amongst team members.	Pre-test results of the CSACD showed that about 50% of participants were dissatisfied with current decision-making. Two week post-test showed CSACD median scores had improved significantly (4.2 to 5.1 on a scale of 1-7; $p < 0.002$). The significant improvement was sustained at a two month follow up ($p < 0.002$). There was no significant difference between 2-week and 2-month post-tests ($p < 0.24$).	This was a single center study with a convenience sample of limited size. Volunteers were recruited for participation as opposed to requiring participation. A volunteer group may differ in the composition of its personalities as opposed to a random sample group. There was a wide range of experience between RPs and nurses.	IIA
Patterson et al. (2013)	Participants: 289 attended initial training. 151 attended the re-evaluation. Setting: Cincinnati Children's Hospital Pediatric Emergency Department	Comparison cohort; Pre-test post-test design	Five simulations totaling 12 hours occurred over the course of two days, and focused on CRM, teamwork behaviors, and communication skills. Simulations were videotaped. Debriefings occurred post-simulation. Simulations were supplemented	Knowledge test scores for baseline, post-intervention and re-evaluation were 86%, 96%, and 93%, respectively. Significant increases in SAQ scores for teamwork; 73.2, 78.6 & 76.8 for baseline, post-intervention, and re-evaluation ($p<0.05$)	This was a single center study. There was a significant loss of those that attended initial training to those that attended re-evaluation. The knowledge questionnaire was not independently validated. Inter-rater agreement for the Behavioral Markers Scale was not strong. (k = 0.41-0.80) and (k = 0.21-0.41) for some components. Technical difficulties interfered with videotaping of actual	IIA

			with additional education. Participants returned for re-evaluation in six months.		patient care.	
Sawyer et al. (2013)	Participants: 42 physicians, nurses, & respiratory therapists. Setting: A 20 bed NICU at the Tripler Army Medical Center in Honolulu, HI.	Comparison cohort; pre-test, post-test design.	Teams of physicians, nurses, & respiratory therapists underwent TeamSTEPPS supplemented with simulation. The simulations were scripted and purposefully incorporated errors that the other profession was expected to challenge. Teamwork performance was rated according to the T-TPOT by two observers.	Attitudes toward teamwork increased from 4.4 +/- 0.8 to 4.7 +/- 0.8 (CI -0.34 to – 0.22, $p < 0.001$). Teamwork knowledge increased from 86.8% +/- 7.5% to 92.6% +/- 6.3% (CI -8.32 to - 3.26, $p < 0.001$). Significant improvements were noted in teamwork skills of team structure, leadership, situation monitoring, mutual support and communication ($p<0.001$).	This was a single center study. To evaluate the effectiveness of adding simulation to the TeamSTEPPS, it would have been beneficial to have a control group of TeamSTEPPS training compared to TeamSTEPPS plus simulation. The observers evaluated the simulations in real time, which did not allow for any review if needed. The observers were not blinded. There was no discussion of how observers were selected. The results of this study have limited generalizability, as the setting was a military hospital. The structuring of the military may have influenced how participants responded.	IIA
Sweeney et al. (2011)	Participants: 76 RPs and approximately 75 nurses. Setting: The setting is not specifically addressed.	Comparison cohort; pre-test post-test design	A mock code curriculum was developed so that a senior RP would be a resident educator (RE). This RE was then responsible for creating their own mock code and implementing it on night shift. Each mock code lasted about an hour, including debriefing.	62% of nurses felt that the curriculum encouraged team communication. 80% of nurses reported that the mock codes helped to better prepare the team for emergencies. Additional Outcomes: Resident participants had significant improvements in confidence in multiple areas of resuscitation ($p<.05$). Nurses felt their anxiety regarding emergencies was reduced and the mock codes helped with critical thinking.	Assumed to be single center study with convenience sample. No discussion of demographics of study population beyond their experience with actual and/or mock codes in the past. Variability between mock codes resulting from different designers/facilitators. Most of the data was presented in graph form but did not list many of the specific values. No discussion of drop out rate.	IIC

Steinemann et al. (2011)	Participants: 137 interprofessional team members Setting: The Queen's Trauma Center (level II); the academic teaching hospital for the University of Hawaii.	Prospective cohort; pre-test, post-test design	In situ team simulation training occurred in the emergency department. Interprofessional groups participated in a three-hour simulation session, which included a didactic section as well as videotaped debriefing.	Significant improvement in mean T-NOTCHES scores for teamwork was seen from first to last scenarios; 16.7 to 17.7 (p<0.05) There was improvement in the number of teams that completed ≥ 7 of 8 key trauma resuscitation tasks; from 32% to 84% (p<0.05). Faster time to completion of tasks was noted (p<0.01).	This was a single center study The research was partially funded by Medical Education Technologies Inc., which may introduce bias. The critical care trauma nurse and research assistants were not blinded. Significant changes in patient outcomes were not found.	IIB
Wehbe-Janek et al. (2012)	Participants: 360 medical-surgical unit nurses completed training; 203 nurses submitted post-training questionnaires. Setting: Scott & White memorial Hospital in Temple, Texas; a 600 bed tertiary academic level I trauma center	Mixed methodology	An IPS program was developed to enhance awareness of the hospital's rapid response team, with a focus on early recognition of patient deterioration and communication. Nurses attended a three-hour session per week, for three weeks. Nursing attendance was required. The sessions included other members of the code blue team such as pharmacists, respiratory therapists, and internal medicine and anesthesia RPs.	The themes of "teamwork and interprofessional team training" "role clarity" "increased knowledge and skills", and "communication" collectively accounted for 43.1% of responses. Among nurses, 98% agreed or strongly agreed that the simulations increased familiarity with resuscitation equipment. 97% of nurses agreed or strongly agreed that the simulation increased familiarity with team roles. Additional Outcomes: Nurses found the "hands-on" aspect valuable. Increased confidence and comfort were identified as additional themes.	This was a single center study. One-word and ambiguous responses were not included (p. 45) which could potentially introduce bias and it should have been explained upfront that one-word responses would not be accepted. All nurses were required to participate but were not required to respond to questionnaire, which may have eliminated a significant portion of the nurses' views. Responses of non-nursing staff members were not collected in this study.	IIB

Note. SAQ = Safety Attitudes Questionnaire; OB = obstetric; MCQ = multiple-choice questionnaire; ICU = Intensive care unit; ED = Emergency department; SBAR = Situation Background Assessment Recommendations CRM = crew resource management; TeamSTEPPS = Team Strategies and Tools to Enhance Performance and Patient Safety; T-TPOT = TeamSTEPPS Team Performance Observation Tool

* Level of Evidence based off of the Johns Hopkins Research Evidence Appraisal Tool

Appendix B

Knowledge Test & Demographic Questions

1. Which set of physiological changes is representative of Cushing's Triad?

A. Increased systolic pressure, bradycardia, & irregular/decreased respirations

B. Hypotension, tachycardia, & hyperthermia

C. Increased systolic pressure, tachycardia, & change in pupils

D. Hypotension, bradycardia, & hyperthermia

2. All of the following are interventions to reduce ICP <u>EXCEPT</u>:

A. Loosening C-collar

B. Limiting stimulation

C. Administering a sedative & a paralytic

D. Administering D5W

3. Per ACLS, the drug to consider for refractory ventricular fibrillation/pulseless ventricular tachycardia is:

A. Amiodarone 300 mg IV push

B. Amiodarone 150 mg/100 mL over 10 min

C. Lidocaine 1 mg IV push

D. Sodium Bicarb 50 mEq IV push

4. With the biphasic Phillips defibrillator utilized at this facility, the correct electrical dose & method for ventricular fibrillation is:

A. Synchronized cardioversion; 100 J

B. Synchronized cardioversion; 150 J

C. Defibrillation; 150 J

D. Defibrillation; 300 J

5. Per the UVA Trauma Handbook goal serum sodium for a TBI patient with ICP bolt in place is:

A. 135-150

B. 130-140

C. 150-165

D. 145-155

6. How often does serum sodium need to be monitored if 3 % saline is infusing?

A. Every 2 hours

B. Every 4 hours

C. Every 6 hours

D. Every 8 hours

7. Per ACLS how often should Epinephrine be given for a pulseless rhythm?

A. Every minute

B. Every 2 minutes

C. Every 3-5 minutes

D. Every 5-6 minutes

8. The patient's ICP has just elevated to 20, your next intervention would be:

A. Administer mannitol per Trauma handbook

B. Determine what other interventions have been completed

C. Book an OR room for craniectomy

E. Notify trauma attending that ICP is 20

9. A correct example of closed loop communication would be:

A. "1 mg atropine IVP given"

B. "Order received and executed"

C. "1 of Atropine given"

D. "Atropine has been given"

Demographic Questions:

1. Please select the position that describes you:
- RN
- Physician

2. If you are an RN, did you participate in the STBICU "mock code" program?
- Yes
- No
- I'm not an RN

3. How many years of experience do you have with the neurotrauma population?
0-1
2-3
3-4
>4 years

4. If you are a RN, how long have you worked in the STBICU?

5. If you are a resident, have you completed a STBICU rotation yet?
Yes
No

Appendix C

Team Skills Scale (TSS)

Team Skills Scale (Self Assessment)

Please rate your ability to carry out each of the following tasks at this point in your training using a five-point scale:

	Poor	Fair	Good	Very Good	Excellent
1. Function effectively in an interdisciplinary team	o	o	o	o	o
2. Treat team members as colleagues	o	o	o	o	o
3. Identify contributions to patient care that different disciplines can offer	o	o	o	o	o
4. Ensure that patient/family preferences/goals are considered when developing the team's care plan	o	o	o	o	o
5. Handle disagreements effectively	o	o	o	o	o
6. Strengthen cooperation among disciplines	o	o	o	o	o
7. Carry out responsibilities specific to your discipline's role on a team	o	o	o	o	o
8. Address clinical issues succinctly in interdisciplinary meetings	o	o	o	o	o
9. Participate actively at team meetings	o	o	o	o	o
10. Develop an interdisciplinary care plan	o	o	o	o	o
11. Adjust your care to support the team goals	o	o	o	o	o
12. Develop intervention strategies that help patients attain goals	o	o	o	o	o
13. Raise appropriate issues at team meetings	o	o	o	o	o
14. Recognize when the team is not functioning well	o	o	o	o	o
15. Intervene effectively to improve team functioning	o	o	o	o	o
16. Help draw out team members who are not participating actively in meetings					

Please rate your attitude:

	o	o	o	o	o
17. Toward other disciplines working in the team setting	o	o	o	o	o
18. About practicing in a team care environment	o	o	o	o	o

Appendix D

TBI Patient Simulation

1. **Patient Information:**

Name: T, F Henderson Gender: F
Age: 44 years old
Ethnicity: Caucasian Height: 5’6” Weight: 157 lb
HPI: TBI after being kicked by a horse in the face 24 H ago
PMH: GERD
Medications: No home meds
Hospital: 3 % saline @ 50 mL/H
NS @ 75 mL/H

2. **Coordinator Overview:**

Patient is 12 hours out from initial injury; intubated & sedated in ICU. ICP Bolt placed 4 hours ago. Scenario starts as patient returns from head CT with ICPs of 30 on 3% saline @ 50 mL/H, Fentanyl @ 100 mcg/H and Midazolam 4 mg/H. Patient will be in diabetes insipitis as evidenced by large amounts of dilute yellow urine. RNs will try initial interventions and then call for RPs. Residents come in and need to determine what interventions have been completed & what to do next. Even with correct interventions ICPs will elevate rapidly and patient will eventually herniate and arrest.

Injuries:

- Subdural hemhorrage
- Basilar skull fracture w/ raccoon eyes
- Face smash
- Left wrist fracture

Teamwork Twists:

- RNs know that INR is 2.0 on recent labs (normal value <1.3)
- MDs will have CT scan that shows worsening bleed with midline shift

3. **Nurse Overview:**

You are coming back from your lunch break. Your patient T,FHenderson is a 44 y/o female who is 12 H out from being kicked in the face by a horse. Injuries include a right SDH, basilar skull fx, and left wrist fx. An ICP bolt was placed in the ED upon admission for AMS. The critical care float RN just took your patient down to CT for their 6 hr scan so you could eat. Before you left your patient was a GCS 6T – opening eyes and withdrawing from pain x 4 extremities. Pupils have been 3 and sluggish bilaterally. She is on Fentanyl 100 mcg/H and Midazolam 4 mg/H. She is intubated, on PRVC, has a right subclavian III lumen, and has been hemodynamically stable. Her labs have also come back and the only abnormality is an INR of 2.

4. **RP Overview:**

T,FHenderson is a 44 y/o female who is 12 H out from being kicked in the face by a horse. Injuries include a right SDH, basilar skull fx, and left wrist fx. An ICP bolt was placed in the ED upon admission for AMS. The critical care float RN just took the patient down to CT for their 6 hr scan. Neurologically she has been a 6T – opening eyes and withdrawing from pain x 4 extremities. Pupils have been 3 and sluggish bilaterally. She is on Fentanyl 100 mcg/H and

Midazolam 4 mg/H. She is intubated, on PRVC, has a right subclavian III lumen, and has been hemodynamically stable. Here is her CT that just showed up in PACS: (Hand over head CT)

5. Performance:

Step 1: (nurses come back from lunch)
- HR 112, BP 160/65, RR 16, SpO2 97% vent, temp 38.9 ICP 29
- Urine output up to 250 mL/H, dilute yellow urine

RN to:

- *Complete neuro exam*
- *Notify RPs*
- *Increase sedation & analgesia*
- *Body & head midline*
- *C-collar loose/off*
- *Elevate HOB*
- *Limit stimulation*
- *Treat hyperthermia*
- *Suggest increasing 3% hypertonic saline*

RPs to:
- *Notify Trauma & neurosurgical attendings*
- *Cis bolus of 14 mg (0.2 mg/kg for 70 kg) ordered and given.*
- *Cis gtt started at 3 mcg/kg/min*
- *State CO2 goals of 35*
- *Order DDAVP for treatment of DI – bonus points*

(4 minutes)

Step 2: (just change vitals as step 1 is occurring- around minute 4)
- ICP continues to elevate to 40 despite interventions
- HR 135, BP 175/63, RR 16, SpO2 97% vent, ICP 40

(2 minutes)

Step 3:
- ICP now showing 50
- HR 64, BP 175/45, RR 16 vent, SpO2 97% on vent, ICP 50
- Neuro exam shows 3mm L sluggish 7mm R non-reactive - uncal aka horizontal herniation indicating R side injury

RN & RP to:

- *Recognize impending herniation (wide pulse pressure)*
- *Reassess pt*
- *Recognize need for STAT Craniectomy*

- Neuro resident present; orders Mannitol 70g (1 g/kg x 70 kg) & hypertonic saline 23% in 50 mL over 10 min

(3 minutes)

Step 4 (Herniates):

- ICP decreases to 39 as mannitol & 23% saline are starting or about to be hung
- HR 64, BP 175/45, RR 16 vent, SpO2 97% on vent, ICP 39
- Neuro exam showing dilated pupils both sides (supratentorial herniation)

(1 minute)

<u>Step 5 (PEA):</u>

- HR 24 junctional irregular (PEA), A-line flat, BP X/X, RR 16 vent, SpO2 0% vent
- *No pulse, start CPR*
- *Epi 1 mg IV*

(2 minutes)

<u>Step 6 (VFib):</u>

- *Pulse check, VFib (force this to occur if they do a pulse check early)*
- *Defibrillate 150 J*
- *Pulse check, pulseless VFib*
- *Defibrillate 150 J*
- *Epi 1 mg*
- *Pulse check, pulseless VFib*
- *Defibrillate 150 J*
- *Consider Amiodarone 300 mg IV*
- *Epi 1 mg (potentially)*
- *Pulse check, sinus brady HR of 60 (give a BP to ensure pulses restart)*

(5 minutes)

<u>Step 7 (ROSC):</u>

Ending scenario – what does the team need to consider?

- HR 60, BP 85/40, RR 16 vent, SpO2 85% on vent, ICP 34
    - *Recognize patient is not a candidate for TTM as pt meets brain death criteria*
    - *Contact LifeNet & family of pt*

(2 minutes)

6. <u>Debriefing & Discussion Points:</u>

- What happened to the patient?
- Semi structured teamwork debriefing w/TENTs tool; highlighting communication and strengths & areas for improvement within the group
- FFP & Vitamin K used to correct INR & improve coagulation
- Train of Four to assess paralysis: goal is 0/4 when ICPs are difficult to control
- CO2 dilates the cerebral blood vessels, increasing the volume of blood within the head; therefore increasing ICP. CO2 34-36 (minimal effect in going lower, as

decreasing further can cause vasoconstriction and decrease bloodflow to brain. Blowing off more CO2 is **emergent**, short term intervention)

- Cushings Triad:
  - Widening pulse pressure
  - Bradycardia
  - Irregular or absent respirations
- Supratentorial herniation = brain death = unilateral dilated pupils
- Pupil will dilate on side of injury due to cranial nerve III compression
- CPP = MAP – ICP
- Raccoon eyes (periorbital ecchymosis) = Basilar skull fx
- Serum osmolality is preferably known prior to administration of mannitol to avoid AKI. Ideally mannitol is not administered if serum osmol > 320
- Never give dextrose fluids to TBI patient; glucose is rapidly utilized and becomes hypotonic, increasing brain edema – Give 0.9% saline
- BIS monitor should be utilized in paralyzed patient

Appendix E

Social Behavioral Science IRB Approval

UNIVERSITY *of* VIRGINIA

OFFICE OF THE VICE PRESIDENT FOR RESEARCH
INSTITUTIONAL REVIEW BOARD FOR THE SOCIAL AND BEHAVIORAL SCIENCES

In reply, please refer to: Project # 2016-0066-00

February 26, 2016

Katharine George and Beth Ann Quatrara
Academic Divisions
3962 Rock Brand Road
North Garden, VA 22959

Dear Katharine George and Beth Ann Quatrara:

Thank you for submitting your project entitled: ""Do Interprofessional Simulations Promote Knowledge Retention and Increase Perception of Teamwork Skills in a Surgical-Trauma-Burn ICU Setting?"" for review by the Institutional Review Board for the Social & Behavioral Sciences. The Board reviewed your Protocol on February 26, 2016.

The first action that the Board takes with a new project is to decide whether the project is exempt from a more detailed review by the Board because the project may fall into one of the categories of research described as "exempt" in the Code of Federal Regulations. Since the Board, and not individual researchers, is authorized to classify a project as exempt, we requested that you submit the materials describing your project so that we could make this initial decision.

As a result of this request, we have reviewed your project and classified it as exempt from further review by the Board for a period of four years. This means that you may conduct the study as planned and you are not required to submit requests for continuation until the end of the fourth year. The Oral Consent Script has been approved for use with participants.

This project # 2016-0066-00 has been exempted for the period February 26, 2016 to February 25, 2020. If the study continues beyond the approval period, you will need to submit a continuation request to the Board. If you make changes in the study, you will need to notify the Board of the changes.

Sincerely,

Tonya R. Moon, Ph.D.
Chair, Institutional Review Board for the Social and Behavioral Sciences

One Morton Drive, Suite 500 • Charlottesville, VA 22903
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www.virginia.edu/vpr/irb/sbs.html

Appendix F

TENTS Tool Used for Semi-structured Debriefing

Teamwork Evaluation of Non-Technical Skills (TENTS) observation tool

Date: __________ Time: _____ Process: ___________

Location/Unit: ________ Observer: ___________

Element	Behavior	0	1	2	3	4	NA
1a Communication	Sends and receives appropriate information						
1b	Asks questions						
1c	Uses feedback between team members						
1d	Sends and receives information to/from patient/family						
1e	Uses appropriate critical language						
1f	Uses teamwork tools						
1g	Debrief completed						
1h	Uses teamwork tools						
2a Leadership	Establishes event leader						
2b	Verbalizes plan: states intentions, recommendations, and timeframes						
2c	Delegates as appropriate						
2d	Instructs as appropriate						
3a Situation monitoring	Visually scans environment						
3b	Cross monitors activities; uses back-up behavior						
3c	Verbalizes adjustments in plan as changes occur						
4a Mutual support/assertion	Secures additional resources						
4b	Supports others						
4c	Prioritizes appropriately						
4d	Uses conflict resolution						
4e	Speaks up/persuades						
5 Overall teamwork							
6 Overall leadership							

0 = expected but not observed.
1 = observed but poor.
2 = observed but marginal.
3 = observed and acceptable.
4 = observed and good.
NA = not applicable.
Any value of "1" or "0" require a narrative comment.

Appendix G

Simulation Survey Responses to:

"What Did You Find Valuable or Enjoy About Today's Training?"

Knowledge-based Responses	Teamwork-based Responses
"Newer nurses learn a lot from seeing the thought process of experienced nurses"	"Validating each person's input regarding the patient's care"
"Experience is the best way to learn"	"Practice with interprofessional teams"
"The real time review. I've actually never had a patient that needed mannitol or 23% saline, so this was a great first time practice."	"Practicing to stay calm in stressful situations"
"Training was very useful for maintaining proficiency and improving skills."	

Appendix H

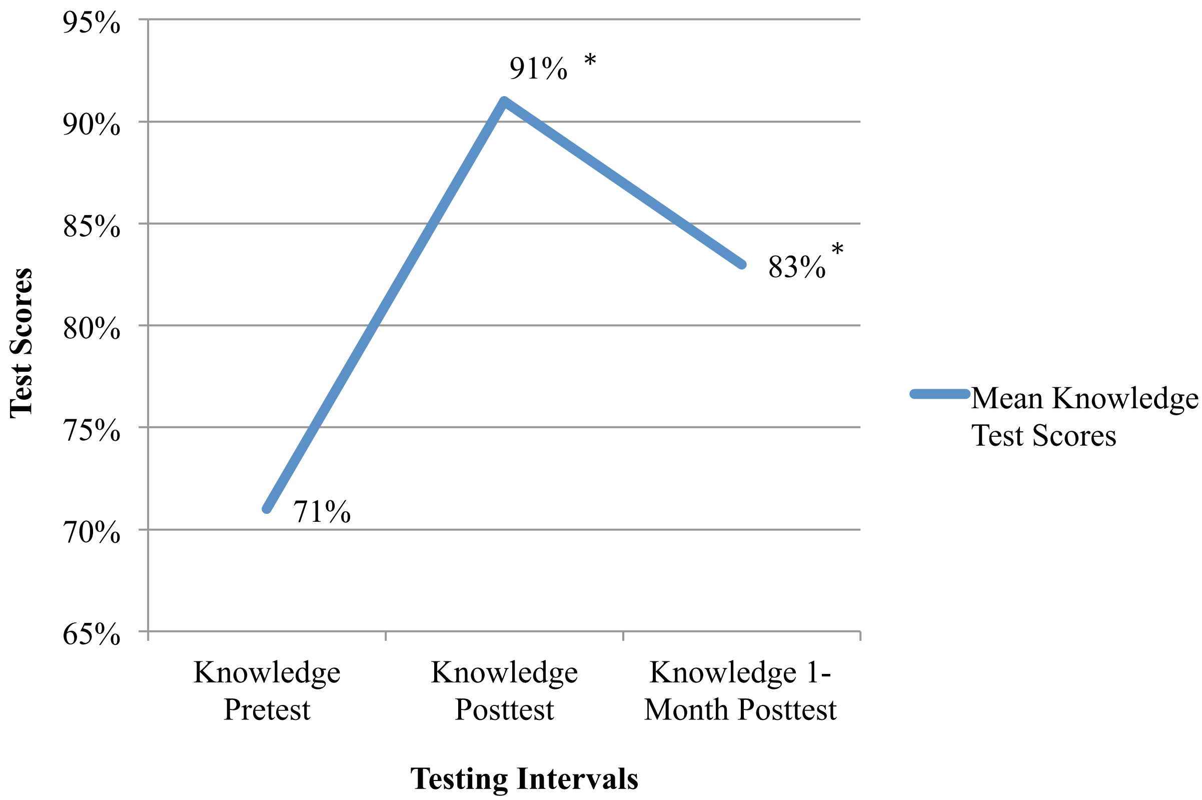

Figure H. Mean Knowledge Test Scores by Testing Interval.
* Indicates significant improvements. $p < 0.05$ was considered statistically significant.

Appendix I

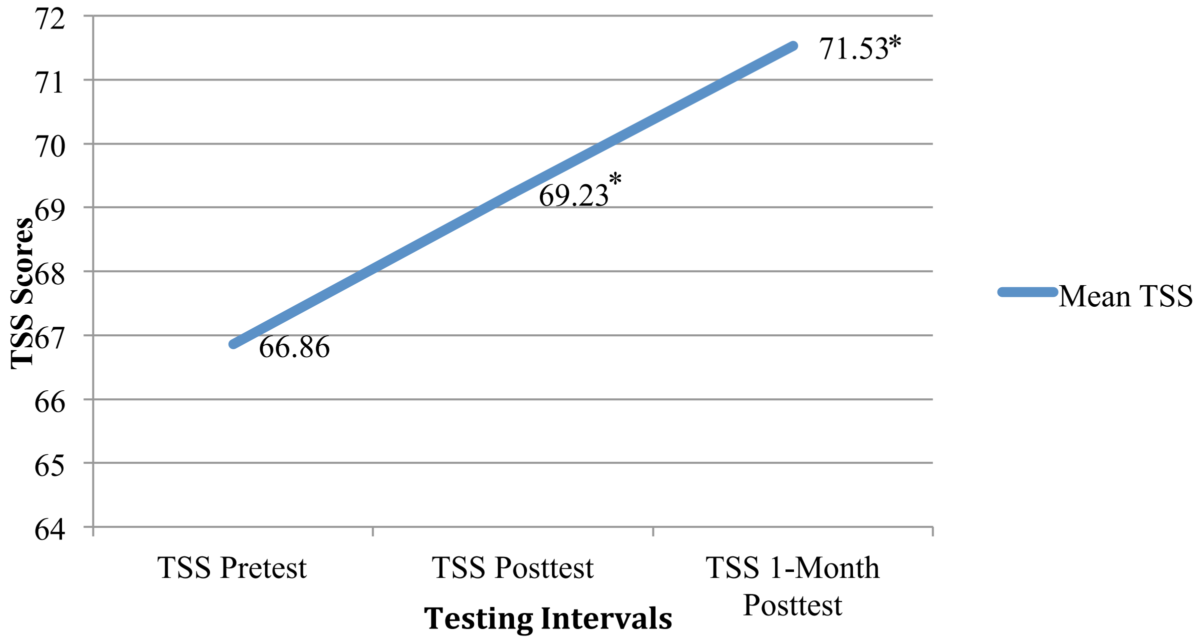

Figure I. Mean TSS Scores by Testing Interval.
* Indicates significant improvements. $p < 0.05$ was considered statistically significant.

Appendix K

Manuscript Abstract for Submission to the American Journal of Critical Care

American Journal of Critical Care

Authorship, Financial Disclosure, Copyright Transfer, and Acknowledgment Form

Each author must read and sign the statements on (1) Authorship, (2) Financial Disclosure, and (3) either Copyright Transfer or Federal Employment. The corresponding author must sign (4) the Acknowledgment Statement. You may photocopy this document to distribute to coauthors.

PLEASE PRINT

Your Name Katie L. George

Telephone and/or Fax Numbers 716-913-3779

E-mail Address Klb5an@virginia.edu

Corresponding Author's Name Katie L. George

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Katie L. George 7/22/16

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• I certify that all persons named in the Acknowledgment have provided me with written permission to be named.

• I certify that if an Acknowledgment section is not included, no other persons have made substantial contributions to this manuscript.

Katie L. George 7/22/16

Corresponding Author's Signature **Date**

Last updated July 2012

Interprofessional Simulations Promote Knowledge Retention and Enhance Perceptions of Teamwork in a Surgical-Trauma ICU Setting

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No conflicts of interest or funding to disclose.

Keywords: Interprofessional simulation, teamwork, knowledge, critical care

Acknowledgements: The author would like to acknowledge Dr. Beth Quatrara, Dr. Tina Brashers, Jon Howard, and Dr. Robert Sawyer for their unwavering support and mentorship throughout this process.

Abstract

Background: The ability to function proficiently in critical care relies on knowledge, technical skills, and interprofessional (IP) teamwork. Integration of these factors can improve patient outcomes. Simulation provides "hands-on" practice and allows for the integration of teamwork into knowledge/skill training. However, simulation requires a significant investment of time, effort, and financial resources.

Objectives: To 1) evaluate knowledge retention and analyze changes in perceptions of teamwork amongst nurses and resident physicians (RPs) in a STICU setting after completion of an interprofessional critical event simulation, and 2) provide insight for future interprofessional simulations, including the ideal frequency of such training.

Methods: A comparison-cohort pilot study design was utilized. A one-hour critical event interprofessional simulation was held for nurses and RPs in a STICU setting. The simulation required the team to employ interventions to reduce elevated ICPs, and then perform cardiac resuscitation according to ACLS guidelines. A semi-structured debriefing guided by the TENTS tool, highlighted important aspects of teamwork. Participants took knowledge and TSS pretests, posttests, and one-month posttests. Mean scores were calculated for each time point (pre, post, and one-month post) and paired t-tests were used evaluate changes.

Results: Mean knowledge test and TSS scores statistically significantly improved both significantly elevated after the simulation, and remained significantly elevated at one-month follow-up.

Conclusion: Significant improvements on both knowledge test, and TSS scores, demonstrate the effectiveness of this intervention, and retention of the skills. Participants valued the intervention and recommended to increase the frequency of such training.

Background

The current state of healthcare encompasses highly acute, complex patients, managed with ever-changing technology. Healthcare team members are expected to be expert critical thinkers, aware of the most recent evidence, and function effectively in emergency situations. Healthcare leaders struggle with the challenging task of keeping staff up to date on so many fronts.[1] This challenge is intensified in the intensive care unit (ICU) setting.

To function safely in critical care, nurses and physicians need to collaborate effectively and maintain a high level of clinical knowledge & skills. This is especially true during patient care emergencies, such as cardiopulmonary arrest situations, in which discrete teamwork behaviors can improve patient outcomes.[2] Turnover in critical care is the highest amongst all fields of nursing. The concept that patient outcomes suffer as experienced nurses leave the bedside, is well supported in the literature.[3] This further highlights the need to ensure clinicians are well prepared for the complexity and high-acuity nature present in the ICU setting.

Simulation learning is a primary component of education for nursing and medical students.[4] It is generally well accepted that adult learners prefer interactive teaching methodologies to classical didactic instruction.[5] Yet the concept of simulation is integrating much more slowly into the practical arena.[1,6] The recent emphasis on patient outcomes is forcing hospitals to evaluate their existing systems, including educational methods. Simulation learning holds promise as an exciting and effective tool for education of staff[4], yet few studies demonstrate clinical efficacy.

Continued examination of patient outcomes reveals the importance of teamwork, which is now accepted as an essential component of patient care.[7] Multiple studies show a relationship between poorly functioning teams and increased medical errors, which may lead to suboptimal patient outcomes.[7-9] Andreatta and colleagues (2011) demonstrated a positive correlation between pediatric cardio-pulmonary arrest survival rates, and the inception of their mock code curriculum. The survival rate significantly increased from 33% to approximately 50% within one year of the formal mock code program's implementation (p=0.000).[10]

Recommendations made by the 2015 Institute Of Medicine (IOM) report *Measuring the Impact of Interprofessional Education (IPE) on Collaborative Practice and Patient Outcomes,* include "strengthening the evidence base for IPE" and "linking IPE with changes in collaborative behavior" (p. 2). A report in 2002 "emphasized that for healthcare providers to work collaboratively, the education and training they receive should prepare them to work together and share expertise".[11]

Objectives

A pilot study was developed to 1) evaluate knowledge retention and analyze changes in perceptions of teamwork amongst nurses and RPs in a STICU setting after completion of an interprofessional critical event simulation, and 2) provide insight for future interprofessional simulations (IPS), including the ideal frequency of such training.

Methods

A quasi-experimental comparison-cohort pilot design was utilized. Approval to conduct this study was obtained from the institution's Social Behavioral Sciences Institutional Review Board. A one-hour simulation was conducted five times. Each session included one to two RPs and three to four nurses. To assess knowledge acquisition, a nine-question knowledge test was created for use and reviewed for content validity. The Team Skills Scale (TSS) is a self-reported, validated, reliable tool that measures clinicians' perceptions of their teamwork skills.[11] Participants completed the knowledge test and the TSS before and after the simulation, and again one-month post-simulation. An open-ended Simulation Survey elicited participants' feedback and recommendations about future training.

The actual simulation scenario was that of a traumatic brain injury (TBI) patient with high intracranial pressures (ICPs). The team employed interventions to reduce ICPs based off of the institution's Trauma Handbook. Although all interventions may have been correct, the severity of the TBI resulted in brainstem herniation and subsequent cardiac arrest. The team then ran through advanced cardiac life support (ACLS) code management in real-time.

The simulation was followed by a semi-structured debriefing session. The TENTS tool assesses the four components of teamwork; communication, leadership, situation monitoring, and mutual support[12] and was used to guide the session. The debriefing also answered participants' questions about ICP management and ACLS code management, and reinforced key concepts.

Results

A total of 22 clinicians, including 16 nurses and six resident physicians participated in this study. The mean knowledge pre-test score for all participants was 6.41(SD 1.37) out of a total of 9 possible points (a score of 71.2%). Paired T-tests demonstrate that mean post-test and one-month post-test scores were statistically significantly higher at 8.23(SD 1.02) (91.4%) and 7.5(SD .95) (83.3%) respectively ($p<.001$).

Mean TSS for pre, post, and one-month post-tests were 66.86 (SD 5.68), 69.23 (SD 8.31), and 71.53 (SD 9.05), respectively, out of a total possible score of 90 (Figure 1). Paired T-tests revealed statistically significant improvements between each measurement ($p<.000$). When compared by role, nurses' mean scores were 67.94, 70.88, and 69.93 respectively. RP's TSS scores increased the most at one-month follow up, with scores of 64, 64.83, and 76 respectively.

Participants felt this training would assist them in caring for critically ill TBI patients and would assist them with ACLS certification/renewal. Aspects of the training perceived to be valuable included interprofessional teamwork, reality of the scenario, hand-on exposure, instability of the patient, debriefing, and the efficient use of time. The majority of respondents felt that such training should occur quarterly to biannually.

Conclusions

This pilot study demonstrates the successful implementation of an IPS in a critical care setting. The statistically significant improvements on both knowledge test, and TSS scores, demonstrate the effectiveness of this intervention, and retention of the improvements. Additionally, open-ended questions revealed that participants valued the intervention and would recommend increasing the frequency of such training. This simulation format can be adapted to virtually any type of practice setting. Future research should continue to strengthen the body of literature supporting IPS by exploring relationships between IPS and actual changes in practice, and ultimately associating IPS with changes in patient outcomes.

The recent national focus on enhancing patient safety requires that health care professionals collaborate effectively as a team. Remaining clinically competent and integrating evidence based practice at the bedside is essential given the highly acute nature of hospitalized patients. IPS has the ability to conquer each of these requirements as it promotes knowledge and skill refinement simultaneously while fostering teamwork. This study demonstrated that IPS is an effective method for promoting knowledge acquisition and increasing teamwork in the management of high acuity patients. Future studies should attempt to develop a framework for "best practice" IPS, measure changes in actual bedside practice, and ultimately seek correlations between IPS and improved patient outcomes.

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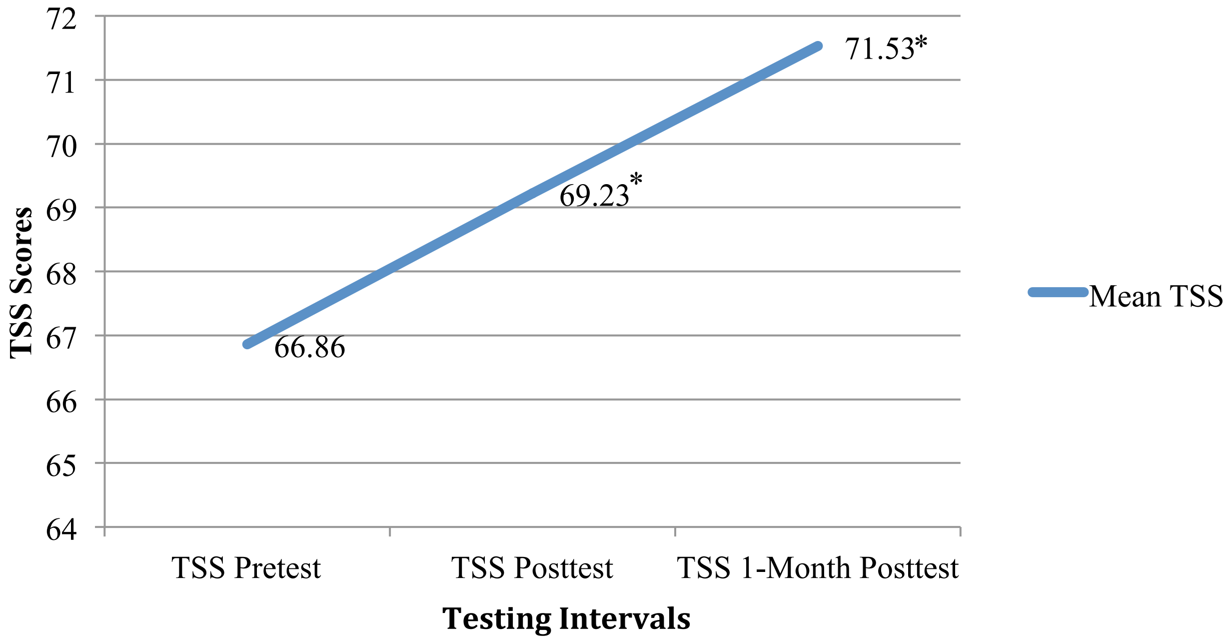

Figure I. Mean TSS Scores by Testing Interval.
* Indicates significant improvements. p <0.05 was considered statistically significant.