



Facilitators and barriers to the clinical application of teamwork skills taught in multidisciplinary simulated Trauma Team Training

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ABSTRACT

Background: Efforts to improve teamwork in trauma include simulation-based team training with a non-technical skills (NTS) focus. However, there is a lack of evidence to inform the development of team training programs for maximum uptake of NTS in clinical practice. This descriptive paper aims to evaluate the extent NTS were practiced by the trauma team in a Level 1 trauma hospital after NTS training and to identify facilitators and barriers to use of NTS in clinical practice.

Method: A 38-item questionnaire targeting clinicians who attended a simulation based multidisciplinary Trauma Team Training program was developed. The questionnaire was developed using the Theoretical Domains Framework, a validated tool to identify what practices need to change. It included questions on the current practice of NTS in real life trauma resuscitation.

Results: Eighty six of 235 eligible participants (rate 37%) responded to the questionnaire. All relevant professions and clinical services were represented. There were 15 facilitators and 12 barriers identified. Barriers and facilitators were allocated to categories of factors known to influence trauma team practices. These were: (1) organisational factors that influence the trauma team, (2) team factors that influence teamwork and (3) cognitive factors that influence team decision making.

Conclusion: NTS were being used by frontline clinicians in real world trauma resuscitations to varying degrees, depending on organisational, team and cognitive facilitators and barriers. Facilitators to the implementation of NTS skills during trauma emergencies included team composition, roles and responsibilities, procedural compliance and leadership. Barriers included decision making and communication. This study described team members experience of using NTS in 'real world trauma resuscitation' to inform future team training interventions.

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What is known about this topic?

Non-technical skills (NTS) are recognised as critical skills required by trauma teams when resuscitating critically injured trauma patients. There is a rapidly growing interest in using simulation to improve the nontechnical skills of trauma teams. However, we do not know whether this education strategy results in the use of non-technical skills during actual patient resuscitation.

What this paper adds

NTS taught in a simulated multidisciplinary Trauma Team Training program were practiced by the trauma team in the clinical setting to varying degrees. Fifteen facilitators and twelve barriers to the use of NTS during actual resuscitation of critically injured trauma patients were identified. Ensuring that frontline clinicians are capable of and willing to apply non-technical skills to real life cases requires these barriers and facilitators to be addressed.

Background

Management of trauma requires multiple clinicians from different disciplines, such as emergency physicians, nurses, surgeons, anaesthetists, and allied health to function as a team [1]. This multidisciplinary team must treat critically ill patients,

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who require rapid resuscitation, diagnosis, and management, within the context of intense time pressure [2]. For trauma teams to be effective, each team members' requisite skills must go beyond clinical skills to include individual non-technical skills (NTS) [3–5]. NTS is a collective term to describe an individual's cognitive and social skills that complement their technical expertise [6]. Individual team members must possess core NTS prior to working in a team. In a team environment, NTS describe team members' behaviours that focus on interaction (e.g. how the team works together), reasoning (e.g. how the team makes decisions) and resource skills (e.g. how resources are allocated) [7,8].

Teamwork does not occur spontaneously; it must be learned. Conventional training of healthcare teams has not traditionally involved multidisciplinary team training, perhaps because of the assumption that teamwork is learnt in an ad hoc way through clinical experience [9,10]. The performance of resuscitation teams is not explained by differences in the skills of the individual team members; rather it is about how team members interact and work together that impacts team performance [11]. The importance of NTS in teams was emphasised in the 2010 Helsinki Declaration on Patient Safety [12]. Methods to teach teamwork to trauma teams include multidisciplinary simulation-based team training programs [13,14].

In 2008, the study site conducted a review of its trauma service [15,16]. The review identified features of teamwork that were problematic, which included overcrowding in the trauma area, ineffective communication due to noise levels and disjointed teamwork. There was a lack of harmony between colleagues of different professions. There was also a lack of leadership and clarity about roles within the team. TTT was identified as the intervention to address these teamwork issues. This led to a contextualised simulated multidisciplinary Trauma Team Training program (hereafter called TTT) being used to train staff in teamwork. The program commenced in 2009 and included simulation-based team training with a non-technical skills (NTS) focus.

The aim of this study was to (1) identify which components of NTS trauma team members believed were frequently or infrequently practiced in real world resuscitations, following TTT and (2) to identify barriers and facilitators to the use of NTS in the practice of emergency trauma resuscitation.

Methods

This descriptive study was conducted at a Level 1 Trauma hospital in Sydney, Australia. The Emergency Department (ED) in this hospital treats over 73,000 adult patients annually and manages the largest number of trauma patients in Sydney, around 4250 annually; 450 of these are classified as major trauma (Injury Severity Score > 12). This study forms the second phase of a larger embedded experimental mixed methods study evaluating the impact of simulated multidisciplinary Trauma Team Training on patient outcomes and team performance and has been described elsewhere [17–20]. Approval to conduct the study was granted from the local Human Research Ethics Committee; Reference No. 4199. All participants gave informed consent.

The intervention

TTT commenced at the study site in 2009. Staff enrolled in the TTT program were members of the trauma team and had completed previous trauma resuscitation training (e.g. Early Management of Severe Trauma). The teaching faculty were inter-professional (nurse, doctor) and multidisciplinary (emergency, trauma, anaesthetists, educators) and comprised of trained simulation instructors.

The program was an 8-hour training day which started with a brief overview of simulation and NTS and addressed questions

from participants. This opening session was followed by the faculty demonstrating a trauma simulation. A subsequent debriefing session centred on the trauma system activation, team composition, team and environmental preparation. This aspect of the program aimed to illustrate how a high-performance team should function and was an interactive strategy to explain the concepts around how the team was structured to deliver trauma care. It also aimed to resolve questions or anxiety about simulation performance and encourage participant engagement in simulation activities.

Following the faculty demonstration, staff attended three 60-minute workshops to learn NTS. Instruction on teamwork, leadership, and communication principles (graded assertiveness) were provided as well as training on resource allocation, situational awareness, decision-making (shared mental model) and care coordination in the context of trauma resuscitation [6].

After the workshop sessions, staff participated in simulated scenarios. The simulation environment was a high-fidelity simulation lab at the study site. Photographs of the site's resuscitation bays were used to turn the simulation centre into an accurate representation of the team's working environment. The equipment and layout in the simulation centre was identical to the site's resuscitation bay. All simulation cases were practised with a computer-enhanced mannequin simulator. There were four trauma scenarios: penetrating trauma (stabbing to the chest), blunt trauma (fractured pelvis), traumatic head injury and blunt multi-trauma. Participants were instructed to provide care in the same way they would in the real-world clinical situation. Following the scenario, a trained instructor facilitated a debriefing session where participants were encouraged to reflect on and discuss their performance. The aspects of NTS discussed included graded assertiveness, closed loop communication, shared mental model, decision making, leadership and resource allocation [6].

Four simulated multidisciplinary TTT programs were conducted each year. The participants included medical officers from emergency, intensive care, anaesthetics, general surgery, and trauma as well as emergency nurses, radiographers, and social workers. Medical staff were at consultant and registrar level, while nursing staff had a minimum of 2 years emergency nursing experience. New graduate nurses and junior doctors were not members of the trauma team due to their inexperience and did not participate in the study.

Data collection

Data were collected using an electronic questionnaire that addressed the perceived uptake of NTS, and the barriers and facilitators that influenced team members' use of NTS. The questionnaire included questions on the current practice of NTS during resuscitations and was informed by the Theoretical Domains Framework (TDF) [20], a validated tool to identify what practices need to change. This enabled collection of data for design of future interventions. The questionnaire contained 38 questions and was structured in four sections:

- 1 Clinician demographics: including trauma experience, discipline, and role within the discipline.
- 2 Use of NTS in trauma resuscitations (communication techniques, leadership, decision-making, information acquisition, protocol compliance, team collaboration)
- 3 Identification of barriers and facilitators to the use of NTS
- 4 Recommendations for enhancements to the TTT program.

Participants were asked to rate the extent to which they believed that NTS were used in trauma resuscitation using a 5-point Likert scale, with response options ranging from 1 (never)

to 5 (all the time). A free text option prompted descriptive comments after each question. Eligibility to participate in the study comprised of participants having completed the program and being currently employed at the study site as members of the trauma team. During October and November 2016, the 345 clinicians who had completed the program were emailed an invitation to participate in the study with a link to the online questionnaire. This was sent by the research team to staff email addresses. Reminder emails were sent after 2 and 4 weeks. Participation in the study was voluntary and confidential. Participants were advised that they could withdraw their consent prior to completion of the questionnaire. Non-identifiable data were collected using REDCap, an electronic data capture tools hosted at the University of Sydney [21].

Data analysis

Quantitative data were analysed using SPSS (IBM V 23) [22]. Participant characteristics and responses to questions on team preparation, team structure and teamwork, resource management and communication were assessed using descriptive statistics. Responses were reviewed to identify barriers and facilitators to the use of NTS in a trauma resuscitation. Barriers and facilitators pertain to places/things, people or emotions that make it easier (facilitators) or more difficult (barriers) for a specific population to perform a target behaviour [20,23]. A facilitator is something when present, increases the chance the behaviour will be performed. A barrier is something, when present, decreases the chance the behaviour will be performed. The researchers concluded that NTS should be demonstrated 'all or most of the time' in clinical practice to promote effective teamwork by the multidisciplinary trauma team. Where there was 70% or more consensus by respondents that an action was performed 'all or most of the time', it was identified as a facilitator. In contrast, where an action was reported as 'never, rarely or sometimes carried out' with more than 30% consensus, it was identified as a barrier. These numerical facilitator and barrier values were informed by the original trauma service review and the Normalisation Process Model [24], a structured tool that assigns numerical scores to conditions that impact on the implementation of complex interventions into clinical work. Using this information, the research team identified that actions needed to occur at a consistently high frequency (all or most of the time) to ensure that the TTT program outcomes were integrated into clinical practice.

Barriers and facilitators were allocated to categories of factors relevant to trauma team practices [8] (Table 1). These categories were: (1) organisational factors that influence the trauma team, (2) team factors that influence teamwork and (3) cognitive factors that influence decision making by the trauma team. Development of the categories was informed by the results of a literature review on the impact of multidisciplinary team simulation

Table 1
Grouping of barriers and facilitators into categories that influence trauma team practices.

Category	Factors that influence trauma team practices
Organisation	<ul style="list-style-type: none"> Standardised procedures Protocol compliance Team structure, roles and responsibilities
Team dynamics	<ul style="list-style-type: none"> Communication Leadership Teamwork
Cognition	<ul style="list-style-type: none"> Knowledge acquisition Decision making

training on team performance and patient care [8], and the recommendations of the original trauma service review [15,16]. The literature review identified that NTS practiced in conjunction with clinical skills, contribute to effective team work in a trauma resuscitation. The service review recognised specific barriers to clinical practice by the trauma team relevant to the study site (i.e. team composition) and identified potential solutions to change local practices.

Results

Sample characteristics

Of the 345 clinicians who had completed TTT and were invited to participate in the study, 110 were no longer employed at the study site and not eligible to participate, reducing the sample size to 235. Of these 235 participants, 86 returned the questionnaire (response rate 37%). All professional groups were represented; about half of respondents were nurses (53.0%, n = 44) followed by doctors (43.0%, n = 37) and allied health (4.0%, n = 5). Most participants were from ED (66.0%, n = 58), followed by Trauma Service (14.0%, n = 12), Anaesthetic Service (11.6%, n = 7), Radiology (3.5%, n = 3), Intensive Care (2.4%, n = 4) and Social Work (2.3%, n = 2). Most staff had between 1–5 years trauma experience (45.3%, n = 39); 15.0% (n = 13) had < 1-year trauma experience and 39.5% (n = 34) had more than 5 years' experience.

Facilitators and barriers to uptake of NTS taught during the TTT program

There were 15 facilitators and 12 barriers identified as impacting the uptake of NTS. Table 2 presents a summary of these within each of the three categories of NTS, with percentage of participant agreement/disagreement identified. Supplementary data were provided in free text responses in the questionnaire and some illustrative quotes are included with the results.

Organisational factors that influence the trauma team

Organisational factors comprised of operational processes, procedures and protocols taught during TTT. They were actively used during trauma resuscitations, with eight facilitators to team work identified and no barriers. Participants reported that a *prompt response* by the trauma team happened 80% of the time. This was also indicated in the free text comments.

'As the radiographer, I rely on the team being present and prepared as it is clear what is expected of me.' (Radiographer)

Protocols regarding *team size*, as well as identification of team members roles (i.e. Team Leader, Circulation Nurse) using colour-coded *role tags*, were adhered to consistently. Participants agreed that features such as team size were crucial for teamwork. When these protocols were followed it was possible to coordinate the wide range of *interdependent services* that support a trauma response, including pre-hospital and in-hospital services (medical subspecialties, support services such as radiology). Participants identified that teamwork could be compromised when protocols were not followed.

'The size of the trauma team is great but when some specialties bring others with them, we have too many people in the resuscitation bay.' (Emergency Nurse)

Participants reported adherence with pre-hospital and structured communication procedures; 87.0% (n = 75) rated adherence to *structured handover* and 83.0% (n = 72) compliance with the location of handover. *Equipment checking* procedures were reliably followed (91.0%, n = 78).

Table 2
Participants identification of barriers and facilitators to the practice of non-technical skills by the trauma team in the clinical setting.

Factor	Sample item	Frequency			Barrier	Facilitator
		All the time	Sometimes	Never		
Organisation	Each team member wears coloured role tags	72.1% (n = 62)	26.7% (n = 23)	1.2% (n = 1)		
	Pre-hospital information is displayed in the resuscitation bay	90.7% (n = 78)	7.0% (n = 6)	2.0% (n = 2)		
	On activation of a major trauma call the team members attend promptly	80.2% (n = 69)	16.3% (n = 14)	3.5% (n = 3)		
	The size and composition of the trauma team is appropriate	82.5% (n = 71)	14.0% (n = 12)	3.5% (n = 3)		
	Resuscitation equipment is checked and assembled as needed	90.7% (n = 78)	7.0% (n = 6)	2.3% (n = 2)		
	Relevant support services (radiology, blood bank, subspecialties) are notified	80.2% (n = 69)	17.5% (n = 15)	2.3% (n = 2)		
	Structured handover procedures are used	87.2% (n = 75)	9.3% (n = 8)	3.5% (n = 3)		
Teamwork	Handover from ambulance occurs on the ambulance trolley, as per protocol	83.4% (n = 72)	14.0% (n = 12)	2.3% (n = 2)		
	All team members introduce themselves by name and role	44.2% (n = 38)	51.2% (n = 44)	4.7% (n = 4)		
	Team members familiarise themselves with their role and responsibility	72.1% (n = 62)	26.7% (n = 23)	1.2% (n = 1)		
	Team members are confident to 'speak up' to communicate a problem	51.2% (n = 44)	47.6% (n = 41)	1.2% (n = 1)		
	Trauma team members practice closed loop communication	59.3% (n = 51)	37.2% (n = 32)	3.5% (n = 3)		
	Requests are made for team member assistance using name/role	58.1% (n = 50)	39.6% (n = 34)	2.3% (n = 2)		
	The team leader maintains 'hands free' approach to leading the trauma	86.0% (n = 74)	10.5% (n = 9)	3.5% (n = 3)		
	There is clear delegation of workload by the Team Leader	67.4% (n = 58)	30.2% (n = 26)	2.3% (n = 2)		
	The Team Leader identifies him/herself to the treating paramedic	75.6% (n = 65)	22.1% (n = 19)	2.3% (n = 2)		
	Trauma team members know each other's roles and responsibilities	69.6% (n = 60)	26.7% (n = 23)	3.5% (n = 3)		
Decision making	Team members are confident to decide when to activate a Major Trauma Call	64.7% (n = 59)	0.0% (n = 0)	31.3% (n = 26)		
	Decisions are made with input and shared knowledge from team member	72.1% (n = 62)	23.3% (n = 20)	4.7% (n = 4)		
	Cognitive aids (i.e. Trauma app) are used to assist decision making	53.5% (n = 46)	38.4% (n = 33)	8.1% (n = 7)		
	Team members know when to activate a major trauma call	68.6% (n = 59)	1.2% (n = 1)	30.2% (n = 26)		
	Team members know how to activate a major trauma call	66.3% (n = 57)	3.5% (n = 3)	30.2% (n = 26)		
	Patient management plan is formulated using pre-hospital information	76.8% (n = 66)	20.9% (n = 18)	2.3% (n = 2)		
	Prior planning and preparation assist the team to manage a major trauma	91.9% (n = 77)	5.8% (n = 5)	2.3% (n = 2)		
	Team members are reluctant to question the senior's decisions or actions	15.1% (n = 13)	80.2% (n = 69)	4.7% (n = 4)		
Team Leader updates the team by recapping the patient management plan	60.5% (n = 52)	37.2% (n = 32)	2.3% (n = 2)			
The Team Leader seeks input from team members and listens to feedback	59.3% (n = 51)	38.4% (n = 33)	2.3% (n = 2)			

All the time includes 'All the time' and 'Most of the time'.

Sometimes includes 'Sometimes' and 'Rarely'.

Never includes 'Never'.

Team factors that influence trauma team work

Team factors that influenced teamwork included communication, leadership, and collaboration. In this category barriers outweighed facilitators. Six team factors were not sufficiently practiced and therefore acted as barriers to team performance. These included *not knowing the team* (identity and professional role) and *inconsistent team introductions*. Thirty-eight participants (44.0%) did not know team members' names and abilities, and over half indicated *inconsistent compliance with clear requests for assistance using team member names or roles*. These barriers may arise because trauma teams often form as clinical situations develop and thus have unstable membership. Team composition may rarely be fixed due to rotating shift patterns and organisational constraints. This results in new members constantly joining the team. Although they may be wearing a trauma role tag, team members may not know each other's name, speciality or experience as they may not have worked together previously. A lack of clarity in communication was also identified as a barrier. *Closed loop communication*, the verbal reporting of task completion to the team leader, was not used routinely.

'I still find that the surgeons in the trauma team talk to their team rather than communicating through the designated team leader. I think that the information in the room should be shared.' (Doctor)

The practice of team members speaking up to voice concerns was limited, with only 51.2% (n = 44) stating they were confident to 'speak up' to communicate a problem during a resuscitation. Medical staff made up the majority of the group who were confident to escalate concerns (69%, n = 30.3). This was a potential barrier to teamwork, predominantly for nursing staff.

Leadership was considered a facilitator when there was a clearly identifiable leader giving explicit directions to the team (86.0%,

n = 74). Leadership was demonstrated by their position in the room and their communication skills. These behaviours had a positive effect on participants' attitudes towards the leadership role and teamwork in general (75.6%, n = 65). Leadership became a barrier when the leader failed to co-ordinate the team and prioritise or delegate tasks (67.4%, n = 58).

Cognitive factors that influence decision-making in the trauma team

Cognitive factors are related to how the team acquires information and make decisions. This category comprises of how information was shared between team members, how the team problem-solved and made decisions. Items used to examine team decision-making were: declaring the emergency promptly using the trauma activation system, the use of cognitive aids to standardise care (i.e. trauma app) and the process of formulating and re-evaluating management plans. Four facilitators and six barriers were identified.

Collaborative processing of information from multiple sources facilitated effective decision-making. Sixty-six (76.8%) participants reported that *pre-hospital handover* was used to formulate treatment priorities and seventy-seven (91.9%) identified that *prior planning* was the all-important step that optimised the subsequent resuscitation roadmap.

'Traumas that get the most prior notice and planning are the ones that go well.' (Doctor)

The process for declaring a trauma emergency promptly was not sufficiently embedded in practice. There was a lack of confidence in deciding when or how to *activate the trauma response system*. *Cognitive aids* such as trauma algorithms were only used 53.0% of the time to make decisions (n = 46). Seeking out information from multiple sources and providing clinical updates on patient status were underutilised practices. When coupled with

a reluctance to question decisions and actions, the team were potentially prevented from making safe decisions.

Discussion

In this study we reported the extent to which team members identified NTS, taught in a TTT program were practiced in the clinical setting. It describes how a simulated training program, contextualised to a specific setting, and incorporating local processes, can prepare a multidisciplinary team to resuscitate a critically injured patient and is supported by the literature [8,11]. NTS were being used in resuscitation events in this Level 1 trauma centre to varying degrees, dependent on organisational, team and cognitive facilitators and barriers.

Organisational factors relating to team, environment and equipment, promoted effective use of NTS in trauma resuscitations. TTT was designed to purposefully orientate team members to the organisational processes specific to the institution's trauma team. Our results show that teaching these contextualised organisational factors in TTT offered the team a structure that optimised non-clinical processes before and during resuscitation. This structure mitigated potential chaos.

Team factors, such as communication and leadership were challenging to translate into clinical practice. A range of barriers were evident despite the training. Techniques that address critical communication during clinical crises were taught in TTT. However, our results highlight that many factors impact team communication. Simple communication practices such as team introductions (identity and professional role) were not included in the program, but evidently require some attention. Although team members knew what their individual roles were, they did not introduce themselves to each other, and therefore did not know their team members. We found that this seemingly routine aspect of interpersonal communication did not occur spontaneously. This may be due to the team typology. Trauma teams are 'ad hoc teams [25,26]', spontaneously created with constantly changing membership. To improve communication in an 'ad hoc' team, training needs to include strategies that address fundamental interpersonal communication alongside other solutions, such as use of names on role tags. It cannot be assumed that individuals acquire adequate competency in communication through experience. There is need to more formally assist staff to develop communication skills specific to the emergency context. These skills include but are not limited to closed loop communication, graded assertiveness, shared mental model of patient status, team briefings⁸

Leadership was identified as having a clear impact on team factors. Critical aspects of effective leadership, such as identification of the team leader and maintaining a hands-free approach when leading a trauma, were evident following TTT. This result is in keeping with other studies that report the pivotal role of the team leader in creating and maintaining effective teams [8,27]. Conversely when the leader failed to direct team members' contributions and prioritise team tasks, a negative effect on team performance was experienced. This points to a need to further strengthen leadership training in TTT.

Cognitive factors, such as how the team acquired information and made decisions were the most challenging of all NTS to translate into clinical practice. Limited sharing of information between team members, restricted team input into problem solving and a hierarchy of decision making were perceived as major barriers. However, the urgency of the clinical situation, the need to multi-task and the reality of frequent interruptions may also limit sharing of information, restrict team input and curb assertiveness. Team members were reluctant to speak up to highlight a problem, clarify information or question a senior's

decision when they were concerned. The team showed no performance benefits in these areas after the training. Our results are supported by the literature [8,14,28,29]. There is need to define what team behaviours are associated with decision making so that participants can be taught what is expected of them.

The TDF [20] was used to guide the development of the questionnaire and employ a theory driven approach to identify barriers and facilitators to operationalising learnings from TTT into real world resuscitation. Clinicians were required to change their previous behaviours to use the new ways of working in a team following TTT. Changing behaviour is not straightforward, but is most effective if interventions are based on the principles of behaviour change [20,23]. We would like to emphasise that a translational science approach to implementing NTS into clinical practice is needed to further clarify the relationship between training and systems-level outcomes.

Limitations

The first limitation is that there are many factors that influence the practice of NTS in real-life situations and hence the outcomes cannot be directly attributed to the simulated TTT program. Every effort was made to examine any factor that could have influenced the results (for example, increase in trauma workload, severity of injury, staffing and rosters, organisational change, team member's experience). With the exception of an increase in the number of senior doctors employed to provide weekend cover, there were no other significant factors identified. Another limitation is the self-reported nature of the survey. Possibilities for outcome assessment could have been an observational study of the prevalence of observable NTS demonstrated by the trauma team members during real life trauma resuscitation. Unfortunately, this was not possible at the time of the study as such studies are resource intensive and sensitive regarding privacy. We would however argue that this was done in the trauma redesign project and to understand trauma team members' perspectives and experiences of teamwork in real world trauma resuscitations is the more relevant issue. Participants' recall of their training may be impacted by the passage of time. The questionnaire was completed in October and November 2016 and participants participated in the training between January 2010 and December 2013; however, participants were currently employed at the study site as members of the trauma team and we would argue this identifies the gap between TTT and the practice of teamwork in real world resuscitations. The use of a single site means that local contextual issues may influence results, and we did not assess whether the intervention improved teamwork during actual patient care.

Conclusion

Trauma team members, who had previously completed TTT, stated that NTS were reportedly practiced in the clinical setting to varying degrees. Fifteen facilitators and twelve barriers to the use of NTS during trauma emergencies were identified. Identification of barriers and facilitators to successful implementation of NTS by a trauma team, following TTT, provides evidence that may be used to inform development of future training programs for trauma teams. TTT achieved some positive changes in behaviour and team work and thus provides a relevant case study to explore the factors which drive successful implementation of multidisciplinary team training programs. Future research should include clinical observation work and interviews to improve understanding of practice, processes, principles and attitudes embedded in the clinical work and social interactions of trauma teams to help inform future training programs [30].

Author contribution

MM, KC, and AM conceived and designed the study. KC and AM oversaw all aspects of the study. MM conducted data collection, MM conducted data cleaning and interpretation, KC, MM and AM conducted the statistical data analysis. All authors have been actively involved in the drafting and critical revision of the manuscript.

References

- [1] Carne B, Kennedy M, Gray T. Review article: crisis resource management in emergency medicine. *Emerg Med Australas* 2012;24(Febuary (1)):7–13.
- [2] Edwards S, Siassakos D. Training teams and leaders to reduce resuscitation errors and improve patient outcome. *Resuscitation* 2012;83(1):13–5.
- [3] Berg GM, Acuna D, Lee F, Clark D, Lippoldt D. Trauma performance improvement and patient safety committee. *J Trauma Nurs* 2011;18(4):213–20.
- [4] Banks D, Trull K. Optimizing patient resuscitation outcomes with simulation. *Nursing* 2012;42(March (3)):60–1.
- [5] Catchpole K, Mishra A, Handa A, McCulloch P. Teamwork and error in the operating room: analysis of skills and roles. *Ann Surg* 2008;247(April (4)):699–706.
- [6] Flin R, O'Connor P. Safety at the sharp End. A guide to non-technical skills. London: CRC Press; 2017.
- [7] Bristowe K, Siassakos D, Hambly H, et al. Teamwork for clinical emergencies: interprofessional focus group analysis and triangulation with simulation. *Qual Health Res* 2012;22(October (10)):1383–94.
- [8] Murphy M, Curtis K, McCloughen A. What is the impact of multidisciplinary team simulation training on team performance and efficiency of patient care? An integrative review. *Australas Emerg Nurs J* 2016;19(Febuary (1)):44–53.
- [9] Curtis K, Tzannes A, Rudge T. How to talk to doctors—a guide for effective communication. *Int Nurs Rev* 2011;58(March (1)):13–20.
- [10] Granheim BM, Shaw JM, Mansah M. The use of interprofessional learning and simulation in undergraduate nursing programs to address interprofessional communication and collaboration: an integrative review of the literature. *Nurse Educ Today* 2018;62(March):118–27.
- [11] Siassakos D, Fox R, Bristowe K, et al. What makes maternity teams effective and safe? Lessons from a series of research on teamwork, leadership and team training. *Acta Obstetrica et Gynecologica Scandinavica* 2013;92(November (11)):1239–43.
- [12] Mellin-Olsen J, Staender S, Whitaker DK, Smith AF. The helsinki declaration on patient safety in Anaesthesiology. *Eur J Anaesthesiol* 2010;27(July7):592–7.
- [13] Siassakos D, Fox R, Crofts JF, Hunt LP, Winter C, Draycott TJ. The management of a simulated emergency: better teamwork, better performance. *Resuscitation* 2011;82(Febuary (2)):203–6.
- [14] Murphy M, McCloughen A, Curtis K. Enhancing the training of trauma resuscitation flash teams: a mixed methods study. *Australas Emerg Care* 2018 (October) In press.
- [15] Edwards C, Seggie J, Murphy M. Redesigning the response to patients with trauma. *Emerg Nurse* 2012;20(May (2)):31–6.
- [16] Murphy MM, Edwards CM, Seggie J, Curtis K. Emergency department trauma redesign in a level 1 trauma centre. *Australas Emerg Nurs J* 2011;14(Febuary (1)):50–8.
- [17] Murphy M, Curtis K, Lam MK, Palmer CS, Hsu J, McCloughen A. Simulation-based multidisciplinary team training decreases time to critical operations for trauma patients. *Injury* 2018;49(May (5)):953–8.
- [18] Murphy M, McCloughen A, Curtis K. Enhancing the training of trauma resuscitation flash teams: a mixed methods study. *Australasian Emergency Care* 2018 2018(October) Accepted for publication.
- [19] Murphy M, Curtis K, McCloughen A. Perspectives and experiences of team work following simulated multidisciplinary Trauma Team Training: a qualitative study *Australasian Emergency Care* 2018 Accepted for publication: November. 2018.
- [20] Atkins L, Francis J, Islam R, et al. A guide to using the Theoretical Domains Framework of behaviour change to investigate implementation problems. *Implement Sci* 2017;77(June (12)).
- [21] Harris PA, Taylor R, Thielke R, Payne J, Gonzalez N, Conde JG. Research electronic data capture (REDCap). A metadata-driven methodology and workflow process for providing translational research informatics support. *J Biomed Inform* 2009;42(April (2)):377–81.
- [22] Statistical package for the social sciences (SPSS) Inc., Chicago, IL, USA (computer program). Version 2015. Chicago, IL, USA.
- [23] Michie S, van Stralen MM, West R. The behaviour change wheel: a new method for characterising and designing behaviour change interventions. *Implement Sci* 2011;42(April (6)).
- [24] May C, Finch T. Implementing, embedding and integrating practices: an outline of Normalization process Theory. *Sociology* 2009;43(June (13)):535.
- [25] Andreatta PB. A typology for health care teams. *Health Care Manage Rev* 2010;35:345–54.
- [26] Salas E, Rosen MA, Burke CS, Goodwin GF. The wisdom of collectiveness in organizations: an update of the teamwork competencies. In: Salas E, Goodwin GF, Burke CS, editors. *Team effectiveness in complex organizations. Cross-disciplinary perspectives and approaches*. New York, NY: Psychology Press; 2009. p. 39–82.
- [27] Ford K, Menchine M, Burner E, et al. Leadership and teamwork in trauma and resuscitation. *West J Emerg Med* 2016;17(September (5)):549–56.
- [28] Arain NA, Hogg DC, Gala RB, et al. Construct and face validity of the American College of Surgeons/Association of Program Directors in Surgery laparoscopic troubleshooting team training exercise. *Am J Surg* 2012;203(January (1)):54–62.
- [29] Figueroa MI, Sepanski R, Goldberg SP, Shah S. Improving teamwork, confidence, and collaboration among members of a pediatric cardiovascular intensive care unit multidisciplinary team using simulation-based team training. *Pediatr Cardiol* 2013;34(3):612–9.
- [30] Fry M, Curtis K, Considine J, Shaban RZ. Using observation to collect data in emergency research. *Australas Emerg Care* 2017;20(1):25–30.