Understanding the Role of Team Coordination in Military Medical Teams

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Abstract

This study characterizes and examines the cognitive demands of team coordination in military medical teams as they solved three team-based simulations. A mixed methods design was used. Forty-four behaviors pertaining to eight coordination strategies were analyzed according to team performance (high and low) and task-load (high and low). The team leaders' problem-solving activities during the task were determined and the extent to which knowledge was shared among team members was measured using a network analysis approach. Both high and low performing teams achieved coordination by executing actions predominantly related to trust in the leader, situation awareness and explicit communication. Differences yielded in the proportion with which coordination strategies were implemented. High performing teams implemented a greater proportion of situation awareness (M=31.33) than low performing teams (M = 26.67). A within-subjects factor analysis revealed that coordination activities significantly changed in teams during high- and low- load segments of the task. These changes followed a quadratic trend that indicated a U-shaped relationship between coordination activities and task load.

Coordination activities occurred in nine different conditions. However, one activity which involved the identification of general injuries accounted for 34.3% of the variance in performance. Models of leaders' problem-solving activities suggested that leaders of high performing teams engaged in coordination actions that aimed to structuring type of leadership by organizing the task and managing team members. Leaders of low performing teams focus on technical processes such as the collection and transfer of information, which correspond to a content-oriented type of leadership. High performing teams demonstrated fully connected networks that evidenced that team members shared substantial amounts of knowledge about coordination strategies. In contrast, low performing teams had disjointed matrices that showed team members had not compatible knowledge. The research findings have implications for the design of better team training in simulated-based learning environments.

Resumé

Cette recherche examine les exigences cognitives dans la coordination au sein des équipes médicales militaires lors de la résolution de trois simulations. Une combinaison de méthodes qualitatives et quantitatives a été utilisée à cette fin. Quarante-quatre comportements, se rapportant à huit stratégies de coordination, ont été analysés en fonction de la performance des équipes (haute et moindre) et de la charge de travail (haute et moindre). Les activités de résolution de problèmes des chefs d'équipe tout au long de la tâche ont été identifiées et la mesure dans laquelle la connaissance fut partagée entre les membres des équipes a été identifiée en utilisant l'approche d'analyse des réseaux. Auntant les équipes ayant de hautes performances que celles ayant des faibles performancess ont toutes atteintes la coordination grâce à la réalisation d'actions liées à la confiance envers le leader, à la conscience de la situation et à la communication dite explicite. Or, des différences ont été observées par rapport à la fréquence d'utilisation de stratégies de coordination. Les équipes performantes ont employé un plus grand degré de conscience de la situation (M = 31.33) par rapport aux équipes de faible rendement (M = 26,67). Une analyse intra-sujets a révélé que les activités de coordination au sein des équipes changent de manière significative par rapport à la charge de travail. Ces changements ont suivi une tendance quadratique qui indique une relation en U entre les activités de coordination et la charge de travail.

Les activités de coordination ont eu lieu dans neuf conditions différentes. Toutefois, une seule de ces conditions, se référant à l' identification de blessures générales, représentait 34,3 % de la variance de la performance. La modelisation des activités de résolution de problèmes des leaders des équipes performantes suggère que

ceux-ci s’engagent d’avatage dans des actions de coordination visant à organiser la tâche et à gérer les membres de l'équipe, ce qui est lié à un type structurant de leadership. À l’inverse, les chefs des équipes les moins performantes se concentrent plutôt sur les processus techniques tels que la collecte et le transfert de l'information, ce qui correspond plutôt à un type de leadership orienté vers le contenu. De plus, les équipes performantes constituaient des réseaux entièrement connectés, permettant un partage important de connaissances sur les stratégies de coordination entre leurs membres. Inversement, les équipes à moindre performance constituaient des reseaux disjoints en ce qui concerne les connaissances partagées par leurs membres. Ces résultats ont des implications pour la conception de meilleures activités de formation des équipes dans des environnements d'apprentissage basés sur la simulation.

Dedication

This thesis is dedicated to my beatiful family, Gonzalo my husband, Sebastian my son and Maria Eugenia my mother, who have always inspired me to be a better person, and for their unflagging love and support throughout my studies.

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CHAPTER 1

INTRODUCTION

Teams that come together for a short period of time, be it an hour, weeks, or a month, are called action teams (Wildman, Fiore, Burke, & Salas, 2011). Such teams have little or no time to develop traditional sources of coordination, such as explicit communication strategies, pre-plans, and relationships based on mutual trust (Wildman et al., 2011). Medical teams are standard examples of action teams; they are required to perform immediately and often in urgent and ambiguous conditions that evolve rapidly and have intense time pressure, information overload, and severe consequences in cases of error (Orasanu & Salas, 1993; Wildman et al., 2011). The combination of these features may lead teams, especially those less skillful, to experience an unexpected loss of coordination or performance breakdowns (Klein, Feltovich, Bradshaw, & Woods, 2005; Klein, Ziegert, Knight, & Xiao, 2006; Mckinney, Barker, Davis, & Smith, 2005; Weick, 1990; Wilson, Salas, Priest, & Andrews, 2007; Xiao & LOTAS, 2001; Xiao & Moss, 2001) that can cause medical errors or patient mortality (Reader, Flin, Mearns, & Cuthbertson, 2007). The literature has shown that effective teams are able to perform smoothly and overcome coordination breakdowns by implementing a range of explicit/implicit coordination strategies, such as monitoring other team members' activities and providing unsolicited task relevant information (Künzle, Zala-Mezö, Kolbe, Wacker, & Grote, 2010; Künzle, Zala-Mezö, Wacker, Kolbe, Spahn, & Grote, 2011).

This study aims to examine the coordination strategies implemented by military trauma medical teams and how these strategies affect performance. The teams performed seven high fidelity team-based simulations. The simulations recreated a battlefield medical unit in Kandahar where combat-injured patients were treated. Trauma teams were asked to react as a team and implement crisis resource management to war-injured/wounded patients. They were expected to act in a coordinated manner and to identify a leader rapidly, assign roles to team members (e.g. manage airway, intravenous, etc.), stabilize the patient, and identify and treat the main injury causing the deterioration of the patient. All simulations were built based on a stepwise approach of increasing complexity, and performed during a two-week intensive trauma team course delivered by a military forces trauma center.

Study Aims and Research Questions

The general purpose of this study was to examine the relationship between coordination strategies and team performance. Specifically, this study addresses the following research questions:

1. What coordination activities do high and low performing teams implement when solving a trauma team-based simulation?
2. To what extent are coordination activities different during high- and low-task-load periods of the task in high and low performing teams? To what extent do team members implement coordination activities differently during high-task-load?
3. Under what conditions do leaders' coordination behaviors occur? What is the relationship between leaders' coordination behaviors and the conditions in which they occur?
4. What problem activities do team leaders' engage in at different phases of the task?

5. To what extent is knowledge shared among team members of high and low performing teams?

Team research has shown that high performance teams often achieve coordination with minimum explicit, verbal communications (Xiao & LOTAS, 2001; Xiao, Mackenzie, & Patey, 1998). Team members of these teams adapt the amount and the content of their communications according to the workload of the task. Non-stressful moments of the task (e.g., when the patient is stable) are used by team members to explicitly communicate about roles, problems and tasks, while stressful moments (e.g., when the patient is deteriorating) are characterized by minimum communications that are restricted to task relevant information and by active leadership behaviors (Zala-Mezö, Wacker, Künzle, Brüesch, & Grote, 2009). High performing teams are able to implement a rapid sequence of actions effectively by knowing how to adapt their amount and type of communication based on the content of information and the task workload (Orasanu, 1990; Xiao & Moss, 2001).

The literature has shown that the lack of appropriate communication during crisis situations leads less performing teams to coordination breakdowns (Klein et al., 2005; Klein et al., 2006; Mckinney et al., 2005; Weick, 1990; Wilson et al., 2007; Xiao & LOTAS, 2001). Crisis situations, which are characterized by high workload, rapid exchange of information, and changes in communication and leadership patterns, are likely to cause breakdowns of common ground and loss of shared mental models (Klein, 2008; Klein et al., 2005; Klein, Schmitt, McCloskey, & Phillips, 2000; Weick, 1990; Wilson et al., 2007). For instance, people working on their individual assignments can get confused over who knows what, or they lose perspective on the general picture of what is happening around them or with other team members and the task in general. This phenomenon is known as lack of situation awareness (Cooke, Stout, & Salas, 2001; Kaber & Endsley, 1998; Wickens, 2008).

For the purpose of this study, high performance trauma teams are predicted to increase the use of implicit communication and leadership behaviors during high task-load moments (e.g. when the patient is deteriorating) and concentrate on relevant-task information, while less performing teams are predicted to respond to these moments with more explicit communication, less leadership behaviors and focus on non-essential information. It is also expected that effective teams increase coordination behaviors during high task-load moments while less effective teams decrease them.

CHAPTER 2

LITERATURE REVIEW

The study of coordination is essential to understanding which elements characterize an effective team and subsequently how to train teams to be effective. Three characteristics define a team: Interdependency of sub-task, synchronization of work and shared goals (e.g. Salas, Dickinson, Converse, & Tannenbaum, 1992). Although, researchers have used the term teams and groups interchangeably (Blickensderfer, Reynolds, Salas, & Cannon-Bowers, 2010) relevant differences among these terms exist.

Teams are characterized as having clearly defined roles, differentiated tasks, and high levels of task interdependence (e.g. surgical teams) (Baker & Salas, 1992; Blickensderfer et al., 2010). Groups, on the other hand, are defined as people working together toward a common goal or an individual goal, where functions can be interchangeable and role delimitation is not needed (e.g. a semester-long group research project) (Brannick & Prince, 1997; Peterson, Mitchell, Thompson, & Burr, 2000). In team tasks “team members are not interchangeable, nor can they perform the task if a member is missing (i.e., the surgeon and the nurse could not perform surgery if the anesthesiologist is missing)” (Blickensderfer, et al., 2010). However, a group task, such as complete a semester-long research project (Peterson, et al., 2000), may be performed even if one of the students decides not to take part in helping with the task. These examples demonstrate how coordination requirements and interdependence among tasks and roles are key elements that distinguish teams from groups. The present study is aimed to understand the coordination patterns of teams, more specially those of medical teams.

Definition of Coordination

Coordination is an overarching concept in team cognition and it is the mechanism that teams use to manage inter-dependencies among sub-tasks, resources and people (Khan, Lodhi, & Makk, 2010a; Klein et al., 2005; Malone & Crowston, 1990; Neville, Fowlkes, Milham, Bergondy, & Glucroft, 2001; Wilson et al., 2007). In fact, coordination has been defined as "a kind of dynamic glue that binds tasks together into larger meaningful wholes" (Holt, 1988, p. 109).

The degree to which coordination is implemented in a team task may vary according to the level of interdependence that is required to perform the task successfully. Although, all types of team tasks involve a certain degree of coordination, coordination is more likely to emerge in tasks that require high levels of interdependence (Katz-Navon & Erez, 2005). Interdependence has been defined as the extent to which "individuals' outcomes are affected by other team members' actions" (Johnson & Johnson, 1989, p. 2).

Coordination plays a central role in effective team performance (Elias & Fiore, 2012; Fernandez, Kozlowski, Shapiro, & Salas, 2008; Klein, 2001; Salas, Sims, & Burke, 2005; Salas, Wilson, Murphy, King, & Salisbury, 2008). Effective teams implement coordination in order to: adapt their behaviors to the changing conditions of the situation, reduce verbal communication under high workload phases of the task, anticipate the needs and the actions of other team members, and complete tasks without wasting valuable resources such as time and personnel (Khan et al., 2010a; Rico, Sanchez-Manzanares, Gil, & Gibson, 2008; Wilson et al., 2007). Researchers often look at coordination as a general phenomenon that applies relatively similarly to all teams (Malone & Crowston, 1994). However, coordination may be applied differently according to the type of team, task, stage of the task, and changes in dependencies across task (Espinosa, Lerch, & Kraut, 2004).

In this chapter, I examine how coordination is applied in a set of teams known as action teams. These teams perform tasks that are highly specialized and that impose high demands of coordination due to the dynamic environments they take place in. Dynamic environments are typified by rapidly evolving and ambiguous situations that involve trained specialists who are requested to perform immediately without time to planning, and for which improvisation is often required (Orasanu & Salas, 1993). Moreover, the type of problems that action teams solve are characterized as ill-structured problems, which are essentially difficult to define due to ambiguous, incomplete and challenging information (Lajoie, Azevedo, & Fleiszer, 1998; Simon, 1977). Action teams often face unpredictable circumstances where there may be no “optimal” answers, information overload, and intense time pressure. These circumstances could lead to severe consequences where errors occur (Orasanu & Salas, 1993). Prototypical action teams include emergency management teams, medical teams, command and control military teams, cockpit crews, control-tower teams, oil-rig crews, submarine teams, sport teams, space exploration teams, research-and-development teams, construction teams, and marketing teams (Salas, Stagl, Burke, & Goodwin, 2007; Sundstrom, 1999).

Team Coordination and its Components

The study of coordination is predominately inter- and trans-disciplinary and applies to both human and non-human phenomena (Elias & Fiore, 2012). Different fields such as management, psychology, economics, and computer sciences have studied coordination processes in order to understand how different kinds of actors (e.g. people, information systems and computer processors) jointly solve problems and make decisions effectively (Malone, 1988). The understanding of coordination has proven to be effective for different purposes in different areas. For instance, from an industrial management perspective, coordination effectively reduces costs (Malone & Crowston, 1994); from an economic perspective coordination serves to optimize the overall allocation of resources (Malone & Crowston, 1994), and from a team performance perspective, it helps to understand what separates effective from ineffective teamwork (Salas et al., 2005).

Malone and Crowston (1990) define four overlapping preconditions for coordination to happen: (1) there has to be at least two actors (e.g., person A/person B, sub teams, systems, etc.), (2) who perform some activities directed toward a specific end, (3) who are required to act interdependently in order to perform a task, and (4) who share common goals. These four components are meant to set up the preconditions for people to work together in a synchronous manner.

The first component of coordination implies that at least two actors, or entities are required to act conjointly, meaning that in addition to being interconnected they have unique responsibilities and roles in the team (Johnson & Johnson, 1989). A certain degree of independence and self-sufficiency is required too, whereby people can act autonomously and react under challenging circumstances without the need of explicit direction (Elias & Fiore, 2012; Klein, 2001). Certain degrees of freedom support team problem-solving, specifically in situations in which team members have to challenge the decisions made by the leader in order to contribute new or better alternatives (Elias & Fiore, 2012).

Although, actors are expected to act autonomously, they are also expected to limit their independence of action in order to act synchronously with other members who are equally bounded through a general and shared goal (Klein, 2001). In fact, "if things can be done totally independently, then there is nothing to coordinate" (Espinosa et al., 2004, p. 109). For instance, interdisciplinary action teams such as medical, military, and aircraft teams are composed of individuals with particular expertise, who, however, are not expected to act in an isolated manner. In fact, individual experts will not be able to complete the task independently but rather depend on the other team member's actions to complete their mutual goals. Finding the right balance between team members' autonomy and interdependence among team members' tasks is often the responsibility of the team leader (Barach & Weinger, 2006).

Since coordination requires a division of labor, it is expected that resources such as information or materials necessary for the task, be distributed among group members. Meetings that clarify how each part intervenes in the whole task are needed so that each individual understands what it is expected from him/her, what to expect from others and more importantly, how to combine resources to achieve the task goal (Johnson & Johnson, 1989). The link between individual activities and common goals reveals task inter-dependencies that describe how the task is divided into subunits and how these are to be performed in order to accomplish the global task (Johnson & Johnson, 1989).

Common goals help teams to create a general script/plan that put actors "on the same page" (Klein, 2001; Mohammed, Ferzandi, & Hamilton, 2010, p. 2). From a cognitive perspective, the common understanding of the script, the inter-dependencies between tasks and resources and goals are called shared mental models (SMMs)

(Klimoski & Mohammed, 1994; Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000; Salas et al., 2005). The relationship between SMMs and coordination will be further discussed in this chapter.

Coordination requires a division of labor that imposes order and time constrains to the work of the team (Elias & Fiore, 2012; Johnson & Johnson, 1989). Coordinated tasks compel individuals to share resources and to synchronize their individual contributions in a timely and order manner, so that they can achieve mutual goals (Malone & Crowston, 1994). For instance, team members' contributions have to be co-ordered among team members and therefore, they are expected to be integrated at predetermined points in time (e.g. surgery can only begin after the patient is anesthetized). The inter-dependencies among the team tasks are commonly managed by a team leader or in some cases by the team as a whole (Elias & Fiore, 2012) in which case shared leadership is implemented (Carson, Tesluk, & Marrone, 2007; Ensley, Hmieleski, & Pearce, 2006; Fiore & Salas, 2002).

Consider the case of trauma medical teams that have to coordinate assessment of Airway, Breathing, Circulation etc., upon the patient's arrival. This ABCDE's algorithm needs to be performed quickly and without deviations within the first five to 8 minutes, for which the leader assigns roles and tasks to individuals and structures patient treatment through active information gathering and interpretation of data (Künzle et al., 2011; Shapiro et al., 2008). The ABCDE algorithm restricts participants to work in a certain order. Team members cannot go from a higher to a lower letter without first completing the task under the initial letter (Lu, 2007). The consequences of not performing the ABCDE's algorithm systematically and within the minimum time might lead to patient injury and even death. This ABCDE task is difficult to achieve if the individual tasks are not coordinated. The work of trauma teams, as the work of other action teams such as aircrews, is considered to be a co-ordered activity and therefore time constrained (Klein et al., 2006; Xiao & LOTAS, 2001).

The relationship between coordination and team performance has been the focus of considerable research (e.g. Kidd, 1961) and continues to be a focal point in contemporary research (e.g. Elias & Fiore, 2012). However, researchers in this field often use terms i.e. cooperation, coordination and collaboration interchangeably to refer to people working together. We differentiate between these concepts in Table 1 by describing the different reasons that people may work together to share information and resources. For example, if the purpose of working together is to achieve a mutual goal, team members are compelled to share information and resources in order to coordinate their actions in a timely and organized manner, for which the establishment of roles and inter-dependencies is necessary. Furthermore, in coordinated efforts, a central authority figure integrates information from each individual part of the team.

On the other hand, cooperative work requires group members to share information and resources in order to facilitate the accomplishment of a goal, which can be either mutual or individual. In cooperative efforts, fragmented contributions are nor ordered or bounded by a time sequence, and interactions are not formally defined in terms of roles (e.g., there is no central authority figure). Cooperative work does not rely on group performance but rather on individuals' success. Collaborative efforts require two or more parts (e.g. corporations, teams, countries, etc.) to work together to generate a novel outcome (e.g. new product, solve a problem, etc.) for which the parts may share information and resources. Unlike coordination and cooperation, collaboration requires members to contribute in an innovative way to create something new (e.g. develop a product or an innovative solution) (Gray, 1989; Wood & Gray, 1991). This approach has been mainly studied from political, management, and IT perspectives (e.g., Butterfield, Reed, & Lemak, 2004; Compton, 1992; Mattessich & Monsey, 1992; Mintzberg, Jorgensen, Dougherty, & Westley, 1996). Coordinated and cooperative work might be needed at some stages of the collaborative effort. Finally, collaborative relationships are more durable and pervasive in comparison to cooperative and coordinated efforts (Mattessich & Monsey, 1992).

Table 1
Differences Between Coordination, Cooperation and Collaboration According to Mattessich and Monsey (1992)

	Coordination	Cooperation	Collaboration
Type of Relationship	Formal relationship and understanding of compatible goals and mission. Planning and establishment of roles are required	Informal relationships that exist without a commonly defined mission, structure or effort	Formal relationships that are more durable. Individuous are fully committed to the mission
Establishment of Authority	There is central authority	Authority is retained by each of the parts	Authority is determined by the collaborative structure
Information and Resources	Information is shared and communication channels are established. Resources are shared	Information is shared and resources and rewards are separate	Information is shared and resources could be separate or shared according to the phase of the collaboration

Summary. This section has shown the different definitions and characteristics of coordination. Coordination is defined in terms of synchronized efforts of two or more actors solving a task, for which they have an interdependency of roles, resources and common goals. Coordination is different from other similar concepts such as cooperation and collaboration. In coordination, people working together are required to work as a unit rather than as independent elements, while in cooperative efforts people working together are not bounded by the same goals and people can act based on personal agendas. On the other hand, collaboration may imply the use of both coordinated and cooperative efforts for long periods of time, in which people seek to solve a problem or task in an innovative or creative way. While coordination seems to characterize the work of teams, cooperation seems to be closer to the type of work that groups often conduct.

The next section of this paper describes in detail how coordination is applied to teamwork and the processes through which team coordination can be fostered.

The cognitive and motivational antecedents of team coordination. The study of coordination has increasingly become important to understand which elements characterize an effective team. The literature has shown evidence that effective teams are able to synchronize individual tasks and make adaptations in order to act conjointly, whereas ineffective teams show disconnects in timing that lead to low performance (Klein, 2001). In fact, difficulties in managing coordination have been recognized as the primary source of team breakdowns (Entin & Serfaty, 1999; Fernandez et al., 2008; Fussell, Kraut, Lerch, Scherlis, McNally, & Cadiz , 1998; Khan et al., 2010a; Miller, Scheinkestel, & Joseph, 2009; Wilson et al., 2007; Xiao et al., 1998). For instance, if a team member fails to communicate relevant information to the team, or if a team member makes an error in the procedure, it is likely that this will affect another team member, and become a potential source of error that may lead to further difficulties of coordination that will ultimately lead to complications and lost time (Fussell et al., 1998; Wilson et al., 2007).

Research has predominately focused on cognitive and motivational antecedents for explaining effective team performance. Researchers looking at the former category built on information processing theories (Peterson et al., 2000). They are mainly concerned with how team members use, distribute and share information before, during and after the tasks. The literature suggests that the management of information among team members has a strong impact on team coordination and ultimately on team performance; thus, understanding of the factors that affect coordination constitutes the overarching goal of team cognition (Fiore & Salas, 2006; Salas, Fiore, & Letsky, 2012; Salas & Fiore, 2004). From this perspective, team members implement cognitive strategies in order to manage interdependence among sub-tasks. Thus, interdependencies are managed through organized plans, monitoring of actions, decision-making processes, and development of shared representations of the general task and the individuals' tasks (Cannon-Bowers & Salas, 2001a; Klimoski & Mohammed, 1994; Salas et al., 2005; Stout, Cannon-Bowers, Salas, & Milanovich, 1999).

Examples of research using this perspective include models of common knowledge in which team members develop similar representations of the task and the situation, otherwise called Shared Mental Models (SMMs) (e.g. Mesmer-Magnus & Dechurch, 2009); research on how teams learn and how teams use strategies to manage information under heavy workload periods, known as transactive memory (e.g. Nandkeolyar, 2008); and research on team metacognition, and team problem solving (e.g. Fiore, Rosen, Salas, Burke, & Jentsch, 2008; Hinsz, 2004). Studies in this area have highlighted the fact that common mental models about the task, the situation, and teammates allow team members to implement coordinated performance (Klein, 2001; Salas, et al., 2005). Team cognition research has often looked at teams with high levels of task interdependence and high constrains of team coordination such as action or performing teams. The type of tasks these teams perform are seen as truly coordinated activities in which management of inter-dependencies is at the very heart of successful performance as opposed to just co-ordered activities (Cooke, Gorman, Myers, & Duran, 2012).

On the other hand, social cognitive theories have been used to examine team member motivation, team cohesion, mutual trust and collective efficacy. These constructs look at members' beliefs about how well they can perform or how good they are as a group (Peterson et al., 2000). Bandura (1997), a leader exponent of the socio-cognitive theory, has noted that team tasks "require intricate coordination, and the team attainment is highly dependent on how well its members work together" (p. 403). In this line of research, the literature has shown that teams that believe that they can succeed in a group task will produce higher levels of effort and persistence, which consequently has been proposed as a primary mediator of effective team performance (Gibson, Randel, & Earley, 2000; Katz-Navon & Erez, 2005; Peterson et al., 2000). Sport teams such as soccer and baseball teams and organizational and managerial teams have been mainly analyzed from this approach (e.g. Feltz & Lirgg, 2001; Morrow, Hansen, & Pearson, 2004).

A recent but limited body of studies has looked at the mediation effects of affective variables in the implementation of team based cognitive skills (Eccles &

Tenenbaum, 2004; Peterson et al., 2000). Some of the findings from this new line of research suggest that motivational components i.e., collective efficacy may increase the possibilities of developing SMMs and vise versa. For instance, Peterson and colleagues (2000) found that groups of students working on semester long-research projects that have both greater collective efficacy (a group's judgment of their ability to perform a particular task) and more shared mental models (models of the group structure, process and the task, that members hold in common) had higher performance.

The present study uses a predominately cognitive focus on team coordination (e.g., SMMs) but some affective components (e.g. mutual trust) their influence in developing team mental models are addressed later in the paper.

An overview of the different types of team coordination is addressed bellow.

Explicit and implicit coordination. Research on team coordination has consistently reported that teams use explicit and implicit coordination as the two primary mechanisms to manage dependencies (Bourbousson, Poizat, Saury, & Seve, 2010; Entin & Serfaty, 1999; Espinosa et al., 2004; Fiore, Salas, Cuevas, & Bowers, 2003; Klein, 2001; Malone & Crowston, 1994; Rico et al., 2008; Salas et al., 2005).

Explicit coordination consists of intentional behaviors team members apply "to articulate plans, actions, and responsibilities" (MacMillan, Entin, & Serfaty, 2004, p. 63). This type of coordination relies on oral or written communication, which is most commonly implemented either during the first phase of the task (prior to group interaction) characterized by preplanning behaviors (e.g. assignation of roles and discussion of procedures), or during the task itself when the team members are making decisions, negotiating, giving or receiving feedback, updating the initial plan, or repeating task relevant information (Espinosa et al., 2004; Kolbe, Künzle, Zala-Mezö, Wacker, & Grote, 2009; Strack, Kolbe, & Boos, 2010). Research has shown that as the task progresses and team members interact, they learn to distinguish relevant from irrelevant information and to recognize team members' expertise (Cruz-Panesso, 2011; Fiore, et al., 2008). Accumulating knowledge about the task and team members helps teams to reduce the amount of time invested in explicit communication and engage on implicit coordination. In this regard, Lajoie and colleagues (Lajoie & Lu 2013; Lu, 2007; Lu & Lajoie, 2008; Lu, Lajoie, & Wiseman 2010) found that medical teams that implement planning (e.g., looking for particular information to make decisions) and orienting (e.g., establishing tasks demands) activities early on, in the context of decision making in simulated emergencies, are more likely to develop common ground and to reduce the need for explicit communication later during the simulation.

On the other hand, implicit coordination is characterized by team members' anticipation of the actions and/or information that other team members may need (Entin & Serfaty, 1999; Espinosa et al., 2004). This type of coordination is based on SMMs, which consist of the common knowledge team members' hold about the task, the team members' role, and the situation (Mohammed et al., 2010). According to Entin and Serfaty (1999), SMMs "allow one team member to preempt the actions and needs of another so that actions can be coordinated and needs met in the absence of explicit communication" (p. 313).

Recent research has shown that implicit and explicit coordination are both useful for managing information and action dependencies (Kolbe et al., 2009). However, some authors have argued that these two types of coordination are implemented differently according to the nature of the task (e.g. task complexity, task interdependence), characteristics of the team itself (e.g. team size, familiarity of team members), type of team (e.g. action or performing vs.. planning teams, synchronous vs. asynchronous), and context of the task (e.g. time pressure, routine vs.. non-routine procedures) (Espinosa et al., 2004). Furthermore, research has shown that even for the same task, team members may need to switch from explicit to implicit coordination and vise versa as a mechanism to cope with workload and situational changes of the task (Zala-Mezö, Wacker, Künzle, Brüesch, & Grote, 2009).

Team tasks have different levels of workload according to situational changes that demand teams to use different types of coordination (Espinosa et al., 2004; Kozlowski, Watola, Nowakowski, Kim, & Botero, 2009). The team ability to effectively implement either implicit or explicit coordination in order to cope with changes in the situation has also been called adaptive team coordination (Entin & Serfaty, 1999; Manser, Howard, & Gaba, 2008). According to Entin and Serfaty (1999) effective teams are able to adapt their coordination behaviors under circumstances of stress and time-pressure. This is especially true for action teams that perform in fluid environments characterized by rapidly evolving and ambiguous situations (Klein, 2000; Orasanu & Salas, 1993; Salas et al., 2007; Sundstrom, 1999).

For instance, medical emergency situations, characterized by high workload, may require team members of emergency teams to limit explicit coordination in order to reduce cognitive workload. In these cases, team members are expected to focus their attention on stabilizing the patient in the shortest time possible, for which each team member is expected to act his role (e.g. insert IVs, initiate patient on oxygen, check for injuries) with low levels of explicit coordination (Fernandez et al., 2008). Klein and colleagues (2005) note that in moments of crisis or the high workload, team members are expected to bear their portion of the responsibility to establish and sustain common ground. Furthermore, a variety of studies have shown that under periods of high workload, effective teams change the communication interactions and engage on implicit coordination; while, low workload periods are used to establish team situation awareness (e.g. establishment/ recognition of what is going around the team) and to update SMMs through explicit coordination (Entin & Serfaty, 1999; Orasanu, 1990; Orasanu & Salas, 1993).

Literature has reported that good performing teams use both implicit and explicit coordination; however, the predominance of one or the other during performance varies according to the type of task, levels of task load and changes of task inter-dependencies during the task (Espinosa et al., 2004). For instance, Zala-Mezo et al. (2009) found that anesthesia teams spent more time performing highly standardized activities in which implicit coordination is predominant (60% of the time). During less standardized periods of the task, these teams use explicit communication (40% of the time). Interestingly, a higher density of coordinated actions was observed when anesthesia teams were implementing explicit coordination, indicating that teams use these periods of time for developing common ground that will later ease coordination and the necessity to coordinate explicitly. In contrast, some other authors have argued that certain team dependencies are better managed with the use of explicit coordination mechanisms alone (Espinosa et al., 2004). For example, large-scale software project teams rely on explicit coordination since they have to work with people who may not even know each other and who may be even working within different time zones. Coordination in such teams is formal and occurs via meetings and documents. According to Espinosa and colleagues, team tasks such as software teams may not even need implementation of team cognition (e.g. SMMs) or implicit coordination to improve coordination in general. Experimental research with manipulation of task dependencies may be needed to clarify these issues for which simulations may be a key resource (Zala-Mezö et al., 2009).

The following section describes three coordinating mechanisms included in a framework called the “Big Five of Teamwork” (Salas et al., 2005), which integrates cognitive and affective mechanisms that support implicit and explicit coordination, namely SMMs, mutual trust and closed loop communication.

Team Coordinating Mechanisms

Espinosa et al. (2004) define coordination mechanisms as the means that teams use to manage dependencies in order to act as a unit rather than independent individuals. Although, communication (via implicit or explicit information exchange) has often been cited as the main mechanism to manage team task inter-dependencies, there exist other mechanisms that emphasize the cognitive and attitudinal components that support team coordination and teamwork processes. These universal mechanisms are described as being needed in all cases of team coordination and will have little variance across the team or the type of task (Salas et al., 2005, p. 564): SMMs, mutual trust and closed loop communication (Salas et al., 2005). According to Salas and colleagues, coordinating mechanisms are meant to engage team members in the implementation of five relevant teamwork processes such as team leadership, mutual performance monitoring, backup behavior, adaptability, and team orientation (Salas et al., 2005). Although, the three mechanisms are the key to implementing coordination behaviors, literature on team cognition has primarily focused on SMMs.

It has been repeatedly suggested that SMMs improve team performance (Mohammed, Klimoski, & Rentsch, 2000). Moreover, understanding SMMs can facilitate our comprehension of team performance and lead to improvements in team effectiveness (Cannon-Bowers & Salas, 2001a). Other authors have emphasized that the utility of understanding SMMs is that they "help us to explain what separates effective from ineffective teams" (Cannon-Bowers & Salas, 2001a, p. 196; Mohammed et al., 2000). In fact, empirical evidence supports the notion that effective teams use SMMs to interpret information in a similar manner, to anticipate who needs to be supported, "to share expectations concerning future events, and to develop similar causal accounts for a situation" (Mohammed et al., 2010, p. 4).

Some authors have shown evidence that the use of SMMs lead team members to coordinate actions and tasks more efficiently (Klein et al., 2000). The validity of this assumption has been tested within different types of teams and different team tasks. For instance, researchers have looked at military teams performing combat operations simulations (Klein et al., 2000), medical teams performing simulations on trauma resuscitation (Xiao, Seagull, Mackenzie, & Klein, 2004), and air traffic controllers working on tower facilities (Smith-Jentsch, Mathieu, & Kraiger, 2005), among others. These tasks require teams to perform under time pressure and rapidly evolving situations, in which safety is a major issue (Orasanu & Salas, 1993). The literature agrees in that SMMs enhance coordination between team members and that they "offer a powerful explanatory mechanism for understanding complex performance" (Cannon-Bowers, Salas, & Converse, 1993, p. 227).

In the following sections theories of SMMs, mutual trust and closed loop communication will be addressed as a mean to explain the nature of a coordinated team performance.

Shared Mental Models (SMMs)

Within the team cognition literature, SMMs (referred to as team knowledge by Blickensderfer, Cannon-Bowers, Salas, & Baker, 2000; and as common ground by Klein, et al., 2005) are described as the main mechanism for teams to implement coordination strategies through explicit and/or implicit communication (Orasanu, 1990, 2005). For instance, teams use explicit communication to update SMMs that can latter be applied in situations that require implicit coordination. Although, SMMs can be found in both types of coordination, the studies have found that SMMs are more intimately linked to implicit coordination (Khan, Lodhi, & Makk, 2010b; Rico et al., 2008; Toups & Kerne, 2007).

Given the importance of SMMs as a key aspect affecting team performance researchers are refining the conceptual definition of the term. Some authors have argued that the term SMM has been used indiscriminately to describe different types of knowledge, and that the term "sharing" is vague (Salas, Rosen, Burke, & Goodwin, 2009). Along with Salas et al. (2009), other scholars have further agreed that "sharedness" must be defined in terms of what type of knowledge must be shared to guarantee team effectiveness. (Cannon-Bowers & Salas, 2001a; Cannon-Bowers, Tannenbaum, Salas, & Volpe, 1995).

Some authors distinguish (e.g. Blickensderfer et al., 2000; Cooke, Salas, Cannon-Bowers, & Stout, 2000) between two types of effective team knowledge namely pre-task and dynamic team knowledge (see Table 2).

Table 2
Types of Knowledge Effective Teams Implement

Type of knowledge	Characteristics	Examples
Pre-Existing Knowledge	a. Task specific knowledge	Sequences, actions, strategies
	b. Team members knowledge of each other	Distribution of expertise within the team
Dynamic Knowledge	Developed during team performance and updated through shared situational awareness	Compatible interpretation when the situation changes

Pre-task team knowledge refers to the knowledge team members acquired individually rather than by the team as a whole. This type of knowledge is often acquired before the task (e.g. through previous experiences), and can be related to technology/equipment (e.g. equipment functioning, operating procedures, system limitations, and likely failures); job/task (e.g. task procedures, likely contingencies, likely scenarios, task strategies, environmental constraints, and task component relationships); team interaction (e.g. roles/responsibilities, information sources, interaction patterns, communication channels, role inter-dependencies, and information flow); and the team itself (e.g. teammates' knowledge, teammates' skills, teammates' attitudes, teammates preferences, and teammates tendencies). Individual knowledge must be compatible across team members allowing the team to set common goals. Team members with common pre-task knowledge ensure that everyone is working toward the same goal with similar expectations (Blickensderfer et al., 2000).

Dynamic team knowledge, also referred to as adaptive team coordination by Neville and colleagues (2001), refers to the use of knowledge about the situation, the team, and the plan, that guide the selection and use of appropriate team skills (see Table 2). This type of knowledge is developed during the actual performance of the task (in-situ), for which shared pre-task knowledge and shared situational awareness are the main sources. Blickensderfer et al. (2000) further define dynamic knowledge as:

> "[T]he degree to which teammates develop compatible assessments of cues and patterns in the situation, the implications of these for the team and task, how the team is proceeding, and particular actions that certain team members need to take. (…) Dynamic understanding combines pre-performance knowledge with cognizance of the specific characteristics of the current situation" (p. 436).

Dynamic knowledge is mainly exhibited in the performance of expert teams that not only know how to use team skills (e.g. how to be a supportive team member) but know how to select and implement them appropriately throughout the different phases of the task (Cannon-Bowers & Converse, 2001; Neville et al., 2001).

Mohamed et al. (2010) further distinguish between different types of SMMs according to the content and properties. The different types of knowledge (e.g. knowledge about the task, the team roles, the understanding of equipment and team members' beliefs) represent the content of SMMs while the properties refer to the similarity and accuracy of SMMs (Mohammed et al., 2010). Similarity is defined as the degree of agreement between team members' interpretations about the task, team members' roles, equipment and other functional parts of the task. Accuracy or consistency refers to the quality of the information that is shared. Most of the studies in SMMs have focused on the measurement of similarity of mental models, where for instance, participants are asked to rank in order the strategies implemented in the task) (Edwards, Day, Arthur, & Bell, 2006). Less work has been done measuring the accuracy of SMMs, since such measures require a team expert model as referent. The degree of overlap between the trainee mental models and that of the team expert model serves as a measure of accuracy (Edwards et al., 2006).

Edward et al. (2006) examined the relationship between the similarity and accuracy of SMMs and also compared the unique contribution of each in the prediction of team performance in a longitudinal study. Participants in this study were non-professional teams performing a video game that simulates a complex and dynamic aviation environment. These authors found that during the first days of training, similarity, and accuracy of mental models positively predicted team performance. However, after four days of training, the accuracy of team mental models was a stronger predictor of subsequent performance, suggesting that accuracy measures are better predictors when considering longitudinal studies. Consistent with this finding, Smith-Jentsch et al. (2005) found that in real field settings (e.g. air traffic controllers), accuracy was also a better predictor of team performance. These results lead to further questions about the appropriateness of the measures used to assess SMMs.

Measurement approaches for studying SMMs have been characterized for following either a collective or a holistic approach. In the collective approach team mental models are viewed “as a collection of the knowledge of the individual team members” (Cooke et al., 2000, p. 158). In this approach, team knowledge is elicited at the individual level and then aggregated across team members. In the holistic approach, team mental models are viewed as the consequence of the interaction. Here, mental models emerge in the context of the interaction during the actual task. Measurement of SMMs from the holistic approach may result in the assessment of team processes such as communication, situation assessment, and coordination (Cooke et al., 2000). Cooke and colleagues argue that studies should look at the comparative value of both approaches (Cooke et al., 2000; Cooke, Salas, Kiekel, & Bell, 2004). The integration of the collective and the holistic approach is well exemplified by Cook, Gorman, and Winner (2007) who used a mixed design method to achieve higher standards of validity.

In Cooke and colleagues' study, team processes and team coordination are assessed using qualitative analysis of video records of the simulations (a command-and-control simulated-setting) (Cooke, Gorman, & Winner, 2007). In addition, each team member answered individual multi-choice tests about team/task knowledge after each simulation. Then, collective knowledge was assessed through collective debriefing sessions. The general results of this study put in evidence that, during training sessions, teams acquire knowledge that goes beyond knowledge about the task. In fact, knowledge about the task is the platform for teams to develop new knowledge and strategies during the task as the situation and the team interaction changes.

We would additionally argue that the uses of collective and/or holistic measures of SMMs have further theoretical implications. Researchers relying on collective measures tacitly define SMMs as static representations. In these cases, researchers inquire about SMMs at one point in the study either at the beginning or at the end of performance, which implicitly lead researchers to ignore the fact that individuals' mind change while solving a problem and that the team-mind changes across the task. In evidence of this argument, Lee and Johnson (2008) found that two types of SMMs change over time, namely Team-SMMs and Task-SMMs. These authors found that these two types of SMMs adaptively change during team tasks depending on the changing requirements of the situation/task.

Teams develop and use SMMs in different ways according to their level of expertise. Burke and colleagues (2004) note that the ability of team members to develop shared knowledge is a remarkable characteristic of effective teams that use this knowledge “to guide coordinated actions and to determine when something is out of place” (p. i100). In consequence, SMMs are often analyzed in order to illustrate the concept of team expertise or team effectiveness.

A few studies looking at SMMs in expert teams demonstrate that expert teams share similarities to individual experts in that they have the ability to identify, anticipate and respond to cues in a proactive way making use of the knowledge acquired in past experiences (Cannon-Bowers et al., 1993; Neville et al., 2001; Seamster, Redding, Cannon, Ryder, & Purcell, 1993). Garrett, Caldwell, Harris, and Gonzalez (2009) identify six cognitive dimensions of expertise for team coordination. These dimensions describe the content knowledge individuals need to complete the task at the team level including (1) subject matter expertise or individual knowledge in a specific subject area that facilitates information flow among team members; (2) situational context expertise referred to as the ability to identify and understand the current and changing context and how it affects goal-oriented strategic performance; (3) interface tool expertise, which describes someone’s ability to interact with the tools necessary to apply their subject matter expertise; (4) expert identification expertise, which refers to the knowledge of who has expertise in a specific area, which is thought to increase the amount and quality of information available during decision-making processes; (5) communication expertise defined as the ability to transmit knowledge and information effectively, which involves knowledge of what and how to communicate; and (6) information flow path expertise that include the technical knowledge of what communication paths exist and which is most appropriate to use, within specific task and situational constrains.

Neville and colleagues (2001) found that expert air naval teams use team skills (e.g. how to be a supportive team member) and know when to select and implement them appropriately in different phases of the task. These teams exhibited well constructed knowledge about: plan flow (i.e., who is supposed to be where and at what time), tactical communication and prioritization of information to be passed to teammates (i.e., when is it appropriate to speak and in what phases is it relevant to pass information to other team mates), allowable risk (i.e., the margin of risk the team should accept), and threat awareness (i.e., anticipated knowledge of actual task/threat environment). Similarly, Seamster et al. (1993) found evidence that expert air traffic control teams have knowledge about planning strategies (i.e., knowledge about when to start an action, backup plans, how and when to prioritize actions), monitoring strategies (i.e., monitor start and sequences of the tasks), and workload management strategies (i.e., knowledge about the actions to implement in low and high workload periods, knowledge of the actions that require minimum and maximum coordination).

In the context of medicine, skilled surgical and trauma teams are often referenced to illustrate the concept of expert teams (e.g. Fernandez et al., 2008; Kolbe et al., 2009;

Manser, Howard, & Gaba, 2009; Sundstrom, De Meuse, & Futrell, 1990; Xiao & Moss, 2001). For instance, Fernandez et al. (2008) develop a taxonomy related to the processes and mechanisms that describe effective teamwork in emergency medicine. For these authors, effective teams are capable of implementing: (1) planning processes intended to prepare team members for task accomplishment including mission analysis, goal specification, and strategy formulation; (2) action processes implemented during the actual task, including monitoring progress toward goals, tracking of resources and the environmental conditions related to patient care, anticipation of team members need otherwise known as back-up behavior, and coordination of activities in terms of sequence and time; (3) reflection process including post-task debriefing sessions in which the team leader evaluates the team performance of the team and recognizes error that can be avoided in future situations; and finally (4) supporting mechanisms such as team leadership skills, team cognition (e.g. SMMs), and closed-loop communication.

SMMs are known as important sources of shared beliefs, whether these beliefs are about team goals, or beliefs about the ability of the team to perform team tasks. Cannon-Bowers et al. (2001a) have argued that although team coordination is the most salient outcome of having SMMs, other hypothesized outcomes are cohesion, motivation, and consensus among team members (Cannon-Bowers, Salas, & Converse, 2001). The following subsection examines the theoretical and empirical components of mutual trust in teams.

Mutual Trust

Mutual trust is defined as a coordinating mechanism that involves "the shared belief that team members will perform their roles and protect the interest of their teammates" (Salas et al., 2005 p. 561). Trust is further thought of as an attitudinal competence that affects team coordination and team performance; that is to say, mutual trust affects the participants' willingness to contribute to the team effort through sharing information relevant to the task and by accepting leadership behaviors coming from the leader or from other team members (Burke, Sims, Lazzara, & Salas, 2007; Cannon-Bowers, et al., 1995; Dirks & Ferrin, 2002; Salas, et al., 2005; Webber, 2002). Webber (2002) defines team trust in terms of team climate as the "shared perception by the majority of team members that individuals in the team will perform particular actions important to its members and that individuals will recognize and protect the rights and interests of all team members engaged in their joint endeavor (p. 205).

Trust is essentially based on two overlapping cognitive elements: the perception that other team members can act in appropriate manner (Meyerson, Weick, & Kramer, 1996; Morrow et al., 2004) and the collective belief that team members have the "conjoint capabilities to organize and execute the courses of action required to produce given levels of attainments" (Bandura, 1997, p. 477), otherwise called collective efficacy. As has been said previously in this paper, groups that hold the belief that they can be successful in a group task will produce higher levels of effort and persistence, which consequently has been proposed as a primary mediator of team performance (Dirks & Ferrin, 2002; Gibson et al., 2000; Katz-Navon & Erez, 2005; Peterson et al., 2000). Similarly, Sundstrom and colleagues (1990) found that team interventions targeting interpersonal processes and mutual trust are likely to contribute to build team cohesion, which facilitates the development of the team and team performance.

Mutual trust promotes interaction, including communication and coordinated behaviors (Webber, 2002). For instance Khan and colleagues found that the more that team members trust each other the higher the possibilities to share information and to ask for help from team members (Khan et al., 2010a). Mutual trust behaviors are associated with team effectiveness since they prevent team members from doing unnecessary checking of other team members' work; instead, the energy and attention is put into communication and coordination (Salas et al., 2005). Klein (2006) further argues that the lack of credibility or trust in team members may impede the capacity of the team to recognize initial cues related to coordination breakdowns. Other attitudinal aspects affected by team members' trust include team efficacy beliefs including the shared belief that team members will undertake a given task, will be confident in the ability of the teams and, therefore, will collaborate in defining task requirements (Khan et al., 2010a).

Three antecedents of mutual trust are role clarity, willingness to perform the role and the tasks assigned, and information sharing defined in terms of the degree to which team members share information about their role/task (Meyerson et al., 1996). Research has shown that the presence of these antecedents is closely linked to leadership behaviors (Cruz-Panesso, Lachapelle, & Lajoie, 2011; Dirks & Ferrin, 2002).

Some other authors suggest that leadership behaviors implemented by the leader prior to actual team formation may enhance the development of a good team climate and promote team trust (Burke et al., 2007; Webber, 2002). According to Burke et al. (2007) and Webber (2002) actions prior to the formation of the team include the selection of high ability team members, team members who are all at the same organizational level, team members who have worked well together and with the leader in the past. Although, these actions are preferable, they are not implemented equally in all teams. For instance, action teams characterized as temporary teams are composed of people with little or no prior knowledge of each other (Mckinney et al., 2005; Wildman et al., 2011), and may not have the time or the resources to implement these pre-task actions (Meyerson et al., 1996). This issue will be further elaborated under the section of action teams.

Actions during the formation of the team may involve negotiation of expectations with functional leaders, building of a positive relationship with other team leaders, promotion of a shared commitment for the project, and development and articulation of a clear mission for the team (Webber, 2002). Webber (2002) suggests that team leaders be trained prior to the team conformation and team task since the team leader has a structural role in the development and consolidation of mutual trust.

Closed Loop Communication

Closed loop communication refers to the effective and efficient exchange of information between the sender and the receiver (McIntyre & Salas, 1995) which is especially important in dynamic settings with a high information flow such as emergency situations (Lajoie et al., 1998; Salas et al., 2005). Moreover, communication helps team members establish common understandings about the task goals and task relevant knowledge, which is related to SMMs (Cannon-Bowers et al., 1993). It is hypothesized that team communication enhances adaptive performance when situations change and when changes in the planned intervention are needed (Salas et al., 2005).

Team communication is the basis for developing other important team behaviors such as coordination, team situation awareness, and team problem solving. Previous research has shown that effective medical teams communicate and share their individual awareness of the situation in order to establish SMMs of the task (Orasanu, 2005). However, too much information is not necessarily synonymous with effective communication and can cause information overload and decrease team performance (Salas et al., 2005). In addition, not all types of communication are effective, and we should look at what teams need to communicate, how they communicate that information, and when the information is needed. In this regard, Orasanu (1990) found that the content of communication between high and low performing teams vary significantly. While effective teams communicate explicitly about problems, plans and situational changes, less effective teams tend to infer this information after team members' actions, which increases mental workload and leads to breakdowns in coordination (Orasanu, 1990).

Effective team communication is not the natural result of bringing people together (Burke et al., 2004); instead, such skills need to be learned and practiced (Baker, Gustafson, Beaubien, Salas, & Barach, 2005). How teams implement communication may change as a consequence of team maturity. Espinosa et al. (2004) suggest that teams that have reached a certain level of maturity are able to coordinate in an implicit way with a minimum of verbal communication. In addition, teams, which team members have SMMs, are able to code or abbreviate communications (e.g. using professional terminology) allowing them to optimize the process of communication and pass large amounts of communications quickly (Klein et al., 2005).

In the medical field, 30% of the communication failures occur during procedurally relevant exchanges among team members resulting in inefficiency, team tension, resource waste, delay, patient inconvenience, and procedural error (Lingard et al., 2004). The use of checklists, formal procedures of communication respecting a pre-established hierarchy, and preoperative briefings are options that medical teams have adopted from other safety risk industries, such as aircraft and military (Leonard, Graham, & Bonacum, 2004). Medical communities often use acronyms that help them to structure communication.

For instance, the SBAR (Situation, Background, Assessment, and Recommendations) is an acronym used to improve communication and to develop SMMs more effectively (Haig, Sutton, & Whittington, 2006; Hunt, Mininni, & DeVita, 2008; Leonard et al., 2004). The SBAR acronym encourages people to communicate the state of the Situation (e.g. what is happening at the present time), explain the Background or circumstances that led up to the situation, Assess the problem (e.g. establish what the problem is), and Recommendation to correct the problem (Haig et al., 2006). Other algorithms, such as the AMPLE (Allergies, Medications, Past medical history, Last meal/latest labs, and Event) help teams to collect critical patient data and to organize the treatment procedures (Hunt et al., 2008).

Although research has shown that most of the communication failures come from internal factors associated to the team interaction, external factors such as noisy environments can also bias communication systems (Salas et al., 2005). Salas and colleagues suggest that both internal and external factors should be explored looking at communication issues. McIntyre & Salas (1995) defined three sequences of behaviors that enhance effective closed-loop communication:

1. The sender initiates the message

2. The receiver accepts the message and provides feedback to indicate that the message has been received.
3. The sender double-checks to ensure that the intended message was received

These behaviors occur pretty much like a two-way radio communication, in which someone transmits and another person acknowledges that the message has been received. The break in this process may lead to ineffective team communication where people may transmit information, but others may not receive, analyze and integrate the information. In such cases the leader must integrate the information and function pretty much as central control tower.

Summary. This section has described the theoretical features of team coordination from two different but complementary perspectives, namely the cognitive and motivational approach. The cognitive approach built on the understanding of how team members use, distribute and share information at different times throughout the task. While the motivational one, emphasizes how team members develop common beliefs about how well they perform together. This section has also shown how the "Big five of Teamwork" framework integrates aspects of the two approaches to explain the coordinating mechanisms that underlie effective team coordination and implementation of other team processes (e.g. leadership, backup behaviors, etc.). This framework highlights the fact that effective team coordination is achieved through the implementation of SMMs, closed loop communication, and mutual trust attitudes (Salas et al., 2005). SMMs help team members organize and mentally recognize their own and other team members' roles in providing information. SMMs are key to implementing implicit and explicit coordination. Closed loop communication is presented as the mechanism for implementing effective communication characterized by the transmission of the main findings or results of each individual's work in order to promote the dynamic development of team situation awareness. Finally, mutual trust is shown as an attitudinal component that guarantees that all team members have the disposition to work in a collaborative fashion in order to achieve a common goal. The next section builds on these concepts in the specific case of action teams.

Coordination in Dynamic Action Teams

Within the team literature, teams have been analyzed from different perspectives and in consequence different taxonomies have arisen either according to the type of team members' interactions and/or life span of the team (e.g. project teams, functional teams, and virtual teams) (Pritchard & Watson, 1992; Scholtes, Joiner, & Streibel, 2003), or according to the requirements and competencies that the task imposes to the team members (Klein, 2000; McGrath, 1984; Salas, Rosen, Burke, Nicholson, & Howse, 2007). From a cognitive perspective, teams can be analyzed according to the actual requirements that the task imposes on team members and the features of the environment in which teams need to take decisions (Klein, 2000). Klein (2000) refers to planning and action teams. The job of planning teams is to produce a plan in which the distribution of knowledge and task are important for implementation of the plan. For example, in the military domain, planning teams are expected to generate air-tasking orders based on both the information that several members bring and the goal of the operation (Klein, 2000). Action teams are created to accomplish a task. These teams may carry out a plan or perform a plan as well (Klein, 2000). For instance, cockpit crews, military command

and control teams, submarine teams, sport teams, and emergency management medical teams are good examples of action teams (Salas, Rosen, Burke, et al., 2007).

Action teams perform highly interdependent tasks that require coordination among specialized roles in which “individual members must not only maintain special technical skills but also the teamwork skills needed to synchronize their own performances with those of their counterparts” (Sundstrom, 1999, p. 21). According to Orasanu and Salas (1993) action teams often have to make decisions in fluid environments characterized by rapidly evolving and ambiguous situations, no optimal answers, information overload, intense time pressure, and severe consequences in cases of error.

Action teams are also referred to as short-term or swift starting teams (Mckinney et al., 2005; Wildman et al., 2011) that consist of evolving interdisciplinary teams composed of “relatively well trained individuals” (Wildman et al., 2011, p. 71), who come together for small periods of time or even for one shot performance (e.g. emergency trauma resuscitation units). Team members in these teams have little or no prior knowledge of one another and are required to perform immediately, often in urgent situations, with short or no time to develop traditional sources of coordination such as strategies or pre-plans (Wildman et al., 2011). In these circumstances, team members are compelled to engage in swift coordination and team processes such as “swift trust”, which means that team members rely on team members’ roles as opposed to knowledge of the individuals (Meyerson et al., 1996).

According to Meyerson and colleagues, swift trust is a form of collective perception that allows people of temporary systems to act quickly in the face of uncertainty. Therefore, team members' roles are standardized, and team expectations are built in terms of tasks and specialties (Meyerson et al., 1996). Mutual trust facilitates the process of information sharing among team members, hence facilitating coordination through communication and decrease of mutual performance monitoring. Along with swift trust, communication has been cited as the main mechanism action teams use to coordinate task inter-dependencies (Ellis, Bell, Ployhart, Hollenbeck, & Ilgen, 2005).

Standardization of procedures is implemented regularly to support swift coordination (Kolbe et al., 2009; Manser et al., 2008; Zala-Mezö et al., 2009). Standards are thought of as strategies to support implicit coordination, in which team members focus their attention on their individual tasks. One could also see standards or routines such as the ABCDE's algorithm (cited elsewhere in this paper) as a guarantee of shared procedural knowledge that is especially useful in crisis situations when actions need to be taken right away.

Zala-Mezo et al. (2009) investigated the influence of standardization and task load on team coordination and communication patterns during anesthesia inductions. They found that anesthesia teams tend to reduce the frequency of explicit coordination, leadership behaviors, and heedful interrelating during high standard phases with low task load (e.g. preparation of patient and transport to OR), while they tend to increase heedful interrelating during phases with moderate standardization and high task load. These results suggest, "that standardization may ease implicit coordination and may serve as a substitute for leadership" (p. 129).

These previous findings are consistent with other studies that have shown that communication patterns change during a crisis situation. For instance, Weick (1990), in his analysis of the Tenerife air disaster that occurred in 1977, found that during crisis situations, crew-members increased implicit communication, changing the patterns not only of communication but also of leadership. While in routine operations communication among crew-members tended to move downward (from leader to subordinate) in crisis situations, the communication moved upward (from subordinate to leader).

Similarly, other authors have argued that within action teams, such as anesthesia teams in which tasks are highly standardized, leadership is divided among team members, as opposed to a hierarchical structure in which leadership is carried out by a senior team member (Künzle et al., 2010). For instance, in anesthesia teams, roles may change during the performance and experienced members (e.g. experienced nurse) may take leadership over inexperienced leaders (e.g. inexperienced resident physician) (Künzle et al., 2010; Künzle et al., 2011). According to Kunzle et al. (2011), anesthesia team members are expected: (1) to actively engage in leadership behaviors that contribute to the understanding of the task and to the process of decision making (e.g. acquisition and transmission of task relevant information, verbalization of a problem and provision of interpretation of it); (2) to actively engage in coordination tasks such as assigning roles or tasks to other team members, offering clear performance strategies, initiating an action without being asked, managing staff and equipment resources.

Furthermore, some other studies have highlighted the fact that leadership in action teams is characterized by short-term leadership functions, which support the strategic direction (e.g. patient treatment) as opposed to long-term leadership functions that support development of long-term strategies (Klein et al., 2006). Since, action teams are characterized as temporary systems with regular turnovers, these teams are likely to need task- and team- generic training, as opposed to task- and team specific training (Cannon-Bowers & Salas, 2001b; Cannon-Bowers et al., 1995; Paris, Salas, & Cannon-Bowers, 2000). According to Cannon-Bowers and colleagues, task and team generic training allow team members to gain a variety of individual teamwork skills to work on multiple teams and tasks. While task-and team specific training allow teams that work together on a specific task to imporve as a team. This type of training is suitable for teams that are stable and work with the same members on the same task. The next section of this paper describes the context of specific medical action teams that perform in a battlefield.

Military Trauma Teams

Military trauma teams often perform in a battlefield where there are three different levels of care, level one to level three. Level one, refers to the primary care that is provided by physician assistants (PA) or physicians, and medical technicians in any secured forward position otherwise called forward operating base (FOB). Whereas, level three refers to a major facility very much like a hospital, where all the appropriate states of care are provided (Canadian Armed Forces, 2009, December 15). For the purpose of this study, only level three of care are studied and therefore only the characteristics of the teams at this level are presented next.

Hospitals at level three of care are fully-equiped medical clinics that have the capacity for providing advanced medical, surgical and trauma care to injured soldiers pertaining to the Navy, Army, or Airforce (Canadian Armed Forces, 2013). These facilities are similar to civilian trauma centers where relevant consultants are available (Tien, Farrell, & Macdonald, 2006). Casualties brought to Level 3 care have already received basic life support at the front line and during transportation in helicopters, which constitutes Level 1 and 2 of care, respectively.

There are some differences between military and civilian trauma care. For instance, the combat injury patterns are rarely seen in civilian practice and are often related to multiple fragment wounds, blast injury to the lung and bowel, avulsive amputations and contaminated balistic wounds (Champion, Bellamy, Roberts, & Leppaniemi, 2003; Hodgetts & Turner, 2006, p. 7) . Medical devices such as tourniquets and topical haemostatic products are specifically developed for these military issues and physicians require this specific knowledge. Unlike civilian trauma units, in military trauma facilities laboratory results can be obtained within seconds or minutes, which minimized the time for diagnosis and interventions (Canadian Armed Forces, 2013). In addition, some variations to generic algorithms used in civilan trauma are implemented. For example, a "C", that stands for contol of catastophic hemorrhage, has been added to the common ABC algorithm.

Military trauma teams are composed of multidisciplinary professionals (e.g., critical care physician, and two intensive care qualified nurses) who are responsible for the initial resuscitation and management of the trauma patient. The objectives of these trauma teams are similar to those of the civilian trauma teams (Driscoll & Skinner, 1990a):

- Identify and correct life threatening injuries
- Resuscitate the patient and stabilize vital signs
- Determine the extent of other injuries and

- Prepare the patient for definitive care, which might involve transporting the patient to a major facility center in the country or aboard

One of the most salient and unique characteristics of these teams is that team members most content with a wide range of ranks ranging from Field Grades Officers (e.g., Majors and higher) at the top of the system all the way down to Medical Technicians and Ancillary staff (i.e., enlisted personnel) (Alonso et al., 2006). Some studies looking at military teams have highlighted the fact that team members' status, rank, or tenure can impede the free flow of necessary feedback (McIntyre & Salas, 1995). Another characteristic of these teams include the constant rotation of team members, which causes a logistic challenge (Alonso et al., 2006). Team members come together for short periods of time, be it an hour, weeks, or a month, (Wildman et al., 2011). As other action teams, these teams have little or no time to develop traditional sources of coordination, such as explicit communication strategies and pre-plans (Wildman et al., 2011).

The nature of the competencies required in military trauma teams can be framed as task-contingent. This means that "team members perform a specific team task [military trauma interventions] but do not work with consistent set of teammates (because of rapid turnover), [so], they must possess team competencies that are specific to the task [and roles] but not dependent on particular teammates" (Cannon-Bowers et al., 1995, p. 363). The following section look at team training for actions teams such as military trauma teams.

Team training for action teams. Several team-training strategies have been developed by industries where coordination is fundamental to ensure safety (e.g. military, aircraft, etc.). Some of these include cross training, team coordination training, team self correction training, team building, assertiveness training, metacognition training, stress exposure training (Burke, et al., 2004). For instance, Crisis resources Management (CRM), a type of coordination training that addresses practice in simulation-based learning environments and teamwork, is a method originally developed to promote aviation safety and to reduce aircraft accidents caused by human error such as failures of interpersonal communications, decision-making, and leadership (Cooper, White, & Lauber, 1980).

Lighthall (2008) summarizes eleven core concepts often targeted in CRM training. These include maintenance of situation awareness, prevention of fixation errors including engagement in tasks that have little relationship to the primary problem, distribution of workload according to specific professional expertise and requests in a crisis, ability to recognize the need for calling for help (e.g. knowledge of different types of help and effectiveness of the help at different times in performance), effective leadership including the ability to identify and communicate priorities, effective communication (e.g. closed loop communication), ability to allocate attention wisely (e.g. understanding the patient’s problem vs.. monitoring team activities), anticipation and planning (e.g. consideration of reassessment and backup plans), use of all sources of information and cross-check data streams (e.g. checking of monitors data that may elicit actions), and finally, use of cognitive aids to assure completeness (e.g. use of treatment algorithms).

In order to better understand coordination and to better guide the development of team training, it is helpful to identify the sources of coordination breakdowns. The next section addresses coordination breakdowns issues.

Coordination Breakdowns

Several authors addressing issues in coordination breakdowns, in different action teams (e.g. aviation, medical, and military teams), have looked at crisis or potential crisis situations as the main causes of changes in communication and, therefore, as the main sources for potential breakdowns in team coordination (Klein et al., 2005; Klein et al., 2006; Mckinney et al., 2005; Weick, 1990; Wilson et al., 2007; Xiao & LOTAS, 2001). Crisis situations, characterized by high workload, rapid exchange of information, and changes in communication and leadership patterns are likely to cause breakdowns of common ground and lost of SMMs (Klein, 2008; Klein et al., 2005; Klein et al., 2000; Weick, 1990; Wilson et al., 2007). For instance, people working on their individual assignments can get confused over who knows what, or loose perception of the general picture of what is happening around them or with other team members and the task in general, otherwise known as lost of situation awareness (Cooke et al., 2001; Kaber & Endsley, 1998; Wickens, 2008).

In crisis situations team members are compelled to sustain, update, monitor and repair situation awareness and SMMs. Klein and colleagues (2005) found six different actions that teams often implement before and during performance in order to support common ground/SMMs (p.10):

1. Structuring the preparations in order to establish initial calibration of content, and to establish routines for use during execution.

2. Sustaining common ground by inserting various clarifications and reminders, whether just to be sure of something or to give team members a chance to challenge assumptions.
3. Updating others about changes that occurred outside their view or when they were otherwise engaged.
4. Monitoring the other team members to gauge whether common ground is seriously compromised and is breaking down.
5. Detecting anomalies signaling a potential loss of common ground.
6. Repairing the loss of common ground.

Failures to update and monitor team members are the most frequently cited sources of lost of common ground. Wilson et al. (2007) have argued that breakdowns in coordination can be affected by a number of factors including individual, team, organizational, task, and technological/environmental factors. In spite of this, these authors recognize that human errors are the ones that contribute the most to accidents. For instance, medical errors are a well-recognized and important phenomenon in healthcare. Error can cause significant adverse effects to the health of individuals and can be life threatening. Unlike what one might think, these errors are usually not due to lack of knowledge or lack of technical skills of health care professionals. Most errors are rather due to difficulties in teamwork, more specifically lack of communication and coordination among team members (Reader et al., 2007).

Although most of the studies addressing the contribution of human error to accidents have attempted to address “what” are the consequences of coordination breakdowns, few studies have specified “why” coordination breakdowns occurs. Xiao and colleagues (2001) however, have established three type of situations in which coordination breakdowns occur in trauma medical teams: (1) when there is pressure to seek alternative solutions, usually triggered by unexpected patient responses that prevent the implementation of routine procedures; (2) when an unexpected, non-routine procedure is initiated by a team member, which could not be anticipated neither supported by other team members; (3) when a non routine event disturbed the routine distribution of responsibilities, usually observed when the patient condition is too unstable, and the team needs to move from a diagnostic to an action mode, which requires adjustment of responsibilities accordingly to the new situation. In the last situation, team members are expected to abandon the process of obtaining diagnostic cues and start intervening in the patient or acting their roles right away (e.g. applying IVs, start oxygen, etc.).

Compatible with Xiao and colleagues results, Klein et al. (2005) found that the main cause for coordination breakdowns is the continuous deterioration of the common ground-defined in terms of the shared knowledge that supports interdependent actions. According to these authors, teams tend to loose common ground for the following reasons: (1) the team members may lack experience in working together, (2) they may have access to different data; (3) they may not have clear rational for the directives presented by the leader; (4) they may be ignorant of different demands (e.g. some may have higher workload and competing priorities); (5) they may experience an unexpected loss of communication or lack the skill at repairing this disruption; (6) they may fail to monitor confirmation of messages and get confused over who knows what.

Similarly, Klein (2006) found that often teams fail to recognize and interpret initial cues. This author concluded this after analyzing 24 incidents, including those happened in neonatal intensive care unit, in military decision making, and in recognized events like those occurred with Apollo 13 and the attack of Pearl Harbor during the second world war. He also found that the barriers related to problem detection in teams can be grouped in four categories including problems to implement: (1) detection of initial alerts, usually missed by teams under pressure circumstances; (2) cue recognition often associated with disconnected communication between the people who have critical information and the people who understand the significance of that information; (3) sense-making associated with the difficulty to recognize that a common understanding has been lost and that problem indicators may be repressed; (4) and the lack of implementation of actions related to challenges in the credibility of some team members.

The following section addresses the different forms to assess team coordination.

The Assessment of Team Coordination

As coordination is defined in terms of the management of dependencies among sub-tasks, resources and people, some authors have argued that coordination can be measured as a process and/or as an outcome (Espinosa et al., 2004). According to Espinosa and colleagues, when coordination is seen as a process, the management of inter-dependencies among team members during performance is the focus of the analysis, while coordination as an outcome looks at how effective the team was in managing the dependencies (e.g. were the team goals met? Were the team goals met according to the established procedures?). In spite of this, some other authors have argued that "good coordination is nearly invisible, and we sometimes notice coordination most clearly when it is lacking", or when a negative outcome comes out (Malone & Crowston, 1990, p. 357). For instance, in the case of medical teams, bad patient outcomes are frequently associated to low team performance due to breakdowns in coordination.

The most common methods for analyzing coordination include coding of verbal communication (e.g utterance), questionnaires (e.g. self report measures), and behavioral observations (e.g. actions). Manser, Harrison, Gaba and Howard (2009), in assessing anesthesia and emergency crews, looked at coordination as a united process in which implicit and explicit coordination are not separated but rather analyzed overall into a united category of coordination. These authors analyzed four categories that described the coordination process in general: information management; task management; coordination via the work environment; meta-coordination defined by the authors as "coordinated activities that team members use to coordinate about their coordination process" (p. 1157).

Manser and colleagues analyzed the four categories of coordination throughout four phases of the surgical procedure. The amount of time spent on coordination activities during each of the four phases and what member of the team executed the coordination activity was also analyzed. These authors found that high performance teams use different patterns of coordination according to the phase of the procedure. For example, surgical teams use less task management, more situation assessment and higher levels of information transfer during the first five minutes after the declaration of the crisis. These findings support Espinosa and colleagues (2004) idea that team tasks, especially those performed by action teams, are characterized by different levels of interdependence and different patterns of coordination over time. Similarly to Manser and colleagues, some other authors have discriminated two categories of coordination for analyzing the performance of anesthesia teams (Kolbe et al., 2009). These categories correspond to information exchange and coordination of actions.

Often team coordination taxonomies are developed based on video data analysis, for which researchers use video annotation and event marking to develop codes. In developing these codes, researchers have looked at the implementation of coordination over time with time-line analysis. For instance, Manser et al. (2008) analyzed the amount of time spent on coordination activities during each of the four phases of cardiac surgery, in order to find patterns between high effective and low effective teams.

Researchers agree in that in order to study coordination, dependencies of the team task have to be established for understanding what are the coordination strategies required throughout the task and how teams can implement them effectively (Espinosa et al., 2004; Katz-Navon & Erez, 2005). Cognitive Team Task Analysis (CTTA) is a recommended approach to conduct studies that address the understanding of team cognition, and also the design of team training, and assessment of team performance (Lorenzet, Eddy, & Klein, 2003). CTTA includes the assessment of individual cognition and team cognition required in team-based tasks (Arthur, Edwards, Bell, Villado, & Bennett, 2005; Baker, Salas, & Cannon-Bowers, 1998).

More specifically, two sets of skills are defined in CTTA namely individual team member's skills also called taskwork, and teamwork skills (Glickman et al., 1987). As has been said previously in this paper, taskwork consist of behaviors that are performed by individual team members and are critical to the execution of individual team member functions. Whereas teamwork consist of behaviors that are related to team member interaction and are necessary to establish coordination among individual team members in order to achieve team goals. Therefore, the final goal of CTTA is to understand the interdependency between sub-task, the nature of the interaction and coordination between team members across the complete task, rather than just individual and separated sub-tasks (Arthur et al., 2005; Paris et al., 2000).

Despite numerous publications, including books, articles and conference, dedicated to the study and characterization of teams in different domains, there is a general agreement that CTTA is a major area for new developments (Scharaagen & Chipman, 2000). In this regard, Baker et al. (1998) noted that there is still a lack in the definition of methodologies to analyze “what teams do”. However, more recently some researchers have started to use technologies that allow them to analyze what teams do in a more effective and faster way. Some software tools used by researchers include NVivo, MacSHAPA (see Mackenzie, Xiao, & Horst, 2004) and INTERACT. These software allow marking and coding of events without the need of transcribing the communication, which is a time consuming activity. More recently, software such as studio code or the Palm- or Newton-based PDA (personal digital assistant) are used for both reviewing videotapes and doing real-time observation and coding (Xiao & LOTAS, 2001).

CHAPTER 3

METHODOLOGY

This study is a continuation of a larger study conducted by the researcher (McGill IRB File #: 20-0609). Past studies looked at team effectiveness and the team's learning trajectories in simulation based learning environments (Cruz-Panesso, 2011). The present study sought to characterize and examine the cognitive demands of team coordination as teams solved team-based simulations. Five simulations performed by six military trauma teams were examined. Raw data (e.g., video records and instructors' assessment) from the five simulations were first checked for missing values, validity, and consistency and inter-rater reliability. There was no video record of team 4 in simulation 4 and therefore data from this team was removed for this specific simulation. Additionally, data were organized and recoded with the purpose of depicting objective and subjective measures of team performance. A mixed-design was used in this study and consisted of qualitative (e.g. video analysis) and quantitative data (e.g. questionnaires). Data analysis was anchored around a team Cognitive Task Analysis (CTA) method, which consisted of a family of observations and interviews. Team CTA was used to systematically understand and characterize the cognitive demands of coordination in trauma teams in terms of the decision-making, planning, strategies and mental model processes (Crandall, Klein, & Hoffman, 2006). The team CTA was based upon the following specific data sources:

- Three interviews with subject matter experts
- Seven online videos and interviews with military teams performing in the field
- Researcher's notes from the debriefing sessions with participants and experts after each simulation

Results from the team CTA were integrated into a cognitive model of military trauma team interventions. Quantitative data in the form of objective measures (e.g., number of treatments done by team during the simulation, etc.) and subjective measures (e.g. raters evaluations) were used to derive an overall indicator of team performance for each team across the five simulations. Quantitative data analyses were then used to screen for teams that consistently have a higher/lower performance on objective and subjective measures. Video records of the simulations and the teams chosen were then analyzed qualitatively following a video analysis method with the purpose of analyzing the coordination activities along the different phases of the task.

In this section, I provide detailed information on the participants, simulator scenarios, measures, and data analysis procedures.

Participants

Six military trauma teams that performed five simulations were selected as a convenient sample to engage in this research. These teams were involved in an intensive trauma team course (ITTC) offered by Military Forces-Health Services. The ITTC constituted casualty care training for military physicians and nurses who were going to be deployed in a battlefield. Oral and written information was given to participants during the introduction section of the course. Participation in the study was voluntary and only teams in which all team members agreed to participate were taken into account. Participants were informed that their decision to engage or refuse to participate in the study would not affect the quality of their training, which was also guaranteed by keeping their names anonymous to the set of instructors that participated in the training.

Team Composition

The ITTC consisted of different training modules that included lectures, surgical skills training and team practice in simulation-based team scenarios. For the purpose of this study, only the teams formed to perform the simulation sessions were taken into account.. Simulations 1 to 5 challenged teams to manage one injured patient at the time, whereas simulation 6 to 7 involved the management of two patients. The management of two patients requires more team members and a set of complementary skills of the leader and team members. For instance, it requires the leader's ability to perform a quick and strategic evaluation of the patients' injuries, otherwise known as triage, divide up the team and assign a temporary leader for the second patient. These additional abilities may affect team's coordination behaviors and may require a different approach in which coordination between two teams is considered. Considering the scope of this research records and data from teams that performed simulation six and seven were retained for future studies.

The instructors leading the training assigned participants to temporary teams, according to their specialties. For simulations 1-3, participants were assigned to three 3-person teams and worked together for simulations 1-3 (see Figure 1). New teams were then formed for simulation 4-5. All teams performed one simulation per day, starting on day one of the course.

Teams were composed of three-members (on average): A critical care physician and two nurses who performed different roles (leader, airway, and intravenous). Table 3 summarizes the number of participants per team and their specialties. Physicians generally played the role of the leader, but in some exceptional cases, cross training occurred, where nurses would lead as well. Cross training of trauma team staff to serve in each other's roles help team members to improve team communication by facilitating development of shared expectations of each other's roles and decision processes, which in consequence provides flexibility and enhanced team performance (Barach & Weinger, 2006).

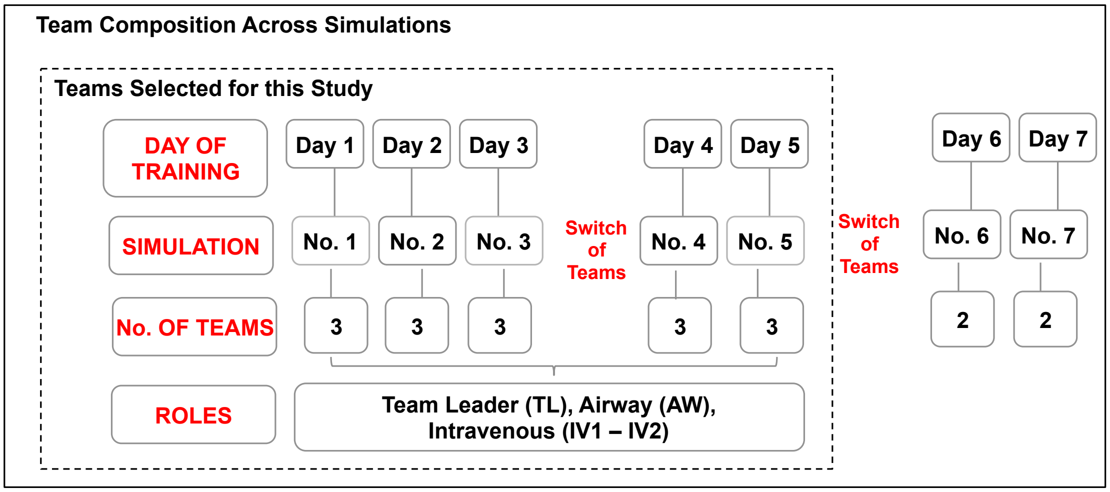


*Figure 1***.** Team composition across simulations and the teams selected for the present study.

Table 3
Data Summarizing the Number of Participants Per Team, Per Simulation, and Their Specialties

Week	Simulation No.	Team No.	Team Members' specialty
One	1, 2, and 3	1 (n = 4)	3 Nurses 1 Physician
		2 (n = 4)	3 Nurses 1 Physician
		3 (n = 3)	2 Nurses 1 Physician Assistant
Two	4 and 5	4 (n = 4)	3 Nurses 1 Physician
		5 (n = 4)	4 Nurses
		6 (n = 3)	2 Nurses 1 Physician

The teams participating in this study were trained to perform level 3 care, where the simulation consisted of a mobile battlefield hospital unit that provides temporal care to injured soldiers or civilians injured during war.

Team-Based Simulation Scenarios

Teams selected for the present study performed one simulation per day for a total of five team-based simulations (see Figure 1). The simulations confronted teams with case-based scenarios from real-world situations documented by military physicians who had previous experience in the battlefield. All five-simulator scenarios were different and were designed on the basis of a stepwise approach of increasing complexity. All scenarios were built to trigger team coordination throughout the rapid delegation and recognition of roles, management of the Airway, Breathing, Circulation, Disability, and Exposure (ABCDE), and rapid identification and treatment of war-related injuries, otherwise known as “mechanism of injury” (see Table 4).

Simulation-scenarios were run in a high fidelity room that recreated a role 3-trauma hospital (see Figure 2). In battlefield circumstances, patients who are brought to role 3 hospitals have already received basic life support at the front line and during transportation in helicopters. For the purpose of this study, all teams performing the simulations received their patients from a paramedic that had already administered some life support to a patient during transportation in helicopters.

The high-fidelity simulations incorporated human patient mannequins (HPM) (Beyea & Kobokovich, 2004) that were programmed to produce vital signs, to respond to medical interventions, and to interact with clinicians like a regular patient (see Figure 2).

Table 4.

Simulation Scenarios: Description of each Case, Medical Report, Mechanims of Injury, Triggers and Team Roles

Sim.	Description	Medical Report	Mechanism of Injury	Trigger	Treatment/ Actions(s)	Team Roles
1	Patrol caught in land mine. Two soldiers dead. One found 10 meters from explosion. Brought directly to FAB	Conscious patient, BP 110/60, RR 30, O2 started, IV right decubital, collar in place	Chest trauma/closed head injury	Increasing respiratory difficulty until chest tube & intubation	1. Bag/mask 2. IV fluids 3. Chest tube 4. Intubation	- ABCE - Recognition of laboured breathing →Requirement for chest tube - Delegate work to airway while chest tube inserted
2	37-year-old Afghan police officer in back of pick-up, which passes over a land mine. Vehicle is projected in the air. Police officer lands on lower extremities	Patient brought in by stretcher, conscious, C/O pain left leg wrapped, blood, gross deformities, BP 90/40, RR 30, P 115	Bilateral lower limb injuries/shock	Patient will continue to deteriorate until both tourniquets are applied	1. Additional IV, 2. Blood and products 3. Intubation with in-line traction 4. Quick extremity inspection 5. Reapplication of tourniquets 6. 2nd assessment (other injuries?) 7. Release right tourniquet Fast CXR	- Quick A, B, C, E assessment - Collar, IV's oxygen, - Recognize bleeding from limbs 7& application of bilateral tourniquets
3	Platoon attacked by suicide bomber and there are multiple casualties. The med techs have transported the most urgent cases in a scoop and run fashion	Patient brought in by stretcher, faint pressure detected on field, subsequently lost. Pulse of 130, RR 30, no intravenous, no oxygen, clearly has difficulty breathing, there are wounds over the left abdomen and chest	ABD/Thoracic trauma – Agonal injury	Left hemothorax with persistent bleeding and right pneumothorax. Liver and spleen injury. Bleeding from thigh wound. Ongoing bleeding from thorax and abdomen	1. Bag mask 2. Intubation 3. Large bore/IV/Fluids 4. Chest tube 5. Secondary Survey 6. Rapid infuser 7. Requirement for DPL – call surgery	Extremely rapid assessment and treatment; roles must be defined quickly with leadership

Table 4. (continued)

Sim.	Description	Medical Report	Mechanism of Injury	Trigger	Treatment/ Actions(s)	Team Roles
4	Patient has a missed L chest injury from exit wound which is bleeding. The left shoulder area is packed with op site over it. There is a bandage abdominal entry site in upper left quadrant and thigh has tourniquet in place and no pulse in right leg. The IV in righ arm is out.	Patient brought in by stretcher, initial resuscitation and treatment at Role I. Multiple gunshots. Right thigh with tourniquet (2 hours ago). In bound by helicopter 2 hours. BP 90/50, P 100, SAT 92%, RR 24, On O2 with IV in right arm and decreased consciousness	Multiple penetrating trauma abdomen/chest/ extremities	Left hemothorax with persistent bleeding. Patient will deteriorate until chest tube is applied	1. Right arm IV 2. IV fluids/ blood products 3. Bag/mask 4. 2nd survey identification of chest injury 5. Chest tube intubation 6. Consult Ortho/surgeon	- Extremely rapid assessment of ABCD and treatment - Roles must be defined quickly with leadership
5	There has been an explosion. The sentry has been trapped in a vehicle for at least 5 minutes. There is a distracter. Fellow combatant comes in with patient. He is silent and then collapses from exhaustion as first patient is being resuscitated. He has no injuries.	Patient is unconscious, BP 90/50, Respiratory rate 120, RR 26. Paramedics has started and IV and oxygen	Blast/ burn injury – Pelvic trauma	Burns over the right and left arms as well as the chest covering about 40% of the patient's body. There is blood at the meatus	1. Cricothyrotomy for airway 2. Larger IV 3. Rapid fluid resuscitation 4. Treat pelvis fracture with pelvis stabilization device (TPOD)	- Recognition of the need of a cricothyrotomy. - Assessment and appropriate RX of distracter. Distribution of workload

The patient (played by a HPM) was programmed to deteriorate until the main life threatening injury was identified and treated by the team adequately according to decision trees designed for each simulation (examples of decision trees are provided later under the measure section).

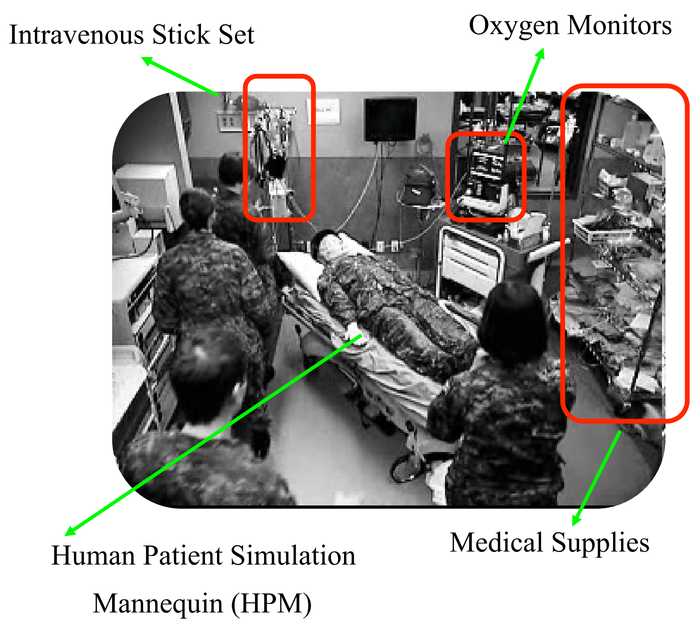


Figure 2. Simulator scenario that recreated level-3 of care in a battlefield with a human patient simulator mannequin.

All simulations were video-recorded with a special video system hanging from the ceiling that captured a panoramic view of the room, in which all team members were visible, as well as the vital signs of the patient (e.g., blood pressure). Information recorded from different angles of the room was integrated into one screen shot, thus allowing the researcher an easy review of the team members' actions and the patient's outcomes.

Measures

Demographic Questionnaire

A demographic questionnaire was used to gather information about participants' ages, professional background, military rank, years of experience in civilian and/or military trauma teams and experience in simulation-based training. There were two physicians (one male and one female), eight nurses and (six females and two males), 1 physician assistant (male) (see Table 5). Team members' ages ranged from 25 to 45+ years with a mean age of 34.58 years. For 27% (*n* = 3) of the participants, English was not their first language, Polish Arabic and French was. 73% (*n* = 8) of the participants had previous experience in civilian trauma teams, but only 36% (*n* = 4) had experience in combat casualty care, indicating that participants were relatively inexperienced in combat casualty care. Participants were familiari with simulation training; 82% (*n* = 9) reported involvement in a variety of simulation training experiences.

Specific demographics for team members of high and low performing teams are shown in Table 5.

Team Performance

Teams' skills were appraised using both objective and subjective measurements. The former involves an impartial measurement that is not bias (e.g. time spent for solving the simulation, etc.), whereas the latter involves measures that were influenced by the instructors' judgment of how well the teams met the objectives of the simulations (DeChurch & Mesmer-Magnus, 2010). Given the obvious differences in the scale of the objective and subjective measures (e.g., minutes, seconds versus 5-point likert scale etc.) algebraic transformations were done for the overall team performance analysis to be

Table 5

Demographics for the Team Members of High and Low Performing Teams

Sim.	**Team performance**	**Team member ID**	**Team member specialty (sex)**	**Military rank**	**Role played in the simulation**	**Months of experience in civilian trauma teams**	**Months of experience in military trauma teams**
1	High (n = 4)	6	Nurse (male)	Captain	Airway	6	0
		7	Physician (male)	Captain	Leader	84	0
		8	Nurse (male)	Lieutenant	Intravenous2	84	12
		9	Nurse (female)	Captain	Intravenous1	36	0
	Low (n = 3)	14	Nurse (female)	Lieutenant	Airway	36	0
		15	Nurse (female)	Lieutenant	Intravenous1	0	0
		16	Physician Assistant	Master Warrant Officer	Leader	0	10
3	High (n = 3)	6	Nurse (male)	Captain	Airway	6	0
		7	Physician (male)	Captain	Leader	84	0
		8	Nurse (male)	Lieutenant	Intravenous1	84	12
	Low (n = 3)	11	Nurse (female)	Captain	Airway	30	12
		12	Nurse (female)	Lieutenant	Intravenous1	0	0
		13	Physician (female)	Major	Leader	0	0
5	High (n = 3)	7	Physician (male)	Captain	Leader	84	0
		11	Nurse (female)	Captain	Airway	30	12
		15	Nurse (female)	Lieutenant	Intravenous1	0	0
	Low (n = 4)	6	Nurse (male)	Captain	Intravenous2	6	0
		9	Nurse (female)	Captain	Intravenous1	36	0
		13	Physician (female)	Major	Leader	0	0
		14	Nurse (female)	Lieutenant	Airway	36	0

possible. Transformations were carried out using IBM SPSS v.21 and applying the visual binning procedure to create categorical variables from a quantitative (scale) variable (Seltman, 2012). This procedure is based on grouping contiguous values of existing variables into a limited number of distinct categories (IBM, 2011). Examples are provided under each section. Objective and subjective measures were converged to calculate an overall team performance score that informed which were the most and the least effective teams per simulation (see data analysis methods on page 70). The variables pertaining to the objective and subjective measures are described next.

Objective Performance Measurements. Objective performance measures included completion and proficiency in solving the simulation. Three variables were taken into account: time spent for solving the simulation, adequate number of treatments and triggers sent to the team when the things were not going in the right direction.

Time spent for solving the simulation. This variable was computed from the moment the patient was brought to the operating room (OR) to the moment the team stopped treating the patient. Participants stopped either because the patient was stabilized and main injuries treated or because the instructors told them that the time for the simulation was over (10 minutes per simulation in average). Time durations were then transformed into a 5-point likert scale (where 5 is the highest score and indicates that the team performed the simulation in the shortest amount of time) using the visual binning method in SPSS. Five cut-point intervals were generated based on the lowest and highest time duration for each simulation. For example, in simulation one the time duration for the three teams varied between 10:10 (minutes: seconds) and 15:26. For this example, the five cut-points intervals were defined as follows:

5: < = 10:00

4: 10:01 – 11:32

3: 11:33 – 12:63

2: 12:64 – 13.95

1: 13.96 +

In this example, the team that did the simulation in 15min and 26sec (15:26) got a rate of 1 on the 5-point likert scale.

Adequate number of treatments. This variable was computed based on algorithmic decision trees designed by the instructors for each simulation (see an example on Figure 3). Decision trees for simulation one and three can be found on Appendix A and B). Video records of the simulations were tagged each time an adequate treatment was observed and the number of treatments was totalled for each team. For this purpose, a video sharing service called Youtube (Youtube, 2013) was used to create time-based annotation. This tool has recently been incorporated into other research studies (Gomes & da Graca Campos Pimentel, 2011; Guimarães, Cesar, & Bulterman, 2010; Winkler, Ide, & Herczeg, 2011).

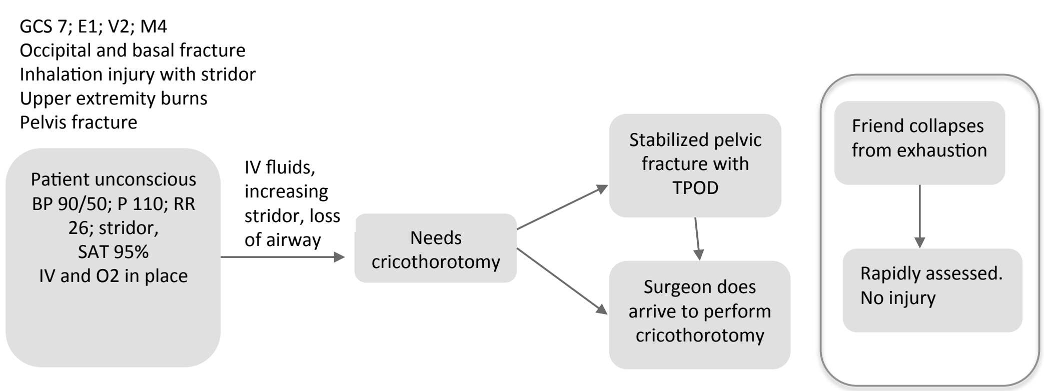


Figure 3. Example of algorithmic decision trees for simulation 5.

The total number of treatments conducted by each team during each simulation was transformed into a 5-point likert scale (where 5 is the highest score) using the visual binning method in SPSS. Five cut-point intervals were generated based on the lowest and highest number of treatments done by the teams per simulation. For example, in simulation one the number of treatments for the three teams varied between four and two (see Table 6). For this example, the five cut-points intervals were defined as follows:

5: 3.51+

4: 3.01 – 3.50

3: 2.51 – 3.00

2: 2.01 – 2.50

1: < = 2

In the example above, the team that conducted four treatments got a rate of 5, while the team that conducted two treatments got a rate of 1 in a 5-point likert scale.

Triggers. A trigger consisted of an event or action that is intended to prompt or to make participants aware that something is going wrong, either they missed a diagnosis or they are fixated in one part of the process. For the purpose of this study, triggers came from different sources such as patient's vital signs (e.g., monitors), information given by the paramedic during the handover (which all teams received) and/or a senior Doctor (Dr.) sent in without being called when fixation errors occurred. Although, the simulations integrated different sources of triggers, the only trigger considered in this study was the doctor, who was sent to help the team. Patient's vital signs were excluded given the fact that not all teams received feedback from the vital signs monitors on a regular basis due to technical failures with the computers. A doctor was sent in after the technician who manages the computerized mannequin and the vital sign monitors has gone through the protocol of the case (eg., decision trees designed before hand by experts). The senior doctor was sent in only once per simulation, thus triggers were computed in terms of presence/absence of the Dr. If the trigger was present a rate of 1 was assigned, which corresponded to a 5 on the likert-scale, and if it was absent then a rate of zero was assigned, which corresponded to a 1 on the likert-scale.

Subjective Performance Measures. Subjective performance measures were based on a team performance questionnaire developed by the researcher. The pool of instructors observed team's performance thorugh a one-way mirror, and completed the team performance questionnaire right away before the debriefing session. The pool of instructors consisted of three-trained civilians and eight military physicians. All instructors had previous experience in delivering intensive trauma team courses and/or experience in battlefield medical care. Instructor bias was minimized given that civilian instructors rotated and military instructors did not work with the same teams more than one simulation.

The team performance questionnaire consisted of four parts (see Appendix C). The first part was an adapted version of the Anesthesia Crisis Resources Management (CRM) criteria developed by Gaba (Gaba, Howard, Fish, Smith, & Sowb, 2001). Gaba's criteria assess five CRM skills, namely awareness and utilization of all available resources, anticipation/planning, teamwork, routine re-evaluation of the situation, and communication. The raters assessed team CRM using a 5-point likert scale (5 = strongly agree, 1 = strongly disagree) (see Appendix A). Some examples of the criteria used in this section are: "the team mobilized all available resources" and "the team distributed workload appropriately. The second part of the questionnaire assessed overall team performance and required instructors to provide an overall appraisal of each team's performance. This part consisted of a 5-point response scale (5 = very good performance, 1 = poor performance). Computations for the first and the second section are described in the section immediately following.

The third part consisted of a qualitative assessment in which raters were asked to list three strengths and weaknesses observed during team performance. Finally, the fourth section inquired about individual team members' performance using a five-point likert scale (5 = very good performance, 1 = poor performance). Data from individual performance was not properly collected and therefore, incomplete information was obtained. This section was excluded.

Crisis resources management (CRM) Evaluation. This variable was computed as the instructors' average responses to ten statements that assessed team performance based on crises resources management criteria (Gaba et al., 2001). These statements were rated on a 1-5 point Likert scale where five was a better score. The CRM statements were found to be highly reliable (Cronbach-α = 0.91). Inter-rater reliability was estimated using intra-class correlation coefficients (ICC). ICC measures the percentage of variance in the scores among raters. ICC ranges from 0 (no agreement) to 1 (perfect agreement). Low ICC values (near 0) indicate that CRM scores vary greatly among raters. High ICC values (near 1) indicate there is minimal variance in CRM scores among raters. Overall inter-rater reliability for CRM was moderate (mean ICC = 0.52).

Global Team Performance (GTP). This variable was derived from the aggregation of the overall team performance score given by each instructor to each team. Overall SD for Global Team Performance (GTP) was (mean SD = 0.45).

Shared mental models. A network analysis approach (Espinosa & Clark, 2012) was used to represent team members' shared knowledge in four domains namely, leadership, mutual trust, situation awareness and explicit communication. Shared mental models in the four domains were computed from the team questionnaire (see Appendix D), which was completed by each individual team member. This questionnaire consisted of 26 teamwork statements that were adapted from previous studies (Glickman et al., 1987), and from behavioral markers of teamwork included in a model called "the big five of teamwork" (Salas et al., 2005). The 26 statements assessed team members' perceptions, about teamwork in different domains including those mentioned above, using a 5-point likert scale (5 = strongly agree, 1 = strongly disagree). The number of questions assessing each domain varied as follows: Four questions assessed leadership (question 1, 2, 3 and 4), two questions assessed mutual trust (question 9 and 16), two questions assessed situation awareness (question 25 and 26) and finally two questions assessed explicit communication (question 19 and 22). Some examples of the statements in this section are: Leadership: "In this simulation the leader of my team clarified team members roles"; mutual trust: "members of my team knew how to perform their required tasks and roles", situation awareness: "members of my team identified cues that a change had occurred, and developed a new plan to deal with changes and"; and explicit communication: "communications were clear among members of my team".

Team members' scores to questions about leadership, mutual trust, situation awareness and explicit communication were averaged and then integrated into a knowledge matrix that contains one row for each of the team members and one column for each of the shared knowledge domains. The average knowledge similarity for the four domains is obtained from the average value across all dyads in the team (Espinosa, 2001).

In this study we utilized network analysis methods to measure shared mental. models (Espinosa & Clark, 2012; Espinosa, 2001; Espinosa et al., 2002). For this purpose, adjacency matrices for each domain were constructed using knowledge similarity values for each dyad. These matrices recorded information about the links between each pair of team members, for example the amount of knowledge of the least knowledgeable member in the dyad. The rows recorded the source of the links and the columns the domain. Visual representations of the sociomatrices (also known as sociograms) were depicted for the four domains for each team in each simulation. Nodes represent individual team members and the links between nodes are knowledge relationship between members. In this approach, "Knowledge is viewed as a network of content nodes, one for each member, with every pair of nodes connected with links describing their respective knowledge relationship" (Espinosa & Clark, 2012, p. 295). The links in the sociograms were drawn using a cutoff value of 2.5 ($\geq$ 2.5 line and $\leq$ 2.5 no line), which is the midpoint of the 1 to 5 rating scale used in the team questionnaire, where 1 was the minimum and 5 was the maximum possible rate. An example with data from this study illustrates how the computations were done (see Figure 4).

1

Team members' rates to questions in each domain are averaged and then integrated into a knowledge matrix in step 2

Team Members' Rates to Questions in Each Domain

Domain	Questions	L	AW	IV1	IV2
Leadership	Q1	4	4	4	4
	Q2	5	5	4	4
	Q3	4	4	4	4
	Q4	4	4	4	4
	Average	4.25	4.25	4	4
Mutual Trust	Q9	3	4	4	4
	Q16	4	4	4	4
	Average	3.5	4.0	4.0	4
Situation Awareness	Q25	4.0	4.0	4.0	4
	Q26	3.0	3.0	4.0	4
	Average	3.5	3.7	4.0	4
Explicit communication	Q19	4	4	4	4
	Q22	3	4	4	4
	Average	3.5	4	4	4

Knowledge Matrix

Team Member	Leadership	Mutual Trust	Situation Awareness	Explicit communication
L	4.25	3.5	3.5	3.5
AW	4.25	4	3.7	4
IV1	4	4	4	4
IV2	4	4	4	4

2

To construct the adjacency matrix for leadership (step 3), we compare the leader with each of the team members (dyads), and then we write down the number that corresponds to the least knowledgeable member in the dyad

3

Adjacency Matrices for each Domain

Knowledge similarity: Leadership

Team Member	L	AW	IV1	IV2
L		4.25	4	4
AW	4.25		4	4
IV1	4	4		4
IV2	4	4	4	

Knowledge similarity: Mutual trust

Team Member	L	AW	IV1	IV2
L		3.5	3.5	3.5
AW	3.5		4	4
IV1	3.5	4		4
IV2	3.5	4	4	

Knowledge similarity: Situation Awareness

Team Member	L	AW	IV1	IV2
L		3.5	3.5	3.5
AW	3.5		3.7	3.7
IV1	3.5	3.7		4
IV2	3.5	3.7	4	

Knowledge similarity: Explicit communication

Team Member	L	AW	IV1	IV2
L		3.5	3.5	3.5
AW	3.5		4	4
IV1	3.5	4		4
IV2	3.5	4	4	

4

The average knowledge similarity for the four domains is obtained from the average value across all dyads in the team

e.g. 4.25 + 3.5 + 3.5 + 3.5 = 14.5 ÷ 4 = **3.69**

Average knowledge similarity: Four domains

Mbr	L	AW	IV1	IV2
L		3.69	3.63	3.63
AW	3.69		3.93	3.93
IV1	3.63	3.93		4
IV2	3.63	3.93	4	

5

Visual representation: Shared mental models
Cutoff value: (≥ 2.5 line and ≤ 2.5 no line
Dash line indicates the the link with the highest rate

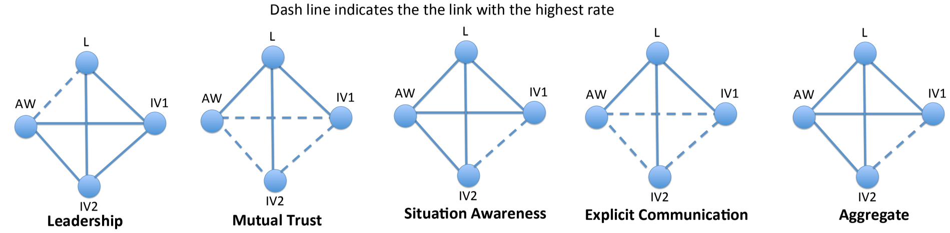


Figure 4. An example illustrating the matrices and sociograms of the network analysis.

Procedure

Simulations

All simulation sessions were divided into three phases including: (1) introduction to the simulation environment, (2) performance of the actual team-based simulation and (3) a debriefing session. The first phase was intended to get participants familiarized with the elements of the simulation room (e.g. visually locate where the medical resources such as blood, drugs, and IVs were, check the equipment of resuscitation and monitors), and to allow participants to distribute roles to be played during the scenario, namely leadership, intravenous, and airway.

Completion of Questionnaires.

After each simulation, team members and instructors individually completed the team and the team performance questionnaire respectively.

Debriefing

Instructors did follow a predefined structure for debriefing. These sessions were broken down into three parts. In the first part, instructors worked specifically with each team in targeting the coordination breakdowns during the simulation and the possible causes of the problems. In the second part, instructors shared their own experiences with team members in terms of how they handled similar experiences in the battlefield or in clinical environments. In the last part, instructors focus on the medical aspects of the simulations, such as how to manage the main mechanisms of injury and possible treatments.

Data Analysis Methods

Weighting Subjective and Objective Measures

It has been recently suggested by some researchers that subjective measures are more strongly correlated with team cognition and team performance than objective measures (DeChurch & Mesmer-Magnus, 2010). Subjective measures help to capture team behaviors and other variables that are outside the direct control of the team (e.g. failure of the equipment) (DeChurch & Mesmer-Magnus, 2010). However, due to the nature of the task that trauma teams perform, objective measures such as time and precision of the procedures are central for saving the patient's life (Orasanu & Salas, 1993). Consequently we decided to treat subjective and objective measures equally in this study. In order to avoid bias, we weighted objective and subjective measures. Each likert scale was given an identical weight (7.14%) that was expressed as a percentage to allow direct comparison. CRM consisted of 10 different questions that were collapsed to simplify data. Weights for CRM were calculated based on the ten questions and therefore its weight was 71.43% (see Table 6). Nevertheless, we recognize that more work is still required in future studies that could consider the distribution of the weights for the subjective and the objective measures according to the objective of the simulation. Different weights could then influence the identification of the best and the worst performers. However, differences in weighting distribution by simulation is left for future research.

Table 6. *Objective, Subjective and Overall team Performance Meassures*

Sim.	Measures		Data	Likert	Weight %	Total	Data	Likert	Weight %	Total	Data	Likert	Weight %	Total
1	**1. Objective**													
	1.1 Time (Min:Sec)		10:00	5.00	7.14	0.36	10:32	4.00	7.14	0.29	15:26	1.00	7.14	0.07
	1.2 Treatments (4)		4.00	5.00	7.14	0.36	3.00	3.00	7.14	0.21	2.00	1.00	7.14	0.07
	1.3 Triggers		0.00	5.00	7.14	0.36	0.00	5.00	7.14	0.36	1.00	1.00	7.14	0.07
	2. Subjective													
	2.1 CRM	*M*	3.58	3.58	71.43	2.56	3.23	3.23	71.43	2.31	2.77	2.77	71.43	1.98
		ICC	0.26				0.43				0.50			
	2.3 GTP	*M*	4.00	4.00	7.14	0.29	3.33	3.33	7.14	0.24	2.66	2.66	7.14	0.19
		SD	0.00				0.58				0.58			
	3. Overall			4.52	100.00	**3.91**		3.71	100.00	**3.40**		1.69	100.00	**2.38**
2	**1. Objective**													
	1.1 Time (Min:Sec)		13:05	1.00	7.14	0.07	10:00	4.00	7.14	0.29	9:08	5.00	7.14	0.36
	1.2 Treatments (8)		6.00	5.00	7.14	0.36	5.00	3.00	7.14	0.21	4.00	1.00	7.14	0.07
	1.3 Triggers		0.00	5.00	7.14	0.36	0.00	5.00	7.14	0.36	1.00	1.00	7.14	0.07
	2. Subjective													
	2.1 CRM	*M*	3.32	3.32	71.43	2.37	2.24	2.24	71.43	1.60	3.14	3.14	71.43	2.24
		ICC	0.68				0.76				0.53			
	2.2 GTP	*M*	3.40	3.40	7.14	0.24	1.80	1.80	7.14	0.13	3.20	3.20	7.14	0.23
		SD	0.55				0.45				0.84			
	3. Overall			2.54	100.00	**3.40**		2.21	100.00	**2.59**		2.47	100.00	**2.97**

Table 6. (continued)

Sim.	Measures		Team 1 Data	Team 1 Likert	Team 1 Weight %	Team 1 Total	Team 2 Data	Team 2 Likert	Team 2 Weight %	Team 2 Total	Team 3 Data	Team 3 Likert	Team 3 Weight %	Team 3 Total
3	**1.Objective**													
	1.1 Time (Min:Sec)		10:73	2.00	7.14	0.14	10:88	1.00	7.14	0.07	10:30	5.00	7.14	0.36
	1.2 Treatments (7)		5.00	5.00	7.14	0.36	5.00	5.00	7.14	0.36	4.00	1.00	7.14	0.07
	1.3 Triggers		0.00	5.00	7.14	0.36	0.00	5.00	7.14	0.36	1.00	1.00	7.14	0.07
	2. Subjective													
	2.1 CRM	*M*	4.00	4.00	71.43	2.86	3.63	3.63	71.43	2.59	4.10	4.10	71.43	2.93
		ICC	0.26					0.64				0.73		
	2.2 GTP	*M*	4.67	4.67	7.14	0.33	3.66	3.66	7.14	0.26	4.33	4.33	7.14	0.31
		SD	-0.58				0.50				0.50			
	3. Overall			3.13	100.00	**4.05**		2.66	100.00	**3.64**		2.89	100.00	**3.74**

Sim.	Measures		Team 4 Data	Team 4 Likert	Team 4 Weight %	Team 4 Total	Team 5 Data	Team 5 Likert	Team 5 Weight %	Team 5 Total	Team 6 Data	Team 6 Likert	Team 6 Weight %	Team 6 Total
4	**1. Objective**													
	1.1 Time (Min:Sec)		NO- VIDEO				12.47	5.00	7.14	0.36	12.91	1.00	7.14	0.07
	1.2 Treatments (7)						7.00	5.00	7.14	0.36	7.00	5.00	7.14	0.36
	1.3 Triggers						0.00	5.00	7.14	0.36	0.00	5.00	7.14	0.36
	2. Subjective													
	2.1 CRM	*M*					3.97	3.97	71.43	2.84	4.13	4.13	71.43	2.95
		ICC					0.21				0.23			
	2.2 GTP	*M*					3.67	3.67	7.14	0.26	4.00	4.00	7.14	0.29
		SD					0.58				0.00			
	3. Overall							4.53	100.00	**4.17**		3.83	100.00	**4.02**

Table 6. (continued)

Sim.	Measures		Team 4 Data	Team 4 Likert	Team 4 Weight %	Team 4 Total	Team 5 Data	Team 5 Likert	Team 5 Weight %	Team 5 Total	Team 6 Data	Team 6 Likert	Team 6 Weight %	Team 6 Total
5	**1. Subjective**													
	1.1 Time (Min:Sec)		12:75	1.00	7.14	0.07	12.00	3.00	7.14	0.21	11.37	5.00	7.14	0.36
	1.2 Treatments (4)		2.00	1.00	7.14	0.07	4.00	5.00	7.14	0.36	4.00	5.00	7.14	0.36
	1.3 Triggers		1.00	1.00	7.14	0.07	0.00	5.00	7.14	0.36	0.00	5.00	7.14	0.36
	2. Subjective													
	2.1 CRM	*M*	3.38	3.38	71.43	2.41	3.85	3.85	71.43	2.75	4.53	4.53	71.43	3.24
		ICC	0.69				0.45				0.95			
	2.2 GTP	*M*	2.50	2.50	7.14	0.18	3.50	3.50	7.14	0.25	5.00	5.00	7.14	0.36
		SD	0.58				0.58				0.00			
	3. Overall			1.78	100.00	**2.81**		4.07	100.00	**3.93**		4.91	100.00	**4.66**

Note: Sim = simulation; Min = minimun rate given by the instructors; Max = Maximum rate given by the instructors; CRM = Crisis resources management rate; GTP = Global team performance.

Identifying High and Low Performing Teams per Simulation

Performance indicators from the objective and subjective measures were used to identify the high and low performing team per simulation. Several steps were carried out. First, data were screened to identify the highest and the lowest score in each measure (see Table 6). We found that not all the teams had consistently high or low scores in objective and subjective measures. Only the simulations and the teams in which objective and subjective measures were consistently high or low were retained for further qualitative analyses namely, simulation one (team 1 and 3), simulation three (team 1 and 2) and five (team 4 and 6).

Video Analysis of High and Low Performing Teams per Simulation

Video records of the high and low performing teams were analyzed with the purpose of characterizing behavioral and verbal interactions related to (a) coordination strategies and (b) features of coordination breakdowns. These categories have been depicted in previous studies looking at team coordination (Manser et al., 2008; Rico et al., 2008; Xiao & LOTAS, 2001). Figure 5 provides a synthesized map of the observation categories that are used to code coordination strategies and coordination breakdowns. A full list of the observations categories used in this study including definitions, examples and relevant references can be found in Appendix E. The observation system consisted of six categories and fifty-seven codes that described coordination strategies (see Figure 5 and Table 7).

Two independent coders coded 10% of the videos. Differences were solved throughout discussions. As the two coders reached a 74% of agreement, the coding scheme was considered consistent and then a single coder coded the rest of the video.

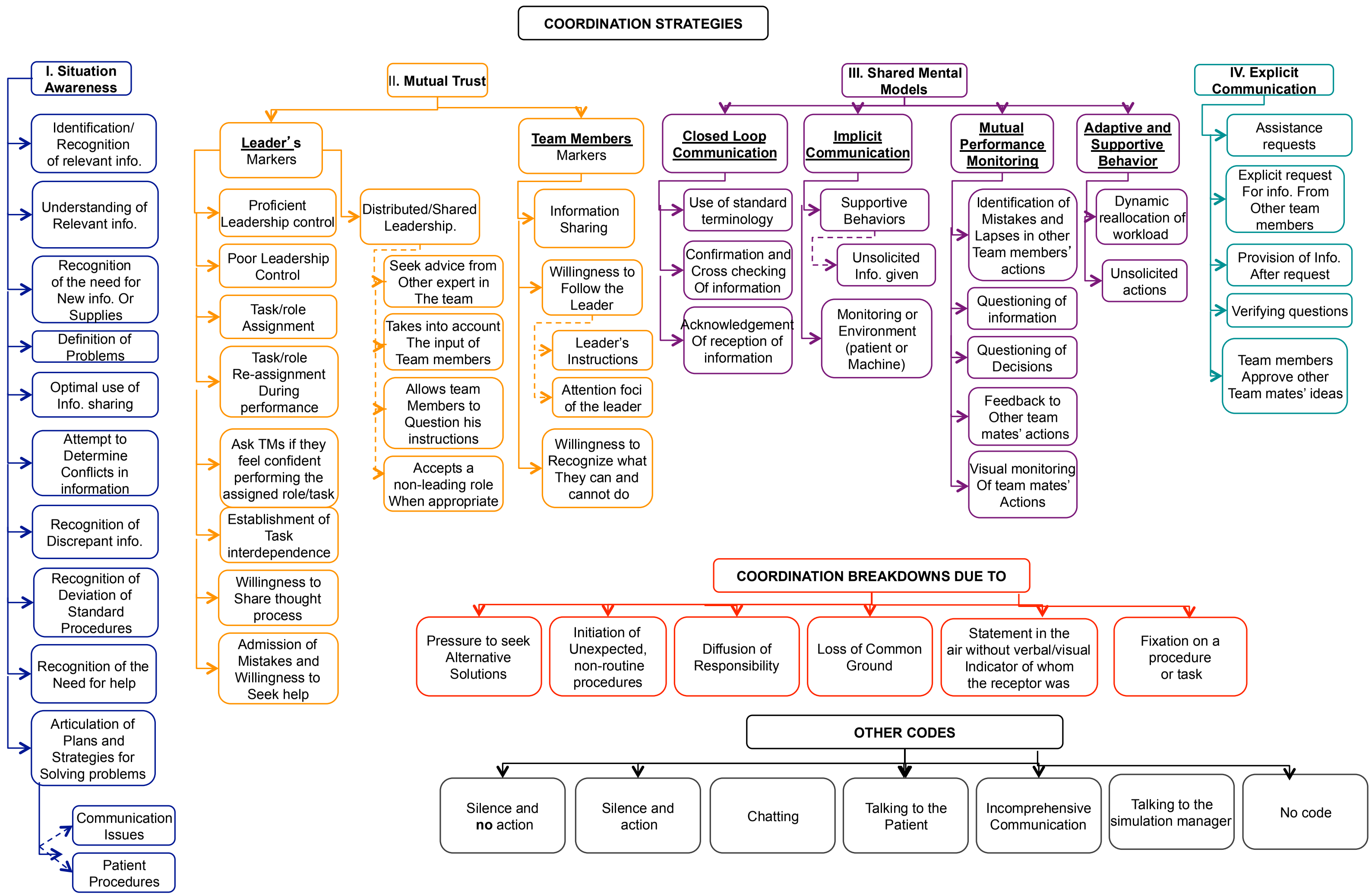


Figure 5. Synthesized map of the observation categories.

Table 7
Examples of Categories and Codes of the Observation System

Coordination Behaviors	**No. Codes**	**Description**	
		Key Behavior	**Example**
1. Situation Awareness	10	Detection that a problem exists or will soon exist	"We have a problem here, I don't hear anything in the chest"
2. Mutual Trust			
Leader	13	Team leader communicates both clearly and with authority	"Eric, take care of the airway. Claire put the IV here and here (pointing)"
Team Members	4	Willingness to follow the leader (L)	When the leader assigns airway position to a team member, this team member immediately position himself and starts procedures
3. Shared Mental Models			
Closed loop Communication	3	Acknowledgement of reception of information	"Okay" "ummm hmm"
Implicit Coordination	2	Provision of unsolicited *information*	"Chest tube is in, some blood is coming out"
Mutual Performance Monitoring	5	Feedback to other team members	"That's not the way to use that stuff, you should…."
Adaptive and Supportive Behavior	2	Provision of unsolicited *task-relevant actions*	The "L" says: "I'm going to make a surgical airway". The nurse immediately get the traq kit
4. Explicit Communication	5	Request for information	"I'm not hearing anything from airway, how's that coming along?"

Verbatim data were first transcribed onto a time-stamped observation grid then videos were encoded in a Mac Laptop using Microsoft Office excel. Coordination strategies were coded across the different phases of the tasks based on the procedures done and the triggers that were sent to the teams were specified (see and example in Figure 6).

A four-stage process was used in the analysis of the videos. In the first stage, video records were segmented every thirty seconds. In the second stage, videos were screened and the different phases of the task were identified (e.g., preparation, patient handover, primary and secondary survey). In the third stage, segments were transcribed and coded according to the observation categories (see Appendix E). Coordination strategies were coded in terms of who executed the strategy and to whom it was addressed (Manser et al., 2008). Number one (1) shows an excerpt from simulation 1 – team 1. The central part of the figure shows an example of the excel spreadsheet used to code the video-records. In the upper level of the figure, number two (2) shows that the excerpt analyzed corresponds with the second minute of video record. Number three (3) shows that the team was performing the primary survey. The observations codes were applied according to the actions and verbal utterances described in the excerpt. The categories and the codes used in this example are described in the right side of the figure corresponding to number four (4). For instance, when the leader mentions “looks like we have a problem in the lungs”, this was coded as detection that a problem exist (SA4) and willingness of the team leader to share his thought process with TMs (MT6). The leader was talking to the TMs and this was represented in a parenthesis (L:TMs). Number five (5) shows that the key event of the whole segment was that the leader reported a ventilation problem and that he ordered to IV2 to address it. Number six (6) shows that there were no procedures done during this segment and the “patient” kept coughing to trigger TMs about a ventilation injury, which correspond to number (7).

In the fourth stage of video analysis, a grounded theory approach was conducted. Grounded theory (GT) is a qualitative inductive methodology that aims to uncover the emergent patterns embedded in data coming from human performance in a particular setting. According to Glaser (Glaser, 2008), "conceptualization is the medium of

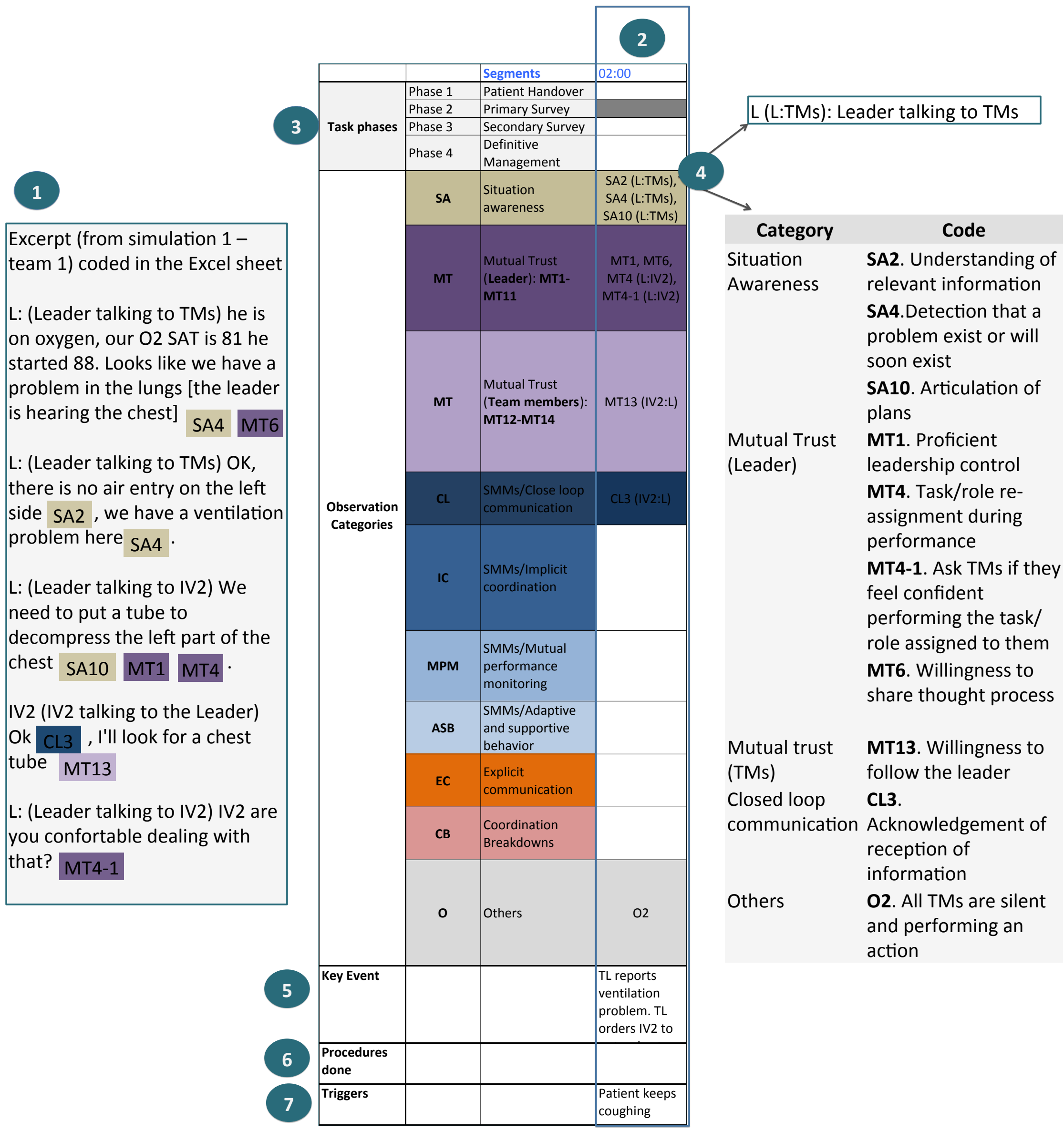


Figure 6. Example of an Excerpt Coded in the Excel Sheet.

grounded theory" (p. 26), in that GT is a form of latent structure analysis in which the researcher finds patterns in the data, otherwise known as open coding, that become categories or concepts. These concepts come from the voice of the participants instead of from formal or well-known theories.

The final goal of the GT is theory development, which comes from an analysis of the patterns in the data. Theory development is guided by the establishment of the relationship among concepts (axial coding). GT has predominately been linked to traditional qualitative data sources such as interviews, focus groups, field notes and memos. More recently, several authors have contended that GT is a suitable method to analyze less common sources of data such as visual media (including video-records, films and photographs), artwork, and music (Birks & Mills, 2011; Konecki, 2011; Nilson, 2011; Xiao et al., 2004).

Audio and video data give the researcher flexibility to revise their coding as many times as possible and from different perspectives. However, Glaser (2008) argues that there is a risk in trying to analyze too much video data since it can be overwhelming. According to Nilson (2011), there are different ways to overcome this problem by translating the captured activity into words. For instance, video data can be organized as a sequence of events whereby transcriptions of the observed activities can be made. Describing the key behavior and the context in which this happened can reduce the data analyses (e.g., Xiao et al., 2004). For the purpose of this research, visual representations of the simulations were created. These representations allowed the researcher to manipulate and compare data much easier than examining the raw video data (see Appendix 2). In addition, selected simulations were transcribed with detailed descriptions of behaviors and non-verbal language in order to help other people recreate what happened in the simulation.

Team Cognitive Task Analysis

Team Cognitive Task Analysis (CTA) is proposed, as a method to examine coordination demands in team tasks (Espinosa, et al., 2004; Katz-Navon & M. Erez, 2005). Team CTA is a collection of methods useful for gaining access to the cognitive processes and skills that underlie team performance. This method has been used to conduct studies that address the understanding of team cognition, and also the design of team training, and assessment of team performance (Lorenzet et al., 2003). Team CTA includes the assessment of individual cognition and team cognition required in team-based tasks (Arthur et al., 2005; Baker et al., 1998).

For the purpose of this research, a team CTA was performed to characterize individual and team coordination strategies implemented by trauma medical teams. Two sets of skills were analyzed, namely individual team member's skills also called taskwork, and teamwork skills. Taskwork consists of behaviors that are performed by individual team members and that are critical to the execution of individual team member functions. Teamwork consists of behaviors that are related to team member interactions and that are necessary to establish coordination among individual team members in order to achieve team goals (Glickman et al., 1987). Results from the team CTA were integrated into a cognitive model of military trauma team interventions and were also used to develop a coding scheme for the video analysis, which is described later in this section.

Figure 7 shows the different steps and data sources (interviews, video analysis, etc.) that were used in the team CTA. The first steps were aimed at understanding and characterizing the dependencies of the team task and coordination strategies required throughout the different task phases (Espinosa et al., 2004; Katz-Navon & Erez, 2005). The last steps looked at how effective and less effective teams implemented coordination strategies. The following sections show a detailed description of the different methods and data sources that were used for conducting the team CTA.

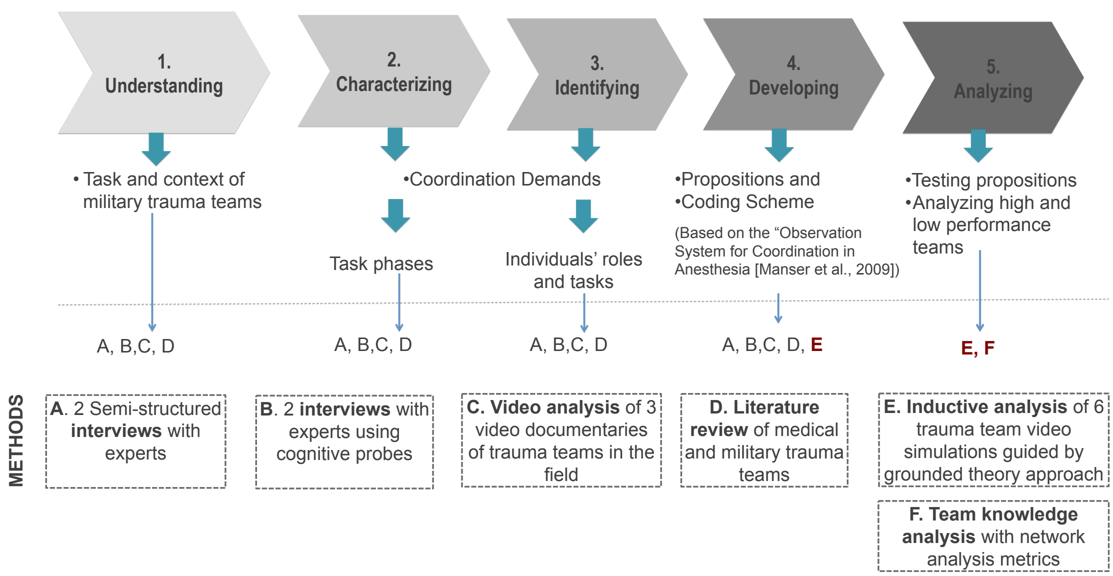


Figure 7. Team Cognitive Task Analysis (CTA) steps.

Team CTA Methods.

Semi-structured interviews with subject-matter experts (SME). Three semi-structured interviews guided by open-ended questions were conducted with three subject matter experts (SME). The purpose of these interviews was to understand the requirements of team training and team coordination. The SMEs were two civilian physicians who had experience delivering simulated team based-training and one military physician who had been deployed several times to the battlefield as part of a military medical team. The three SMEs collaborated in the design of the simulations studied in this research. The first interview was a three-hour interview with the two civilian physicians. Examples of the questions that guided the interview are detailed in Table 8. During the interview, the physicians showed the researcher some videos of previous team simulations to exemplify what a good and a bad team reaction looked like.

A second interview with one of the civilian physicians was conducted with the purpose of clarifying/extending some of the questions asked in interview one. For this purpose a combination of open-ended questions and the use of cognitive probes pertaining to the Critical Decision Method (CDM) (Crandall et al., 2006; Hoffman, Shadbolt, Burton, & Klein, 1995; Klein, Calderwood, & MacGregor, 1989) were used (see the probes in Table 4). The CDM is an intensive interview with the SME about the details and the setting in which any particular task occurs. The CDM aims to understand the cognitive demands of any particular task (e.g. a team task) in terms of the decision-making, planning, sense making, strategies and mental models processes (Crandall et al., 2006). The CDM probes were used to comprehensively understand and contextualize the cognitive abilities experts put in practice when performing in a medical trauma team.

A third interview with the military physician was also conducted (Crandall et al., 2006). This interview also followed the Critical Decision Method (CDM) (Crandall et al., 2006; Hoffman et al., 1995; Klein et al., 1989). The military physician was asked to remember a case or a specific situation in which his abilities and experience made the difference in the way the situation turned out (e.g. a specific case with a patient in which the medical team needed to react under extreme circumstances).

Table 8
Questions that Guided the Semi-Structured Interviews with Subject-Matter Experts (SME)

Topic of the Question	Questions
Design of team-based simulation scenarios	How are the cases for the simulation selected? What are the sources for the cases? Is there an ideal (s) resolution for the cases? If so, do participants have access to it? What type of military medical care do the simulations support (e.g. care under fire, tactical field care, combat casualty evacuation care) What are the learning outcomes of the team-based simulations?
Principles for crisis resources management	1. Leadership and followership: How is the leader selected? In what moment should the leader assume his/her position of leader? When should the leader be replaced? Can anyone be the leader? What needs to be coordinated by the leader and when? What can and cannot be delegated? What is the specific knowledge about the task the leader holds? What does the leader need to know about the role of other team members? How should the leader react when there is an emergency? 2. Effective communication: What is the specific information each team member holds? When is the right moment to communicate the specific information? What aspects are emphasized in the management of ttrauma patients (i.e. assessment, stabilization, and disposition)? 4. Distribution of workload: What are the roles and function of each team member? What is the information that team members get from others? 5. Decision-making: What are the critical and difficult decisions? What actions need to be synchronized (actions doing at the same time)? What are the key decisions team members must make? What cues do they depend on? What relationships between cues are important to monitor? How are the operators (the team) deriving inferences form the cues? 6. Call for help: In which cases should they call for help? Who should be consulted? 7. Using all available resources: What are the resources they have? When is the right moment to use them?

A series of cognitive probes that helped the physician to deepen his answers were adapted from Crandall et al. (2006) (see Table 9). It is well known from the literature that by conducting interviews with the CDM, researchers can obtain relevant information about the cues and patterns that experts perceive, the rules of thumb they have devised, the kind of decisions they have to make, the features that make decisions tough, the features that make cases typical or rare cases (Crandall et al., 2006).

Table 9
Questions and Cognitive Probes Used in Interviews with SME (adapted from Crandall et al., 2006)

Questions Do you remember a situation or case particularly challenging in which your knowledge and experience made the difference in the way the incident turned out?
Could you please provide me with a brief account of the story from the beginning to end?

Type of Probe	Probes
Cues	What were you seeing, hearing, smelling, noticing etc.?
Information	What information did you use in making this decision or judgment? How and where did you get this information, and from whom? What did you do with the information?
Analogs	Were you reminded of any previous experience? What about that previous experience seemed relevant for this case?
Standard operating procedures	Does this case fit a standard or typical scenario? It is a kind of event you were trained to deal with?
Goals and priorities	What were your specific goals and objectives at the time? What was most important to accomplish at this point in the incident?
Options	What other courses of action were considered or were available to you? How was this option chosen or others rejected? Was there a rule that you were following in choosing this option?
Experience	What specific training or experience was necessary or helpful in making this decision?
Assessment	Suppose you were asked to describe the situation to someone else at this point. How would you summarize the situation?
Mental Models/ strategic thinking	Did you imagine the possible consequences of this action? Did you create some sort of picture in your head? Did you imagine the events and how they would unfold?
Decision-making	What let you know that this was the right thing to do at this point in the incident? How much time pressure was involved in making this decision?
Guidance	Did you seek any guidance at this point in the incident? How did you know to trust in the guidance you got?

Interviews were transcribed by the researcher and proofread by a third party (a research assistant) with experience in transcription of audio and video records. Interview transcripts were segmented and analyzed according to the following categories:

- Phase of the task: Description of the different phases of the task

- Thinking: Description of the questions that should guide the thinking process of team members during each phase.
- Actions: Description of the critical behaviors individual team members should engage in.
- Potential Errors: Description of the possible errors or the cues that team members could potentially miss.

Table 10 shows an example of a segmented transcript according to the categories described before. Data from the interviews were used to feed a cognitive model of military trauma team interventions, which can be found latter in this section.

Table 10
Example of a Segmented Transcript According to the Analysis Categories

PHASE OF THE TASK. Preparation (pre-planning): This phase goes from the moment the team members come together until the moment the patient arrives			
Thinking	**Actions**	**Possible error**	**Notes from the interviews**
- Who is good doing what? - How we can interact and communicate? - What I should communicate and to whom?	- Assign a leader - Clarify each team member's role and position: leader (L), intravenous (IV), airway (AW), note taker - Anticipate what to do if fixation errors occur	- Assign or assume roles with which team members do not feel comfortable or prepared to assume - People do not know what their role was - The leader doesn't assign roles	**Dr. R**: "Leaders are totally chosen before hand" "Right before each scenario they [the participants] choose among themselves who is going to lead" **Dr R;** Usually right away [answering to the question about when is the best moment to assign roles], even before the patient arrives **Dr. L**; … "[G]enerally there are four/five people per patient" **Dr. R**: "One person is in charge of a airway, then you have a person for IV and also for chest tube in the other side, and then you have the leader right here [in front of the patient] watching them"

Fieldnotes. The researcher took notes during the debriefing sessions, in which medical instructors with experience in the battlefield and in civilian trauma scenarios gave feedback to the teams. These notes focused mainly on the instructors' perceptions of what went well or wrong in terms of teamwork and in terms of the medical aspects of the simulation. Likewise, the researcher took notes of the personal experiences of the instructors in similar situations. Fieldnotes served as a complement of the information provided by the instructors in subjective measures. Fieldnotes helped the researcher describe more deeply what aspects influenced good and bad team performance and to understand the medical components of each simulations.

Videos/documentaries of military trauma teams performing in battlefield. A selection of nine interviews and documentaries of military nurses and physicians posted on YouTube were reviewed. The selected interviews look at real experiences from health care professionals who are or who have been deployed in a war field. Some of them explore the distinctions between civilian and war trauma care. Others show the journey of military health care teams in the field while treating patients. The purpose of using these interviews and documentaries was to gain an accurate understanding of the military health care scenarios in the real field and to better characterize the role and demands of military trauma teams. Table 11 shows a detailed list and description of the interviews and videos that were used.

Videos were partially transcribed and only the segments in which the interviewees spoke about the trauma team's roles and the characteristics of the environment in level 3 of care were transcribed as quotes. These quotes were coded according to the following categories:

- Characteristics of military trauma teams: Quotes that referred to the features of the environment in which trauma teams perform.

- Roles: Excerpts that described the responsibilities of different members of trauma teams.
- Primary Survey: Quotes that discussed the tasks in which trauma teams engage into when the patient arrives.
- Secondary Survey: Quotes that mentioned the treatments after the patient is stabilized.

Table 11

List of the Interviews and Videos Collected from Internet and the Description of the Topics discussed on Them

Interview/Video	Description of the Topic Examined in Interview/Video
1. Interview with a military nurse	The role of the military nurse/ difference between civilian and military nurse work (Infirmière Militaire, 2012).
2. Documentary with doctors and nurses at War	Work of Royal Army Medical Corps (RAMC) and Queen Alexandra's Royal Army Nursing Corps (QARANC) doctors and nurses as they cared for members of the British Army wounded or injured in conflict zones of the Southern Afghanistan (Qaranc, 2006).
3. Military medical response team	Detail following of the logistics and procedures followed by military health care teams (Natocommunity, 2009).
4. Military health care providers treating wounded patients at a hospital facility	The video looks at the work of Army Doctors and nurses headquartered at an Afghan US airbase (Natocommunity, 2008).
5. Nurses serving in Afghanistan combat	The video looks at Medical Emergency Response Team (MERT), specifically at the work of military nurses (Nurespot, 2009).
6. Interview with a critical care nurse at Bagram Air Field Afghanistan	This video shows an interview with about the job of Capt. Christine Collins who is a critical care nurse at Bagram Air Field Afghanistan (Usfora, 2009).
7. Bagram emergency room military medicine in Afghanistan	This video shows how US Military Facility worked at Afghanistan and how medical teams respond to injured and wounded patients (3rdID8487, 2008).
8. The work of a trauma surgeon in Afghanistan	This is a short film documenting about the work of a British Army trauma surgeon in the war Hospital in Camp Bastion, Afghanistan (1st4film1, 2011).
9. Video about medical decisions in Afghanistan	This video emphasizes on the critical decisions health care providers have to take in the field when treating an injured or wounded patient (AIJazeeraEnglish, 2009).

-

Table 12 shows an example of how the quotes, from interviews and documentaries, about trauma teams in the field were coded.

- Data from the documentaries helped the researcher to understand and to characterize the context in which trauma teams perform. The section below describes the cognitive model created of military trauma team interventions.

Table 12

Example of How the Quotes, from Interviews and Documentaries, about Trauma Teams in the Field were Coded

Description: Quotes from the Video: Real Combat Hospital in Afghanistan. Documentary with US service members who worked at the Salerno Hospital in Khost, Afghanistan in 2009 and 2010 (Ham, 2012)

Person Been Interviewed	**Time**	**Quotes**	**Category**
Lt. Col. Benjamin Kam Orthopedic Surgeon	01:00	"Any time a trauma is brought in, we kind of need everyone to come in and make sure that the patient is taking care"	Primary survey
	02:33	"Trauma tends to be a chaotic experience the patients are running with no clear definitive diagnosis"	Characteristics of military trauma
	02:55	"Each of us bringing their own expertise in the table and we have broken things down into a system where each one has a responsibility or responsibilities"	Roles
Lt. Col. Forrest Fernandez Trauma Director	03:05	"We actually have a sequence that we kind of go through, so as you're watching you may not be able to sort of perceive that, but there actually is a relative checklist to make sure nothing get missed for evaluation and treatment of the patient"	Primary-Secondary survey
Col. Scott Russi Chief Trauma Surgeon	03:24	"... OK, the things we're concern about are airway: Do they have an open airway? And can they breath? Those are the first two questions we ask. If they don't have an open airway we open it for them and that might be putting an ET tube down the throat or doing a Cricothyrotomy in the neck. We have two technicians one of each other side, one responsible for starting the IV's	Roles Primary Survey

A Cognitive Model of Military Trauma Team Interventions

A team CTA approach was used to identify and characterize the cognitive components of coordination in trauma teams in terms of the decision-making, planning, strategies and mental model processes. This characterization was integrated into a team cognitive model of military trauma team interventions in a level-3 care facility. The questions that guided the model were as follow:

- What are the phases for managing trauma-war injured patients?
- What are the goals of these phases?
- What are the roles played by team members?
- What are the expected competencies for each team member's role during the management of trauma-war injured patients?

Phases of the Cognitive Model of Military Trauma Team Interventions in a Level 3-care Facility.

This model is presented in a sequential manner in which five phases of the tasks performed by trauma teams are considered and analyzed (see Figure 8). The first phase is characterized by the preparation of the team, the equipment, drugs and space. This phase goes from the moment the team comes together until the moment the patient arrives. The second phase involves the patient handover, which refers to the transfer of information, professional responsibility and accountability (for all aspects of care for a patient or a group of patients) from paramedics to the trauma team (Brithish Medical Association, 2004; Evans et al., 2010). This phase starts from the time the patient is brought until the moment the paramedic ends the description of the patient. The third phase involves the identification and correction of life threatening problems that lead to stabilization of vital signs, which is medically known as the primary survey (Driscoll & Skinner, 1990a). This phase starts from the end of patient handover until the end of assessment and resuscitation. Before engaging in the third phase, resuscitation efforts, performed in the primary survey, must be well established and vital signs must be normalized.

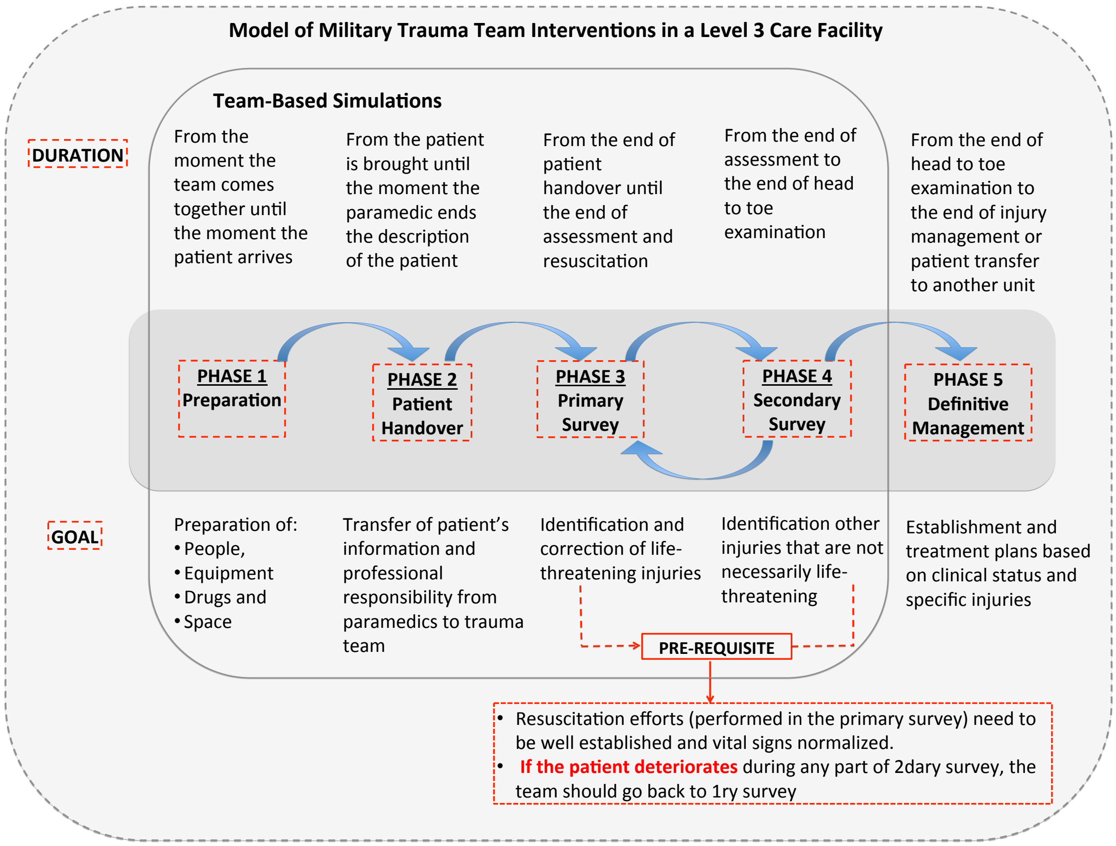


Figure 8. A model of military trauma team interventions in a level 3 care facility.

The fourth phase, known as the secondary survey, consists of a head to toe examination of the patient. This examination often leads to the identification and treatment of other injuries that are not necessarily life-threatening. (Driscoll & Skinner, 1990b). This phase starts from the end of assessment and resuscitation to the end of head to toe examination. In the case that the patient's vital signs deteriorate during the secondary survey, the team must systematically go back to primary survey and normalize vital signs as indicated by loop arrows in Figure 8. The last phase involves patient's definitive management, which consists of establishing treatment plans based on clinical status and specific injuries (Driscoll & Skinner, 1990b; Hodgetts & Turner, 2006). Although phase five is part of the routine management of trauma patients, this phase was not part of the simulation scenarios. Team-based simulations were short (on average 9 minutes) and teams were expected to cover from phase 1-4.

The four phases targeted during team-based simulations were broken down into a more detailed analysis that specifies the goals, sub-goals, roles, team members' actions according to their roles, possible errors, team members' and team leader's knowledge, skills and attitudes. In addition, rules and some possible exceptions to the rules are considered for each phase. This work is described next.

Phase 1: Preparation/Planning

Preparation phase consists of the time that team members allocate for organizing the activities required to perform together and for getting familiarized with the operating theatre and the other team members' roles. The goal of this phase is to optimize the smooth running of the resuscitation (Hodgetts & Turner, 2006). The time for preparing may change depending on how many casualties are received, how they are spaced and the type of injuries. For instances, casualties in the field typically have moderate to severe penetrating injuries and come in batches (e.g. 17 patients) within five to ten minutes of notice (Champion et al., 2003), which limits the time for preparation. For the purpose of the simulations referred to in this study, the allocation time for this phase varied between 5 to 8 minutes. Key actions of the preparation phase include preparation of people, equipment, drugs and space (Hodgetts & Turner, 2006).

Preparation of people involves the explicit and inmediate allocation of roles according to team members' expertise and the definition of coordination cues. The trauma team roles consist of a team leader (TL), airway (AW), and intravenous (IV) positions (see Figure 9).

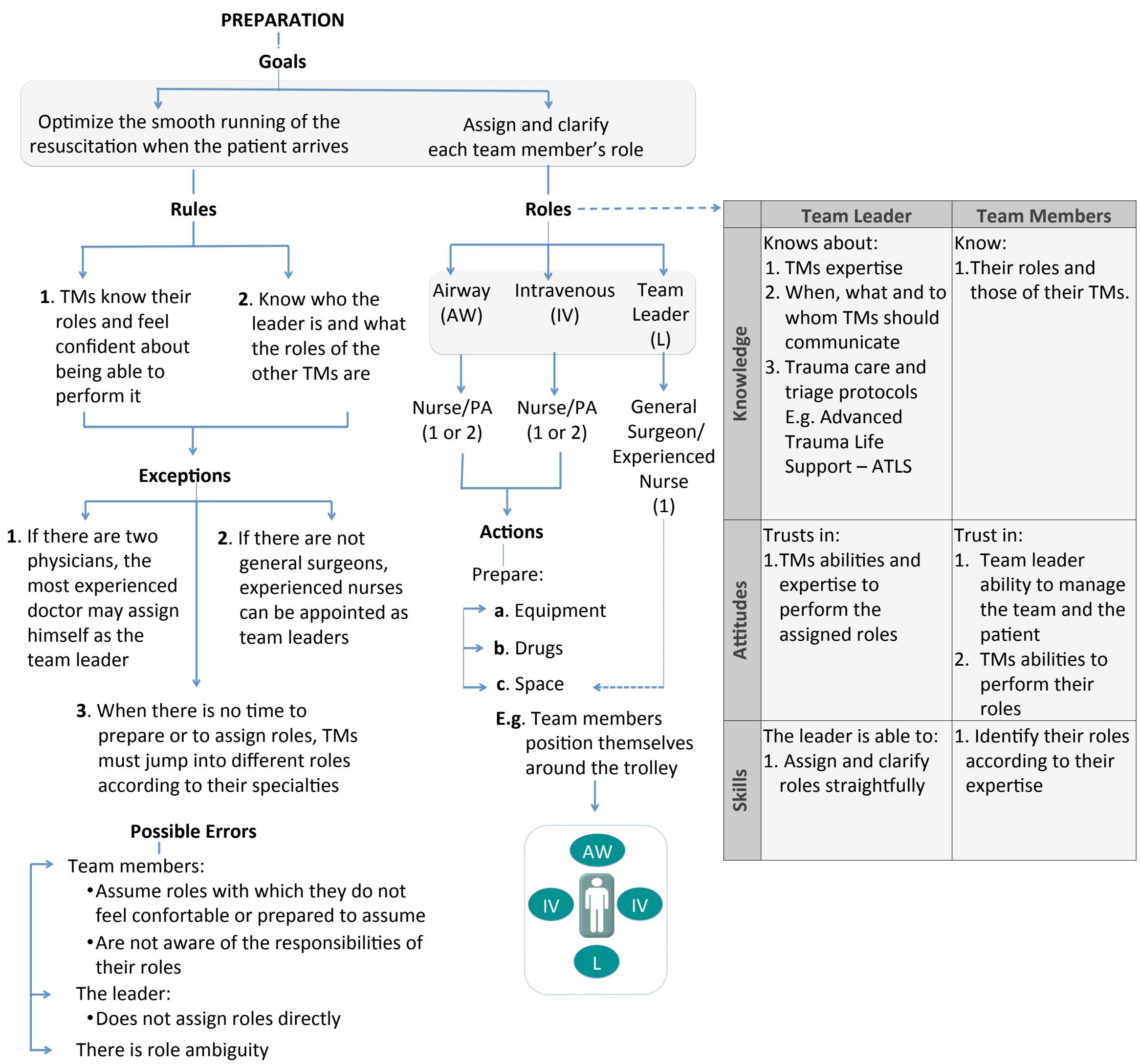


Figure 9. Summary of the cognitive analysis of the preparation phase. Note: TMs = Team members.

A medical-surgeon officer plays the role of a team leader. When a surgeon is not available, a critical care experienced-nursing officer can exceptionally play this role. In such a case, the background of the individual acting as TL is less important than the fact that they have the leadership competencies required to lead the resuscitation (Mackway-Jones, 2012). These competences include:

- Ability to assign and clarify roles clearly before and during the resuscitation.
- Sound knowledge of trauma resuscitation and triage protocols (e.g. Advanced Trauma Life Support, ATLS), consolidated through experience (Ravinder, 2011).
- Ability to analyze the array of physical findings and make judgment on priorities for investigation and treatment.
- Ability to communicate both clearly and with authority (Hodgetts & Turner, 2006, p. 17).

In addition, the TL must have teamwork attitudes such as trusting team members' expertise and their ability to perform the assigned roles. The leader's attitude toward teamwork helps to foster team members' willingness to share information relevant to their positions (Salas et al., 2005), which then, supports the smooth running of the resuscitation.

In the case where two surgeons are part of a team, the TL role should be handed on to the more senior surgeon (Hodgetts & Turner, 2006). The overall responsibilities of the TL start during the preparation phase where the TL must: (1) clarify the aims of each team member's role, (2) clarify the general goal of the intervention, and (3) establish coordination cues that facilitate the smooth running of the resuscitation. For instance, a TL might instruct their teammates to communicate everything as they proceed "I will tell you everything as we go along and I'd like you to tell me so that we always know how we are doing" (Manser et al., 2008). More examples pertaining to data collected in this study are shown in Table 13.

Table 13
Example of a Team Leader Clarifying the Aims of Each Team Member's Role

Context
The team receives the following information:"There is a patient arriving in five minutes or less because is your second notification. They [mhm, mhm] the medic test think of critic consciousness, they have him on oxygen and an IV in the right arm. That's your next call, OK?"
Clarification of Roles:
L: "OK, so, lets start the airway as soon as the patient is coming in, so somebody could do that, lets get some blood from the lab, Karine lets get some blood from the lab. Let's start with four liters
Karine: "I'm going to call right now and let you know"
L: Looks to another team member and says "lets get some blood, call the lab and tell them to send me 4 litters of blood right away"
Karine: "I'm calling, I'll call back".

Critical care nursing officers often play the airway role and they are in charge of primary patient care. Medical technicians can play either the airway or the intravenous role. A medical technician is a healthcare professional licensed to practice medicine under the supervision of a licensed physician (Hooker, MacDonald, & Patterson, 2003).

Teams with more than four members may allocate two people for the IV position (see Figure 6). The scope of the activities that a medical technician may get involved in includes: provision of basic life support treatment, prescription of some medications, medical support during environmental operations, collection of specimen and performance of basic laboratory procedure, operate and maintain medical and life-support equipment (Canadian Armed Forces, 2013). If the TL does not specifically assign roles, team members must undertake the tasks according to their experiences (K, Lachapelle, personal communication, November 25, 2009). With some exceptions and specifically in the cases where there is no time to prepare or to assign roles, team members must jump into the different positions almost automatically and update the team about their roles. To ensure the smooth running of the simulation, team members must know about the specific role responsibilities, requirements for task sequencing, team role interaction patterns, and mechanisms and procedures for task accomplishment (Cannon-Bowers et al., 1995). This knowledge is referred in Figure 2 as teamwork knowledge.

Team members should feel comfortable and ready to perform the assigned roles, which should match their professional skills. Recognition of their own ability to perform the assigned role is an important aspect for avoiding errors (Hodgetts & Turner, 2006). For instance, a TL who does not feel prepared to lead the team may not assign and re-assign roles appropriately and may not communicate clearly and with authority, leading to ambiguity and an atmosphere of mistrust that eventually deteriorates team cohesion, thus team performance. Similarly, team members who are not fully aware of the responsibilities of their roles may fail in recognizing and transmitting important information related to their individual task which affects other team members' tasks.

The preparation of the equipment and the drugs involves a quick visual inventory of the available equipment (e.g. intubation and chest drain gear, oxygen mask, etc.) and drugs (e.g. analgesics, intravenous fluids, etc.). The people playing the role of AW and IV usually do this inventory. Finally, the preparation of the space involves the strategic allocation of the team members according to their specific roles (see Figure 9). The AW position is placed at the top of the patient's head or at the top of the trolley, while people playing the IV position allocate themselves at each side of the patient. The team leader is responsible for managing critical care and must not be involved directly with clinical procedures, as this would compromise the leader role (Mackway-Jones, 2012). Instead, the TL assumes a managerial and monitoring role characterized by delegating tasks and checking that the resuscitation is proceeding satisfactorily (Sugrue, Seger, Kerridge, Sloane, & Deane, 1995). To do so, the TL should be situated at the foot of the bed where he or she can have a good perspective of what is going on (Hodgetts & Turner, 2006). One-way of limiting the participation of the TL in interventional skills (securing an airway, chest drain, intravenous access) is crossing their arms (cite debriefing sessions) (see Figure 10).

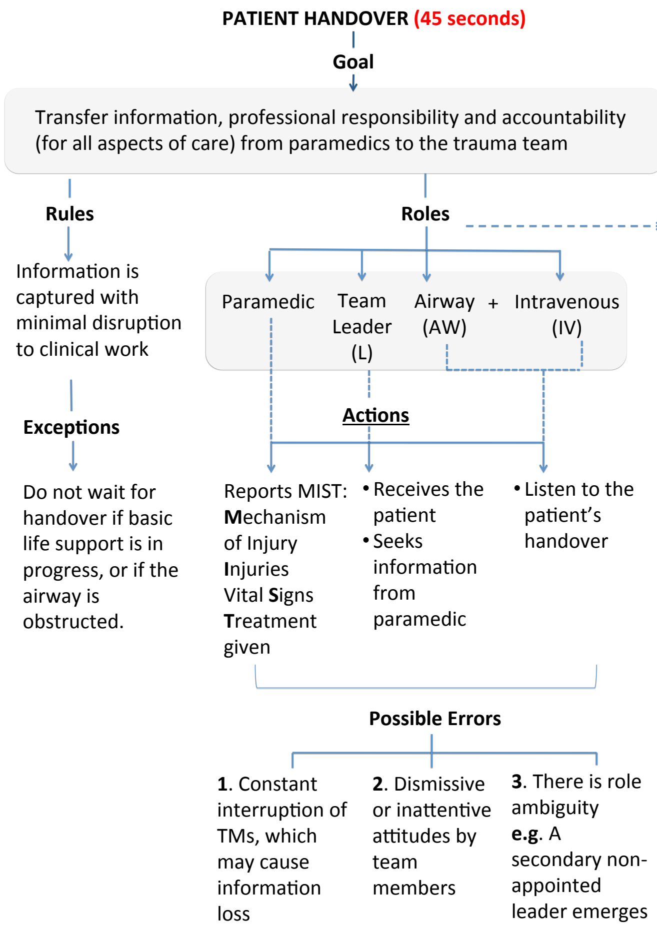
Figure 10. Picture showing a team leader at the foot of the bed with crossed arms.

Phase 2: Patient Handover

The patient handover phase involves the transfer of the patient care from the paramedic crew to the receiving trauma team. The goal of this phase is not only to transfer the patient to a different location (i.e., from the helicopter to a combat support hospital), but to transfer the patient's medical information and the professional responsibility and accountability for all aspects of care from the paramedic to the trauma team (Brithish Medical Association, 2004; Evans et al., 2010) (see Figure 8). The patient handover occurs in a time-pressured environment that is particularly error-prone (Evans et al., 2010). During this time, the paramedic needs to transmit succinct but critical information that helps the receiving trauma team, more specially the team leader, to make decisions about patient care and establishment of a course of actions.

This phase is characterized by a high load of information in which communication difficulties can lead to errors. For instance, the information from the paramedic is incomplete and/or inaccurate (Evans et al., 2010), which can lead to inappropriate management of the patient and even death. Another example of these difficulties has to do with the fact that team members interrupt constantly, show dismissive or inattentive behaviors, which can lead to information loss (Evans et al., 2010; Hodgetts & Turner, 2006) (see possible errors in Figure 11). Even though the paramedic must transfer all the information and care responsibility to the TL, the rest of the team members must listen to it with minimal disruption to clinical work (Hodgetts & Turner, 2006). Attentive listening to the handover by TMs ensures that more than one person absorbs the required information about the patient's condition, which helps to reduce unnecessary repetition and avoids further waist of time. Effective handover practices can help team members to develop good situational awareness, as all members have sufficient information that helps them to contribute to the interpretation of patient's injuries, which is referred as teamwork knowledge in Figure 8.

The only circumstance in which the team should skip the patient handover is when basic life support is in progress or if the airway is obstructed (see exceptions in Figure 11). In this regard, Col. Scott Russi, Chief Trauma Surgeon in Afghanistan, notes that two important questions should always be asked: Does the patient have an open airway? And, can the patient breath? (Ham, 2012).



	Team Leader	Team Members
Knowledge	Understands: 1. What is the critical information 2. What is the context of the accident in which the patient was found (e.g. land mine, etc.) 3. What is the main injury and how is this affecting the vital signs of the patient	1. Develop a general picture of what is going on with patient before performing any procedure
Attitudes	1. Assumes the care of the patient and **communicates with authority** to paramedic and team members	1. Respect the leader's authotity and be prepared to carry out his instructions
Skills	Is able to: 1. Make hypotheses about the mechanism of injury 2. Make a judgment on priorities for investigation and treatment	1. Make hypotheses about the mechanism of injury

Figure 11. Summary of the cognitive analysis of the handover phase. Note: TMs = Team members.

Although, the handover is short in terms of time, all TMs play an important role. The actions according to each team members' role are (Hodgetts & Turner, 2006):

- Paramedic: Delivers a brief account of the patient's status and the procedures done during transportation. This description last 45 seconds in average and should follow the MIST algorithm:

  M: Mechanism of injury (e.g., explosion, blast injury, etc.)

  I: Injuries including the region (e.g., head, neck, chest, abdo, etc.) and the description (e.g., amputation, crush, spinal, fracture bones or pelvis, burns, etc.)

S: Signs (respiratory rate, oxygen saturation, pulse rate, blood pressure)

T: Treatment given

- Team Leader: Liaise with the paramedic and receives full briefing of the patient's information and actively seeks more information that is omitted or inconsistent.
- The airway and intravenous roles: Should listen to the patient handover in order to build a similar understanding of the patient's condition, otherwise known as shared situation awareness (Bolstad, Cuevas, Gonzalez, & Schneider, 2005; Salas, Prince, Baker, & Shrestha, 1995).

Role ambiguity can limit the flow of communication during the handover. For instances, a second leader emerges to the detriment of an appointed leader who does not exercise his role with authority. The secondary non-appointed leader may step in and try to seek information from the paramedic, which is disruptive and creates ambiguity in the hierarchy of roles. In addition, this situation can cause diffusion of the critical information, which should be told by the TL. Team members of the trauma team must respect the leader's authority "and be prepared to carry out the leader's instructions" (Hodgetts & Turner, 2006, p. 17). One of the attitudes expected from the team leader during this phase is to assume the care of the patient and communicate with authority to paramedics and team members (see Figure 11).

The knowledge, skills and attitudes of the TL during the handover phase are listed in the left part of Figure 11. The main responsibility is to liaise with the paramedic and receive full briefing about the accident context and the patient's injuries, which should help create a hypothesis and to prioritize investigation and treatment (Hodgetts & Turner, 2006; Mackway-Jones, 2012).

The TL has to actively seek information from the paramedic for which some pertinent questions include: Does the patient have an open airway? Can he breath? (Ham, 2012). Have other procedures been done? If yes, what time where they done (e.g. tourniquets)? Where previous interventions successful? This information can help the TL. To develop situation awareness about the patient's condition and to start generating hypothesis about the main mechanism of injury.

Although, the paramedics have already started some patient's care procedures during transportation, the TL should perform a complete reassessment of the patient and the procedures that have been done. This is discussed in the next phase.

Phase 3: Primary Survey

As a rule of thumb, primary survey must start with a quick re-evaluation of the patient to check previous procedures done during transportation (i.e., check for tourniquets, sometimes they are badly placed) and missing injuries causing deterioration of the patient (Hodgetts & Turner, 2006) (cite debriefings sessions). Failure to reassess the patient or the assumption that previous procedures are well done and not verified may lead to a misdiagnosis (Hodgetts & Turner, 2006). Besides, the team may engage in procedures that are not useful for the patient, which as a consequence, could lead the team to lose time and make mistakes (see possible errors in the bottom of Figure 12). Reassessment allows the team members and especially the team leader to develop their own mental model of the situation (Klein, 2006).

Primary survey consists of an initial patient's vital signs assessment and resuscitation that is aimed to identify and correct life threatening injuries (Driscoll & Skinner, 1990a). It follows a series of tasks that are performed automatically, systematically and simultaneously by the team (see rules in Figure 12) within the first four to five minutes of the patient arrival (Ham, 2012). These tasks become sub-goals that are performed as a kind of checklist and involve the assessment and treatment of catastrophic hemorrhage, obstructed Airway, Breathing, Circulation and central nervous system (Hodgetts & Turner, 2006) (see Figure 12). These tasks, known as the ABC, should be re-checked every time the patient deteriorates (Driscoll & Skinner, 1990a). In all circumstances, the airway must take priority and succsess should be maximized at the first attempt (Hodgetts & Turner, 2006). Procedural errors may be prompted by a (a) failure to systematically implement ABC, and a (b) light approach in which shortcuts are taken and assessment of vital signs are left as a secondary procedure or disregarded (see Figure 12). Other TL's behaviors that can lead to errors in the primary and the secondary survey are:

The Team Leader:

- Carrying out interventional skills (e.g., securing airway; chest drain; intravenous access, etc.), so he/she loses the ability to control the team and the general picture of what is going on.
- Does not prioritize tasks and set priorities (Fackler et al., 2009)
- Does not realize that he/she has a problem and that is not receiving information on a regular bases from team members
- Does not ask team members for information when he/she is not receiving it in a regular basis
- Does not communicate with authority and does not give the sense of urgency to team members (e.g. "you get to do this now")

- Does not recognize that the patient is getting worse
- Focuses attention on minor injuries and not on the major injury that can potentially cause dead.
- Lists many tasks simultaneously without even assigning them to team members explicitly.
- Does not monitor that the assigned tasks get done and that he/she is kept updated
- Does not call for help when needed
- Does not identify conflicting or contradictory information between team members
- Does not clarify or remind team members about patient's main mechanism of injury
- Does not update team members about changes in hypotheses about main mechanism of injury and care management
- Does not integrate or interpret information coming from team members (Fackler et al., 2009)
- Do not give team members the opportunity to challenge his/her assumptions (Fackler et al., 2009)
- Does not make final decisions and when he/she makes the decisions, the orders are unclear and very vague (Wallin, Hedman, & Meurling, 2009)
- Tries to do it all (Wallin et al., 2009).

Team members, who ideally know in advance what their individual responsibilities are, undertake a task (IV, airway, etc.) and work synchronously. For this to happen, the TL and other team members should be briefed upon completion of each task, which helps them to be aware of their own activities and those of others (Mackway-Jones, 2012). For instance, the IV report to the rest of the team “the IV is in”. Team members, but more especially the TL, are expected to acknowledge the reception of this information and keep a kind of a two-way radio communication, in which the interaction works as a back and forth system (T. Razek, debriefing session, December 1, 2009). Such behavior contributes to maintain shared situation awareness of the patient’s condition and a closed loop communication.

Similar to phase-two, team members are under a high load of information coming, for instance, from team members’ briefed and from the vital signs monitors. Medical officers deployed in Kandahar have described the operating theatre as a “chaotic” and “hectic” place, which nevertheless works smoothly thanks to clear team members’ roles and a horizontal team approach where individuals work simultaneously (Sugrue et al., 1995). The use of standard systematic checklists and sequences to evaluate and treat patients enhances efficient teamwork. Some officers’ comments about the environment in Kandahar are:

> “It looks like chaos but everybody who is here has a specific job that they know how to do very well” (Ham, 2012).
>
> “Trauma tends to be a chaotic experience the patients are running with no clear definitive diagnosis” (Ham, 2012).
>
> “Each of us bringing their own expertise in the table and we have broken things down into a system where each one has a responsibility or responsibilities” (Ham, 2012).

> "We actually have a sequence that we kind of go through, so as you're watching you may not be able to sort of perceive that, but there actually is a relative checklist to make sure nothing get missed for evaluation and treatment of the patient" (Fernandez, 2012).

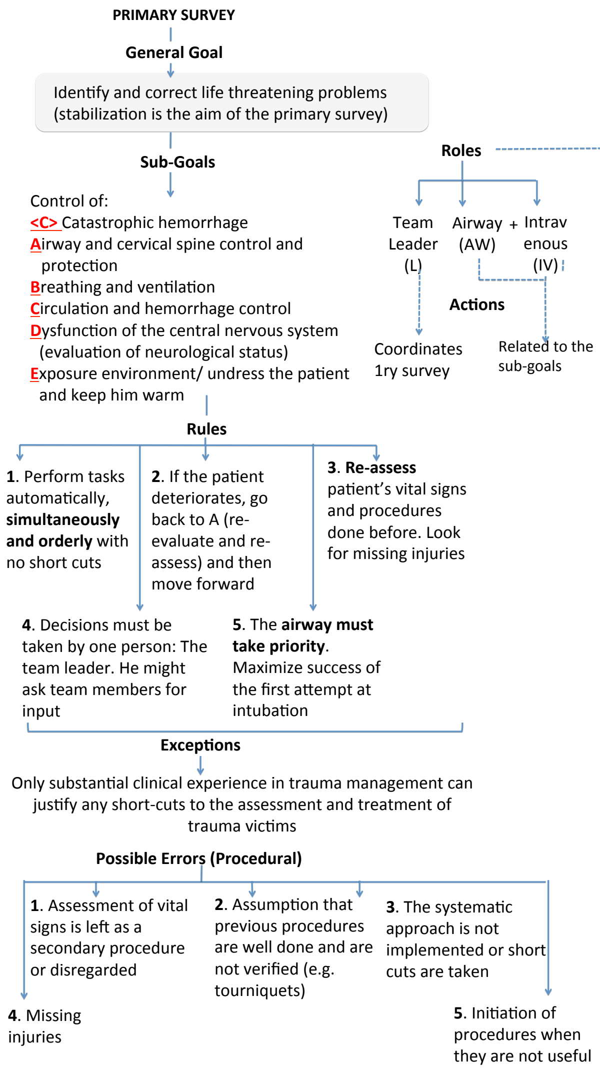
Under the circumstances described above, the TL must be the person integrating the information and making the decisions. However, he might ask team members for input, especially, when he is in doubt or he is not receiving information about the patient status on a regular bases (see rules in Figure 12) (K, Lachapelle, personal communication, November 25, 2009). One of the main skills of the TL is being able to differentiate the need for feedback (coming from team member) and the need for calling for help (coming from consultant surgeons or other specialties) (Mackway-Jones, 2012).

The TL assumes not only the patient's healthcare responsibility but also the responsibility of directing a group of health care providers, which is more of a managerial role (i.e. assigning tasks, checking procedures, etc.) (Sugrue et al., 1995). He is expected to merge the information coming from different sources (team members, monitors, patient), give it meaning and share it clearly with the rest of the team members (Salas et al., 2005) (see TL's attitudes in Table 12). For instance, the TL may think aloud while making decisions as a way to share his thought process, which in turn, contributes to having a common understanding of the case.

The TL's specific knowledge and skills during the primary survey phase are detailed in Figure 12. The TL should be able to coordinate the primary survey and to establish a sequence of evaluation and treatment. He must integrate the information that he has received as briefing to him by team members and establish clinical hypotheses about the mechanism of injury. The hypothesis about the mechanism of injury should guide the clinical investigation and treatments. The TL should be alert to ambiguities or conflicting information (Klein, 2006; Mackway-Jones, 2012b) coming either from the team members or the resuscitation machines. For instance, a team member may report that the airway has been secured but the machines indicate that blood pressure is dropping.

Some of the attitudes that help the TL to achieve the integration of information coming from team members and ultimately to manage the trauma patient include: Taking into account the inputs of team members (Salas et al., 2005), being willing to admit mistakes and ask for help (Salas et al., 2005) (e.g. when he/she is fixating in his thought process about patients management), seeking advice from other expert members of the team (Hodgetts & Turner, 2006, p. 17), and allow team members to question his instructions (Hodgetts & Turner, 2006)

Although, team members' roles have been set up during the preparation phase, it is the TL's responsibility to re-assign roles as needed. For instances, a team member working on IVs might be called to collaborate with the airway position as this is typically the main complication.



	Team Leader	Team Members
Knowledge	Knows: 1. What is the patient's present condition? 2. What are the probabilities of the patient to live? Pertinent questions: •How stable are the vital signs? •What are the life threatening injuries? •Where previous procedures done in a right manner? Always check (e.g. tourniquets) •Are there any occult injuries?	1.Know the pertinent actions relevant to their roles and those of TMs
Attitudes	1. Is willing to share his thought process (e.g. clinical hypotheses) with TMs 2. Takes into account the inputs of the TMs 3. Is willing to admit his mistakes and ask for help 4. Seeks advice from other members of the team 5. Allows TMs to question his instructions	1. Are willing to admit capacities and limitations to perform the assigned tasks 2.Are willing to follow the leader's instructions 3.Assume a hands-on approach 4.Challenge the leader's assumptions when needed in order to avoid errors
Skills	1.Anticipates if the resuscitation is going to have an impact on the patient's vital signs 2.Communicates both clearly and with authority the priorities and the plan for investigation and treatment 3.Analyze the array for physical findings 4.Verbalize thought process about clinical hypotheses 5.Provide feedback and guidance when uncertainty arose 6.Differentiates the need for feedback (coming from TMs) and the need for calling for help	1.Recognize relevant information for their roles and communicates it without being told to do so 2.Anticipate other TMs' need 3.Asks for help when need it

Figure 12. Summary of the cognitive analysis of the primary survey phase. Note: TMs = Team members.

The expected actions for team members are detailed in the right part of Figure 5. These actions include provision of backup behaviors and unsolicited information, especially when uncertainty arises (McIntyre & Salas, 1995) in order to keep shared situation awareness. Team members' behaviors that can lead to errors in the primary and the secondary survey include:

Team members:

- Do not verbalize their findings or fail to communicate necessary information (McIntyre & Salas, 1995)
- Are not flexible with their initial role and they do not accept new roles
- Try to help but they do not know what is going on with the patient
- Do not call for help when needed
- Take on the leader's role causing confusion on decision-making processes
- Do not monitor other team members' work in order to provide help or prevent mistakes
- Do not challenge leader's assumptions when needed (Fackler et al., 2009)
- Take on other team members' roles creating role ambiguities
- Challenge the leader in an obstructive way (Wallin et al., 2009, p. 139)
- Stand back and take a hands-off approach (Wallin et al., 2009)
- Perform task duties, but only on demand

Phase 4: Secondary Survey.

Before addressing the secondary survey, resuscitation efforts (performed in the primary survey) need to be well established and vital signs normalized. The general goal of the secondary survey is to identify and treat other/new injuries that were not addressed in the previous phase. Similarl to the primary survey, the procedures done during this phase have to be implemented in an orderly fashion and systematically (Driscoll & Skinner, 1990b) and if the patient deteriorates during any part of the secondary survey, the team should go back to primary survey.

The TL is responsible for directing a head to toe examination, which once again has to be performed in a particular order and completely with the purpose of identifying missing injuries (see Figure 13). Two major steps include the log roll of the patient to check for injuries in the back that might be related to internal bleeding or that might be compromising airway, in which case the team will have to address them immediately. However, before engaging in this step, team members have to make sure that it is safe for the patient to turn him. In some cases, neck injuries may difficult it or even compromise the movement of the patient. Team members should question if it is safe to turn the patient in all moments.

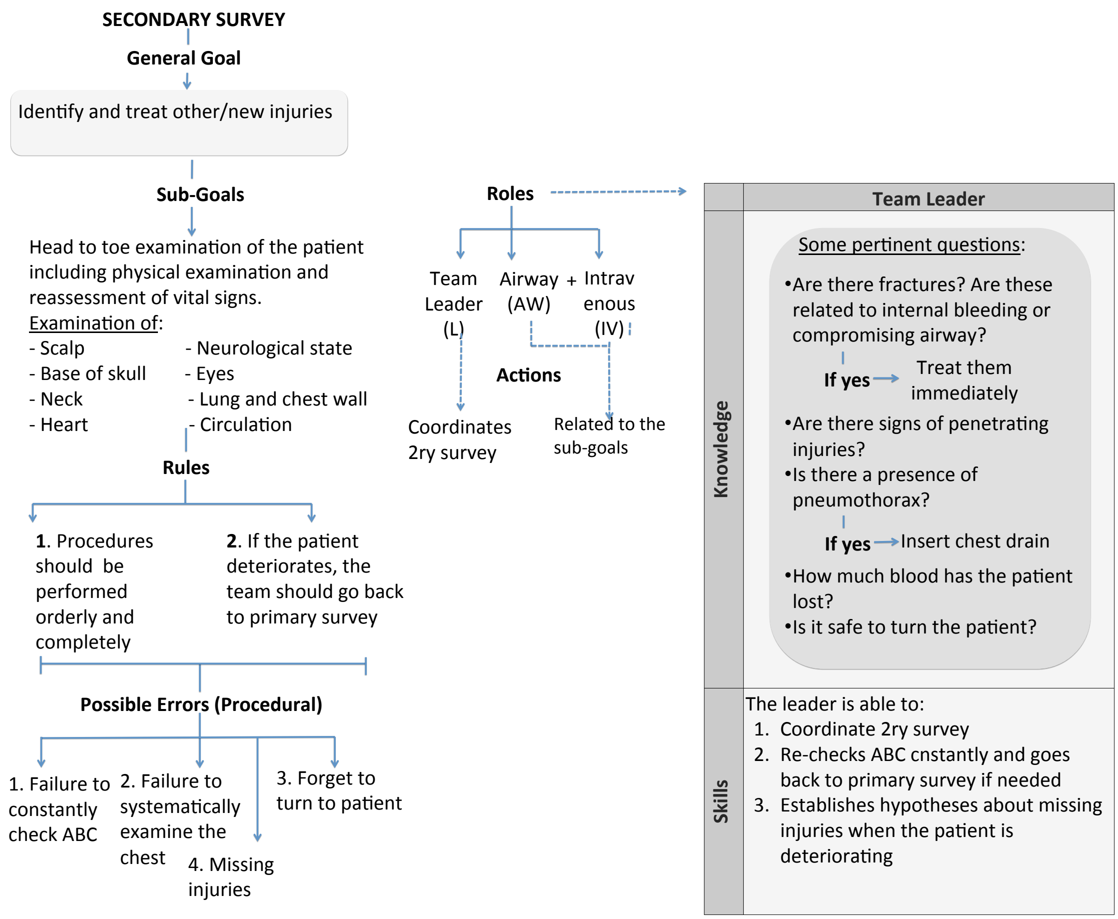


Figure 13. Summary of the cognitive analysis of the secondary survey phase.Note: Team members knowledge, skills and attitudes are not specified in this diagram, because they are the same than in primary survey (see Figure 12).

The second major step involves systematic examination of the chest in order to detect pneumothorax (collection of free air in the chest cavity), open pneumothorax (chest wall injury caused by stab or bullet wounds), fail chest, massive hemothorax (blood accumulating in the pleural cavity) and cardiac tamponade (Carrero & Wayne, 1989). In cases where pneumothorax is detected, team members should address it immediately with a chest drain in order to re-establish good breathing. Therefore, some possible errors include failure to constantly check ABC, failure to systematically examine the chest, forget to turn the patient and missing injuries (see Figure 13).

CHAPTER 4

RESULTS

This study examined and characterized the cognitive demands of team coordination in high (n = 3) and low (n = 3) performing military medical teams as they solved three team-based simulations. Performance indicators from the objective and subjective measures were used to identify the high and low performing team per simulation (see Chapter 3, performance measures). Only the teams that had consistently high and low scores in these two measures were retained for qualitative video analysis. A mixed methods approach was conducted. Research questions 1 and 2 addressed the qualitative and quantitative differences in coordination activities according to team performance (high and low) and task load (high and low). A coding system of forty-four behaviors pertaining to eight coordination strategies was developed. These strategies consisted of situation awareness, mutual trust in the leader and team members, closed loop communication, implicit coordination, mutual performance monitoring, adaptive and supportive behavior, and explicit communication. A total of 144 video segments (30 seconds each segment) from 6 cases were analyzed. We first examined the overall frequency of the coordination strategies employed by high and low performing teams, followed by an examination of the amount of high- and low- task load segments by teams in each simulation. Statistical procedures (e.g., independent sample t-test, R-MANOVA) were applied to test significant differences between high and low performing teams and high and low task load segments. Coordination activities performed by individual team members under high-load segments of the task were also analyzed.

Research question 3 and 4 addressed the team leaders' coordination strategies. For this purpose, a grounded theory approach was used and the conditions under which coordination strategies occurred were identified. A case study design that examined three simulations in depth was used to establish three models of problem solving activities during the different phases of the task.

Finally, research question 5 addressed how knowledge is shared among team members of high and low performing teams. A case study design was used again and a network analysis approach that measured knowledge similarity among team members was developed for each case. Research questions and results are presented next.

Research Question 1 and 2: What coordination activities do high and low performing teams implement when solving a trauma team-based simulation? To what extent are coordination activities different during high- and low-task-load periods of the task in high and low performing teams? To what extent do team members implement coordination activities differently during high-task-load?

Coordination Activities

An independent sample t-test was performed to compare the frequency of coordination activities in high and low performing teams. No significant results were found between high (M = 142.67, SD = 25.11) and low (M = 147.33, SD = 49.89) performing teams, $t(4) = -.145$, $p = 0.892$. This result suggest that the number of coordination activities performed by teams did not have an effect on the level of performance. However, a qualitative analysis, derived from video analysis, revealed that differences in the frequency with which these activities were performed. There was a trend towards a higher proportion of employment of coordination behaviors in high performing teams, except for simulation 1 (see Figure 14).

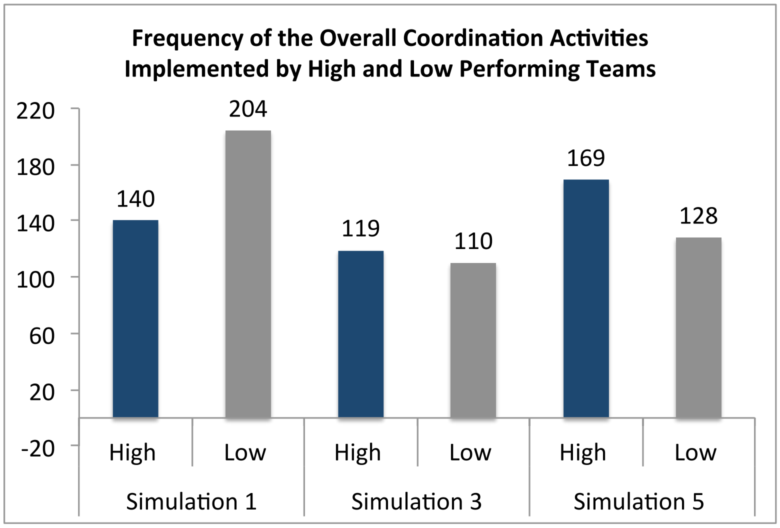


Figure 14. Frequency of coordination activities implemented by high and low performing teams in simulation 1, 3 and 5.

Figure 14 shows a breakdow of the overall frequency counts of coordination activities implemented by high and low performing teams in the three simulations examined. In simulation 3 and 5, high performing teams performed more coordination activities than the low performing teams (4% and 14%, respectively). Whereas, in simulation 1, the low performing team had a higher frequency of coordination activities (19% more) than the high performing team.

Descriptive statistics by coordination activities are shown in Table 14. Overall, high and low performing teams engaged more frequently in activities related to mutual trust in the team leader (M=33.67, SD=8.41) followed by situation awareness (M=29.00, SD=8.90) and explicit communication (M=25.50, SD=11.01). Slight differences were observed between high and low performing teams. For instance, while high performing teams tended to employ more situation awareness as a coordination strategy, less performing teams relied more frequently on mutual trust in the leader and explicit communication.

Table 14
Means and Standard Deviations of Coordination Activities According to Team Performance

			Team Performance			
	Overall		High		Low	
Coordination Activity	*M*	*SD*	*M*	*SD*	*M*	*SD*
Situation awareness	29.00	8.90	31.33	11.84	26.67	6.43
Mutual Trust (Leader)	33.67	8.41	31.67	2.89	35.67	12.50
Mutual trust (TMs)	21.33	5.68	21.33	2.08	21.33	8.73
Closed loop communication	8.33	5.75	8.33	2.52	8.33	8.73
Implicit coordination	13.50	6.89	13.00	3.00	14.00	10.44
Mutual performance monitoring	6.17	4.45	5.33	3.22	7.00	6.08
Adaptive and supportive behavior	7.50	3.94	7.33	2.08	7.67	5.86
Explicit communication	25.50	11.01	24.33	12.58	26.67	11.85

Further differences between high and low performing teams are addressed in the next section where coordination activities were discriminated in terms of task load (high and low).

Task-Load

In order to identify high- and low-task-load segments, three variables were calculated per team: the time spent in task, the number of segments (of 30 seconds each) and the average number of coordination activities (see Table 15). When the number of coordination activities per segment was over the average, this was coded as a high-load segment. High-load segments were therefore characterized by an increase in the coordination and situational demands. Below average segments were coded as low-load. Task load (high and low) was analyzed in terms of team performance (high and low).

Figure 15 provides a visual representation of how these variables were grouped for the purpose of analysis.

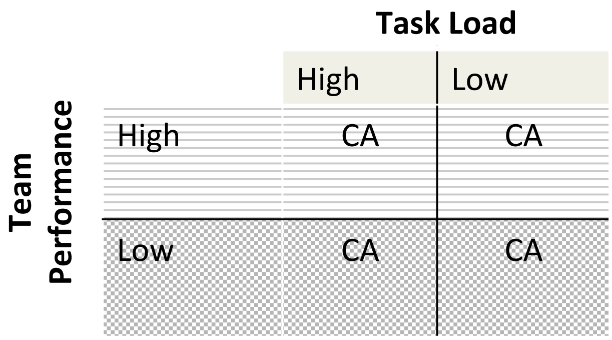


Figure 15. Visual representation of how coordination activities (CA) were examined according to team performance and task load.

Table 15 shows the percentage breakdown of the time spent in task by each team and the frequencies of task load segments (high and low) for high and low performing teams. Low performing teams spent overall more time for solving the simulations, except for simulation 3 where the high performing team spent slightly more time (43 seconds more) than the low performing team.

Table 15
Time Spent in Task by Teams and Frequency of High- and Low-Task-Load Segments

Team Performance	Time spent in task (No. of segments of 30 seconds each)	Average of Coordination Activities per Segment	Frequencies of High-Task-Load segments	Frequencies of Low-Task-Load segments
Simulation 1				
High	10:00 (20)	7.37	9 (45%)	11 (55%)
Low	15:26 (31)	7.03	14 (45%)	17 (55%)
Simulation 3				
High	10:73 (22)	6.10	11 (50%)	11 (50%)
Low	10:30 (21)	5.38	15 (71%)	6 (29%)
Simulation 5				
High	11:37 (24)	7.04	12 (50%)	12 (50%)
Low	12.75 (26)	5.00	11 (42%)	15 (58%)

The frequencies of high and low task load segments varied among teams and simulations. Largely, teams spent more than 42% of the total time in high-task-load segments. Interestingly, high performing teams tended to have fewer segments of high-task-load, except for simulation 5.

Frequencies of eight coordination activities were calculated for high- and low-load segments for each team (see Figure 16) Coordination activities included: (1) Explicit communication, (2) adaptive and supportive behavior, (3) mutual performance monitoring, (4) implicit coordination, (5) closed loop communication, (6) mutual trust in team members, (7) mutual trust in the team leader and finally (8) situation awareness.

As we see from Figure 16 in low-task-load segments, teams engaged primarily on mutual trust in the leader, followed by explicit communication and situation awareness. According to Grote and Zala-Mezö (2004), explicit communication is more frequently observed during low task load where there is not time pressure and team members have the time to create a common picture of the situation, otherwise called situation awareness. In the coding scheme of the present research, situation awareness was also supported by actions related to trust in the leader (e.g., team leader’s willingness to share his/her thought process). Other coordination activities such as closed-loop communication, mutual performance monitoring and adaptive and supportive behavior were the less frequent during low-task-load. This result was expected, since the literature has shown that these coordination strategies become increasingly more important during high-task-load where unexpected deviation of actions take place and the team to engage in stressful tasks (Salas et al., 2005).

Teams employed overall the same coordination activities to manage high -task-load segments; however, the proportion was significantly different. Mutual trust in the leader continued to be a peak, whereas, situation awareness was slightly more frequent and explicit communication less frequent in comparison to low-task-load.

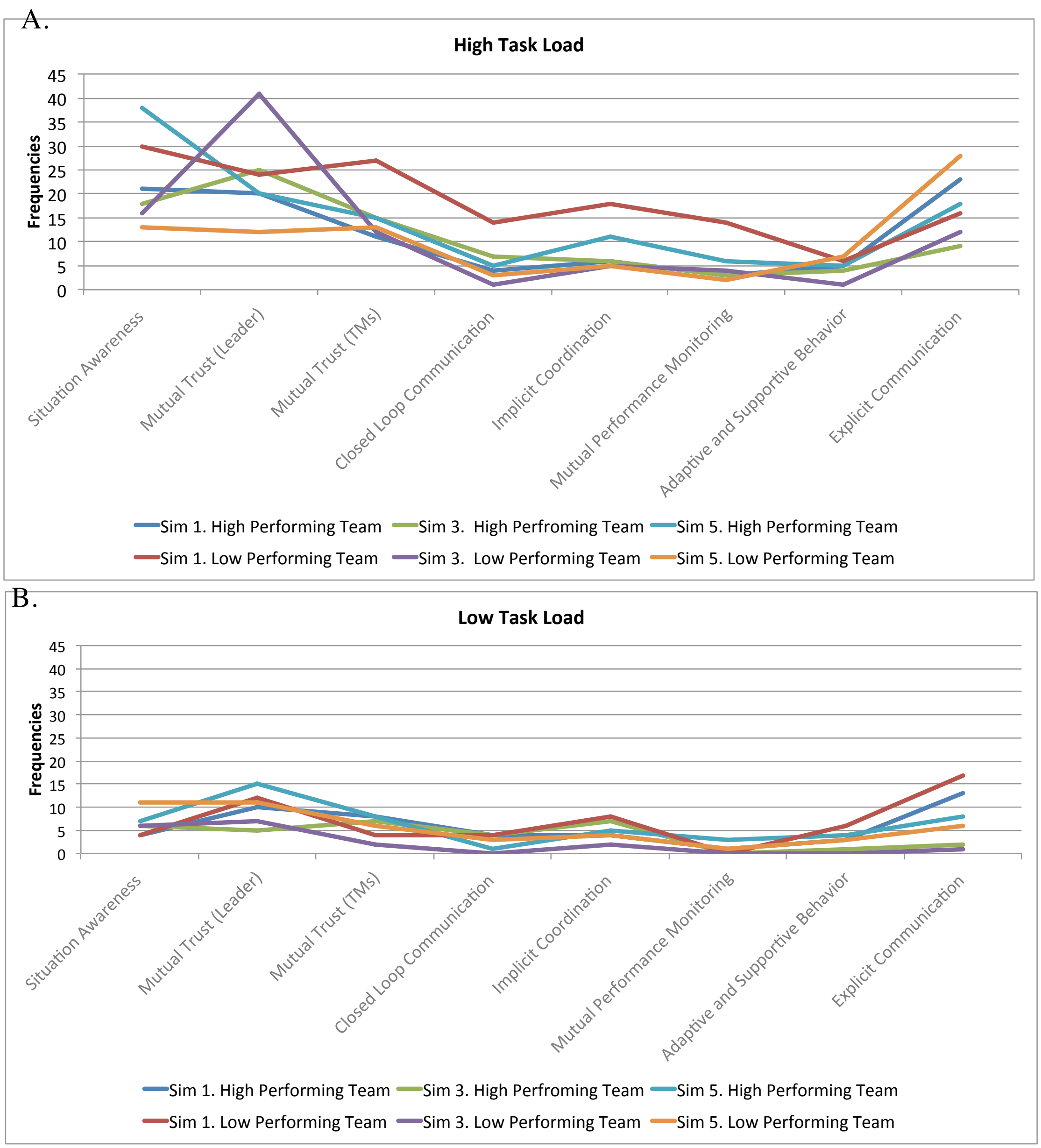


Figure 16. Frequency distribution of coordination activities implemented by high and low performing teams during high (a) and low (b) task load**.**

The fact that overall explicit communication remained one of the three more frequent actions was unexpected as the literature has shown that implicit communication increases when task load rises and there is no time to coordinate explicitly (see Chapter 2, under coordination in dynamic action teams). However, some increase in the frequency of implicit coordination was observed in the high performing team on simulation 5 and the low performing team on simulation 1.

Although, we expected closed-loop communication, mutual performance monitoring, and adaptive and supportive behavior to be more frequent during high-task-load in comparison to low task load segments, this was not the case and only a slight increase was observed. Some differences in the proportion with which coordination activities were implemented by high and low performing teams during high-task-load periods of the task are worth mentioning.

For instance, in simulation 1, the high performing team managed high task load segments of the task by increasing explicit communication behaviors, followed by situation awareness, and trust in the leader. Whereas, the low performing team managed these periods by increasing coordination behaviors related to situation awareness and team members' mutual trust followed by leader's mutual trust. Overall, the low performing team implemented a higher proportion of coordination activities to manage high-load-periods of the task than the high performing team.

Contrary to simulation 1, in simulation 3, the high performing team implemented a higher proportion of coordination activities to manage high-task-load segments in comparison to the low performing team. The former team engaged mainly on leader's mutual trust, followed by situation awareness and team members' mutual trust. Whereas the low performing team significantly increased leader's mutual trust, followed by situation awareness, team members' mutual trust and explicit communication.

In simulation 5, the high performing team performed far more coordination activities to manage high-task-load segments in comparison to the low performing team. The former engaged more frequently in actions related to situation awareness, followed by leader's mutual trust and explicit communication. In contrast, the low performing team managed high-load segments of the task by increasing explicit communication followed by team members' mutual trust, situation awareness and leader's mutual trust.

A repeated measures analysis of variance was performed to examine differences in coordination activities between high- and low-task-load-segments and teams with high and low team performance. The within-subjects factor was coordination activities (8 levels). The between subjects factors were team performance (2 levels: high and low performance) and task-load (2 levels: high- and low-task load). Results showed a statistically main effect of coordination strategies $F(7, 2) = 44.13$, $p = .022$, partial $\eta^2 = .99$, suggesting that there was a significant variation between the frequencies of the eight coordination strategies. However, the interaction effect between coordination activities, team performance and task-load was not significant, $F(7, 2) = 1.99$, $p = .38$, partial $\eta^2 = .99$.

In order to know whether there were differences in coordination activities in individual teams during high- and low-load segments of the task, a within subject analysis was performed. As the assumption of sphericity was violated, Mauchly's test of sphericity $p < .05$, Greenhouse-Geisser corrective coefficients were reported. The results showed a significant interaction effect between coordination activities and task load, F(7,

56) = 3.40, p = .042, partial η^2 = .30. This result affirmed that the frequency of coordination activities significantly changed witin teams during high- and low- load segments of the task. A significant quadratic trend was observed between cloosed loop communciation, implicit coordination, mutual performance monitoring, and adaptive behavior, $F(1, 8) = 10.66$, p = .000. This trend indicates a U-shaped relationship between these coordination activities and task load (see Figure 17). Figure 17 shows that teams tend to increase implicit coordination while reducing mutual performance monitoring behaviors during high-task-load.

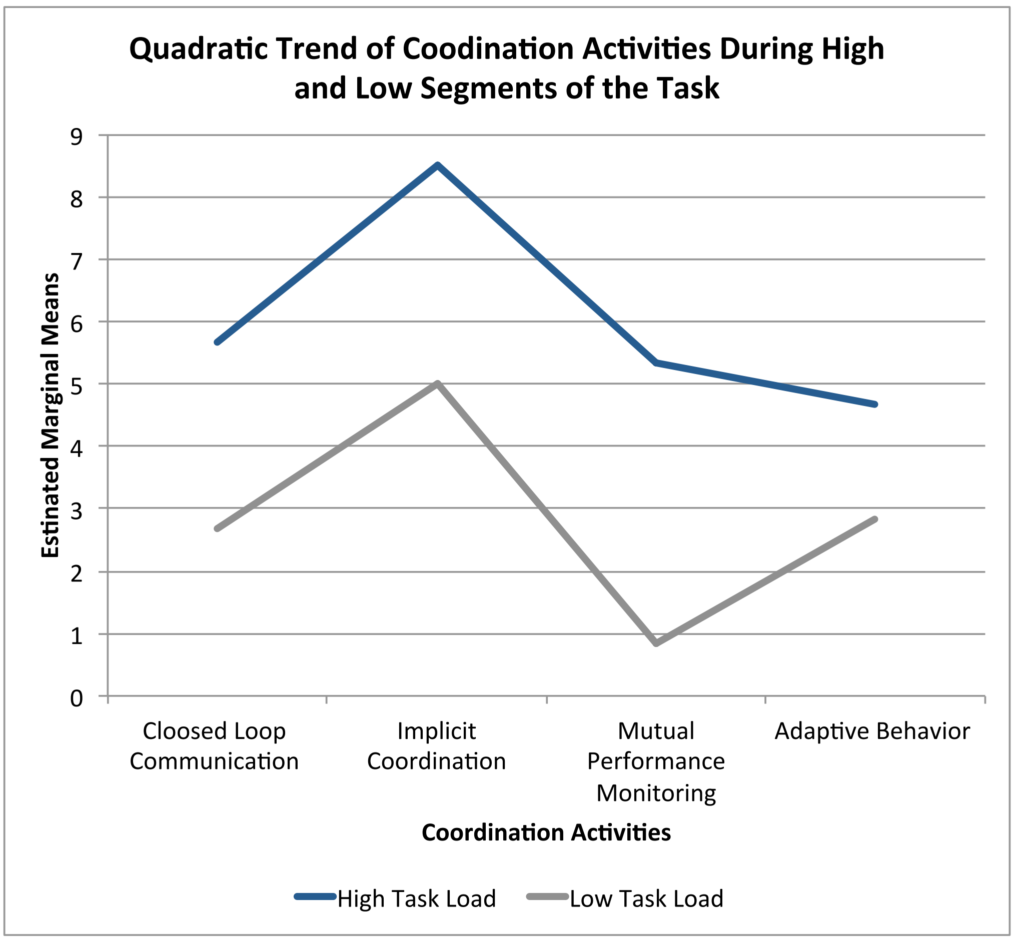


Figure 17. Quadratic trend of coordination activities during high-and low-task-load segments.

Coordination activities performed by the individual team members under high-task-load. Table 17 shows the frequencies of coordination activities carried out by individual team members of the six teams during high-task-load periods of the task. We found that team leaders performed a higher proportion of coordination activities (see highlighted information on Table 17), with the exception of the low performing team on simulation 1. In the latter the higher count of coordination activities was for the person playing the airway position (46%), who had an active role in trying to understand why the patient was deteriorating. Since the literature has recurrently highlighted the importance of the leader in coordinating the team actions (Kozlowski, Watola, Nowakowski, Kim, & Botero, 2009; Webber, 2002; Y. Xiao, Seagull, Mackenzie, & Klein, 2004), this result was expected.

Frequencies and proportion of coordination activities performed by individual team members under high-task-load segments are shown in Table 17. Overall, these results revealed that individual team members with the higher count of coordination activities engage more frequently in actions related to team leader's mutual trust, situation awareness and explicit communication.

Bivariate correlations between the coordination activities performed by individual TMs were calculated. Results showed that the lowest correlation, with a weak magnitude, was between closed loop communication and situation awareness ($p = .04$) (this correlation was not significant) (see Table 16). Conversely, the highest correlation, with moderate magnitude ($p > 0.4$ and < 0.7), was between situation awareness and leader's mutual trust ($p = 0.55$), situation awareness and explicit communication ($p = 0.48$). The results also showed significant positive correlations, with strong magnitude ($p > 0.7$ and

< 0.9), between implicit coordination and TMs' mutual trust (p = 0.78) and implicit coordination and mutual performance monitoring (p = 0.72). A significant negative correlations between team members' trust and leaders' trust (-.650) is worth to note, as this indicates that when team members' behaviors related to trust increase, the leader's behaviors related to trust decrease and vise versa. This finding indicates that team members compensate for leaders' lack of trust behaviors, and that in the case when team members lack trust behaviors, leaders tend to compensate for those as well.

Table 16

Correlation Between Coordination Activities Performed by Individual Team Members

	1	2	3	4	5	6	7	8
1. Situation awareness	1.00							
2. Mutual trust (Leader)	.554*	1.00						
3. Mutual trust (TMs)	-.153	-.650**	1.00					
4. Closed loop communication	.044	.286	-.122	1.00				
5. Implicit coordination	.229	-.301	.778**	.204	1.00			
6. Mutual performance monitoring	.470*	-.101	.523*	.331	.715**	1.00		
7. Adaptive and supportive behavior	-.038	-.522*	.695**	-.193	.619**	.261	1.00	
8. Explicit communication	.476*	.519*	-.461*	-.064	-.197	-.107	-.285	1.00

Notes: * $p < 0.05$; ** $p < 0.01$; n = 20 individual team members

Table 17

Frequency of Coordination Activities Carried Out by Individual Team Members During High-Task-Load Periods of the Task

		High Performing Teams				**Low Performing Teams**			
Sim.	**Coordination Activity**	**L**	**AW**	**IV1**	**IV2**	**L**	**AW**	**IV1**	**IV2**
1	*Coordination actions*	52 (56%)	8 (9%)	19 (20%)	14 (15%)	49 (33%)	69 (46%)	31 (21%)	-
	Situation Awareness	18	-	2	-	3	24	3	-
	Mutual Trust (Leader)	20	-	-	-	24			-
	Mutual Trust (TMs)	-	2	4	5	-	15	12	-
	Closed Loop Communication	2	1	-	1	10	2	2	-
	Implicit Coordination	1	-	3	2	3	11	4	-
	Mutual Performance Monitoring	1	-	1	1	3	8	3	-
	Adaptive and Supportive Behavior	-	2	1	2	-	4	2	-
	Explicit Communication	9 (10%)	3	8	3	6	5	5	-
3	*Coordination actions*	55 (63%)	8 (9%)	24 (28%)	-	64 (70%)	18 (20%)	10 (11%)	-
	Situation Awareness	18	-	-	-	14	2	-	-
	Mutual Trust (Leader)	25	-	-	-	41	-	-	-
	Mutual Trust (TMs)	-	4	11	-	-	7	5	-
	Closed Loop Communication	4	1	2	-	-	1	-	-
	Implicit Coordination	1	-	5	-	1	2	2	-
	Mutual Performance Monitoring	2	1	-	-	-	4	-	-
	Adaptive and Supportive Behavior	1	-	3	-	-	-	1	-
	Explicit Communication	4	2	3	-	8	2	2	-
5	*Coordination actions*	61 (52%)	33 (28%)	24 (20%)		32 (39%)	17 (20%)	22 (27%)	12 (14%)
	Situation Awareness	27	10	1		6	2	4	1
5	Mutual Trust (Leader)	20	-		-	12	-	-	-
	Mutual Trust (TMs)	-	6	9	-	-	5	4	4
	Closed Loop	-	4	1	-	1	-	1	1

Table 17

Frequency of Coordination Activities Carried Out by Individual Team Members During High-Task-Load Periods of the Task

		High Performing Teams				**Low Performing Teams**			
Sim.	**Coordination Activity**	**L**	**AW**	**IV1**	**IV2**	**L**	**AW**	**IV1**	**IV2**
	Communication								
	Implicit Coordination	1	5	5	-	-	-	4	1
	Mutual Performance Monitoring	2	3	1	-	-	1	1	-
	Adaptive and Supportive Behavior	1	1	3	-	-	3	3	1
	Explicit Communication	10	4	4	-	13	6	5	4

Note: Sim. = Simulation; L = Leader; AW = Airway; IV1 = Intravenous1; IV2 = Intravenous 2.

Research Question 3. In what conditions do leaders' coordination behaviors occur? What is the relationship between leaders' coordination behaviors and the conditions in which they occur?

Axial coding was performed to examine the concurrent conditions under which three coordination behaviors occurred, namely situation awareness, leader's mutual trust and explicit communication. These coordination behaviors were the most significant in the above analyses. Nine conditions were identified throughout individual transcripts of six video-records consistent of 144 segments of 30 seconds each: (1) Monitoring TMs' actions, (2) decision-making about patient procedures and TMs' roles/tasks, (3) identification of general injuries and the mechanism of injury, (4) listing procedures done, (5) checking vital signs, (6) deterioration of vital signs, (7) asking for help; (8) sharing leadership, and (9) performing procedures. Description of the conditions and examples are shown in Table 18.

Table 19 shows an aggregated matrix for high (*n* = 3) and low performing teams (*n* = 3) with the frequencies of occurrences of the observed relationships in the segments analyzed. This table shows that high performing teams implement significantly more behaviors related to situation awareness (266) than low performing teams (97). Besides, this table shows that the leaders of high performing teams engage more frequently in decision-making about patient procedures (145) and performing procedures (118). Under these conditions, they tend to perform coordination behaviors related to situation awareness (266) and mutual trust (276). Similarly, the team leaders of low performing teams engaged more frequently in decision-making about patient procedures (112) and checking vital signs (74). Unlike the leaders of high performing teams, the leaders of low performing teams tend to perform coordination behaviors related to mutual trust (278) and explicit communication (113).

Table 18
Description of the Conditions and Examples Identified in Axial Coding

Condition		**Example**
1. Monitoring TMs actions		"Did you put chest tube on the right side?" "What's my SATs? Pressure?"
2. Decision-making	2.1 About patient procedures	"I want you to secure the pelvis" "We need to intubate and put chest tubes on both sides" "I'm gonna make surgical airway" "We're going to put a dressing on this wound here on the right thigh"
	2.2 About (TMs roles)	"AW, take care of the airway. IV take care of the IVs" IV has finished with IVs and AW has been doing CPR for a while. In this situation the team leader says "IV, AW is getting tired, switch with AW and take over compressions" "AW, expose the patient"
3. Identifying injuries	3.1 General injuries	"OK, let's see the right leg and see if there's any fracture causing hypotension" The patient has been rolled and the leader says: "We're looking for a whole" The patient has been rolled and team leader is examining and says: "There's a rectal damage as well. I see blood on the rectum"
	3.2 Identifying the mechanism of injury	"I'm really worry about a ventilation injury here"
4. Listing the procedures done		"We have two chest tubes in, we have secure the pelvis, we have no other injuries on him"
5. Checking vital signs		"Check that the airway is good" "Check pressure" "O2SAT is 83, that's not good" "SAT is 94, pulse is good, pressure is 90/48"
6. Deterioration of vital signs		"He is hypotensive, shock oppress"

7. Calling for help	“I'm going to call anesthesia to intubate him”
8. Sharing leadership	The person playing the airway (AW) position tells the leader (L): W: “You wanna try more epi?” and the leader answers L: “Yeahp” AW: "I think you should set the airway for good". L: OK, so I'm going to intubate W: L, can we think about carbon monoxide poisoning maybe? L: We're gonna call the lab for that, we're gonna get the labs done and we're gonna get the carbon monoxide level as well.
9. Performing procedures	The team leader is hearing the chest, bagging airway, or placing chest tubes

Independent sample t-tests were performed to compare high and low performing teams in the nine conditions under which the three coordination behaviors occurred. There was a significant difference in identification of general injuries that favored high (M=10.89, SD=7.36) over low performing teams (M = 4.22, SD=3.11). As the Levene’s test for equality of variances for general injuries was violated, we report the modified test for equality of variances not assumed; $t(10.8) = 2.50$, $p = 0.03$. There was also a significant difference in identification of the mechanism of injury for high (M=3.00, SD=2.30) and low performing teams (M=0.78, SD=1.39). Assumptions of equality of variance, as tested by Lavene’s test, were met for mechanism of injury; $t(16) = 2.49$, $p =$ 0.02. There were no a significant differences between high and low performing teams in the rest of the conditions.

In addition, a stepwise regression analysis was conducted, following a forward selection, to evaluate the effects of the nine conditions on overall team performance. In the forward selection, the effect of each predictor is assessed and only those that add significance to the model are retained, the others are excluded (Brace, Kemp, & Snelgar, 2006). A model with only the "identification of general injuries" predictor was significant, $b = .059$, $t(16) = 2.89$, $p < .05$. Identification of general injuries accounted for 34.3% of the variance in performance, $R = .586$, $R^2 = .343$, $F(1,16) = 8.37$, $p < .05$. None of the other predictors had a significant effect on team performance.

Table 19

Aggregated Matrix with the Links and Frequencies of occurrences of Coordination Behaviors (vertical) and the Conditions under which they Occurred (horizontal)

		Decision-Making about		**Identifying Injuries**								
	Monitoring TMs’	**Px. Treat.**	**TMs’ roles**	**Gral**	**Mech. injury**	**Listing treat.**	**Checking vital signs**	**Det. of vital signs**	**Asking for help**	**Shared Leadership**	**Performing procedures**	**Total**
High Performing Teams												
Situation Awareness	16	61	20	42	14	16	29	3	4	10	51	**266**
Mutual Trust	13	60	48	43	8	16	24	2	5	7	50	**276**
Explicit comm.	12	24	9	13	5	4	11	2	-	5	17	102
Total	41	**145**	77	**98**	27	36	64	7	9	22	**118**	644
Low Performing Teams												
Situation Awareness	9	26	6	6	2	10	17	2	6	3	10	97
Mutual Trust	15	68	39	22	1	30	39	2	6	17	39	**278**
Explicit comm.	15	18	14	10	4	11	18	3	3	4	13	**113**
Total	39	**112**	59	38	7	51	**74**	7	15	24	**62**	488

Note: Px. Treat = patient treatments/procedures; TMs roles = team members roles; Mech. Injury = Mechanism of injury; Det. Of vital signs = deterioration of vital signs.

Research Question 4. What problem activities do team leaders'engage in at different phases of the task?

Models of the team leaders' problem solving activities were depicted for each simulation. Models were represented in time-stamped flow diagrams (Xiao & LOTAS, 2001). These models schematically illustrate the different ways in which leaders handle the cases and the choices of action they followed throughout the different phases of the task. The models depicted in the team CTA for each phase and the decision trees created by the instructors for each simulation served as blueprint and informed the following analysis (see Methodology in Chapter 3).

Models of team problem solving activities were characterized accordingly to major themes identified into each simulation:

Simulation 1: Recognizing the mechanism of injury

Simulation 2: Identifying and interpreting relevant information

Simulation 3: Identifying the right moment to call for help

Models of Team Leader's Problem Solving Activities

Simulation 1: Recognizing the mechanism of injury. Simulation 1 confronted participants with a casualty caught in a land mine, who was found 10 meters from explosion. In this case the primary mechanism of injury was a blunt chest trauma. This type of trauma is characterized by a significant acute respiratory distress where breathing and most likely ventilation are seriously compromised. The main conditions to assess within the primary survey include tension pneumothorax (collection of free air in the chest cavity), open pneumothorax (chest wall injury caused by stab or bullet wounds), flail chest, massive hemothorax (blood accumulating in the pleural cavity) and cardiac tamponade (Carrero & Wayne, 1989). Assessment and immediate correction of these conditions during the primary survey are a must in order to prevent rapid death (Carrero & Wayne, 1989). Assessment involves physical examination including inspection, palpation, percussion and auscultation of chest.

Teams were expected to perform four procedures to solve the simulation: Bag-mask, IV fluids, chest tube and intubation (see more details in the methodology section under team-based scenarios). Flow diagrams show that the high performing team implemented four out of the four procedures and even went ahead with extra procedures (e.g. wrapped pelvis), whereas the low performing team implemented only two namely IV and bag mask.

Both teams expended a short period of time (30 seconds) in the handover phase (see Figure 18). Team leaders and TMs attentively listened to the paramedic with no disruption of clinical work (as was indicated before in this chapter under the cognitive model of trauma team interventions). However, only the leader of the former team evoked this information later during the case to establish hypotheses.

Excerpt 1

(2:30 minutes has passed since the patient arrived)

L: He is hypotensive and there is no air entry on the left side. I'm assuming that the patient inhaled smoke

The analysis of these models (see Figure 18) also revealed that in an initial phase of the primary survey, the team leaders of both high and low performing teams systematically assigned roles to TMs, checked vital signs and performed physical examination. However, only two minutes later the former leader quickly (in the first 2 minutes) and accurately interpreted information from the physical examination.

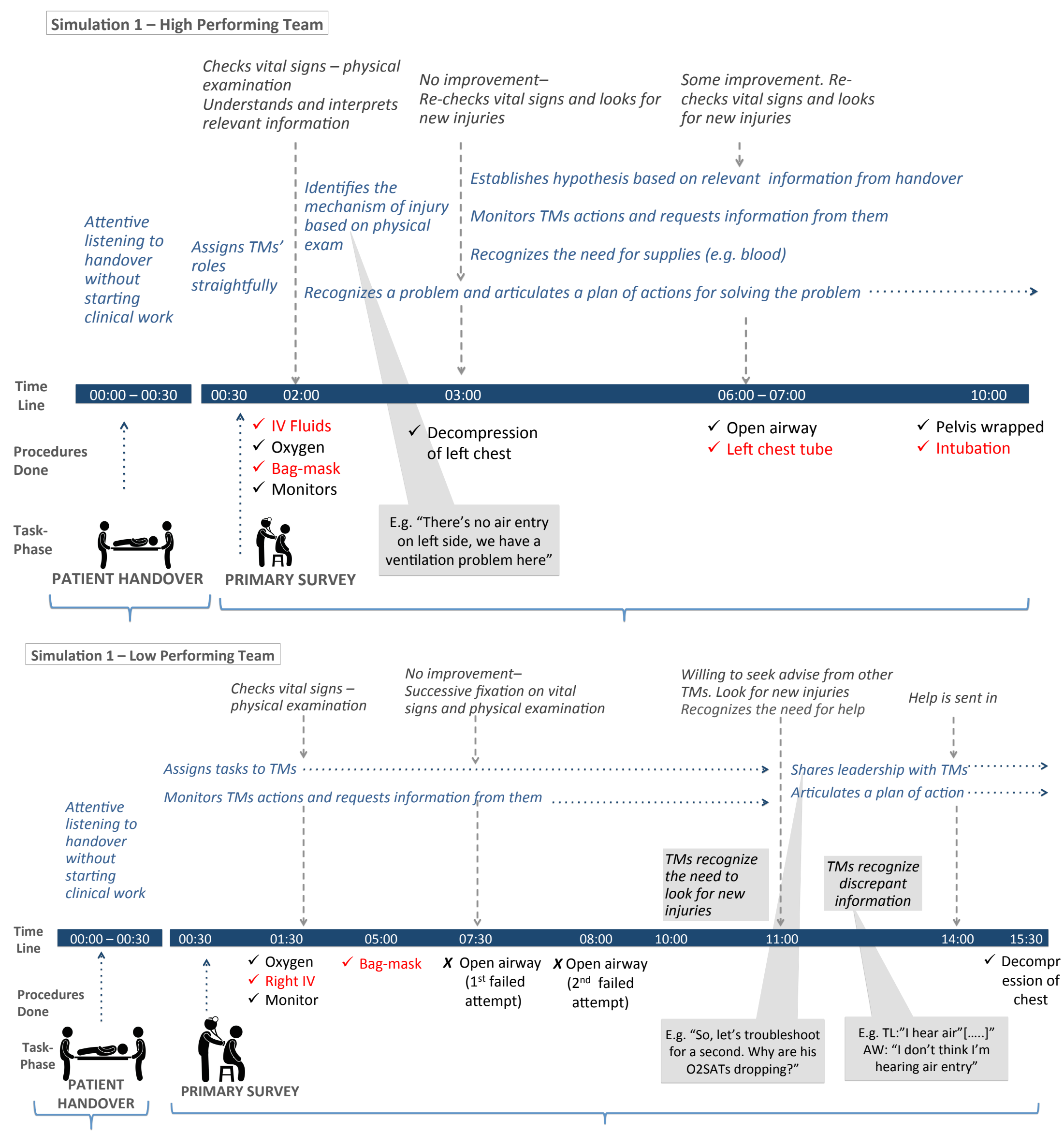


Figure 18. Model of team leaders' problem solving activities in simulation 1. *Note*. Text in red indicates the most relevant procedures that teams were expected to perform. The procedures that are in black letters are extra-procedures performed by teams.

The leader of the high performing team established the main mechanism of injury (chest trauma injury) early on, which guided the articulation of a plan and a further line of actions (e.g., decompression of the chest, chest tube, etc.). Excerpt two illustrates how the leader (L) engaged in this sequence of actions.

Excerpt 2

(2 minutes have passed since the patient arrived)

L: OK, he is been put on monitors, we have an IV going on, he is on oxygen, our O2SATs is 81 he started 88.

(Patient is coughing, he has labored breathing).

L: Looks like we have a problem in the lung

(The L listens the patient's chest and while doing so talks to TMs)

L: Ok, there is no air entry on the left side, we have a ventilation problem here, we need to put a needle to decompress the left part of the chest

When no improvements were observed in the patient, he recursively went back to assess vital signs, look for new injuries and implement treatment.

Excerpt 3

(4:30 minutes has passed since the patient arrived)

L: So, lets check what we have here, we have him on oxygen, SAT is 89, we decompressed the left part of the chest, the chest is not moving equally and we got air back. So, we have to put a chest tube on the left side

(30 seconds later)

L: While you guys are doing that, I'm going to feel the belly.

(The L examines the belly and reports back to TMs)

L: Soft, he is not moaning. I don't feel any tenderness or instability [….]

L: Ok, the pelvis is stable, no tender. Let's see if he has any blood coming from the annus

(30 seconds later)

L: OK, this guy is already on oxygen, we have opened airway

(IV1 adds to what L is saying)

IV1: SAT is down

L: Yes, exactly.

(L continues listing the procedures done so far)

L: We have a chest tube on the left side, I think I need to intubate, we need to open airway.

On the other hand, the leader of the low performing team was successively fixated on listing the vital signs that were dropping without looking for new injuries or establishing hypotheses.

Excerpt 4

(3:30 minutes have passed since the patient arrived. The patient has been hooked up to monitors and oxygen and there is one IV going. The patient stopped coughing 30 minutes ago)

L: Sr. can you please open your eyes? Can you hear me? (Patient did not react)

(4:00 minutes)

L: O2SAT is still 88

(4:30)

L: I'm not happy with that O2SAT there (looking at the monitors), is still at 88

(L moves to the top of the bed to bag air)

Qualitative video analysis revealed that although this leader systematically returned to check vital signs and to perform physical examinations when the patient did not show improvements, he was not accurately interpreting cues that indicated that the patient was experiencing an acute respiratory distress. The leader listened to the patient's chest nine times before performing decompression of the chest at the very end of the scenario. Cues were given to each team starting with the handover when the paramedic informed the leader that the patient was caught in a land mine and found 10 meters from the explosion (see more details in Chapter 3, under team-based scenarios). In addition, the patient kept coughing indicating labored breathing and there was no air entry on the left side of the chest. The leader interpreted the difficulties in breathing and the dropping of vital signs as an airway difficulty rather than a chest trauma. This interpretation misled all his efforts to intubation and got him fixated leaving aside the main mechanism of injury and the conditions to be checked (e.g. pneumothorax). Excerpt 4 exemplifies this situation.

Excerpt 5

> *(15:00 minutes have passed since the patient arrived. A senior consultant [C] was sent in to trigger TMs in the right direction. In the following excerpt the leader [L] is informing the consultant about what was done)*
>
> *L: We tried intubating him, but no luck. His O2SATs kept dropping; we could not get them up. We tried intubation; the tube was in the right place. We thought the chest was arising initially, but we seem to not have good luck with airway. There's no sign of bleeding.*
>
> *C: You couldn't get the tube in the airway? What was the issue with intubation?*

L: Well, we thought it was the airway, but the O2SATs kept dropping… I don't know what we tried to do (he seems confused) we tried intubating him, right? (He asks to TMs)

An accurate initial assessment of patients vital signs and injuries is a crucial prerequisite for an adequate management of trauma patients (Stahel, Schneider, Buhr, & Kruschewski, 2005). In the case of the team leader of the low performing team, the establishment of priorities for patient care were disrupted due to the fact that the leader interpreted findings from physical examination inaccurately. He erroneously and repeatedly reported to the rest of the team that there was air entry from both sides of the chest. The team member playing the airway (AW) position, who was eager to find the cause of deterioration, challenged the team leader to find the cause of the deterioration of the patient. This member undertook the physical examination and disproved the team leader's findings. Excerpt 6 exemplifies this situation.

Excerpt 6

(15:00 minutes have passed after the patient arrived a consultant [C] surgeon is sent in to trigger TMs in the right direction)

C: (asking to AW) You couldn't hear any air entry?

AW: I could not

C: On both sides?

L: When I looked at his chest I heard air entry on both sides

AW: But even now? (AW checks the chest). I only hear air entry on the right side

L: Well, that's OK. [.....] Grab a 14-gauge needle to decompress chest.

Not surprisingly, the higher count of coordination activities in Table 2 came from this member (AW) who actively looked for new injuries and encouraged the team leader to communicate with the rest of the team about the ABC algorithm at different points in the patient management (see Excerpt, 7, 9 and 10).

Excerpt 7

(4:00 minutes have passed since the patient arrived, AW seems lost and without a clear role)

AW: (asks to the L) Where are you now? (She is asking in what part of the primary survey he is)

(4:30)

AW: (asks again to the L) Sorry, where are you? Have you done…? (She does not finish)

Excerpt 8

(9:30 patient is not improving)

AW: (talking to the L) We 're down to 78 (referring to the SAT). So, I'm thinking that perhaps we're not in the right place (referring to the tube to open airway). Do you hear any air? (Coming from the lungs)

L: (he is checking chest) Yep, I hear air

(10:00 patient keeps deteriorating)

AW: (talking to the L) Are we bleeding somewhere? Our pressure is down to 85

L: (talking to AW) Put another IV [.....]

AW: Are we bleeding from somewhere?

Excerpt 9

(11:00 minutes have passed since the patient arrived – patient continues deteriorating)

AW: How is airway? His O2 SATs dropped unexpected […….]

AW: (is checking for other injuries) I'm having a low pulse here (in the right hip)

AW: Cause, he is getting tacky, his pressure is down and his SATs are crappy

L: All right

Excerpt 10

(12:00)

IV: It's hard to bag him, I think there's something wrong

L: OK..

AW: (hears chest) His chest, I don't think I'm hearing air entry

L: OK, let ummm (he is thinking and does not finishes the sentence)

[….]

AW: I think he's getting hypotensive

L: (is at the top pumping air) Yes, I know, I'm just trying to pop air a little bit there, look at his chest again, do you hear anything

The leader assumed a shared leadership style to manage fixation (see Excerpt 11). However, TMs' ideas were not followed by the TL and were not effectively transferred into action to manage the patient.

Excerpt 11

(11:00 minutes have passed since the patient arrived)

L: So, let's troubleshoot for a second. Why are his O2SATs dropping?

AW: Circulation issues?

L: OK

AW: Maybe he is bleeding somewhere

AW: Is the air quite open? [….]

Simulation 3: Iidentifying and interpreting relevant information. Simulation 3 confronted participants with a casualty (mannequin simulator) that was part of a platoon attacked by a suicide bomber. The primary mechanism of injury was an agonal thoracic trauma. An agonal trauma patient is a patient who has lost cardiac output short time ago in which case, resuscitation must be attempted within the first minutes.

Thoracic trauma is a chest injury in which similarly to simulation 1, physicians must assess and correct quickly airway obstruction, tension pneumothorax, cardiac tamponada, massive hemothorax, open pneumothorax and frail chest. In this scenario, the patient exhibited left hemothorax with persistent bleeding and right pneumothorax, liver and spleen injury, bleeding from thigh wound and an ongoing bleeding from thorax and abdomen. The paramedic informed participants that he did not have the time to put an IV. Participants were expected to rapidly address the seven following procedures: bag mask, intubation, IV and fluids, chest tube, secondary survey, rapid infuser and call for surgery for a diagnostic peritoneal lavage (DPL).

Figure 19 shows the model of the team leaders' solving activities in simulation 3. Only slight differences are seen between these models in terms of the procedures performed. For instance, the low performing team performed the bag-mask, the IV and the chest tube within a minute and half of difference in comparison to the high performing team. Nevertheless, the scenario presented participants with an agonal patient who needed intervention quickly and for whom minutes of difference in establishing procedures may cause death.

Both leaders recognized the need for extra-help in the team for CPR. Teams were composed of three members and CPR is a procedure that needs to be constant and therefore a TM had to be allocated for that exclusive position. This situation left teams with two functional members including the team leader, who should ideally be managing the team and not performing procedures (Hodgetts & Turner, 2006). The team leader of the high performing team called for help after 2 minutes have passed whereas the leader of the low performing team did so after 4:30 minutes had passed. This situation forced the leader of the low performing team to get involved in CPR procedures, which created a diffusion of responsibility and limited her managerial role. The leader soon went back on track and asked IV to take over the CPR.

The IV position who was previously being asked to put IVs and did not have the time to do so. While doing CPR, IV was again asked by the leader to interrupt CPR and do a paperwork assuming that the patient was in a shock. As IV seemed a bit lost, the leader asked her to get some drugs and then take on CPR. Up to this moment, IV had not finished any of the tasks demanded by the leader. This could have been bacause the leader had not established clear priorities and had switched from IV, CPR, papers, drugs, etc., as it is shown in the following excerpt. . In addition, she was getting in the process of getting fixated with CPR (see Excerpt 12).

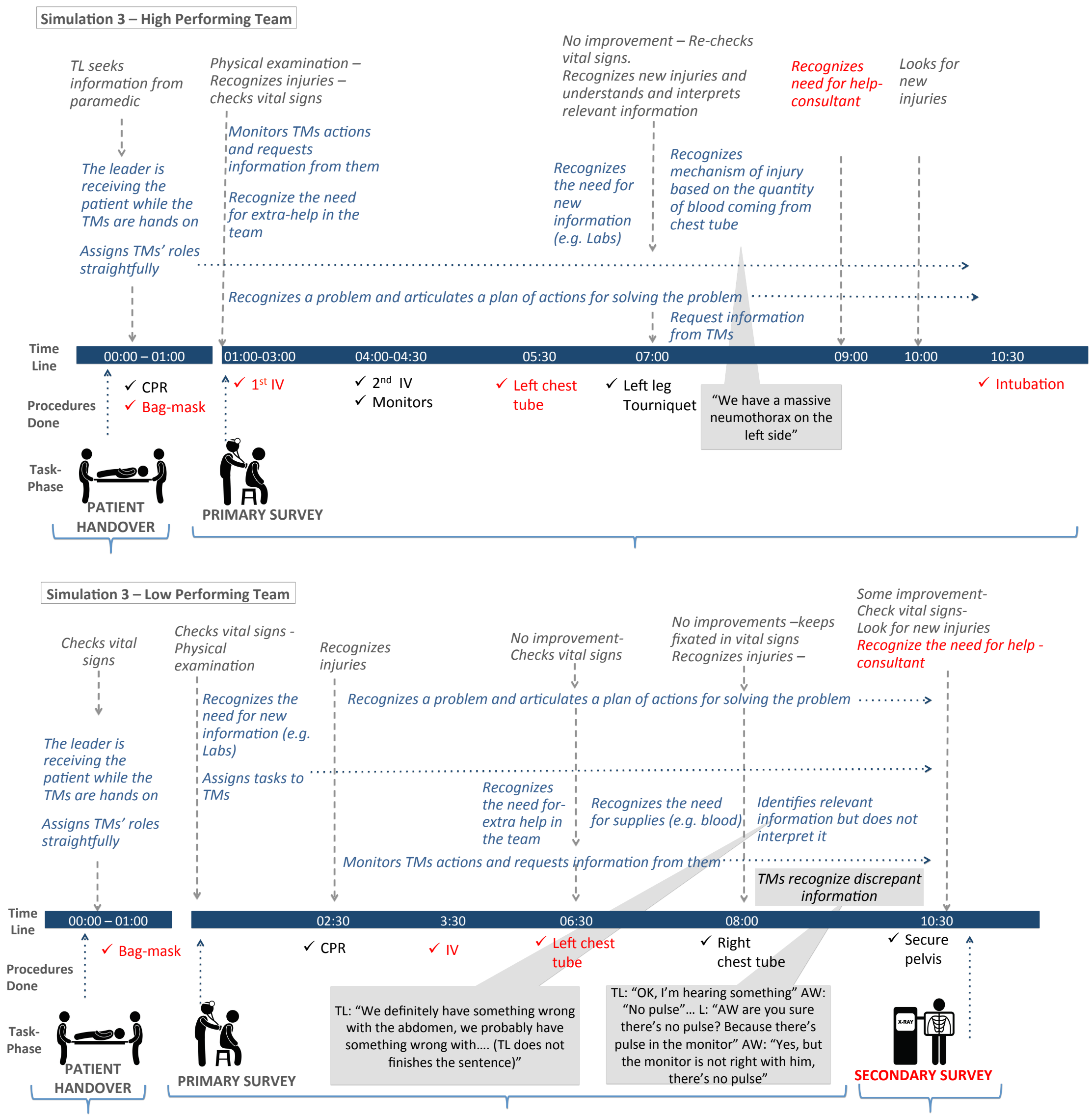


Figure 19. Model of team leaders' problem solving activities in simulation 3. *Note*. Text in red indicates the most relevant procedures that teams were expected to perform. The procedured that are in black letters are extra-procedures performed by teams.

Excerpt 12

(2:00 minutes have passed since the patient arrived)

L: (L is hearing chest and talking to IV) [….] No pulse. Ok, no pulse, no pulse on his arm, we need CPR. Stop that IV and start CPR […..] we do have pulse? Check the femos see what we have.

L: (is checking the patient's pulse on the neck and is also looking down to see the femos assessment) I see nothing (she says this from far, she is not close), what about you? You see anything?

IV: No

L: Continue CPR

AW: There's air entry on the bag

L: OK, now we're gonna need, we're gonna need (she does not finishes the sentence)

L: (talking to IV) We're gonna switch, get the IV in

IV: IV inserted

L: OK, I want you to switch now, but before we do this, he had a shock, we need to do the papers. Do the papers for me (IV seems lost. At this point the vital signs machine sounds). OK, go to the drawers, we're gonna need some drugs, epinephrine 1 mg.

There were differences in the way information was identified and interpreted and managed by team leaders of the high and the low performing team. The team leader of the high performing team got information from the paramedic about how long it had been since the patient lost consciousness, which cued him to implement CPR resuscitation right away from the handover and allowed TMs to realized that the patient was pulseless (see Excerpt 13)

Excerpt 13

(10 seconds have passed since the patient arrived – paramedic [P] is giving the handover)

P: [….] I have a pulse initially, it was 130 with breathing at 30

L: (talking to IV) IV start CPR. AW take care of airway

(30 seconds have passed since the patient arrived)

L: How long has been since the patient loose conscious?

P: 5 minutes ago

L: (talking to AW) set the airway in

In contrast, the team leader of the low performing team omitted to communicate relevant information to TMs about the information given to her during the patient handover, which caused a loss of common ground among TMs. For instance, the leader did not communicate to TMs that the patient was unconscious and pulseless. Therefore, the member playing the airway (AW) role had difficulties understanding the urgency of establishing airway and was misled thinking that the patient was talking (see Excerpt 14).

Excerpt 14

L: (talking to AW) AW you're checking airways

AW: Yep (she is placing the bag-mask), I think he starts talking (she removes the bag-mask)

L: (talking to patient) Hello, hello.

L: (talking to airway) He is not talking but open airway

The leader of the high performing team evoked the mechanism of injury after seven minutes have already passed. However, he was recognizing injuries and articulating a plan of action right away from the handover phase (see excerpt below). This leader made a decision and structured a sequence of actions that enhanced assessment, diagnosis and treatment early on. However, he failed to notify TMs about the mechanism of injury early on during the simulation, which he did later on in minute 7.

Excerpt 15

(1:30 minutes)

L: IV, I want you to start an IV

IV: OK

L: And run 2 liters of lactated ringers warm. In the short time, call for more help, a nurse, or a tech. See if there are bruises in the abdomen

(3:30)

L: (He is hearing the chest). I'm not hearing air entry.

L: (talking to AW) stop (referring to CPR) let me hear.

L: (after hearing the chest) I see a bruise in the left part of the chest, we're gonna put a chest tube in there

Both teams collected information and recognized problems that existed or that were soon to exist. However, only the leader of the low performing team experienced an evident overload of information. This leader identified and verbalized injuries/problems but she failed in interpreting them and giving this information back to TMs. Moreover, she was able to transmit the urgency of the situation but was not effective in making TMs understand what was going on with the patient since she verbalized incomplete statements (see Excerpt 16).

Excerpt 16

(3 minutes have passed since the patient arrived)

AW: There's air entry on the bag

L: OK, now we're gonna need, we're gonna need (she does not finishes the sentence)

L: (talking to IV) We're gonna switch, get the IV in

(8:30 minutes have passed since the patient arrived)

L: We definitely have something wrong with the abdomen, we probably have something wrong with….. (L has not finishes the sentence)

Similarl to simulation 1, shared leadership was mainly observed in the low performing team. The member playing the AW position recognized discrepant information between what she was getting from physical assessment and what was displayed on the monitors:

Excerpt 17

(8:00 minutes have passed since the patient arrived)

AW: (talking to L while checking pulse on the neck) No pulse

L: OK, we're getting pulse on the monitors

[…..]

L: You sure there's no pulse?

P: I can feel the pulse

AW: I'm not feeling pulse

L: Because there's pulse on the monitors

AW: Yes, but the monitor is not right with him (referring to the mannequin), there's no pulse

L: He doesn't have pulse, alright, CPR if no pulse

Simulation 5: Calling for help. Simulation 5 confronted participants with a sentry who was unconscious and who had been trapped in a vehicle for at least 5 minutes after an explosion occurred. The primary mechanism of injury was a blast/burn injury-pelvic trauma. This was a two-folded injury that involved a primary management of a pelvis fracture, probably caused by the pressure wave, and the management of a secondary blast airway injury. In this scenario there was an actor playing the role of a fellow combatant who came with the patient. His role was to distract participants as he collapsed from exhaustion while the first patient was being resuscitated. He had no injuries and was stable. Patients with battlefield pelvis trauma are likely to be hypotensive (abnormal low pressure) and have other associated injuries such as vascular, bowel, genital and bladder injuries in association with a respiratory distress (Ramasamy, Evans, Kendrew, & Cooper, 2012). Participants were expected to recognize the need of a cricothyrotomy (surgical airway), IV, rapid fluid resuscitation, and treat pelvis fracture. In addition, participants were expected to perform a rapid assessment of the distracter, who did not have injuries, and establish the first patient as priority. In the case that team members decided that second patient needed attention, they were expected to call for help for the other patient.

Figure 20 shows the model of team leaders' solving activities in simulation 5. Significant differences are seen between these models. The two leaders had to make several decisions based on their judgment of when to call for help. First, they had to decide if they were going to take care of the second patient, who was a distractor, splitting up the team (or not) for this purpose or calling for help to manage the second patient. Second, they had to decide when to call for a consultant on anesthesia to perform surgical airway, which is a procedure termed consultation. The two models depicted for this simulation showed us a team leader who was over confident in his abilities and decided not to consult with anesthesia, but to do it himself, and another team leader who did not have that level of confidence and doubted about her skills to manage intubation, which they were expected to perform.

In addition, these two models show differences about the number and the timing of the procedures done. While the high performing team identified and addressed the two mechanisms of injury (ventilation injury + pelvis trauma) and implemented four out of the four treatments, the low performing team addressed only one of the mechanisms of injury (ventilation) and only went as far as 2 procedures/treatments. The timing of a crucial procedure, such as surgical airway, was a significant difference between high and low performing team, 4:30 and 12:00 minutes respectively.

Team members of the high performing team constantly and proactively, without being told, gathered task relevant information and communicated back to the team leader, which decreased the amount of monitoring of TMs by the team leader. For instance, the member playing the airway position told the team leader “I think you should intubate for good”, which cued the team leader early on about the urgency of addressing airway. The team leader immediately replied, “Ok, so, I’m going to intubate. The airway might be a problem any time soon”.

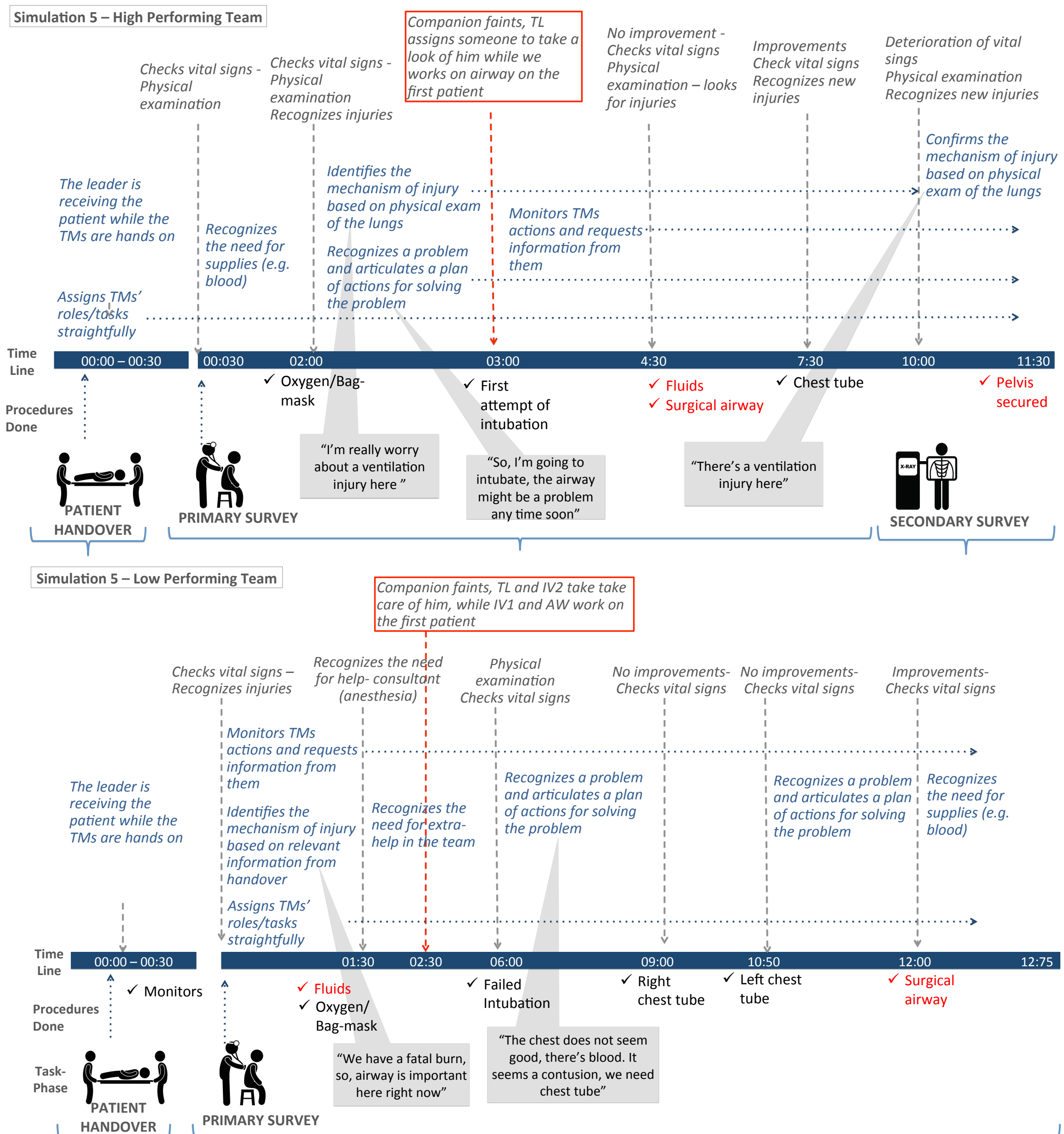


Figure 20. Model of team leaders' problem solving activities in simulation 5. *Note*. Text in red indicates the most relevant procedures that teams were expected to perform. The procedured that are in black letters are extra-procedures performed by teams.

Video analysis revealed that the team leader of the high performing team got involved in procedures several times, but did not lose awareness of the situation of the patient or the tasks delegated to other TMs. For example, while intubating the first patient, the team leader asked the member taking care of the distractor, to report to him (see Excerpt 17).

Excerpt 17

L: (L is intubating first patient while talking to IV) IV, is he breathing? (referring to the distractor)

IV: He is breathing, he is moaning around, he has pulse

L: OK, he has a pulse.

IV: I think he has a burn on his face, he may need to be intubated too

Information given by the IV helped the team leader to prioritize the care of the first patient, as the first one was unconscious and loosing pulse, while the distractor had pulse.

The team leader of the high performing team engaged mainly on structuring leadership behaviors such as determining a clear sequence of actions and constant re-evaluation of vital signs. Although, TMs were expected to address airway, they were certainly not expected to perform surgical airway by themselves. As was noted by the pool of instructors during the debriefing sessions, they should have called an anesthesiologist consultant. However, the team leader affirmed that he was used to working with small teams without the possibility of consultants, but that he was learning to work with more resources and calling them for help.

In contrast, the team leader of the low performing team did call for help early on during the scenario after 1:30 minutes have passed. However, the coordinators of the simulation delayed the help until the team leader attempted intubation first. This leader got fixated on airway for the duration of the scenario. As was established during the debriefing sessions, her confidence in her ability to intubate the patient affected the management of the patient. Since the beginning, this leader attempted to call anesthesia to do intubation, a procedure she was expected to perform herself. After she failed in the first attempt, she opted to wait for anesthesia even though that meant that the patient vital signs were dropping.

Excerpt 18

(30 seconds have passed since the patient arrived)

L: (talking to AW) We have a fatal burn, so airway is important here right now

L: [L was checking IVs and then she said what follows] I'm going to call anesthesia to intubate him.

Excerpt

(10 minutes have passed since the patient arrived. Anesthesia [A] consultant arrives)

L: (talking to IV1) There's no O2 sound?

IV1: Yes

L: I rather wait for anesthesia. They say they were gonna be here

A: I'm anesthesia

L: Anesthesia, we need to get the chest tube up.. sorry (she got confused), we need to intubate, we have an airway injury. All we have is one intubation that failed, the tube did not go in.

In addition, she spent the first three minutes assessing and managing the distractor (who fainted), which caused diffusion of responsibilities and loss of common ground. For instance, the leader divided the team and she and the member playing the role of IV2 took care of the distractor leaving the rest of the team on their own with the first patient. The TMs that took care of the first patient found that he had difficulties breathing and omitted to communicate this to the team leader, who also failed in monitoring the vital signs of the first patient or asking for information when she was not receiving it on a regular bases. While the distractor was breathing, the first patient had difficulty breathing and TMs decided to perform some procedures without communicating back to their team leader (see Excerpt 19).

Excerpt 19

(2:30 minutes have passed since the patient arrived)

L: (is taking care of the distractor who fainted and is talking to IV1 who is also taking care of the distractor) Can you hear me?

IV2: (talking to distractor) Sir? You hear me? (the distractor is moaning).

IV2: (talking to L) He is breathing

L: He is breathing, OK

IV1: (is taking care of the first patient and is talking to AW) He has a lot of difficulty breathing (first patient coughs several times), let him cough in (referring to the bag mask). Maybe suction him?

AW: (talking to IV1) Yep.

IV1: Maybe suction him? (she grabs the instruments to suction)

AW: Yep (she suctions the patient)

IV1: (talking to IV1) SATs starting to fall

As noted by the instructors during the debriefing sessions, this leader did not identify the injuries appropriately. Even though, TMs were actively being informed about injuries, the leader was focused on getting help for managing airway and dealing with the distractor, which made her disregard TMs information about other injuries. Not integrating or interpreting information coming from team members may lead the team leader to make mistakes (Fackler et al., 2009) and cut the flow of coordination (see Excerpt 20).

Excerpt 20

(1:30 minutes have passed since the patient arrived – Companion [Comp] is talking to the patient)

Comp: (to the patient) Hang in there.

L: [….] and breathing is good. Are IVs in?

IV: yes.

L: Two?

IV: Yes

L: With fluids on it? I'm going to call anesthesia to intubate him.

IV2 (Talking to L) There is a strap in the right hip [it seems TL does not hear this, she is dealing with a companion and calling anesthesia].

L: (talking to companion) I want you to sit down, you don't have a chair?

Research Question 5. To what extent is knowledge shared among team members of high and low performing teams?

A network analysis approach (Espinosa & Clark, 2012) was used to measure and represent team members' shared knowledge in four domains namely, leadership, mutual trust, situation awareness and explicit communication. In this approach, 'Knowledge is viewed as a network of content nodes, one for each member, with every pair of nodes connected with links describing their respective knowledge relationship” (Espinosa & Clark, 2012, p. 295). An illustration of how network analyses were computed can be found in the methods chapter under measures-section of shared mental models. In this chapter, only visual representations (sociograms) of shared mental models in the four domains are reported. Team members were asked to rate on a 5-point likert scale a variety of questions in each domain, which were then averaged and integrated into a matrix that compared the amount of knowledge of each member to each other member in a network. Network diagrams, otherwise known as sociograms, were depicted to graphically represent the common knowledge (links) between dyads in the team (content nodes). Fully connected networks suggest shared substantial amounts of knowledge between members and therefore are linked to better performance. The links in the sociograms were drawn using a cutoff value of 2.5 (≥ 2.5 line and ≤ 2.5 no line), which is the midpoint of the 1 to 5 rating scale used. SMMs were analyzed in terms of similarity or the degree of agreement between team members’ interpretations (Mohammed, Ferzandi, & Hamilton, 2010) about leadership, mutual trust, situation awareness and explicit communication. Dyadic knowledge was aggregated into a multidimensional sociogram, representing the shared mental models of the whole team in the four domains, otherwise called average knowledge similarity sociogram (Espinosa, 2001).

The leader of the low performing team in simulation five did not provide answers to the questions related to leadership and, therefore, the average knowledge similarity sociogram was computed only for three domains instead of four: mutual trust, situation awareness and explicit communication. The sociograms for each simulation are explained bellow.

Simulation 1. Figure 21 shows the visual representation of shared mental models in simulation 1 for high and low performing team. We can see that the high performing team has fully connected sociograms, indicating that team members had substantial shared knowledge in the four domains. Except for the leadership domain, the leader and the IV1 shared substantial knowledge among the different domains. These results are consistent with previous results that showed that the highest amount of coordination activities observed in the video analysis during high-task-load periods correspond to activities performed by the leader and the IV1 position, 56% and 20% respectively (see Table 17).

In contrast, sociograms of the low performing team show that knowledge was sparse among team members with only the leader and the IV position sharing substantial knowledge in all domains, except for situation awareness. This, suggests that knowledge was not similar among all TMs, which could affect coordination. These results are also supported by the analysis of problem solving activities which showed that the member playing the AW position had different interpretations of patient vital signs and about injuries.

The aggregate sociogram also shows that AW is a knowledge isolate, which was also supported in the video analysis where AW had relevant information, that could have changed the interventions, but that was not shared on time. In fact, AW waited until the end of the simulation to confront the leader with the fact that he was assessing and interpreting vital signs wrong.

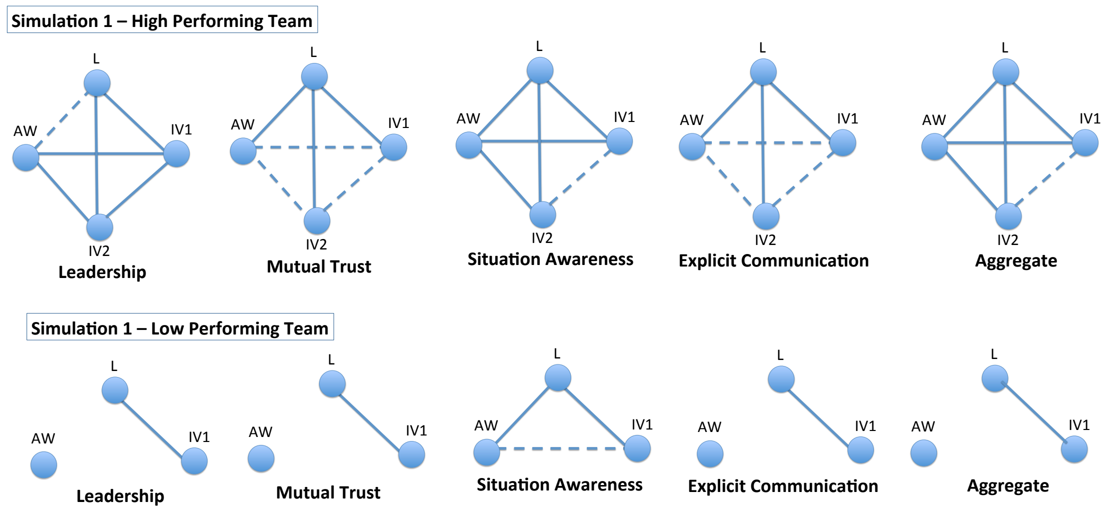


Figure 21. Visual representation of shared mental models in simulation 1 for high and low performing team. Dash lines represent the link of the dyad that has the biggest amount of shared knowledge in the different domains. Note: L = Leader; AW = Airway; IV1 = Intravenous1.

Simulation 3. Figure 22 is a the visual representation of shared mental models in simulation 3 for high and low performing team. Similar to simulation 1, we see the high performing team has fully connected sociograms that provide evidence that team members have strong-shared knowledge in the four domains. Dashed lines among all TMs in four out of the four domains indicate that TMs have a high amount of shared mental models, which indicates that they had similar perceptions about the task and the team, which could potentially enhance coordination by decreasing explicit communication. In fact, Figure 16 shows that under a high-task-load period of the task this team implements less explicit communication behaviors in comparison with the low performing team. However, it is evident that the members playing the AW and the IV1 positions have consistently the highest amount of shared knowledge in all domains.

In contrast, the low performing team had a fair amount of knowledge shared in all domains except for mutual trust where there is weak shared knowledge. In fact, only the leader and the AW shared substantial knowledge.

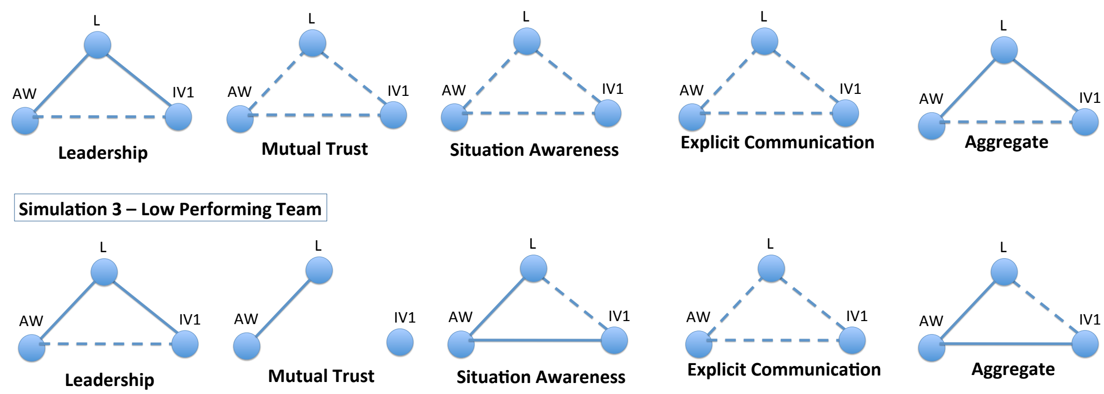


Figure 22. Visual representation of shared mental models in simulation 3 for high and low performing team. Dash lines represent the link of the dyad that has the biggest amount of shared knowledge in the different domains. Note: L = Leader; AW = Airway; IV1 = Intravenous1.

Simulation 5. Figure 23 shows the visual representation of shared mental models in simulation 5 for high and low performing team. Consistent with previous sociograms, the high performing team had fully connected networks among all TMs with the highest amount of sharedness in mutual trust and explicit communication.

In contrast, the low performing team had sparse networks in explicit communication, where AW is an exception with respect to knowledge.

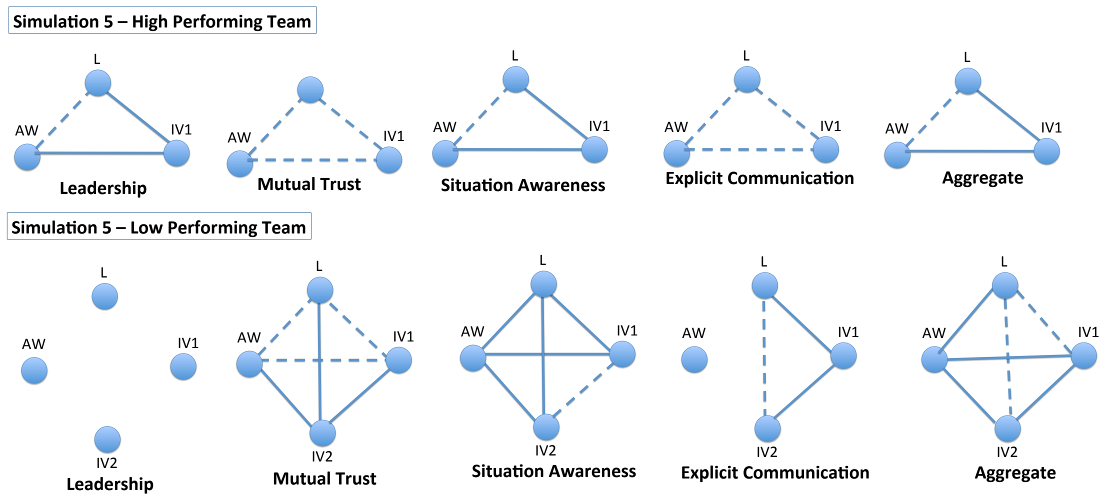


Figure 23 Visual representations of shared mental models in simulation 5 for high and low performing team. Dash lines represent the link of the dyad that has the biggest amount of shared knowledge in the different domains. Note: L = Leader; AW = Airway; IV1 = Intravenous1; IV2 = Intravenous 2.

CHAPTER 5

DISCUSSION

The purpose of this research was to examine the coordination strategies implemented by high and low performing military medical teams. This chapter synthesizes the main results of the current study and examines theoretical and practical implications in team performance and training. First, coordination behaviors pertaining to mutual trust, explicit communication and situation awareness are analyzed in terms of their interrelationships in high and low performing teams. Second, differences in the proportion with which coordination activities were implemented during high and low task load segments by high and low performing teams are discussed. The importance of explicit communication during high-task load segments is also discussed in this section. Third, leaders' problem solving models are examined along with two types of leadership: structuring and content-oriented leadership. Fourth, a profile of the leader of the high performing teams across the three simulations is described including attitudes and behaviors that positively affected team coordination. Fifth, aspects of shared leadership and its impact on low performing teams are discussed. Then, issues pertaining to the emerging non-appointed leaders and the difficulties challenging hierarchies are addressed. Finally, implications and differences in knowledge distribution in high and low performing teams are examined in terms of the network analysis approach.

Coordination Behaviors

Forty-four coordination behaviors were analyzed pertaining to: situation awareness, mutual trust in the leader, mutual trust in the TMs, closed loop communication, implicit coordination, mutual performance monitoring, adaptive and supportive behavior and explicit communication. There was a trend towards greater implementation of coordination behaviors in high performing teams (see Figure 14), which however, did not reach statistical significance. Independent sample-t test revealed that the number of coordination activities performed by teams does not have an effect on the level of performance. Both high and low performing teams achieved coordination by executing actions predominantly related to trust in the leader, situation awareness and explicit communication. However, differences in coordination behaviors emerged when looking at high and low- task load periods, which will be discussed later in this chapter.

Bivariate correlation analyses between coordination activities did reveal a significant association among mutual trust in the leader, situation awareness and explicit communication (see Table 16). Previous literature and studies have already established the importance of these coordination actions in assuring effective team performance (e.g. Salas et al., 2005). Burke and colleagues (2007) have suggested that the aforementioned coordination activities are related. In a multilevel review about trust in leadership, these authors found that structuring leadership behaviors such as providing team members with compelling directions positively impact followers trust in leadership. In turn, compelling directions are made based on explicit communication about task relevant information, changes in initial plan or general decision-making, which are the result of team leaders' adequate levels of situation awareness and clear understanding of the team task, team capabilities and the environment (i.e., contextual information). Evidence from this study showed that overall high performing teams implemented a bigger proportion of situation awareness (M=31.33) in comparison to low performing teams (M = 26.67) (see Table 13).

Interestingly, mutual trust has been mainly studied at the team level, where leader's and team members' trust behaviors are blended and seen as a unit. However, and acknowledging the critical role of the leader in assuring team coordination and effectiveness, we decided to look to leaders' and team members' behaviors of trust separately. The results of this study showed that the proportion of leaders' behaviors of trust was much higher in comparison to those of the team members. Trust has been referred to in the team literature as an attitudinal component of team performance, which is affected by the willingness to contribute to the team effort and the belief that other team members will perform their roles (Cannon-Bowers et al., 1995; Costa, Roe, & Taillieu, 2001; Salas et al., 2005).

Indicators of leaders' behaviors of trust included clear communication of the priorities and plans for investigation and treatment, clear definitions of roles before and during task, establishment of task interdependency, willingness to share thought processes about clinical hypothesis, and willingness to share leadership with team members. These behaviors are thought of as cognitive antecedents of trust, which help individuals to develop a belief or perception of other peoples' performance reliability (Burke et al., 2007; Dirks & Ferrin, 2002). Some authors have advocated for the idea that antecedents of trust are multidimensional and that include both cognitive and affective components based on interpersonal relationships (Webber, 2002). However, our results lead us to suggest that affective antecedents, characterized by, shared experiences, familiarity ties, and reciprocal disclosure among others, are more likely to develop in regular teams, which may have time to build such traditional sources of trust. Traditional sources for developing trust can take time to develop and are, therefore, more suitable for teams where individuals perform together consistently (Meyerson et al., 1996).

On the contrary, temporary teams, such as medical trauma teams are less stable than traditional ones, in that, they consist of individuals who come together for limited periods of time (being hours, days or weeks), for solving a specific task and who most probably have not worked together before and who do not expect to work together again (Mckinney et al., 2005; Meyerson et al., 1996; Wildman et al., 2011). Such teams build team cohesion based on swift trust, which is built on team members' roles as opposed to on knowing other individuals (Meyerson, et al., 1996). According to Meyerson and colleagues, swift trust is a form of collective perception that allows people of temporary systems to act quickly in the face of uncertainty. Our research findings are in line with Meyerson's claims and shows that leaders of high and low performing teams developed trust mainly by assigning and clarifying TMs roles in the initial phases of the task (e.g. patient handover and primary survey) (Meyerson, et al., 1996). In previous studies, the aforementioned behaviors have been linked to the enhancement of swift trust and coordinated actions (Cruz-Panesso, Lachapelle, & Lajoie, 2011).

Coordinated strategies implemented by high and low performing teams are further discussed in the following section, where these strategies are discriminated according to its occurrence in high and low task load segments

Task Load

Actions related to mutual trust in the leader, situation awareness, and explicit communication were observed during both high- and low-task-load. The within-subject analysis revealed that there was a significant difference in the proportion with which coordination activities were implemented during high and low task load segments. Moreover, qualitative analyses showed that high performing teams reacted differently to task load, more specifically to high-task load segments, which were characterized by an increase in the coordination and situational demands. High performing teams demonstrated to have better task-load management strategies characterized by knowledge about the actions to implement in low and high task-load periods. Task-load management strategies have also been reported as a feature of expert teams in other high- risk domains such as air traffic control teams (Seamster et al., 1993).

Furthermore, results from this study showed that:

1. Longer periods of high task load can result in a reduction of the available resources and capacities for processing information, thus affecting performance (Rypkema, Neerincx, & Passenier, 2004). High performing teams have fewer segments of high-task-load in comparison to the low performing teams. High-task load segments were characterized by an increase in the coordination and situational demands. As teams spent more time in high-task load segments, they are compelled to give up some tasks and adjust their work strategies. According to Rypkema and colleagues (2004) some of the adjustment strategies include focusing on a limited amount of information, which in consequence can lead people to ignore relevant information and decrease the quality of their decisions. Data from this study showed that low performing teams concentrated on specific or un-necessary procedures that did not address the main consequences of patient deterioration. For instance, the leader of the low performing team on simulation 1

got fixated on listening to the patient's chest nine times before performing decompression of the chest at the very end of the scenario.

2. High performing teams manage high-task-load periods of the task by implementing a higher proportion of coordination activities in comparison to the low performing teams, except for simulation one (see Figure 16a). A key portion of the coordination activities of high performance teams during high workload was devoted to mutual trust in the leader, situation awareness and explicit communication respectively. Previous studies have showed that effective individuals tend to increase their efforts under time pressure and high workload (Rypkema et al., 2004).
3. Leader's explicit communication behaviors varied greatly among high and low performing teams. For instance, explicit communication of low performing teams was characterized by leaders' directions about team members' roles and tasks whereas leaders of high performing teams implemented the aforementioned behaviors; but in addition, these leaders combined the process of information gathering and interpretation. These latter behaviors facilitated shared understanding of the patient situation, and in consequence, awareness of the actions needed (Shapiro et al., 2008). The implications of the leaders' explicit communication behaviors are further discussed in the leaders' problem solving models section in this chapter.

Explicit communication in high-task load segments. The team literature has consistently reported that high performing teams are more likely to increase implicit communication during high task load in order to reduce cognitive workload (Entin &

Serfaty, 1999; Klein et al., 2005; Zala-Mezö et al., 2009). However, the video-based analysis in this study showed that military medical teams coordinate most of the time using explicit communication during high and low task-load segments, but more especially during high task-load moments (see Figure 16a and 16 b). Although, implicit coordination behaviors were also observed, these were less frequent even during peak load moments. These results correspond with some research that found that successful temporary healthcare teams use more explicit communication than poorly performing teams (Marsch et al., 2004).

Temporary teams, consistent of individuals with little or inexistent history of working together, have the need to coordinate by means of explicit communication, especially during high-load moments. Implicit communication requires team members to be able to anticipate actions and needs of other team members and to provide supportive behaviors in the absence of verbalized requirements (Espinosa et al., 2004; Khan, Lodhi, & Makk, 2010). Therefore, it could be argued that implicit coordination behaviors are most likely to be observed in teams in which individuals have developed certain degree of relationships and are able to create mutual expectations about others team members' work and needs.

Klein and colleagues (Klein et al., 2006), who looked at resuscitation teams, found that the characteristics and the requirements of trauma teams go beyond regular action teams and that they should be better framed as "extreme action teams". These authors argue that members of extreme action teams have to (a) cooperate to perform urgent, highly consequential tasks; while simultaneously (b) coping with frequent changes in team composition; and (c) training and developing novice team members whose services may be required at any time.

We propose that explicit communication has an alternative function within extreme and temporary action teams:

1. It is as a reliable way of communication in the absence of previous experiences that allows team members of temporary teams to make assumptions of how other team members will manage the situation and task interdependencies.
2. Helps individuals to avoid wrong interpretations or the assumption that other team members will perform their roles and that are trusted. Explicit communication could, therefore, be the mechanism teams use to guarantee development of swift trust. However, further studies should look at this.

Implicit coordination in extreme action teams should be looked at differently and we recommend that researchers consider alternative ways to codify this type of coordination. For instance, Zala-Mezo and colleagues (Künzle et al., 2010; Zala-Mezö et al., 2009) contend that implicit coordination might be framed as the use of standard procedures. Standard procedures can help team members to automatically react following the required procedures in the absence of explicit communication. Furthermore, the use of standard procedures has been proposed as a substitute of leadership, in that, TMs know what needs to be done without been told to do so. It could then be expected that the use of standard procedures or algorithms such as the ABCD (see further explanation of the ABCD algorithm in Chapter 2 in the literature review) can also be substitutes for implicit coordination.

Leaders' Problem Solving Models

Effective and ineffective models of team problem solving activities were characterized accordingly to three themes identified in each simulation. For instance, simulation 1 showed an effective model for recognizing the mechanism of injury, which involved the leader's understanding of early cues given by the paramedic during the handover phase. The leader of the effective team used this understanding to articulate hypotheses and to plan a further line of action.

Overall, models of team leaders' problem solving activities revealed that in the initial phase of the task (the patient handover), regardless of the level of team performance, team leaders systematically received the patient and assigned roles/tasks to team members. During the second phase, the primary survey, leaders performed a physical examination while checking vital signs. However, only the leaders of the high performing teams engaged in identification and interpretation of relevant information in phase two. Identify and interpret relevant information have been referred to in the literature as sense-making and sense-given behaviors that are key for developing a more comprehensive and effective representation of the problem, otherwise called a mental model (Zaccaro, Rittman, & Marks, 2002). Sense making bahaviors or the leader's ability to identify and understand the main aspects of patients injuries and intervention has been otherwise framed as a situational context expertise (Garrett et al., 2009). Situational context expertise is one of the six dimensions that constiute team coordination expertise (Garret et al., 2009).

According to Zaccaro and colleagues, "sense-making and sense-given processes include extracting important environmental cues, placing the cues in a team's context, and embellishing the meaning of these cues into a coherent framework" (2002, p. 462). Data from this study show that the leaders of the high performing teams addressed assessment, diagnostic and treatment systematically. They took into account information given in the handover, rapidly identified general injuries, and more importantly, stated loudly the mechanism of injury. These leadership behaviors have been framed in the leadership literature as a structuring type of leadership (Künzle et al., 2010; Künzle et al., 2011; Zaccaro et al., 2002).

Structuring leadership is characterized by coordination behaviors aimed to organize the task and manage team members and resources, such as monitoring TMs actions, making decisions about the patient and TMs roles/tasks, identifying injuries and establishing hypotheses (Künzle et al., 2010). These behaviors were recurrent in the results of the different methods used in this research. For instance, results from the axial coding analysis revealed that team leaders of high performing teams engaged more frequently in actions related to decision –making about the patient procedures and identification of general injuries. Moreover, under these conditions leaders of high performing teams tended to perform coordination behaviors related to situation awareness and mutual trust. Situation awareness helped team leaders to comprehend the meaning of the patient symptoms. In addition, a regression analysis positively confirmed that the leader's identification of general injuries significantly predicted overall team performance. In fact, independent sample t-tests confirmed that high and low performing teams significantly differ in identification of general injuries and the mechanism of injury (see results in research question 2).

While the coordination patterns of leaders of high performing teams correspond to a structuring type of leadership, leaders of the low performing teams tended to engage in technical processes such as the collection and transfer of information, which correspond to a content-oriented type of leadership. These leadership behaviors are aimed at understanding the task and the potential challenges of it (Künzle et al., 2010). Content-oriented leadership behaviors were generally addressed in the coding scheme under situation awareness. Data from this study showed that less effective leaders recognize the importance of systematically checking vital signs but fail to move the team forward to a treatment phase to implement corrective actions.

Leaders of low performing teams tended to get fixated in acknowledging changes in the patient's vital signs or asking TMs to report on them. Our results are in line with other studies looking at medical teams and the leadership interaction between formal leaders and nurses (Künzle et al., 2010; Künzle et al., 2011). In these studies, Künzle and colleagues have reported that while formal leaders of high performing teams assume a structuring leadership style, the leaders of low performing teams adopt content-oriented leadership behaviors. In the Künzle and colleagues study, the nurses of low performing teams were more prompt to assume structuring leadership behaviors.

Team leaders are responsible for assuming a structuring type of leadership and for coordinating team activities that help team members to understand the task and to develop common understanding of the problem, solution generation, and solution selection activities (Kozlowski & Ilgen, 2006; Kozlowski et al., 2009; Zaccaro et al., 2002). This common understanding, otherwise known as a shared mental model, cannot be developed if team leaders do not communicate properly with team members.

Contrary to leaders of high performing teams, leaders of low performing teams evidenced difficulties in communicating relevant information given to them in the handover, interpreting relevant information, and establishing the main mechanism of injury. In addition, fixations impeded these team leaders from interpreting cues faster which delayed the articulation of actions during the second phase of the task. Less effective team leaders were still good at recognizing and interpreting information, collecting and putting information together accurately allowing team members to focus on the appropriate cues. However, results from the axial coding revealed that their focus was on checking patient's vital signs as opposed to identifying general injuries and the main mechanism of injury (see Table 19).

Simulation 3 provides an example of the leader's difficulties in communicating and structuring the task as well as the mental model of the team members. In this simulation, the leader of the low performing team omitted to communicate to TMs that the patient was unconscious and pulseless. Therefore, the member playing the airway (AW) role had difficulties understanding the urgency of establishing the airway and was misled into thinking that the patient was talking. The information that the patient was pulseless was given to the team leader during the handover while the rest of the TMs were already working on their positions. The paramedic disclosed this information to the team leader with the purpose of triggering her and the rest of TMs that they were dealing with an agonal patient, who needed immediate resuscitation.

Some of the rules depicted in the handover phase addressed the issue of having all team members listening during the handover to guarantee that all members start with the same information providing a common starting base to understand what is going on with the patient. During the debriefing session, the leader of the the less effective team admitted that the handover information helped her trigger a mental model about how to react but that she failed to communicate this model to the rest of the team. In addition, she presented incomplete statements that conveyed the urgency of the situation but did not provide information as to what was going on with the patient. Communication of the leader's mental model is a critical step for helping team members develop a common mental model that leads to appropriate next steps (Zaccaro et al., 2002).

The leadership literature states that under stressful situations leaders manage a high information load that can interfere with memory and decision making. Sharing leadership has been proposed as a key element that can ease high stress situations. Issues of sharing leadership are discussed in the following section.

Sharing Leadership

Shared leadership is defined as "the transference of leadership function among team members in order to take advantage of members' strengths (e.g. knowledge, skills, attitudes, perspectives, contacts, and time available) as dictated by either environmental demands or the developmental stage of the team (Burke, Fiore, & Salas, 2003, p. 105). Although, shared leadership has been mainly characterized in effective teams, behaviors related to it emerged from analyses of team leaders of low performing teams. Shared leadership behaviors ocurred in situations in which the appointed team leaders either interpreted data erroneously or attended to cues that were intended to distract them. In these circumstances, TMs actively recognized the discrepant information given by the team leaders and took corrective actions (see examples in models of simulation 1 and 3).

Shared leadership theories support the notion that compatible mental models enable team members to transfer leadership (Burke et al., 2003; Kozlowski et al., 2009). In contrast, data from this study showed that discrepant information between leaders and TMs about patient symptoms and treatments triggered shared leadership behaviors. During the first phases of the task, team leaders prevented and sometimes ignored team members' ideas related to diagnosis; however, towards the end of the scenarios when there was no patient improvement, these leaders accepted and even encouraged TMs to brainstorm about what was wrong with the patient, which led to an enhanced shared situation assessment. Getting ideas and concerns from followers is known as a consultation strategy that leaders use in order to empower members in the decision-making process (Yulk & Fu, 1999). According to Yulk and Fu (1999), consultation can be thought as an "opportunity for subordianted to voice concerns about adverse consequences of a proposed change" (p. 220). Based on our results, we contend that timely shared leadership behaviors can help teams' manage and adapt to coordination difficulties and to increase team performance (Yulk & Fu, 1999) and ultimately better patient outcomes. Shared leadership could be taught as an effective strategy to help teams avoid or correct fixations that led to errors.

Burke and colleagues have proposed shared leadership as an adaptive process that is also mediated by shared situation assessment among team members (2003). According to these authors, situation assessment helps team members recognize and interpret cues that indicate that a problem exists or will soon exist and that actions need to be taken. Moreover, "shared situation assessment should aid in the determination of when the leadership function should transfer (Burke et al., 2003, p. 112).

In studies of resuscitation, teams' shared leadership occurs when active leadership shifts from one member to another (Klein et al., 2006). For instance a senior leader (the attending or the fellow) takes over the strategic direction of the team, assuming a more active and influential role in the team, or, conversely, when a senior leader recedes from strategic direction, assuming a more passive role and implicitly or explicitly delegating the active leadership role to a more junior leader (Klein et al., 2006). However, hierarchies can limit shifts in leadership. This topic is further discussed next.

The emerging non-appointed leaders and the difficulties of challenging hierarchies

The team leaders were the members who executed the highest proportion of coordination activities during high -task-load segments, except for the low performing team on simulation 1 (see Table 15). In the low performing team in simulation 1, the leader demosntrated a lack of understanding of the mechanism of injury and difficulties in managing the team. Under this circumstance another member, playing the AW role, emerged as a non-appointed leader. In fact, AW frequently engaged in leadership behaviors that contributed to re-established situation awareness of the changing condition of the patient. These behaviors included (a) identification and understanding of relevant information, which pertained to situation awareness category; (b) sharing of relevant information, which was a sub-category of mutual trust in TMs; and (c) implicit coordination behaviors that included the provision of information without request. Although, the information communicated by AW could have positively affected the course of actions to manage the patient injuries on time, this member assumed a rather passive leadership role characterized by indirect, and incomplete statements (see

Example in Excerpt 7 and 8). Incomplete communication is an indicator of decreased situation assessment (Salas et al., 1995), which can become a potential source of error and coordination difficulties (Fussell et al., 1998; Wilson et al., 2007). Only towards the end of the scenario, AW confronted the leader and questioned the accuracy of the information given by him and the interpretation of the symptoms.

Although, a study of authority and hierarchies was not the focus of this research, we acknowledge that these elements may have played a mediating role in the team dynamics. We argue that indirect and passive statements from emerging non-appointed leaders might be influenced by the formal hierarchies that characterize medical teams and most especially military medical teams. Respect for the leader's authority is a must in the military trauma team where team leaders must be prepared to carry out a leader's instructions without questioning them (Hodgetts & Turner, 2006, p. 17). Research that has examined resuscitation (Klein et al., 2006) and military teams have highlighted the fact that team members' status, rank, or tenure can impede the free flow of necessary feedback (McIntyre & Salas, 1995). Team members of military teams must contend with a wide range of ranks that include Field Grades Officers (e.g., Majors and higher) at the top of the system all the way down to Medical Technicians and Ancillary staff (i.e., enlisted personnel) (Alonso et al., 2006). Further elements affecting the relationship between team members and the leader include the time team members have performed together and the development of mutual trust. For the team members of the low performing team in simulation 1, this was the first time they had come together to work as a team and therefore they had not developed relationships of trust that could have helped them to confront the authority of the leader.

Shared Knowledge

Network diagrams, otherwise known as sociograms, were depicted to graphically represent the common knowledge (links) between dyads in the team (content nodes) in four domains that were the most significant ones within different methodologies: leadership, mutual trust, situation awareness and explicit communication. Additionally, aggregated matrices looking at the average value across all dyads in the four domains were also computed and plotted. Aggregated sociograms of high and low performing teams were fully connected, except for the low performing team on simulation 1, suggesting that members share substantial amounts of knowledge (Espinosa & Clark, 2013). Fully connected networks demonstrate substantial amounts of shared knowledge between members (through the number of associations) and this phenonmenon is linked to better performance (Espinosa & Clark, 2013). However, further analysis of the task domain networks revealed differences. For instance, low performing teams had disjointed matrices showing isolated nodes that represented members who do not share knowledge with other members, which may have accounted for the low performance. Low performing teams focused their efforts mainly on organizing and establishing common knowledge on situation awareness (e.g. knowing about was going on with the patient), neglecting aspects of leadership, mutual trust and explicit communication.

Aggregated measures, such as those taken into account in the aggregated matrices, follow a collective approach where team knowledge is the result of an overall team knowledge score (Espinosa & Clark, 2013), which represents the collection of the knowledge of the individual team members (Cooke et al., 2000). According to Cooke and colleagues, this approach may underestimate the team knowledge that results from the application of team processes such as situation awareness, communication, mutual trust, etc. In line with these arguments, this study provided support to the notion that aggregated analyses are not predictive of team performance (Cooke et al., 2000). Furthermore, this current work builds on a multidimensional network analysis methodology adapted from Espinosa and colleagues to uncover content (e.g., the four domains mentioned above) and structure of team knowledge (e.g., which members share more knowledge with others and who shares little task knowledge with others).

Results from this study showed that high performing teams have fully connected networks among team members on the four domains: leadership, mutual trust, situation awareness and explicit communication. While, low performing teams had fully connected matrices in situation awareness but disconnected ones in leadership, mutual trust and explicit communication. This finding is similar to the observations of Espinosa and colleagues, who found that high performing teams have fully connected networks with shared substantial knowledge among team members, whereas low performing teams have quite disconnected sociograms (Espinosa & Clark, 2013).

For instance, sociograms of the low performing team in simulation 1 showed that TMs shared knowledge in matters related to situation awareness. The leader and the IV1 were fully connected in all four dimensions, while AW was an isolated node in mutual trust, leadership and explicit communication, which made evident a disruption of knowledge (see Figure 20) that could also have restricted shared leadership as was noted in previous sections.

Network analysis also provided insights about how knowledge was distributed among team members. For instances, team knowledge distribution in high performing teams varied among team members showing that the members who shared more knowledge with other members were not always the leaders, especially in the first simulation. For example, sociomatrices in the four domains for the high performing team on simulation one showed that the leader only shared knowledge with one member (AW) on the leadership dimensions (see Figure 20). However, IV1 and IV2 consistently shared more knowledge than other members in mutual trust, situation awareness and explicit communication. In contrast, sociomatrices of high performing teams on simulation 3 and 5 showed that the leader was the one who shared more knowledge with the rest of the team members (see Figure 21 and 22). These findings warrant further research, as they may suggest that during the first simulation, team members are sorting out who they need to interact with and to whom they should provide relevant knowledge. Moreover, a recent study looking at shared mental models using network analysis have reported that mental models increase and networks became simpler across simulations as “individuals within the team began to understand how they fit into the group and whom is important to communicate with” (Sanders, 2013).

As the role of the team leaders have been highlighted along this chapter, the next section presents a profile of a leader that was remarkably involved in effective teams.

Profile of a Leader of High Performing Teams

Teams that participated in this study were temporary teams, consisting of a physician and two nurses, who switched after three simulations (see Figure 1 in the methods section). Although, the teams had the option to shift roles, they tended to keep the physician as the team leader. The leader of the high performing team remained the same along the three simulations analyzed in this study, although, he changed of crew once for simulation 5 (see Table 5 in the methods section). Data from different sources showed that this leader engaged alternately in structuring and content-oriented leadership. In the initial phase of the task this leader provided structuring leadership by distributing roles and assigning tasks (e.g., “AW take care of the airway”, “IV put the IV here and here”) and he also made decisions about patient’s procedures and structured the work process by determining sequences of actions (e.g., simulation 1: “We need to put a tube to decompress the left part of the chest”, simulation 3: IV is getting tired, switch and take over compressions”).

When assigning roles, this leader took into account TMs’ strengths and weakness, in order to assure that members had the abilities to perform the assigned tasks. For instance, after assigning a task, he frequently asked members: “do you feel comfortable?” referring to intubating, doing chest tubes, etc. In line with these results, previous studies looking at different characteristics of the leaders and different leadership styles have found a positive relationship between leaders’ ability to understand individuals’ strength and weaknesses and trust in leadership (Burke et al., 2007; Conger, Kanungo, & Menon, 2000; Shamir, House, & Arthur, 1993). As was stated before in this chapter, mutual trust in the leader was a hallmark of coordination.

Literature looking at trauma teams has noted that team leaders should not be involved in process (hands-on) and that they should assume a managerial and monitoring role (hands-off) that goes in line with structure leadership behaviors: delegating tasks and checking that the resuscitation is proceeding satisfactorily (Hodgetts & Turner, 2006; Mackway-Jones, 2012; Sugrue et al., 1995). However, our results showed that this effective leader was hands-on during a good portion of the scenarios. However, as the scenarios progressed, he showed the ability to update the TMs maintaining high situation awareness. For instance, he proactively acquired task relevant information (e.g., simulation 1: “is he breathing IV?), he synthetized patient’s symptoms and findings (e.g., simulation 1: “So, lets check what we have here, we have him on oxygen [SAT]is 89, we decompress the left side of the chest, the chest is not moving equally and we got air back, so we have to put a chest tube on the left side”). As was said previously, hands-on behaviors have been associated mainly with nurses (Künzle et al., 2010; Künzle et al., 2011). Interestingly, this leader was able to provide members with a good picture of what was going on with the patient, thanks to his abilities to reflect back to team members but also thanks to the fact that he was involved in procedures (hands-on).

Although, the medical team literature has highlighted the inconveniences of the leader being hands on (e.g., losing situation awareness) (Cooper & Wakelam, 1999; Hodgetts & Turner, 2006), this study shows that highly skillful leaders may engage in procedures and support the development of situation awareness. In this regard, some authors have noted that leadership may vary in extreme action teams. For example, Klein and colleagues (Klein et al., 2006), who looked at medical teams, found that leaders of extreme action teams have four strategic functions including providing strategic directions to TMs, monitoring team members performance, teaching TMs by actively giving instructions on how to perform specific medical procedures and finally providing hands-on treatment of the patient, especially the most critical and complex medical procedures. In line the findings of Klein and colleagues (2006), we observed that this leader tended to take on the difficult procedures. For instance, on simulation in, he performed the surgical airway (see question 3 leaders’ problem-solving models).

Leaders' active participation, being hands on, and the effects on team performance, have been addressed previously with different results. For instance, Cooper and Wakelam (1999), who looked at leaders of resuscitation teams and found that when leaders were hands on, teams were less effective and teams were less structured than teams led by leaders who were hands off. They also observed that leaders who had recently received specialized training (e.g., advanced life support [ALS]) were more likely to not participate in hands on activities.

Based on our results and those of others looking at medical teams, we contend that skillful leaders are able to engage in both structuring and content-oriented leadership. Moreover, these types of leadership are associated with coordination behaviors of mutual trust and situation awareness and should be addressed as key points of training when conducting trauma team simulations. Further studies should look at what the conditions are under which leaders can participate actively, be hands on, and when they should back off, be hands off.

Research Contributions

It has been said that good coordination is difficult to define and measure, "often, good coordination is nearly invisible, and we sometimes notice coordination most clearly when it is lacking" (Malone & Crowston, 1990, p. 357). This study provides evidence that effective team coordination in extreme action teams is linked to the team's ability to manange high and low task load periods of the task with explicit communication, and the ability of the team to recognize and give sense to relevant information. These abilities have been referred to in the literature as team situational context expertise (Garret et al., 2009). Team expertise has often been studied as an extension of the theories on individual expertise; however, team settings require individuals to work in a sincrhonous manner for which additional components that are not considered in theories of expertise for individuals should be considered. Results from this study add to the team expertise literature by characterizing specific components of team effectiveness. For instance, this study has shown that two unique aspects of coordination in extreme action teams are trust in the leader by team members and sharing leadership to avoid fixations. Sharing leadership requires team leaders and team members to know and recognize who has expertise in a specific area, which can increase the amount and quality of information available during decision-making processes (Garret et al., 2009).

We have suggested that sharing leadership can be affected by aspects of hierarchies and ranks for which further studies should look at how to train team members to proactively challenge authority in order to contribute to improve team coordination. This thesis has showen that the fact that team members do not confront leaders directly and promptly was directly linked to treatment delays and erronoeus interpretation of patient symptoms, which caused deterioration of patient's vital signs.

In addition, this study combines methodologies from educational psychology to better understand medical team coordination in a simulated-based learning environments. We used a methodological triangulation to give more validity to our data analyses. Triangulation is defined as the process of "simultaneously collecting both quantitative and qualitative data, merging the data, and using the results to best understand a research problem" (Creswell, 2005, p. 600). In this study we collected qualitative (e.g., interviews with SME and video records of simulations and debriefing sessions) and quantitative data (e.g., team performance and team questionnaire). These data were brought together during the analysis of the results and then qualitative and quantitative methods were applied.

A team cognitive task analysis was conducted to uncover the most critical aspects of the tasks medical trauma teams perform. These aspects included: The phases of the task and the specific demands required by team leaders and TMs in terms of knowledge, attitudes and skills. Results from team CTA have been recognized for being useful in making decisions regarding team selection, designing of team strategies and team training, developing models of team performance and promoting team effectiveness (Blickensderfer, et al., 2000; Lorenzet, et al., 2003; Salas, et al., 2007). In this study, the results of the team CTA were used to build a cognitive model of military trauma team interventions in a level 3-care facility. In addition, team CTA was used to develop an observation code that captured eight critical coordination strategies needed to perform the task. These strategies included: Situation awareness, mutual trust in the leader and TMs, closed loop communication, implicit coordination, mutual performance monitoring, adaptive and supportive behaviors and explicit communication. The observation code fed the video analysis and was applied to a total of 144 segments of 30 seconds each.

Previous research has shown how CTA is a key step in developing intelligent tutoring systems (ITS) aimed to train teams (Zachary, Ryder, & Hicinbothom, 2000) and clinical decision making in medical and related fields (Lajoie et al., 1998). The cognitive model of military trauma team interventions could also serve as a test-bed for developing further computer based learning environments. ITS derived from this research could be used to improve training in leadership and teamwork. Future research in this area could integrate the different models of effective leaders problem solving depicted in this study to train future leaders to identify the appropriate patterns of coordination: (a) Recognizing the mechanism of injury, (b) identifying and interpreting relevant information (c) identifying the right moment to call for help. These models have theoretical and practical implication, in that; they contribute to recognizing and understanding the different patterns of coordination within effective teams.

Our findings are particularly important when considering the context of medical team training in simulation-based scenarios. Our findings across the triangulation process highlighted the fact that although there are several team strategies affecting coordination of military teams in simulated environments, only three strategies are significant ones: trust in leader, situation awareness end explicit communication. These strategies are the most noteworthy for high performing teams during high and low task-load segments. In addition, these strategies were recurrent when leaders were making decisions about patient procedures, identifying injuries and performing procedures.

The team literature has highlighted the existence of several team processes affecting team performance and coordination. A well-known framework is the big-five of teamwork that states there are five-team processes and three coordination behaviors that together affect the team's ability to perform synchronously (Salas et al., 2005). Based on the results of this thesis, we contend that due to the characteristics of extreme action teams (e.g., short term performance), these teams achieve coordination by putting into action a simplified set of team processes (i.e., situation awareness and explicit communication) and a coordination behavior (i.e., trust in the leader), which are however considered in the big-five framework.

Limitations

Although, triangulation has the advantage of providing an accurate understanding of coordination in military trauma teams, certain disadvantages are also worth mentioning. For instance, the length of time required to perform the data analysis using convergent methodologies that involve qualitative and quantitative analysis can restrict the number of teams and simulations included in the study. Further research should investigate whether these results generalize across teams and simulations using a bigger sample size.

One limitation is the generalizability of this research beyond teams working in simulation-based learning environments. Further studies must examine if similar team behaviors transfer to real-environments. The issue of the transferability of skills learned in the simulation environment to the clinical setting is well documented (Devit, Hugh, Kurrek, Cohen, Cleave-Hogg, 2001). However, evidence from other high-risk domain such as aviation and armed services have shown that the degree to which the characteristics of the simulation match those of the real environment accounts for greater transfer of the skills (Allen, Buffardi, & Hays, 1991; Rehmann, Mitman, & Reynolds, 1995). High fidelity simulations, such as those studied in this research may have a higher likelihood of transfer but this will need to be studied in furture work. According to Allen et al. (1991) and Rehmann et al. (1995) high fidelity simulations include (a) equipment fidelity, which refers to the degree of duplication of the appearance and feel of the real system; (b) environmental fidelity, which concerns the duplication of visual and sensory cues; and most importantly (c) psychological and physiological fidelity, which concerns the subjective perception of the trainee that the simulator reproduces its real life counterpart such as the clinical environment or the specific clinical task being simulated. We therefore recommend that future research increase these aspects of fidelity in order to account for transferability.

Conclusion

There are several coordination behaviors affecting team coordination. However, military medical teams manage coordination both during high and low task load by implementing mainly mutual trust in the leader, situation awareness and explicit communication. Mutual trust in the leader was the most salient aspect of coordination in high performing teams. We found different patterns of coordination within effective teams. These change according to the requirements of the simulation but also and most importantly according to the strengths of the leaders. Effective leadership processes influence the development of trust by team members. Indeed, team members are more likely to contribute to the team interaction when leaders are perceived as trustwhorty (Burke et al., 2007). In extreme action teams, such as military medical teams, trust between team members and the leader is an emergent process that must be developed very quickly, otherwise known as swift trust (Adams, Waldherr, Sartori, & Thomson 2007; Burke et al., 2007; Meyerson et al., 1996). The leaders' most critical behaviors to generate trust in team members include defining team members' roles, clarifying and updating goals and interpreting patient vital signs. These behaviors are linked to a specific type of leadership known as structuring type of leadership.

Our results also support previous research about the important role of the leader in ensuring successful development of shared mental models and coordinated actions (Marks, Zaccaro, & Mathieu, 2000; Salas, et al., 2005; Tannenbaum, Salas, & Cannon-

Bowers, 1996). Leaders have a key role in helping team members to develop common knowledge about team members' roles, the task and the simulation. Results from this study showed that team members of high perfoming teams had common knowledge in leadership, mutual trust, explicit communication and situation awareness as measured through a network analysis approach. Team members of low performing teams had different knowledge, which affected the development of a common representation of the patient's situation and thus affected coordination. The establishment of shared mental models facilitates understanding of work interdependencies and helps establish predictions about the behavior and needs of their teammates (Cannon-Bowers, et al., 1993; Cooke, et al., 2000; Glickman, et al., 1987; Salas, et al., 2005).

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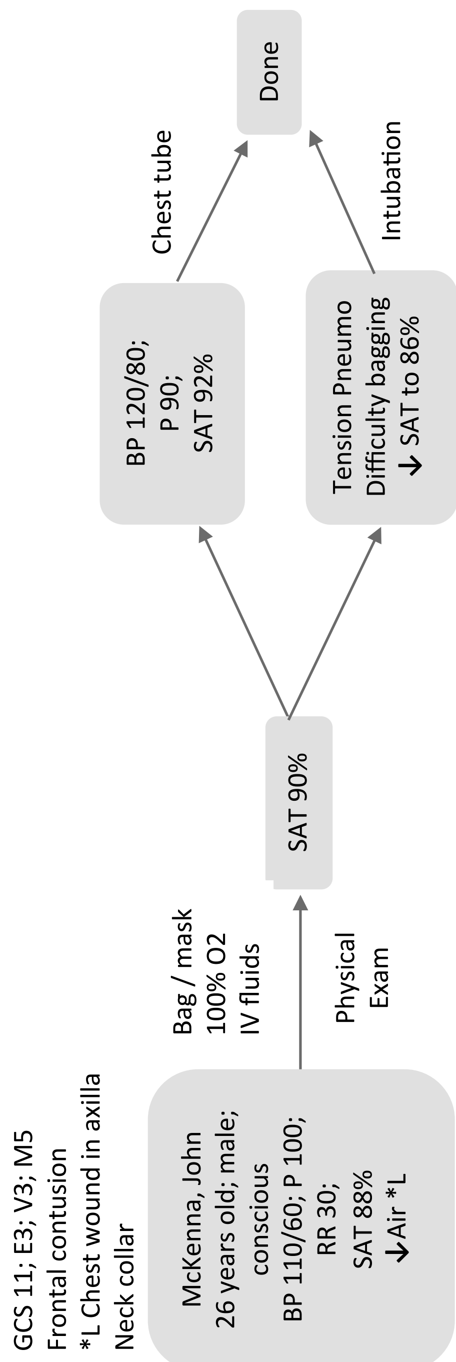
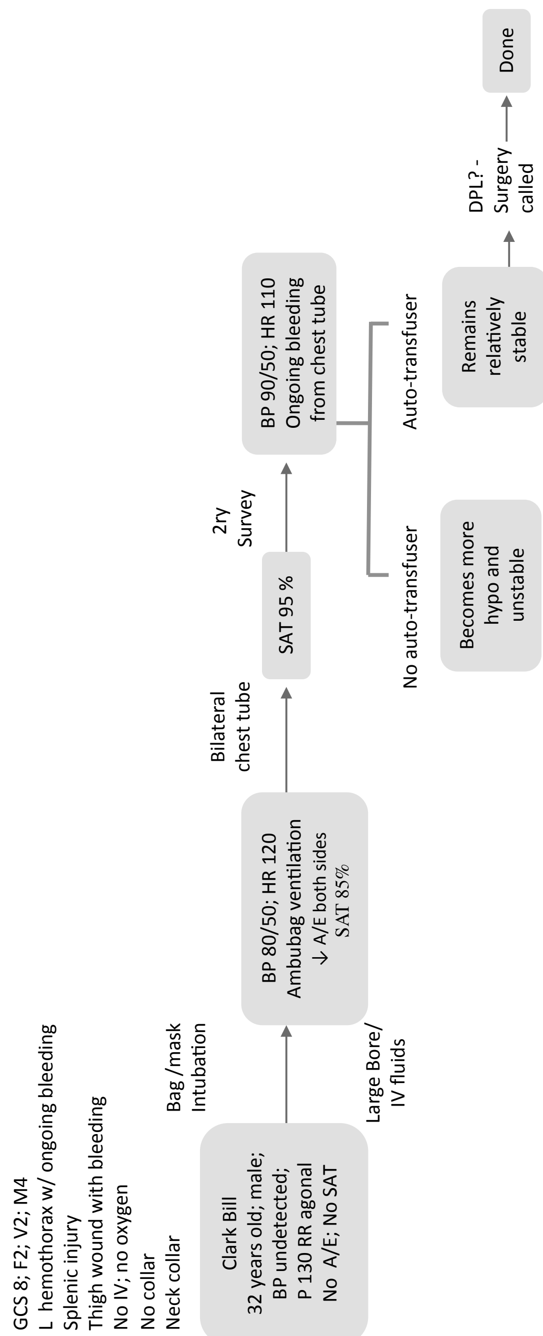
APPENDIX A

Algorithmic Decision Tree for Simulation 1:
Blunt Chest Trauma



APPENDIX B

Algorithmic Decision Tree for Simulation 3:
Agonal Thoracic Trauma



APPENDIX C

Team Performance Questionnaire

Simulation No. _________
Scenario No. _________
Team No. _________

Date: ______________________
Name of the Instructor: ______________________

Instructions: Please indicate below the appropriate score that best represents the overall team performance up to this point in the training. This score should reflect team performance *only*. Please provide additional information concerning the team's most relevant strengths and weaknesses.

Criteria	**Strongly disagree**	**Disagree**	**Not sure**	**Agree**	**Strongly agree**
The team mobilized all available resources	5	4	3	2	1
The team called for help at the right time	5	4	3	2	1
The team anticipated and planned activities based on the changes occurred in the situation	5	4	3	2	1
The team exercised leadership and followership	5	4	3	2	1
The team distributed the workload appropriately	5	4	3	2	1
The team set priorities dynamically	5	4	3	2	1
The team prevented and/or managed fixation errors	5	4	3	2	1
The team used all available information	5	4	3	2	1
The team re-evaluated the situation repeatedly	5	4	3	2	1
The team communicated effectively and conducted cross (double) check	5	4	3	2	1

Please indicate below the overall team performance:

Team performance was very poor		Team performance was average		Team performance was very good
5	4	3	2	1

List three important strengths that you identified in the team:

List three important weaknesses that you identified in the team:

Instructor's Feedback
(Individual Team Performance)

Date: ______________________Name of the Instructor________________________

Simulation No. _________
Scenario No. _________
Team No. _________

Instructions: Upon completion of the current training session, please indicate the level of each individual's performance during the training session by circling the appropriate score. This performance measure should *exclusively* reflect the individual's performance related with his assigned role during the current training session.

	TEAM PERFORMANCE				
Team Member	**Very poor**		**Average**		**Very good**
Leader	5	4	3	2	1
Airway	5	4	3	2	1
Intravenous1	5	4	3	2	1
Intravenous2	5	4	3	2	1

If you would like to add details to your previous answers, please do so in the space below.
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APPENDIX D

Team Questionnaire

Name: ________________________________

Simulation No. _________
Scenario No. _________
Team No. _________

What was the major injury of this patient?

What was your role in this simulation?

Instruction: We invite you to think about the simulation you performed and to identify (by circling the appropriate number) the level that best represents your perception of each statement.

Please note that the **only** people who are going to see your answers are: the principal researcher and her supervisor

Statement	Strongly disagree	Disagree	Not sure	Agree	Strongly agree
1. In this simulation, the leader of my team showed ability to direct and coordinate the activity of other team members	5	4	3	2	1
2. In this simulation, the leader of my team clarified the roles of all team members	5	4	3	2	1
3. In this simulation, the leader of my team synchronized and combined individual team member contributions	5	4	3	2	1
4. In this simulation, the leader of my team sought and evaluated information that affects team functioning	5	4	3	2	1
5. Members of my team identified mistakes made by another member	5	4	3	2	1
6. Members of my team provided feedback regarded team member actions to facilitate self correction	5	4	3	2	1
7. Members of my team told me about the things I needed to know to do my job	5	4	3	2	1
8. I knew exactly what I was supposed to do during the simulation	5	4	3	2	1
9. Members of my team knew how to perform their required tasks and roles	5	4	3	2	1

10. I completely understood how my position fits in with the work of other members of the team	5	4	3	2	1
11. Members of my team discussed ideas about how to proceed in this simulation	5	4	3	2	1
12. My team felt that the success of individual members was the most important objective of this simulation	5	4	3	2	1
13. Success in my job depended heavily on the actions of other team members	5	4	3	2	1
	Mention other team members (roles) who were important to the success of your work.				
Statement	**Strongly disagree**	**Disagree**	**Not sure**	**Agree**	**Strongly agree**
14. I was not satisfied with my team's performance on this simulation	5	4	3	2	1
	What could have been done in a better way?				
15. Members of my team cooperated with each other during the simulation	5	4	3	2	1
16. Members of my team told me about the things I needed to know to do my job	5	4	3	2	1
17. Members of my team had confidence in the accuracy of the information we got from each other	5	4	3	2	1
18. When we had questions, we could turn to others for help	5	4	3	2	1
19. Communications were clear among members of my team	5	4	3	2	1
20. Communications were not always clear among members of my team	5	4	3	2	1
	What would have been important to communicate?				
21. It took too long to coordinate information in my team	5	4	3	2	1
22. Members of my team asked if the procedure or information was correct when they weren't sure	5	4	3	2	1
23. Members of my team who needed assistance asked for help	5	4	3	2	1
24. In order to help another team member, members of my team performed a task that was not part	5	4	3	2	1

of their job					
25. Members of my team identified cues that a change had occurred, and developed a new plan to deal with changes	5	4	3	2	1
26. Members of my team remained vigilant to changes in the internal and external environment of the team	5	4	3	2	1

If you would like to add details to your previous answers, please do so in the space below. Please mention the number of the statement you are going to refer to.

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Appendix E
Observation Categories

COORDINATION STRATEGIES Coordination is the "mechanism teams use to manage/orchestrate their performance requirements" (Wilson, Salas, Priest, & Andrews, 2007, p. 7) including inter-dependencies[1] among sub-tasks, resources and people (Khan, Lodhi, & Makk, 2010a; Klein, Feltovich, Bradshaw, & Woods, 2005; Neville, Fowlkes, Milham, Bergondy, & Glucroft, 2001; Wilson, Salas, Priest, & Andrews, 2007).				
I	**SITUATION AWARENESS.** "Knowing what 's going on" – is the "perception of the elements in the environment within a volume of time and space, the comprhenesion of their meaning, and the projection of their status in the near future" (Endsley, 1995, p. 36)			
	Codes	**Definition**	**Example**	**References**
SA1	Identification/recognition of relevant information	Team members seek and communicate information relevant to their roles[2,3, 4]	The Airway reports: "There's a complication, patient is not breathing"	(Salas et al., 1995)
SA2	Understanding of relevant information	Team members understand the meaning of the information communicated by them and other team members	The leader says "the patient has a massive blood lost", then th IV says "I'm looking for blood suplements"	(Salas et al., 1995)
SA3	Recognition of the need for new information or supplies	Team members realize that they have limited information or supllies and that they need to collect new information (labs, scans, patient's info., etc.) and new supplies for understanding and treating patients condition	"We don't have labs results, neither patient's information" "We don't have more blood and we need it"	(Salas et al., 1995)
SA4	Detection that a problem exists or will soon exist[5]	Team members detect relevant signals or cues that tell them that they are encountering or that they are going to encounter a problem related to patient's vital signs	Team members realize that vital signs are dropping: "We have a problem here, I don't hear anything in the chest" " It may be a problem with the airway"	(Salas, Rosen, Burke, Nicholson, & Howse, 2007)
SA5	Optimal use of information sharing	Information communicated by team members is used in a number of ways (e.g., to	After a member communicates that thepatient's vital signs are dropping	(Endsley, 1995; Salas et al., 1995)

[1] **Interdependency: "**The extent to which "individuals' outcomes are affected by other team members' actions" (Johnson & Johnson, 1989, p. 2).
[2] "[B]y communicating relevant situation information, "crew members demonstrate knowledge of their overall misssion goals and their individual tasks responsabilities" (E Salas, Prince, Baker, & Shrestha, 1995, p. 129)
[3] Incomplete communciation is seen as an indicator of decreased situation assessment (E Salas et al., 1995, p. 128)
[4] "[G]roup SA could be maximized by having each member monitor different segments of the environment with wnough overlap among members to ensure opportunities for coordination
[5] This demonstrate that team members have relevant knowledge of critical cues in the environment (Endsley, 1995)

		clarify a task, to provide inputs for decision making, for focusing team members' attention)	the leader decides to start a procedure	
SA6	Recognition of discrepant information	Team members realize that information coming from different members or sources is discrepant and attempt to determine the cause of it	In a situation where pulse SATs is ---- and the Ox---- one measure shows deterioration of vital signs and the other shows normality	(Endsley, 1995; Salas et al., 2007)
SA7	Recognition of deviation of standard procedures	Team members identify that standard procedures are not strictly applied	The primary or the secondary survey is not orderly and systematically implemented The primary survey is missed When implementing the scondary survey, the patient vital sign deteiortes, but the team do not go back to assess ABC	
SA8	Recongition of the need for help	Team members realize they need more people, or additional consult with a specialist	"We need to consult with orthopedics" When the team is about to roll the patient they realize they need more people: "Can we have another hand here for the log roll?" "Can we get two other people"	
SA9	Articulation of plans and strategies for solving problems	Includes verbal statements that <u>address communication issues</u>	In order to improve communciation, the leader says :"From now on, everybody will state loud what you are doing and the result of it"	(Salas et al., 2007)
SA10	Articulation of plans and strategies for solving problems	Includes verbal statements that <u>address patient's procedures</u>	After having stating that the patient may have a problem in airway, a team member says: "I am going to intubate her"	(Salas et al., 2007)

II	**LEADER'S MARKERS OF MUTUAL TRUST** Mutual trust refers to "the shared belief that team members will perform their roles and protect the intersts of their teammates" (Salas, Sims, & Burke, 2005, p. 561)			
	Codes	**Definition**	**Example**	**References**
MT1	Proficient Leadership control	The Team Leader communicates both clearly and with authority the priorities and the plan for investigation and treatment	The leader makes clear final decisions and gives clear orders	(Cannon-Bowers, Tannenbaum, Salas, & Volpe, 1995; Hodgetts & Turner, 2006)
MT2	Poor leadership control	The Team leader does not communicate clearly and with authority	The leader does not make final decisions or is unclear and vague when giving orders	(Wallin, Hedman, & Meurling, 2009)
MT3	Task/role assignment	The Team Leader assigns and clarify roles straightfully	The leader assigns roles: Intravenous (IV), airway (Airw), chest tube, note taker	(Cannon-Bowers et al., 1995)
MT4	Task/role re-assigment during performance	The Team Leader re-assign roles, during performance, when is needed	A team member was in charge of IV with patient 1, then is re-assigned to assess vital signs in patient 2	
MT5	Establishment of task interdependence	The Team Leader establish interdependence among team members' tasks	"I'll intubate while you watch the monitor and keep me updated about patient symptoms "	(Kolbe, Künzle, Zala-Mezo, Wacker, & Grote, 2009)
MT6	Willigness to share thought process	The Team Leader is willing to confirm and verbalize decisions.	He/she shares his thought process about clincial hypotheses, patient's condition and treatment with team members	(Salas et al., 2005; Wallin et al., 2009)
MT7	Admission of mistakes and willigness to seek help	The Team Leader is willing to admit his mistakes and ask for help (e.g. when hi/she is fixating in his thought process about patients management)	"We need to consult with orthopedics"	(Salas et al., 2005)
MT8	Distributed/Shared leadership[6]	Seeks advice from other expert members of the team	"What do you think this is about?" "Would you agree with me in that this	(Hodgetts & Turner, 2006, p. 17; Murase et al., 2012)

[6] "[S]**hared leadership** is viewing in team settings where multiple members of a collective take on or transfer the "leader" role among team members in order to take advantage or each member's strengths in an effort to attain the overall team goal. In shared leadership, the empowerement of multiple team members is based on expertise relevant and context" (Murase, Resick, Jimenez, Sanz, & DeChurch, 2012, p. 133).
Distributed leadership is acknowledge when there "is a collection of behaviors that can be rotated among the members of the group. Distributed leadership does not require a member to emerge based on the expertise he or she possesses

			is…”	
MT9	Distributed/Shared leadership	The Team Leader takes into account the inputs of team members	A member of the team offers a hypothesis to the Team Leader “can we think about carbon monixed poisioning maybe” and the team Leader takes that input in consideration: “We’re gonna call the lab for that, we’re gonna get the labs done and we’re gonna get the carbon monoxide level as well”	(Murase et al., 2012; Salas et al., 2005)
MT10	Distributed/Shared leadership	Allows team members to question his instructions		(Fackler et al., 2009; Hodgetts & Turner, 2006; Murase et al., 2012)
MT11	Distributed/Shared leadership	The Team Leader accepts a non-leading role when appropriate		(Wallin et al., 2009)

II	**TEAM MEMBERS’ MARKERS OF MUTUAL TRUST**			
	Codes	**Definition**	**Example**	**References**
MT12	Information sharing	Team members share task-relevant information	When the physician is putting a chest tube: “So, chest tube on the left connected, ohh some problen in here, ohhh, some blood down here”	
MT13	Willigness to follow the leader	Team members follow instructions given by the leader and commit to the roles set by the leader	After the team leader has assigned a person in the airway position, this member inmediately says “OK” and starts working on hi position	(Dirks & Ferrin, 2002; Xiao & LOTAS, 2001)
MT14	Willigness to follow the leader	Team members follow the attention foci of the team leader	Team members are attentive to where the leader is looking	

and how it contributes to the team goal. Intead distributed leadership occurs when the team member dispose of it . It can come about when the existing leader is overwhelmed with his responsabilities, or it can be predetermined by the team, such as with a set sheduale. Thus distributed leadership enable team members to rotate leadership responsabilities, such as coordination and acting as liaisons with other teams” (Murase et al., 2012, p. 134)

III	**MARKERS OF SHARED MENTAL MODELS[7] (Closed Loop Communication)**			
	Codes	**Definition**	**Example**	**References**
CL1	Use of standardized terminology[8]	Team members use standardized terminology	"O2 SAT 83, that;s not good" "SAT back up to 92"	(Rico, Sanchez-Manzanares, Gil, & Gibson, 2008; Salas et al., 2007)
CL2	Confirmation and cross checking of information	Team members verify the information received by other members receiving or ask questions to make sure they are abou to do the right thing	"I'll start now, is that alright?" "You have already administered the atropine, right?"	(Kolbe et al., 2009)
CL3	Ackwnoeldgement of reception of information	Team members make verbal statements indicating one has heard or understood given information	"Okay." "Umm hm"	(Kolbe et al., 2009)

III	**MARKERS OF SHARED MENTAL MODELS (Implicit Coordination)** Implicit coordination refers to those "mechanisms that are available to team members from shared cognition, which enable them to explain and anticipate task states and member actions, thus helping mange task dependencies" (Espinosa, Lerch, & Kraut, 2004, p. 112)			
	Codes	**Definition**	**Example**	**References**
IC1	Supportive behavior – providing unsolicited <u>information</u>	Team members provide information without request	A team member reports on blood pressure without being asked to do so "Blood pressure is Ok"	(Fiore, Salas, Cuevas, & Cannon-Bowers, 2003; Gaba, 2008; Kolbe et al., 2009; Manser, Howard, &; Segal, 1994)
IC2	Monitoring of the environment (patient or machine)	Codes when a team member checks the monitor or behavior of the patient without being asked to do so	Reading indicators on a monitor A team member remembers the team they have not receive the labs they asked for: Did we get our ABG or labs back yet?	(Kolbe et al., 2009)

III	**MARKERS OF SHARED MENTAL MODELS** (Mutual Performance Monitoring) "The ability to keep track of fellow team member's work while carrying out their own" (E. Salas et al., 2007, p. B81) "to ensure that they are following procedures correctly and in a timely manner" (McIntyre & Salas, 1995)			
	Codes	**Definition**	**Example**	**References**
MPM1	Identification of mistakes in other team member's actions	Team members identify mistakes and lapses in other team member's actions		(Klein, Feltovich, Bradshaw, & Woods, 2005; McIntyre &

[7] **Difference between situation assessment and SMMs**: Situation assessment "is different from SMMs in that situation assessment is a process and shared mental models are knowledge" (Salas et al., 2007, p. B82)
[8] "Teams tha adopt highly conventionalized terminology are capable of processing large amounts of information with relatively small effort. This consice communication indicates the presence of shared mental models of the tas and team interaction" (Salas et al., 2007, p. B81)

				Salas, 1995; Salas et al., 2005; Salas et al., 2007)
MPM2	Questioning information	Team members question information by doubting about the accuracy or source of information	"Are you sure he has no allergies"	(Kolbe et al., 2009)
MPM3	Questioning of decisions	Occurs when somebody expresses doubt concerning a decision, order or proposal	"Are you sure you want to intubate right now"	(Kolbe et al., 2009)
MPM4	Feedback to other team members' actions	Team members provide feedback regarding team members actions to facilitate self-correction	When the leader is putting a device to correct a hip fracture, a nurse tells him "That's not the way of using that stuff, you should…"	(E. Salas et al., 2007)
MPM5	Visual monitoring of team members' actions	Team members visually monitor each others performance of the task	Team member watches what another team member is doing	(Kolbe et al., 2009)

III	**MARKERS OF SHARED MENTAL MODELS** (Adaptive and Supportive Behavior) Adaptive ans supoortive behavior refers the "dynamic allocationof task-related resources by team members when hey become aware of workload distribution problem" (E. Salas et al., 2007, p. B81)			
	Codes	**Definition**	**Example**	**References**
ASB1	Supportive behavior- providing unsolicited task-relevant actions	Includes behaviors that show team members providing unsolicited help, or completing task-relevant actions without being asked to do so	After the physician anounce "I can't take more time, I'm going to make a surgical airway", the nurse inmediatley get the track kit.	(Kolbe et al., 2009; Rico et al., 2008; Salas et al., 2005; Salas et al., 2007)
ASB2	Realocation of workload	Team members dynamically reallocate workload		(Salas et al., 2007)

IV	**EXPLICIT COMMUNICATION** Refers to verbal communications team members exchange in order manage their multiple interdependencies			
	Codes	**Definition**	**Example**	**References**
EC1	Assistance requests	Coded when a team member explicitly ask for help	"Can you help me with this?"	(Kolbe et al., 2009)
EC2	Request for information	Includes verbalizations and/or behaviors that shows team members when they are explicitly requesting information from other team members	The leader says: "I'm not hearing anything from airway, how's that coming along?"	(Kolbe et al., 2009)
EC3	Providing information upon request	Team members provide information after request	After someone inquires for information coming from the airway position, the airway	(Fiore, Salas, H. Cuevas, & Cannon-Bowers, 2003; Manser et al., 2008; Zala-

			position reports: "Airway is controled, I'm bagging"	Mezö, Wacker, Künzle, Brüesch, & Grote, 2009)
EC4	Verification questions	Include somebody asking a question to make sure he/she is about to do the right thing or verifying than he/she has the right information	"I'll start now, is that alright?" "You have already administered the atropine, right?"	(Kolbe et al., 2009)
EC5	Team members approve other team members' ideas.	Includes short verbalizations of acceptance in reaction to a proposal	"Good idea" "Okay" "Um hm"	(Kolbe et al., 2009)

COORDINATION BREAKDOWNS DUE TO				
V	**COORDINATION BREAKDOWNS DUE TO**			
	Codes	**Definition**	**Example**	**Selected Citations**
CB1	Pressure to Seek Alternative Solutions	Unexpected situations occur, which prevent implementation of routines procedures	Vital signs dropp dramtically after having implemented the primary sruvey and resucitacion treatments	(Xiao & LOTAS, 2001)
CB2	Initiation of Unexpected, Non-routine Procedures	Team members initiate or adopt non-routine methods without communicating to the rest of the team	Team members deviate fromm or omit to do primary survey	(Xiao & LOTAS, 2001)
CB3	Diffusion of Responsibility	A sudden change of actions take place and distribution of roles and responsibilities is disturbed	The Team leader is not acting as such and an informal second leader emerges	(Xiao & LOTAS, 2001)
CB4	Loss of Common Ground	Team members loose common ground of the situation	Team members have different information about patient's vital signs	(Klein et al., 2005)
CB5		Team member hold important information related to their roles	Team members do not update the rest of the team about their actions and the information related to their roles	
CB6	Statement on the air	Statement on the air without verbal or visual indication of whom the receptor was		

VI	**OTHERS**			
O1	Silence and no action	Coded if a person is obviously doing nothing at all- not even observing	A team member stands around without paying attention to the process	(Kolbe et al., 2009)

O2	Silence and action	Includes situations where team members work silently and independently		(Kolbe et al., 2009)
O3	Chatting	Include non-task relevant talk	Team members talk about the wheatear	(Kolbe et al., 2009; Manser et al., 2008)
O4	Talking to the patient	Includes communicating with the patient beyond garnering or imparting clinical information	“You will start to feel very sleepy”	(Kolbe et al., 2009)
O5	Incomprehensible communication	Serves as category for anything that is acoustically incompressible		(Kolbe et al., 2009)