LEADERSHIP BEHAVIORS FROM STUDENT TEAM LEADERS IN EMERGENCY CARDIOPULMONARY RESUSCITATION SIMULATIONS

MASTER THESIS

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Acknowledgements

I thought my career as a student was never-ending; this thesis, may be an actual end of an era, but moreover, the beginning of a new one. Sadly, I cannot use the excuse “I’m a student” or “I’ve got a lot of homework to do” anymore. From now on, after ten years of education, four years in college, four years at University of Applied Science, and eventually two years University, I have to act as a grownup. And lucky me, lifelong learning is now the standard.

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Tom Swinkels
Amersfoort, December 2017

Abstract

In case of cardiac pulmonary resuscitation (CPR) early initiation is critical. In these situations it is of utmost importance that the team immediately functions effectively to improve the CPR performance. In these situations a formal leader has an important role in quickly coordinating effective collaboration. Hence, the team leader has to provide structure for the team to enable high CPR team performance: clear team leader communication is pivotal. Therefore, the purpose of this study was to examine how Technical Medicine students, participating as team leader in resuscitation simulations, use team leader behaviors and closed-loop communication to increase the team performance. Twenty-two teams participated in this exploratory research, video-observations and coding were employed to assess leader behavior. On the basis of correlational analysis and Mann-Whitney *U* tests, insight could be obtained in which leader behaviors are displayed in high and low performing teams and how closed-loop communication (CLC) was used. The Mann-Whitney *U* tests did not result in significant differences in team leader behaviors between low and high performing teams. However, team leaders (i.e., name calling during CLC) in high performing teams directed their commands, questions or inquires towards one specific individual significantly more often than team leaders in low performing teams. Additional exploratory analysis suggested that CLC complements effective communication. This enhances coordination during critical moments and assures the confirmation of important statements such administering a medicine. Furthermore, team leaders used significantly more commands early in the simulation, indicating that when basic tasks are distributed, team leader's responsibilities shift from structuring the team and initiating tasks, to securing that the guidelines are followed.

Keywords: team leader behavior, simulated cardiopulmonary resuscitation, closed-loop communication, team performance.

1. Introduction

Despite the increasing knowledge of the risk factors for the patient (Kwok, Lee, Lau, & Tse, 2003), cardiac pulmonary resuscitation (CPR) remains a complex procedure (Kneebone, Nestel, Vincent, & Darzi, 2007). Early initiation of CPR is critical; the chance for survival decreases every minute by 10% (Hunziker et al., 2011). Hence, it is of utmost importance that the team immediately functions effectively. Although the European Resuscitation Council Guidelines provides uniform approach for CPR practitioners (Soar et al., 2015), resuscitation performance of the teams may vary widely (Meaney et al., 2013). Effective team interaction is the key to improve resuscitation performance (Hunziker et al., 2011).

While technical medical skills (e.g., selecting the right doses of medication or intubation) are important and increase the individual performance of a team member and the team, non-technical skills such as leadership and communication can also complement or the team's individual technical performance (Hunziker et al., 2009). Moreover, better performing team members increase the performance of the whole team. An increasing amount of studies acknowledge the importance of non-technical skills, but our knowledge about effective leader behavior and team interaction remains scarce.

To improve resuscitation education it is suggested that both leadership (Yeung, Ong, Davies, Gao, & Perkins, 2012) and communication (Andersen et al., 2010) should be an integral part of resuscitation training. The importance of both leadership and communication in ad-hoc teams is also underlined by a study from Roberts et al. (2014). They found that a brief instruction on appropriate team behaviors and team communication significantly improved both leadership and team communication. However, only the team communication showed sustained efficacy after a three week follow-up. Thus, brief training significantly improves the performance of the whole team on short term. Effective leadership skills and behavior are also found to be a key catalyzer for high team performance in a medical setting (Hunziker, Tschan, Semmer, & Marsch, 2013).

Hunziker et al. (2013) revealed that more leadership utterances (e.g., "cancel the intubation now" or "start with compressions") from the team leader were related to better team performance. Behaviors such as commands initiate structure in the CPR team and emphasize the accomplishment of team members tasks (Burke et al., 2006). Therefore, good communication is pivotal to effective coordination of the CPR team. But, good communication is complex and not self-evident (Bergs, Rutten, Tadros, Krijnen, & Schipper, 2005). The team leader has to prioritize his or her communication to avoid task and information overload (Norris & Lockey, 2012) and, even more important, to reduce treatment errors in medical settings (Fernandez Castelao, Russo, Riethmuller, & Boos, 2013).

Cooper and Wakelam (1999) state that effective leadership is characterized by a one-way-communication in which the team leader initiates the communication with the team (i.e., distribution tasks), which is called closed-loop communication in the aviation and military community. With guidance from the aviation and military community, Burke (2004) created guidelines to train expert medical teams on CLC. CLC ensures the acceptance and execution of distributed tasks by the team leader to prevent miscommunications (e.g., one team member assuming that that another will give a drug whereas the other person did not hear that order). Several studies stress the importance of CLC on team performance in CPR settings (Bergs et al., 2005; Fernandez Castelao et al., 2013). Andersen, Jensen, Lippert, and Ostergaard (2010) interviewed Advanced Life Support (ALS) instructors, who teach about how to effectively provide CPR, and found that not all staff members were familiar with CLC. Thus, it might be important to examine 1) which demonstrated behaviors by team leaders increase team performance, 2) and how CLC increases team performance.

2. Conceptual framework

2.1. CPR simulation training

Educational programs that train students to perform an in-hospital CPR such as Advance Life Support (ALS) courses are increasingly using a high-fidelity human patient simulators. Current training places a lot of emphasis on technical skills (Andersen et al., 2010). According the 2005 European Resuscitation Council Guidelines there should be a stronger focus on training in non-technical skills (Soar et al., 2015). To improve the performance of CPR, it is suggested that Crew Resource Management (CRM) should be an integrated part of CPR training (Chamberlain et al., 2003; Hughes et al., 2014). CRM principles are derived from aviation, where non-technical skills such as leadership and communication are integrated into simulation training of flight personal (Bergs et al., 2005; Helmreich, Merritt, & Wilhelm, 1999).

2.1.1. Importance of simulation training

Medical simulations are rapidly becoming the new standard in health care training (Huang et al., 2012; McGaghie, Issenberg, Petrusa, & Scalese, 2010). It enables students to practice under realistic and critical conditions such as performing CPR. It therefore provides similar problems and challenges students might encounter in hospitals (Flanagan, Nestel, & Joseph, 2004). Moreover, simulation offers a risk-free context where trainees can learn and improve their performance (Rauen, 2004; Ziv, Wolpe, Small, & Glick, 2003). In addition, Niemi-Murola, Makinen, Castren, and Group (2007) found that half of the medical students and none of the nursing students in their study felt confident about their ability to work as a team leader and expect a doctor to work as team leader during the resuscitation. While outcomes on the use and effectives of simulation technology in medical education are scattered, Issenberg, McGaghie, Petrusa, Lee Gordon, and Scalese (2005) state that high-fidelity medical simulations does enhance learning. Thus, simulation training is important for students to prepare themselves for future real CPR scenarios.

2.1.2. Studies with simulation training

Currently studies with human patient simulators have advanced the field of CPR research because they showed the importance of studying non-technical skills such as leadership and communication (Hunziker et al., 2013). Several studies indicated how the quality of resuscitations can be enhanced with simulation training in non-technical skills (e.g.,, CRM training);

- delays and interruptions (no-flow time) of chest compressions during resuscitation were reduced (Fernandez Castelao et al., 2011)
- better adherence to the CPR guidelines (Fernandez Castelao, Boos, Ringer, Eich, & Russo, 2015)
- more effective leadership verbalizations (Fernandez Castelao et al., 2015; Fernandez Castelao et al., 2011) and an increase in information sharing by the team members (Fernandez Castelao et al., 2011)
- better use of closed-loop communication (Hughes et al., 2014)
- faster response by the team through improved communication (Blackwood, Duff, Nettel-Aguirre, Djogovic, & Joynt, 2014)
- enhanced overall leadership behavior (Fernandez Castelao et al., 2015)
- effective communication reduced cognitive load for all team members (Fernandez Castelao et al., 2015)
- significant increase in corrections of overly shallow and/or fast chest compressions in a simulated scenario (Haffner et al., 2017)

- training medical students in leadership resulted in better team performance and outcome relevant resuscitation measures such as beginning of CPR and hands-on time on the patient (Hunziker et al., 2010).

2.2. Team leader's influence on team performance in a CPR setting

To perform effectively, members of the CPR team should know how to work effectively in a team (Kneebone et al., 2007). Having one formal leader can enhance the effective interaction of CPR teams. Cooper and Wakelam (1999) showed the negative effects when two senior members both adapt leadership behaviors during a CPR: "both gave orders which at times contradicted and countermanded each other" (Cooper & Wakelam, 1999, p. 36), which initiated confusion within the team. Hence, a clear leadership role in the resuscitation team needs to be established.

Several studies underlined the importance of leadership in resuscitations. Cole and Crichton (2006) found that an individual team leader can affect a trauma's team success or failure; explicit leadership led to higher task-performance scores in items like basic ventilation and chest compression (Cooper & Wakelam, 1999). Furthermore, Yeung, Ong, Davies, Gao, and Perkins (2012) found that leadership improved technical performance (e.g., insertion of a respiratory tube), shorter pre-shock pauses, lower total hands-off ratio by the team members and shorter time to first shock, which resulted in more successful resuscitations scenarios. Also Hunziker et al. (2009) found that hands on time (I.e., giving compressions) and time to defibrillation are negative effected by shortcoming of leadership behavior and can results in significant delays. Lastly, Makinen et al. (2007) compared the performance in CPR between nurses working in two different hospitals. In the hospital were was taught that the leadership position of the resuscitation was assigned to the nurse that uses the defibrillator, scored significantly better in leadership skills than nurses from the other hospital, were leadership was not thought at all. Thus making clear who is in charge and teaching effective leadership behaviors improves resuscitation performance.

2.2.1. Role of the resuscitation team leader

As already mentioned, especially the role of the team leader is pivotal for effective functioning of the CPR team (Cole & Crichton, 2006). Hence, it is important that the leader clearly knows what is expected in his or her role. According to the American Heart Association ("PALS Resuscitation team concept," 2006) the role of the leader encompasses the following:

- organizes the group
- monitors individual performance of team members
- backs up team members
- model excellent team behavior
- trains and coaches
- facilitates understanding
- focuses on comprehensive patient care

This extensive number of responsibilities reveals the complexity of being the team leader during a resuscitation and is often very stressful (Sandroni et al., 2005). It reveals why the team leader is of great influence of the performance of the resuscitation team. Due to the inherent time pressure of a CPR setting the team leader must quickly make a collective decision about the treatment, allocate roles and assign tasks to team members (Fernandez Castelao et al., 2013).

2.3. Team leader behaviors

Hunziker et al. (2009) found that healthcare practitioners or hospital physicians rather demonstrated shortcomings in the quality than the quantity of communication. Despite an equal number of total utterances, team that met prior the resuscitation showed significant more leadership utterances than ad-hoc teams. A follow-up study revealed that more leadership related behaviors, such as giving command or inquire information (e.g., “cancel the intubation now” or “do we have a ventricular fibrillation”) from the team leader were related to better team performance (i.e., high quality behavior) (Hunziker et al., 2011). Also other studies state that leadership behaviors such as task distribution and role allocation, encourage information sharing between the team and making decisions with the team, increased the overall resuscitation performance (Andersen et al., 2010; Cooper & Wakelam, 1999; Fernandez Castelao et al., 2013; Hunziker et al., 2010; Hunziker et al., 2011; Hunziker et al., 2013; Marsch et al., 2004; Norris & Lockey, 2012; "PALS Resuscitation team concept," 2006; Tschan et al., 2006; Tschan et al., 2011).

2.3.1. Commands

Team leaders are able to improve and assure high team performance by building a structure of responsibilities within the team through communicating what needs to be done and how it should be done (Künzle, Kolbe, & Grote, 2010; Streiff et al., 2011). An early establishment of a functional group structure so team members know their responsibilities is crucial.

For this reason resuscitation teams spent almost 25% of their time on task distribution. Hence, this important team leader behavior is directly related with team performance (Schmutz, Hoffmann, Heimberg, & Manser, 2015). Marsch et al. (2004) found that absence of explicit task distribution was associated with poor team performance. Fernandez Castelao et al. (2013) states that role allocation and task distribution are ideally performed by an experienced team leader, so that the other team members can focus on the accomplishment of their assigned tasks (Fernandez Castelao et al., 2015). This will keep the hands and mind of the team leader free to coordinate the whole resuscitation (Fernandez Castelao et al., 2015). Thus, the team leader should be able to distribute task during the resuscitation trough commands.

Fernandez Castelao et al. (2013) state that “the communication process becomes vulnerable to both time delays and errors” (Fernandez Castelao et al., 2013, p. 518) when the CPR task load increases. The resuscitation team should minimize the time used to assign tasks to group members and immediately ensure coordinated action (Tschan et al., 2006). Hence, a major role of the team leader is to monitor individual performance and coordinate tasks according their roles on the team.

Additionally, Cooper and Wakelam (1999) found that leaders who initiate structure (i.e., successfully gave commands and build a structure of responsibilities in the team) within the team not only worked better together, but also performed the task more effectively. Also, leaders who are able to make it clear that they were in charge now had the most effective control with less confusion within the team (Cooper & Wakelam, 1999). Thus, team leader should be clearly identifiable in the team (Andersen et al., 2010). Hence, the following hypothesis was formulated:

Hypothesis 1 (H1): In high performing CPR teams, the team leader uses more frequently the behavior command than team leaders in low performing CPR teams.

2.3.2. Inquiries and questions

Commands structure the team in the beginning of the CPR (Künzle et al., 2010), and when established, the team leader had to reassess the situation and ensure that the relevant information of the situation have been perceived correctly. Team leaders should be able to know which treatment to take when the CPR evolves. Thus, being able to anticipate problems and being aware of the current situation (situation awareness). One way to do this is to ask questions about the patient, the situation, and the interventions that are already performed, in order to assess the initial diagnoses of the team and moreover, to decide which further treatment to take. New information prevents that team leaders become trapped in a specific treatment or diagnostic approach ("PALS Resuscitation team concept," 2006). These questions should go beyond global questions (e.g., “What can we check about the patient?”), but should guide the group to relevant aspects of the situation (e.g., “Does the patient have any deceases?”) (Tschan et al., 2006). Tschan et al. (2006) refers to this as structuring inquiry, and found that it was significantly associated with higher team performance. Furthermore, Tschan et al. (2011) found that in task where the main goal is to establish a diagnosis, explicit information sharing was positively related to resuscitation performance. Thus, the team leader should be able to ask specific questions to select the most effective treatments that increases success of the CPR. In addition, Xiao, F, Mackenzie, Ziegert, and Klein (2003) found that in teams that grew more experienced, team leaders tend to question (e.g., “should we defilbrilate now”) more opposed to command (e.g., “we defilbrilate now”). Hence, the following hypothesis was formulated:

Hypothesis 2 (H2): In high performing CPR teams, the team leader use more frequently inquiry (a) and less frequently questions (b) than team leaders in low performing CPR teams.

Team leaders should monitor and reevaluate the status of the patient, interventions that have been performed and assessment findings ("PALS Resuscitation team concept," 2006). On way to do this is to frequently voice their observations and summarize the current situation. Hunziker et al. (2011) suggest that teams who openly share information by thinking aloud, performing periodic review of data, and voicing specific findings performed better. Moreover, these actions may improve the information flow by including the entire team in the review and decision-making process. Furthermore, Schmutz et al. (2015) found that algorithm-driven tasks like CPR included a higher amount of Provide Information Without Request (PIWR) (e.g. speaking out loud their own observations) than in knowledge driven tasks. This can be explained because noted changes should be verbalized to the team. Thus, the team leader should summarize this information out loud in a periodic update. However, Schmutz et al. (2015) did not find any relation between PIWR and effective team performance. They suggest that this may be because they did not differentiate between whether the information was needed, task related and necessary or already present at that point of time. Therefore they even assume PIWIR may cause communication overload and can harm team performance. Hence, the following hypothesis was formulated:

Hypothesis 3 (H3): In high performing CPR teams, the team leader more frequently voice their observations (a) and summarize (b) the current situation than team leaders in low performing CPR teams.

2.3.3. Suggestions

When team members are relatively inexperienced commands seems to be more effective, while team members who are more experienced and possess the knowledge to make their own decisions benefit more from suggestions (Ford et al., 2016). Therefore, team leaders should be aware of the limitations and capabilities of everyone on the team (Fernandez Castelao et al., 2013; Künzle et al., 2010; Norris & Lockey, 2012; "PALS Resuscitation team concept," 2006). Moreover, allowing team members to participate in the decision making process and discuss their decisions with the team leader facilitates learning (Ford et al., 2016; Yun, Faraj, & Sims, 2005). Moreover, when a constructive intervention from the team leader is neccesary, is should be done tactfully to avoid confrontation with the team members. A way to do this is to suggest an alternative approach in a confident matter or question. Hence, the following hypothesis was formulated:

Hypothesis 4 (H4): In high performing CPR teams, the team leader use more frequently suggestions than team leaders in low performing CPR teams.

2.3.4. Commands in different phases of CPR

Tschan et al. (2006) found that commands by the team leader enhances team performance, however, the effect varies depending on the phases of team composition. When members are joining the CPR team and role allocation and task distribution functions as a team structuring tool, commands enhanced significantly the team performance. But when structure in the team was established, commands seemed to be unrelated to team performance. This could be explained because later in the CPR, the team spend more time in selecting further treatments or making a diagnosis. This arises the question whether commands are always necessary for effective functioning of a CPR team (Wacker & Kolbe, 2014). Additionally, a study from Cole and Crichton (2006) found the same result, communication early in the resuscitation by the team leader was cited by participants in the study as examples of good practice. Hence, the following hypothesis was formulated:

Hypothesis 5 (H5): In CPR teams, the team leader use more frequently the behavior command early in the CPR and less frequently later.

2.4. Closed-loop communication

Cooper and Wakelam (1999) found that effective leadership and team performance was characterized by a one-way-system communication from team leader to the CPR team. More recent studies agree and state that team communication in resuscitations should follow the same principles that are applied in closed-loop communication (Andersen et al., 2010).

2.4.1. Phases of closed-loop communication

Closed-loop communication as a communication strategy include three phases. The first verbalization is called the call-out, usually from the team leader (e.g., Peter, will you prepare for defibrillation?). The call-out has to be concise and spoken with a distinctive speech in a controlled tone of voice, in a calm and direct manner without yelling or shouting. The receiver, usually a team member, accepts and acknowledges the message (e.g., by simply saying “yes”), which is referred to as the check-back. Lastly the team leader verifies that the message has been received and interpreted correctly and closes the “loop” by a confirmation (e.g., thank you) (Hargestam, Lindkvist, Brulin, Jacobsson, & Hultin, 2013). Also, only one person should be talking at a particular time. When this is not taken in account, it can harm effective team interaction ("PALS Resuscitation team concept," 2006). An overview of suitable behaviors in each phase is given in Table 1.

Table 1. *Overview phases closed-loop communication*

	Phase	Individual	Example behavior
1.	Call-out	Team leader	Command, suggestion, question or inquiry
2.	Check-back	Team member	Confirmation or repeating the message
3.	Close the loop	Team leader	Confirmation

CLC is based on the assumption that safe communication in an emergency situation is achieved by standardized terminology and procedures and enables team to priorities their communication to avoid information overload and assures the confirmation of verbal statements (Andersen et al., 2010). An example of a closed loop communication is given:

Team leader: “Richard, can you prepare one ml adrenaline”
Team member: “Yes, preparing one ml gram adrenaline”
Team leader: “Ok”

2.4.2. The relation between team leader behaviors and closed-loop communication

Command, suggestion, question or inquiry are behaviors that can iniatiate a call-out when they are directed towards an individual team member (e.g., inquiry; “Mike, how much adrenaline did you administer?”). The team member response with the check-back (e.g.. “One miligram adrenaline”). Lastly, the team leader should close the loop (e.g., “Thank you”). Thus, to “close the loop” a team member has to react on prior coordination behavior that initiates CLC, the call-out. Therefore the number of initiated CLC largely depends on the behavior of the team leader. Likewise, task distribution from the team leader is limited to the available tasks. Hence, the following hypothesis was formulated:

> **Hypothesis 6 (H6):** In high performing CPR teams, the team leader initiates more frequently call-outs than team leaders in lower performing CPR teams.

2.4.3. Name calling

It is important that the leader ask a specific member to perform tasks such as defibrillation when the team leader initiates a call-out. An example:

> Team leader: “Can you stand clear for defibrillation”
> Team leader: “Richard, can you stand clear for defibrillation”

The differnce is subtile, but as the following example from Cooper and Wakelam (1999) shows determining it effectiveness; “it was noticeable that team leaders tended to ask for adrenaline without referring to a specific member, which often resulted in two or three nurses leaving the room to fetch adrenaline” (Cooper & Wakelam, 1999, p. 36). Moreover, it is ineffective since it may increase the cognitive load of all team members (Fernandez Castelao et al., 2015). Thus, the team leader should ask a specific member to perform tasks and call the person by name *(Cooper & Wakelam, 1999)*. Even if the leader does not know the names of the team members, they should still try to direct reference to them through non-verbal communication, for example, by eye contact. Hence, the following hypothesis was formulated:

> **Hypothesis 7 (H7):** In high performing CPR teams, the team leader use more frequently directed call-outs than team leaders in low performance CPR teams.

2.4.4. Closed-loop communication in practice

Analysis from Schmutz et al. (2015) revealed that task distribution from the team leader is a predictor of Closed-Loop Communication (CLC) and that the task related aspect of CLC ensures the acceptance and execution of distributed tasks. Although CLC is suggested to be important in a CPR setting, Hargestam et al. (2013) found limited use of CLC in trauma teams. Only one out of seven call-outs became complete CLCs and no more than three CLCs were completed per training session (completed the CLC with closing the loop). They also found that in trauma teams were the team member had the opportunity to speak up, used more often CLC compared to trauma team where the team leader showed an autohoritarian leadership style (Tschan et al., 2014). However, this assumes that the frequently of check-back opposed to closing the loop is mandatory for effective communication. Hence, the following hypothesis was formulated:

> **Hypothesis 8 (H8):** In high performing CPR teams, the team members use more frequently check-backs than team members in low performing teams.

3. Design of the study

The aim of this study was to examine how Technical Medicine students, participating in an University's ALS course, use leadership behaviors during resuscitation simulations, initiate closed-loop communication and to what extent it influences the team's performance.

3.1. Context

This study was conducted at the University of Twente located in Enschede within the department Experimental Centre for Technical Medicine (ECTM). The ECTM offers the latest state of the art simulation technology for research, development and education of students and professionals in health care. It fit the high demands for training Technical Medicine students and other health care professionals. The Human Patient Simulator (e.g., METI/METIman) is fitted with state of the art technology that is capable of responding with as a real human (e.g. real reaction of given medication, responding pupils and even coughing). The simulation can replicate different scenarios since every patient and resuscitation is unique. With the HPS, Technical Medicine students and professionals can develop their clinical skill in a safe environment without placing any patient in jeopardy. Furthermore, the two simulation rooms are fully equipped with a METIvision system which captures all sessions on video, a Human Patient Simulator (METI/METIman), a patient monitor (Infinity, Dreager) and defibrillator (Philips). The computer to control the human patient simulators are located in the control room in the middle of the two simulation rooms, but, are controlled by the instructors in the simulation rooms. Each room has three ceiling mounted camera's capturing the greater part of the room with blinded windows in the control room so the researcher was able to unobtrusively observe. Microphones which are located in the simulation rooms can send the audio signal to the control room. The current study was conducted within the course ALS between February 2017 and April of the same year. The goal of this course was to "enable students to adequately assess and treat a patient in resuscitation setting according to protocolled guidelines by making use of a systematic clinical approach and medical technology". See appendix I for a more elaborate description of the course content.

3.2. Research question and model

In the current study the researcher observed CPR simulations and contributes to extent CPR literature in the following way: The study 1) which demonstrated behaviors by team leaders increase team performance, 2) how CLC increases team performance. Furthermore, literature suggested that commands by the team leader enhances team performance, however, the effect varies depending whether the team leader is structuring the team or making a diagnoses. Therefore, 3) the study investigates if the behaviors from the team leader change over time. In order to guide this research the following research question was posed:

> ***How are team leader behaviors and closed loop communication from Technical Medicine students, participating as team leader in resuscitation simulations, associated with simulated resuscitation team performance?***

In the research model (figure 1) an overview is presented of the included concepts and possible relation.

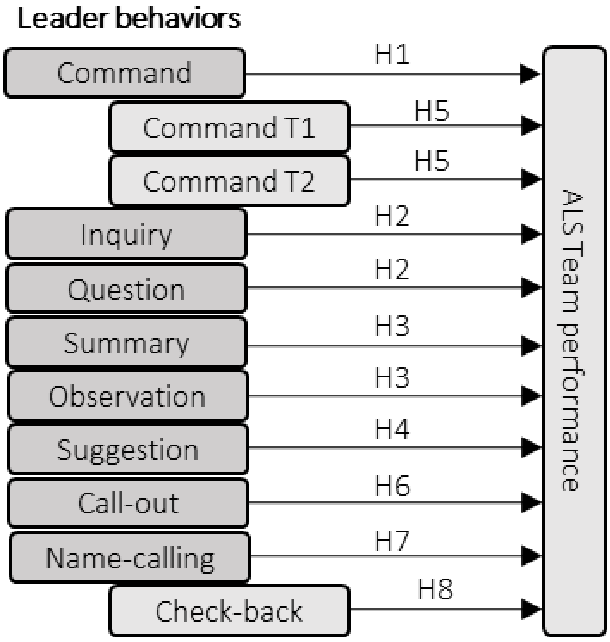

Figure 1. Research model

3.3. Design of the study

Based on (Marsch et al., 2004; Streiff et al., 2011; Tschan et al., 2014) it was decided to code the first five minutes, since these minutes are crucial for structuring the team (Tschan et al., 2006) and are strongly related to team performance (Tschan et al., 2006; Tschan et al., 2014).). Furthermore, the last few minutes of each CPR were coded and made it able to check whether leadership behaviors and the use of CLC changes later in the CPR (Klein, Ziegert, Knight, & Xiao, 2006; Künzle et al., 2010). The Duration of the sessions ranged from 17.84 to 34.88 minutes (M = 26.51, SD = 5.02). To take in account the difference in duration between CPR scenarios, 33% of each assessment was code. The scenario was divided in T1 (16.5%) and T2 (16.5%), see figure 2. The mean duration for the fragments were 272.57 seconds (SD = 61.35). Data was segmented by one researcher and coded by two researchers based on the videotapes recorded during the simulation. Differences between the two coders were resolved by jointly watching 18,18% (N = 8) of the videos (K=<.70) and negotiating a common solution. After this, percentage of agreement between coder was 81.8% and the coder interrater reliability proved a sufficiently reliable codebook (K = .79, p < .001, 95% CI, .78 to .81). See Table 4 for an overview of the coded behaviors and descriptive statistics.

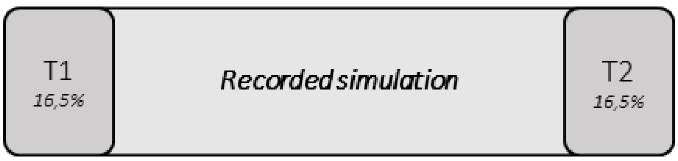

Figure 2. The first 16,5% and last 16,5% of each simulation was coded.

4. Methods

4.1. Respondents

All participants in this study were first year master students of the master programme of Technical Medicine at the University of Twente In total 95 students were enrolled in the ALS course of which 87 students participated (92%) in this study. The total of 87 participants formed 21 teams of four and one team of three by themselves. The three person team used a stand-in from another group so every role of the team could be divided and was therefore not excluded from the analysis. There were 47 female participants (54%) and 40 male participants (46%) and the mean age of the participants was 22.3 (*SD* = 1.55) years old, ranging from the age of 21 to the age of 32 (*SD* = 1.55). The majority of the teams were mixed gender (50%), the other teams consisted of only female (32%) or male (18%).

4.2. Instrumentation

ALS Team performance. The overall team performance was analyzed with a summarized version of the course scoring list, based on the ALS-course competencies: (a) following the ALS-protocol, (b) execution of technical skills, (c) diagnostics and clinical reasoning, (d) therapeutic plan, and method. The scale consists of a Likert-scale from 1 to 5 and was original in Dutch.

Additionally, a scoring list from Gibson, Cecily, and Conger (2009) was used. The scale consists of a Likert-scale from 1 to 7 and one of the four items was, for example: “This team is effective”. The scale was originally written in English, but translated for this purpose to Dutch. Both scales were filled in by the instructors of the course and the value 1 stood for “very inaccurate” and respectively 5 and 7 stood for “very accurate.” See Table 3, for an overview of the descriptive statistics of the variables. A reliability analysis in SPSS over the scale ALS performance and team effectiveness gave a Cronbach’s Alpha of .75 and .97. Both scales can be found in appendix II.

Team leader behaviors and closed-loop communication. An effective method for understanding how team dynamics affects team performance is analyzing the team communication (Pfaff, 2012). As a basis, the codebook by Lei, Waller, Hagen, and Kaplan (2015) was used to describe team leader behavior during resuscitation simulations. The codebook was originally used for flight crews in a simulations setting. Thus, some modifications were needed for our purpose in the present study, found in Table2. The videos have been coded with Observer XT 12.5 (Noldus Information Technology, Wageningen, The Netherlands); this software supports organizing, coding, and analyzing observational data. The observer had the option to allocate behaviors to specific individuals (i.e., the team-member or team-leader), was able to select if the team leader ask a specific individual by name (i.e., when giving a command) and lastly, behaviors such as confirmation (i.e., check-back part of CLC) and talking to the room.

4.3. Procedure

Prior to the study, the researchers contacted the instructors of the ALS course. Together a common goal for this study was set. The scales were explained to the instructors. Instructors watched several recorded resuscitation simulations and differences in scoring between the instructors were resolved by jointly watching the videos and negotiating a common solution. Prior to data collection, approval was received from the Ethical Committee of Twente University and data was encrypted when possible, see appendix III for more information.

At the beginning of this course students were informed about the study and asked to participate. Most of the students gave consent (94%), the respondents filled out a pre-programme survey that consists of demographic information and an question how well they know each other team member at that time.

In the following five weeks, respondents followed theoretical lectures an practical sessions where each team practices five resuscitation simulations. In these session students received support from the instructors and each simulation consisted a debriefing were students received feedback on their performance. The students were able to choose which role they wanted to fulfil during the simulation.

Lastly, students were assessed in a sixth resuscitation simulation, which was used to collect data for the present study. In the assessment, the instructor randomly assign students with a role in the team and started the simulation when all students were present. There were 8 different scenarios and the instructor explained the context of each scenario to the team leader and when necessary, some records of the patient. Subsequently, the resuscitation simulation was finished when the patient was resuscitated or when the instructor indicates the end of the simulation.

In each simulation room, one instructor was present and filled in the scales after the team finished the resuscitation simulation. One researcher was present in the control room to collect the scales that were filled in by the instructors and in case the instructors had further questions.

4.4. Data analysis

In this research, the analysis programme for statistics IBM SPSS version 22 was used to do the analyses. Due to the small groups, median-split analysis was used to turn the continuous variable ALS performance in a categorical variable (High = > 4.00). The Shapiro-Wilk test indicated that both factors ALS performance (p =.00), team effectiveness (p =.00) and most of the coded behaviors were significant (58%), Indicating not normally distributed data. For this reason, further analyses was done with non-parametric tests. Analysis with Spearman's rho indicated that ALS performance and team effectiveness are significantly related (Rs = .86, p = .00). This means that when the team effectiveness score increased, the ALS performance score increased. Since ALS performance represents the simulations better, further analysis was done only with ALS performance. Finally, hypotheses 1, 2, 3, 4, 6, 7 and 8 were confirmed or rejected using the Mann-Whitney U test. Hypothesis 5 was confirmed or rejected using the Wilcoxson Signed Ranks test.

Table 2. *Coding rules for team leader behaviour, check-backs from team members and closing the loop from the team leader*

Group	Category	Only for*	CLC	Definition	Name calling	Example
Task related	Command	TL	Yes	The team leader gives an individual a specific assignment of responsibility (addressed call-out).	Yes	*Wil jij het ECG aanzetten?*
	Observer	TL		The team leader suggests a future action without delegating it to a specific team member (call-out not addressed).		*Ik zie een hartslag.*
	Suggest	TL	Yes	Request for confirmation or rejection of statement from one or more individuals.		*Misschien kunnen we een echo van de buik aanvragen?*
	Inquiry	TL	Yes	Request for factual information, statement, or analysis from one or more individuals.	Yes	*Ademt de patiënt?*
	Question	TL	Yes	Request for confirmation or rejection of statement from one or more individuals.	Yes	*Zullen we even samen kijken naar het scherm?*
	Confirmation	TL		The team leader answers to a question by giving a confirmation.		*Ja*
	Closing the loop	TL	Yes	The team leader closes the communication loop by confirming the check-back of the follower.		*Super, dank je*
	Opinion	TL		The team leader makes a statement to express personal view.		*Dan denk ik toch dat het hypokalinmie is.*
	Summary	TL		Summarization or discussion on the current situation, diagnose and/or information to other team members on what to expect in the next stage. Any repetition of what was discussed with a bystander is also coded as summary.		*We verwachten iets van hypokalinmie.*
	External communication	TL		Any communication directed at someone outside the CPR-team and the team leader. This may include a specialist, doctor, nurse, or relative of the patient. Also communication to someone outside of the simulation (i.e. the teacher) is coded as external communication.		*Is er iemand van familie aanwezig?*
	Check-back	TM	Yes	Reaction by the follower to a call-out of the TL (i.e. Command, suggest, question, or inquiry) in the form of a confirmation, answer or observation..		*Ja, doe ik.*
	Other	TM		Any utterance by the follower that is not a check-back.		
Non task-related[A]	Laugh	TL		Laughter or clearly humorous remark by the team leader.		*Haha.*
	Sorry	TL		Excuses himself		*Oh, sorry*
	Social	TL		Social non-task communication.		*Kut*
Incomprehensible[A]	Incomprehensible	TL		The team leader says something but the content is not understandable or not relevant. Code only when the verbal behaviour is incomprehensible due to half sentences, simultaneous speaking, or background noise (e.g. beep-sound from the patient monitor), or not relevant to the research.		*Jongens*
Intervention[A]	Intervention	B		Intervention by a teacher, simulating a family member, friend or professional.		*Teacher: kan iemand mij hier vertellen wat er aan de hand is?*

Note. (*) TL = team leader, TM = team member, B = bystander. In general: Only verbal behaviour is coded; all behaviors of the TL, follower, and bystander are coded. [A] codes were used in other study carried out simultaneously with the current study.

5. Results

5.1. Descriptive statistics

As can be seen in Table 3 teams were divided in low- and high performing teams. Looking at the descriptive statistics, the standard deviation was greater in low performing teams. Furthermore, three teams received the maximum possible rating (7.00) for team effectiveness from the instructors.

Table 3. *Descriptive statistics of the dependent variables for both low and the high performing teams*

Performance	Low (*N*=11)		High (*N*=11)			
	M	*SD*	*M*	*SD*	Min.	Max.
Team effectiveness[A]	4.48	*1.10*	6.30	*.55*	3.00	7.00
ALS performance[B]	3.35	*.51*	4.31	*.30*	2.40	4.80

Note. [A] On a 7-point Likert-scale. [B] on a 5-point Likert scale.

From the behavioral data, the rate per minute over the observation duration was computed with the use of Noldus, defined as "the mean number of occurrences of a behaviour (either with or without duration) per minute over the total duration of the observation: RPM (observation) = Total number of occurrences * 60 / Duration of Observation (sec)" (Noldus, 2015, p. 320). Table 4 shows an overview of all coded behaviors in Noldus. Team leaders in high performing team showed more directed commands in both T1 (low, M = .80; high, M = 1.18), and T2 (low, M = .13; high, M = .38). Team leaders in high and low performing team had often external communication (e.g. T2 high performance, M = 2.31), increasing over time in both groups (e.g. high performance T1, M = 1.25; T2, M = 2.31). Inquiries and questions from both groups were mainly directed towards the whole team (e.g. questions high performance T2, non-directed, M = .00; directed, M = .39), compared to commands (e.g. high performance T1, M = 1.18), which were often directed towards a specific individual. Team leaders in high performing teams (T1, M = 1.81; T2, M = 1.35) received less check-backs than team leaders in low performing teams (T1, M = 1.95; T2, M = 1.38).

Table 4. D*escriptive statistics output from Noldus; team leader behaviors per minute during T1 and T2*

Time	T1[C]				T2[D]			
Performance	Low		High		Low		High	
Leader behaviors	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Command[A]	.80	*.67*	1.18	*.81*	.13	*.25*	.38	*.51*
Command[B]	1.84	*.92*	1.00	*.74*	.59	*.60*	.42	*.28*
Inquiry [A]	.03	*.05*	.00	*.01*	.02	*.04*	.00	*.00*
Inquiry [B]	.27	*.27*	.20	*.29*	.48	*.48*	.39	*.35*
Question [A]	.00	*.00*	.00	*.01*	.01	*.02*	.00	*.00*
Question [B]	.28	*.20*	.20	*.17*	.31	*.34*	.39	*.33*
Suggestion	1.72	*.94*	1.50	*.94*	1.36	*.83*	1.04	*.66*
External Communication	1.29	*1.29*	1.25	*1.09*	1.61	*1.28*	2.31	*1.74*
Summary	.46	*.28*	.50	*.32*	.38	*.29*	.31	*.27*
Observation	.38	*.19*	.34	*.39*	.45	*.38*	.60	*.61*
Check-Back	1.95	*1.06*	1.81	*1.13*	1.38	*.94*	1.35	*.75*
Closing the loop	.56	*.40*	.45	*.36*	.48	*.39*	.47	*.34*

Note. Directing the call-out towards an individual, [A] Yes, [B] no. Behaviors per minute = total number of occurrences * 60 / duration of Observation (sec). [C] First 16,5% of the CPR, and [D] Last 16,5% of the CPR.

As seen in Table 4, low performing team received more check-backs per minute than high performing teams. Because team leaders showed more behaviors, we had to standardized the results to percentages the following way; 1) Percentage directed call-outs (command, inquiry and questions) = Total call-outs / Directed call-outs and, 2) percentage call-outs followed by a check-back (command, inquiry, question and suggestion) = Total call-outs / Check backs, see Table 5 for more detailed information. Results show that team leaders in high performing teams direct their commands, inquiries or questions more to individual team members than team leaders in low performing teams. Moreover, team leaders in high performing teams receive more check-backs on the call-outs than low performing teams.

Table 5. *Percentages of directed call-outs by the team leaders and check-backs from the members during T1 and T2*

Time	T1[C]				T2[D]			
Performance	Low		High		Low		High	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Directed call-outs of total (H7)[A]	.24	*.16*	.49	*.18*	.10	*.17*	.23	*.19*
Call-outs followed by check-backs (H8)[B]	.40	*.11*	.46	*.09*	.43	*.24*	.56	*.23*

Note. [A] Percentage (H7) = Total call-outs / Directed call-outs. [B] Percentage (H8) = Total call-outs / Check backs. [C] First 16,5% of the CPR, and [D] Last 16,5% of the CPR.

5.2. Hypothesis 1,2,3 & 4: Relationship between team leader behavior and team performance

First we determined the relationship between the dependent and independent variables, namely *ALS performance* and *team leader behavior*. As can be seen in Table 6 and 7, a spearman a non-parametric correlational analysis showed correlations between *ALS performance* and some of the *team leader behaviors*.

Hypothesis 1 proposed that in high performing CPR teams, the team leader uses more frequently the behavior *command* than team leaders in low performing CPR teams. As can be seen in Table 6, no significant correlation was observed between *ALS performance* and *commands* (r_s = -.04, 95% CI [-.41,.34], p = .84). Figure 3 shows that high performing teams had a lower mean rate per minute of *commands* than low performing teams. A Mann-Whitney U test was chosen to calculate whether there was a significant difference in frequency of *command* by the team leader in high- and low- performance teams, supposing more commands for high performing teams. Teams that scored high on *ALS performance* showed not significantly more frequent *commands* (U = 51, p = .562), not in *T1* (U = 59, p = .519), nor in *T2* (U = 49, p = .477) compared to low performing ALS teams. Therefore, H1 is rejected.

Hypothesis 2 proposed that in high performing CPR teams, the team leader use more frequently *inquiry* (a) and less frequently *questions* (b) than team leaders in low performing CPR teams. As can be seen in Table 6, no significant correlation was observed between *ALS performance* and *inquiry* (r_s = -.02, 95% CI [-.33,.34], p = .93) or *questions* (r_s = -.05, 95% CI [-.46,.38], p = .82). Figure 3 shows that high performing teams had a lower mean rate per minute of *inquiries* than low performing teams and an equal mean rate per minute of *questions* than low performing teams. A Mann-Whitney U test was chosen to calculate whether there was a significant difference in frequency of *inquiries* (H2a) and *questions* (H2b). Teams that scored high on *ALS performance* showed not significantly more frequent *inquiries* (U = 46, p = .365), not in *T1* (U = 45, p = .328), nor in T2 (U = 56, p = .785). Teams that scored high on *ALS performance* showed not significantly less frequent showed *questions* (U = 57, p = .847), not in *T1* (U = 46, p = .365) nor in *T2* (U = 50.5, p = .528). Therefore, H2 is rejected.

Table 6. Correlations for the sum of T1 and T2 between team leader behaviors, closed-loop communication and team performance

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
Effectiveness and performance scales												
1. Team effectiveness	-											
2. ALS performance	.80**	-										
	(.62, .90)											
Team leader behaviors												
3. Command	-.17	-.04	-									
	[-.52, .17]	[-.32, .25]										
4. Inquiry	-.07	-.02	.441*	-								
	[-.49, .37]	[-.33, .34]	[.13, .72]									
5. Question	-.03	-.05	.35	.53*	-							
	[-.50, .38]	[-.46, .38]	[-.01, .66]	[.05, .88]								
6. Suggestion	-.34	-.19	.81**	.62**	.44*	-						
	[-.62, .01]	[-.51, .19]	[.56, .93]	[.31, .84)	[4, .75]							
7. External	-.08	.09	-.03	.14	.30	.04	-					
communication	[-.55, .43]	[-.43, .65]	[.41, .39]	[-.23, .51]	[-.17, .67]	[-.39, .43]						
8. Observation	.18	.02	-.50	.29	.28	.40	-.15	-				
	[-.41, .44]	[-.43, .50]	[.10, .80]	[-.12, .66]	[-.14, .64]	[-.08, .78]	[-.67, .41]					
9. Summary	-.27	-.12	.57**	.36	.30	.61**	.24	.28	-			
	[-.60, .13]	[-.57, .43]	[.23, .85]	[.04, .63]	[-.15, .70]	[.36, .81]	[-.27, .64]	[-.16, .78]				
10. Opinion	.03	-.31	.04	-.13	.25	.23	-.11	-.02	.02	-		
	[-44, . 48]	[-.64, .18]	[-.39, .45]	[-.54, . 34]	[-.14, .62]	[-24, .65]	[-.52, . 34]	[-45, .44]	[-41, .46]			
Closed-loop communication												
11. Check-back	.05	.01	.85**	.53*	.60**	.80**	-.10	.46*	.48*	.34	-	
	[-.00, .-02]	[-.36, .39]	[.71, .94]	[.17, .83]	[.30, .84]	[.58, .94]	[-.49, .32]	[.01, .79]	[.13, .74]	[-.03, .65]		
12. Closing the loop	.02	-.02	.55*	.74**	.67**	.56**	.16	.37	.44	.10	.71**	-
	[-.49, .41]	[-.46, .37]	[.32, .80]	[.54, .87]	[.26, .90]	[.33, .78]	[-.25, .51]	[-.02, .66]	[.05, .81]	[-.32, .50]	[.47, .86]	
13. Directed call-outs	-.10	.03	.92**	.30	.27	.817**	.02	.42	65**	.14	.81**	.36
	[-.47, .22]	[-.35, .40]	[.80, .97]	[-.00, .67]	[-.08, .59]	[.70, .92]	[-.34, .49]	[-.04, .74]	[.41, .85]	[-.33, .53]	[.55, .96]	[.08, .66]

Note. N = 22. ** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed. Values in square brackets indicate 95 % confidence intervals for each correlation. Bootstrap results are based on 1000 bootstrap samples.

Table 7. Correlations for T1 and T2 between team leader behaviors, closed-loop communication and team performance

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
Effectiveness and performance scales													
1. Team effectiveness	-	.80**	-.29	-.11	-.23	-.28	-.33	-.15	-.12	.06	.00	-.07	-.30
		[.63, .91]	[-.57, .32]	[-.64, .40]	[-.55, 11]	[-.54, .04]	[-70, .20]	[-.76, .30]	[-.50, .27]	[-.44, .61]	[-29, .29]	[-.49, .31]	[-.57, .03]
2. ALS performance	.80**	-	-.10	-.11	-.31	-.32	-27	-.26	-.06	-.23	-.01	-.02	-.14
	[.63, .90]		[-.39, .22]	[-50, .29]	[-.65, .16]	[-.49, .28]	[-.69, .39]	[-.68, .09]	[-.53, .50]	[-61, .36]	[-.37, .35]	[-.35, .36]	[-.44, .21]
Team leader behaviors													
3. Command	.16	.10	-	.38	.52*	82**	.37	.33	.58**	.11	.85**	.69**	.97**
	[-.30, .54]	[-.29, .44]		[.01, .74]	[.12, .78]	[.58, .96]	[.04, .67]	[.00, .70]	[.25, .83]	[-.26, .49]	[.67, .96]	[.40, .87]	[.93, .98]
4. Inquiry	-.01	.05	.44*	-	.23	.28	.25	.44*	.59**	.53*	.35	.59**	.46*
	[-.40, .37]	[-.28, .40]	[.06, .73]		[-.11, .56]	[-.02, .60]	[-.27, .71]	[-.12, .79]	[.30, .79]	[-.32, 82]	[-.02, .70]	[.34, .84]	[.17, .74]
5. Question	.09	.12	.36	.56**	-	.51*	.16	.55**	.25	.31	.65**	.44*	.59**
	[-.28, .48]	[-.29, .54]	[.00, .71]	[.05, .81]		[.13, .81]	[-.31, .57]	[.31, .85]	[-.21, .64]	[-.07, .61]	[.37, .85]	[.04, .73]	[.29, .83]
6. Suggestion	-.31	-.21	.55**	.68**	.30	-	.40	.40	.69**	-.01	.81**	.51*	.92**
	[-.67, .08]	[-.53, .13]	[.22, .82]	[.49, .83]	[-.22, .69]		[.12, .69]	[.13, .68]	[.38, .88]	[-.32, .29]	[.54, .96]	[.22, .79]	[.78, .99]
7.External communication	.14	.32	-.23	.06	.20	.01	-	-.13	.59**	.29	.18	.32	.40
	[-.31, .51]	[-.13, .67]	[-.56, .25]	[-.31, .48]	[-.29, .62]	[-.42, .47]		[-.48, .34]	[.10, .87]	[-.44, .76]	[-.17, .54]	[.03, .65]	[.10, .66]
8. Observation	.11	.17	.58**	.29	.36	.35	.11	-	.42	.36	.54*	44.*	.43*
	[-.33, .48]	[-.37, .59]	[.33, .88]	[-.14, .71]	[-.07, .74]	[-.04, .73]	[-.40, .55]		[.07, .76]	[-.09, .74]	[.36, .75]	[.09, .17]	[.16, .71]
9. Summary	-.29	-.12	.36	.17	.12	.38	.06	.46*	-	.52	.62**	.48*	.68**
	[-.64, .09]	[-.53, .37]	[-.06, .69]	[-.23, .60]	[-.27, .51]	[.03, .69]	[-.37, .53]	[.13, .75]		[.05, .78]	[.31, .86]	[.24, .73]	[.40, .86]
10. Opinion	.01	-.25	.21	.03	.04	.24	-.12	-.08	-.08	-	.26	.25	.15
	[-.36, .45]	[-.58, .20]	[-.16, .57]	[-.35, .46]	[-.30, .51]	[-.20, .73]	[-.50, .33]	[-.41, .46]	[-.50, .39]		[-.10. .62]	[-.18, .60]	[-.17, .45]
Closed-loop communication													
11. Check-back	.08	.03	.80**	.75**	.65**	.67**	-.05	.49*	.41	.38	-	.67**	.89**
	[-.33, .44]	[-.30, .34]	[.63, 90]	[.47, .90]	[.31, .85]	[.29, .93]	[-.47, .39]	[.19, .79]	[.02, .74]	[.01, .73]		[.43, .86]	[.74, .96]
12. Closing the loop	.11	-.02	.54	.61**	.56**	.50	.02	.35	.42	.22	.78**	-	.69**
	[-.30, .49]	[-.37, .42]	[.15, .81]	[.23, .87]	[-.01, .80]	[.20, .75]	[-.36, .45]	[.01, .17]	[-.03, .79]	[-.11, .58]	[.48, .93]		[.48, .86]
13. Directed call-outs	-.05	-.02	.81**	.81**	.60**	.87**	-.05	.52*	.37	.20	.91**	.69**	-
	[-.50, .36]	[-.35, .33]	[.60, .91]	[.63, .93]	[.19, .83]	[.77, .96]	[-.45, .41]	[.20, .83]	[-.02, .72]	[-.22, .62]	[.73, .98]	[.33, .89]	

Note. N = 22. Black = T1, Grey = T2. ** Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed. Values in square brackets indicate 95 % confidence intervals for each correlation. Bootstrap results are based on 1000 bootstrap samples.

Table 8. Comparison of team leader behavior in T1 and T2 in low- and high performing teams

	T1 [A] + T2 [B]				T1 [A]				T2 [B]			
	M	*M*			*M*	*M*			*M*	*M*		
	Low	High	Mann-Whitney *U*	*p*	Low	High	Mann-Whitney *U*	*p*	Low	High	Mann-Whitney *U*	*p*
Team leader behaviors												
Command (H1)	1.67	1.49	51	*.562*	2.63	2.18	59	.519	.72	.80	49	.477
Inquiry (H2a)	.40	.29	46	*.365*	.29	.19	45	.328	.50	.39	56	.785
Question (H2b)	.30	.30	57	*.847*	.28	.20	46	.365	.32	39	50,5	.528
Observation (H3a)	.42	.47	55	*.748*	.38	.34	49	.467	.45	.60	57,5	.862
Summary (H3b)	.42	.41	60	*1.000*	.46	.50	53	.652	.38	.31	54	.688
Suggestion (H4)	1.54	1.27	49	*.478*	1.72	1.50	52	.606	1.36	1.04	51	.562
Call-Outs (H6)	3.09	3.35	46	*.365*	4.92	4.08	47	.401	2.89	2.62	57	.847
Directed Call-Outs (H7)	.17	.36	23	*.013**	.24	.49	18	.004**	.10	.23	37,5	.119
Check-Backs (H8)	.42	.51	37	*.133*	.40	.46	41	.217	.43	.56	57	.847

Note. *correlation is significant at the .05 level (two-tailed). **Correlation is significant at the .01 level (two-tailed). [A] First 16,5% of the CPR, and [B] Last 16,5% of the CPR.

Hypothesis 3 proposed that in high performing CPR teams, the team leader more frequently voice their *observations*(a) and *summarize*(b) the current situation than team leaders in low performing CPR teams. As can be seen in Table 6 no significant correlation was observed between *ALS performance* and *observation* (r_s = .02, 95% CI [-.43,.50], *p* = .93) or *summary* (r_s = -.12, 95% CI [-.57,.43], *p* = .62). Figure 3 shows that high performing teams had a higher mean rate per minute of *inquiries* than low performing teams and a lower mean rate per minute of *summaries* than low performing teams. A Mann-Whitney *U* test was chosen to calculate whether there was a significant difference in frequency of *observations* (H3a) and *summaries* (H3b). Teams that scored high on *ALS performance* showed not significantly more frequent *observation* (*U* = 55, *p* = .748), not in *T1* (*U* = 49, *p* = .467) nor in *T2* (*U* = 57.6, *p* = .862). Teams that scored high on *ALS performance* showed not significantly more frequent *summaries* (*U* = 60, *p* = 1.000), not in *T1* (*U* = 53, *p* = .3652) nor in *T2* (*U* = 54, *p* = .688). Therefore, H3 is rejected.

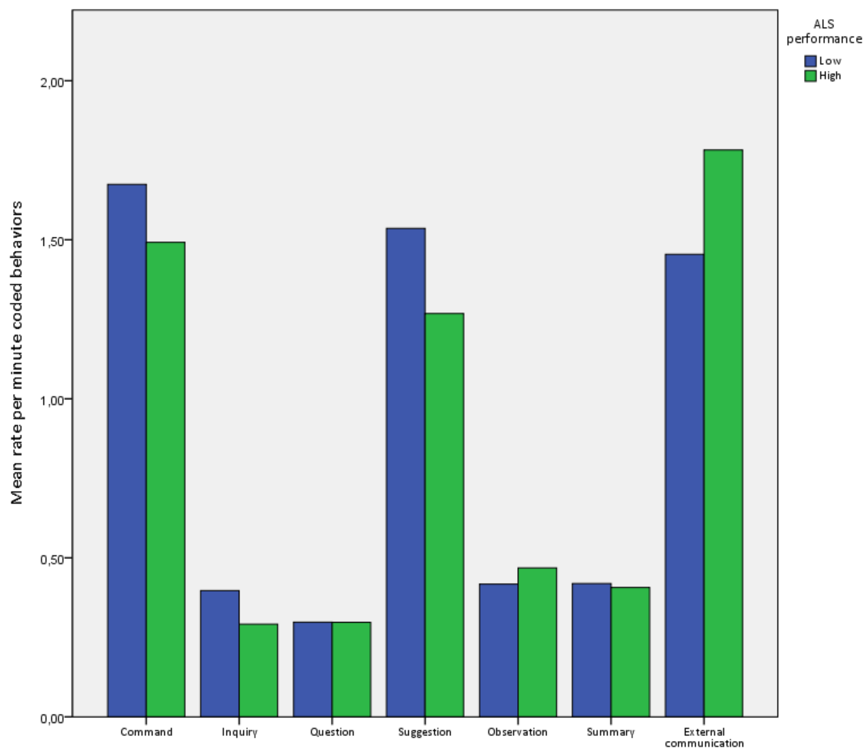

Figure 3. Mean rate per minute coded behaviors for high- and low ALS performance.

Hypothesis 4 proposed that in high performing CPR teams, the team leader use more frequently *suggestions* than team leaders in low performing CPR teams. As can be seen in Table 6 no significant correlation was observed between *ALS performance* and *suggestions* (r_s = -.19, 95% CI [-.51,.19], *p* = .41). Figure 3 shows that high performing teams had a lower mean rate per minute of *suggestions* than low performing teams. A Mann-Whitney *U* test was chosen to calculate whether there was a significant difference in frequency of *suggestions* (H4). Teams that scored high on *ALS performance* showed not significantly more frequent *suggestions* (*U* = 49, *p* = .478), not in T1 (*U* = 52, *p* = .606) nor in T2 (*U* = 51, *p* = .562). Therefore, H4 is rejected.

5.3. Hypothesis 5: Relationship between team leader behaviors in T1 and T2 and team performance

Hypothesis 5 proposed that in CPR teams, the team leader use more frequently the behavior *command early (T1)* in the CPR and less frequently *later (T2).* Figure 4 shows that team leaders in *T1* (*M*

= 2.41, *SD* = 1.37) showed more frequently the behavior *command* than in *T2* (*M* = .76, *SD* = .67). A Wilcoxson Signed Ranks test was chosen to calculate whether there was a significant difference in frequency of *commands,* seen in Table 9. Team leaders in T1 showed significantly more frequent *commands* in *T1* than in T2 (z = -3.685, p = < .001). Therefore, H5 is confirmed.

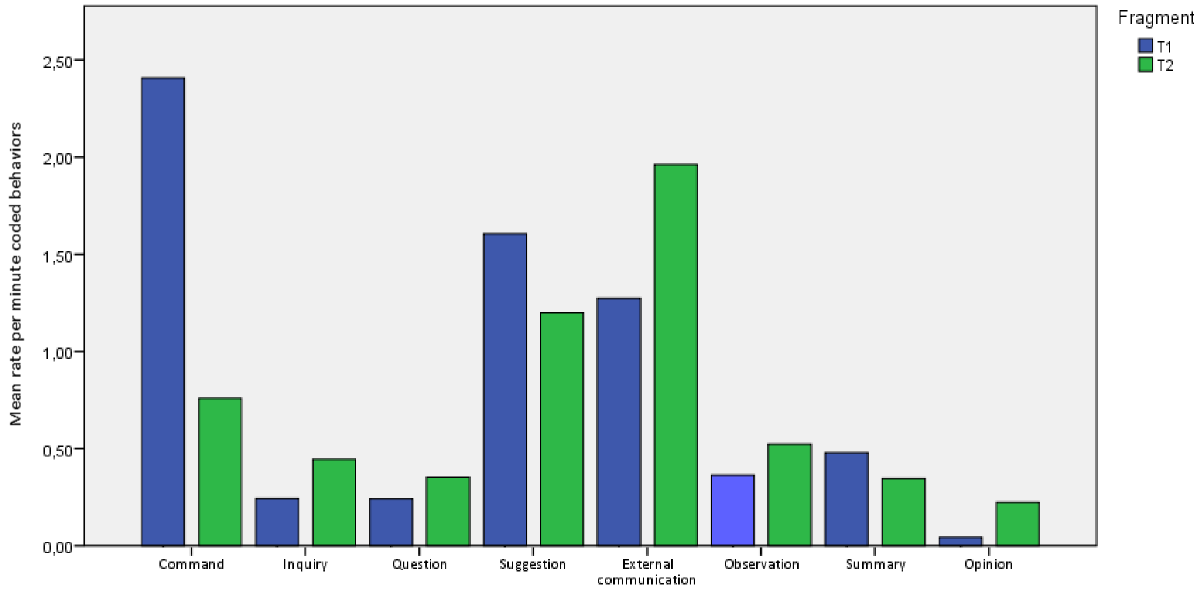

Figure 4. Mean rate per minute coded behaviors for T1 and T2.

Additional analysis shows us several other significant differences. Figure 4 shows that team leaders in T1 showed more frequent the behavior *suggestion* (T1, *M* = 1.60, *SD* = .92; T2, (*m* = 1.20, *SD* = .75) and less frequent the behavior *opinion* (T1, *M* = .04, *SD* = .28; T2, M = .22, *SD* = .25). Team leaders in T1 showed significantly more frequent *suggestions* (z = -2.256, p = .023) in *T1* and showed significantly less frequent *opinion* (z = -2.844, p = .003) in *T2*.

Table 9. Comparison of Team Leader behaviors in the T1 and T2

Team leader behaviors	*M* in T1[A]	*M* in T2[B]	-*z*	*p*
Command	2.41	.76	-3.685	.000**
Inquiry	.24	.45	-1.825	.070
Question	.24	.35	-.925	.371
Suggestion	1.60	1.20	-2.256	.023*
External communication	1.27	1.96	-1.445	.156
Observation	.36	.52	-.925	.374
Summary	.48	.35	-1.867	.063
Opinion	.04	.22	-2.844	.003**

Note. * correlation is significant at the .05 level (two tailed). **Correlation is significant at the .01 level (two-tailed). [A] First 16,5% of the CPR, and [B] Last 16,5% of the CPR.

5.4. Hypothesis 6,7 & 8: Relationship between team leader behaviors, closed-loop communication and team performance

Hypothesis 6 proposed that in high performing CPR teams, the team leader initiates more frequently *call-outs* than team leaders in lower performing CPR teams. As can be seen in Table 6 no significant correlation was observed between *ALS performance* and *call-outs* (commands, inquiry, question, suggestion). A Mann-Whitney *U* test was chosen to calculate whether there was a significant difference in frequency of *call-outs* by the team leader in high- and low- performance teams. Teams that scored high on *ALS performance* showed not significantly more frequent *call-outs* (U = 46, p = .365), not in *T1* (U = 47, p = .401) nor in *T2* (U = 57, p = .847). Therefore, H6 is rejected.

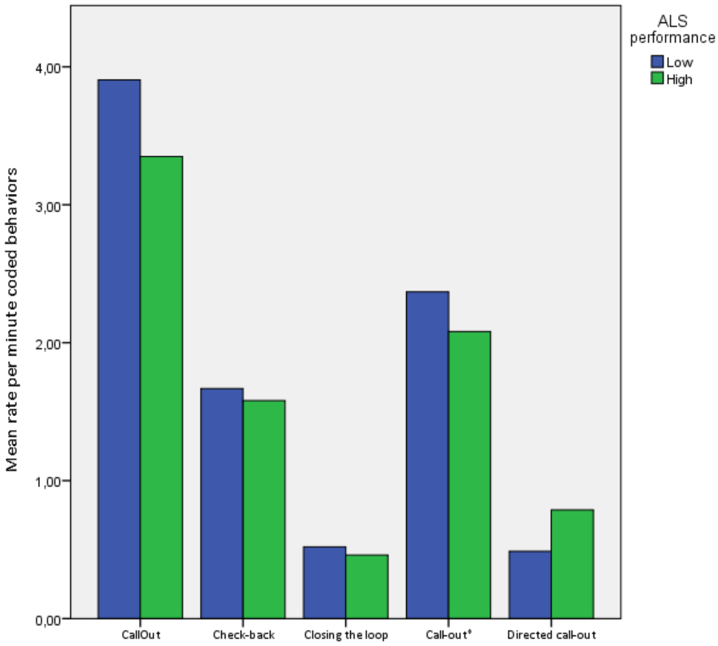

Figure 5. Mean rate per minute coded behaviors. *Call-outs that were able to direct to one individual.

Hypothesis 7 proposed that in high performing CPR teams, the team leader use more frequently *directed call-outs* than team leaders in low performance CPR teams. As can be seen in Table 6, no significant correlation was observed between *ALS performance* and *directed call-outs* (r_s = -.03, 95% CI [-.35,.40], p = .90). Figure 5 shows that high performing teams had a higher mean rate per minute of *directed call-outs* than low performing teams. A Mann-Whitney *U* test was chosen to calculate whether there was a significant difference in frequency of *directed call-outs* by the team leader in high- and low-performance teams. Teams that scored high on *ALS performance* showed significantly more frequent *directed call-outs* (U = 23, p = .013), and in *T1* (U = 18, p = .004). However, there was no significant difference in *T2* (U = 37.5, p = .119). Therefore, H7 is partly confirmed.

Hypothesis 8 proposed that in high performing CPR teams, the team members use more frequently *check-backs* than team members in low performing teams. As can be seen in Table 6, no significant correlation was observed between *ALS performance* and *check-backs* (r_s = -.01, 95% CI [-.36, .39], p = .97). Figure 5 shows that high performing teams had a lower mean rate per minute of *check-backs* than low performing teams. A Mann-Whitney *U* test was chosen to calculate whether there was significant difference in frequency of *check-backs* by the team leader in high- and low- performance teams. Teams that scored high on *ALS performance* showed not significantly more frequent *check-backs* (U = 37, p = .133), not in *T1* (U = 41, p = .108) nor in *T2* (U = 57, p = .423). Therefore, H8 is rejected.

5.5. Bonferroni correction

The current study tested eight hypotheses at a significance level of .05. The probability of observing at least one significant result by chance would be; $1-(1-0.05)^8 = 0.34$ (34%). According to the Bonferroni correction, the significance cut-off should be set at 0.05/8 = .00625 (α / n). With this correction we would have a chance of 4,9% ($1-(1-0.00625)^8 = 0.049$) of observing at least one significant result, thus just under the desired .05 significance level. This would mean that hypotheses significant at α level .05, would be rejected unless lower than α = .00625. This reduces the likelihood of incorrectly rejecting a null hypothesis (e.g., making a Type I error). The consequences for the current study would be that team leaders did not give significant more suggestions (p = .023) in T1 than in T2 (H5), and that direct call-outs overall (T1 + T2, p = .013) did not differ significantly between low- and high performing teams (H7). However, the Bonferroni correction assumes that all of the hypotheses test are statistically independent. But, our hypotheses are to a certain degree dependent on each other. For example, when the frequency of command increases in one team, it is likely that it affect the frequency of other behaviors because a team leader can only make that much behaviors within one simulation. Therefore, the probability of making at least one Type 1 error would be less than the Bonferroni correction assumes. Thus, an α level of .00625 would be an over-correction. Because the exploratory nature of the study, we may conclude that above results could interpret as significant and not a product of multiple hypotheses testing.

6. Discussion

The goal of this study was to investigate students that were performing a realistic simulation exercise, and to shed light on which demonstrated behaviors from team leaders increase team performance, how CLC increases team performance and if the behaviors from the team leader change over time.

6.1. Establishing structure in student CPR teams

The study provides an overview of concrete team leader behaviors from leaders in student CPR team, which enhance team performance, and contribute to research in team leadership, as well in team learning. None of the hypotheses were confirmed (H1, H2, H3 and H4). Literature indicate that leaders who initiate structure within the team, not only worked better, but also performed more effective (Cooper & Wakelam, 1999). In line van der Haar, Koeslag-Kreunen, Euwe, and Segers (2017), who found that high-level effective emergency management command-and-control (ECMM) teams used more structuring behaviors than low-effective ECMM teams. On average, CPR teams spend 25% of their time on task distribution (Marsch et al., 2004), and in our sample, 36% of the coded team leader behaviors in T1 were commands, mainly used to distribute task within the team. For this reason we expected that team leaders who were able to distribute tasks through commands were able to build structure early in the CPR, and thus increased the team performance. However, in contrast with other studies (Marsch et al., 2004; Schmutz et al., 2015), we found no significant relation between commands and higher team performance (H1). In our sample team structure was partly established before the start of the simulation. Each team consisted of four students that each fulfilled one role, each with their own responsibilities. Students had the opportunity to practice five times in this composition, and even more in their free time. For this reason each student knew to a certain degree which tasks they were going to fulfill during the simulation. In our observations we found that each team leader started the simulation almost the same way. Therefore, some of the commands from the team leader seemed rather a formality than a necessary behavior. Thus it seems possible that team leaders in our sample were able to building a structure of responsibilities through communicating what needs to be done and how it should be done (Künzle et al., 2010; Streiff et al., 2011). However, we do not know how much of the variation can be explained by commands from the team leader.

6.2. Effective team communication

Teams who openly share information by thinking aloud, performing periodic review of data, and voicing specific findings performed better (Hunziker et al., 2011) and improves the information flow in the entire team. Contrary to our results, team leaders in low and high performing teams did not differ in the amount of questions, inquires, providing information by voicing observations and summaries (H2 and H3). In our simulation, team leaders had to acquire information from the instructors (e.g., "Does the patient have any deceases?"), these behaviors were coded as "external communication", and may explain why the quantity of inquiry's and questions did not differ in our sample. Because the human patient simulator can only be realistic to a certain degree, team leaders had to ask which characteristics the patient had (e.g. long fingers or the tint of the skin). Explaining the small increase of observations after structure was established (T1 – T2). Our results are in line with the study from Schmutz et al. (2015), who found no relation between PIWR and effective team performance. They suggest that this may be because they did not differentiate between whether the information was needed, task related or already present at that point of time. As for our study, we also did not differentiate between whether the information was needed or already present. Acquired and shared information from the instructors, bystanders or other clinical professionals were coded as external information.

Low performing teams showed more call-outs, this suggests that the quality of team leader behaviors may be more important that the frequency of behaviors. Supported by statements from Fernandez Castelao et al. (2013), who argued that the task load effects of language processing can be reduced by clear and comprehensible verbal communication, and should be a key mechanism in resuscitation. We found also that team leaders tend to shorten the commands during the simulation. One common command from the team leaders were "(name), can you prepare the defibrillator and stand clear for a shock?", shortened to only "charge". We found that team members were able to work autonomous, since "charge" was enough instruction for the member to not only charge, but also to stand clear to give the shock. This reduce the simultaneous lines of conservation and the chance of communication overload (Schmutz et al., 2015).

6.3. Adapting team leader behaviors to CPR needs

Burke et al. (2006) indicated two opposing leadership behaviors, namely directive and empowering leadership. Directive leadership behaviors include: organization of group activities (e.g., "Tim, you take the position as basic life support and start with ventilation"), assignment of tasks (Adrie, can you check of the patient is breathing"), specification of how work should be done ("Jan, can you defibrillate this time with 360 joules"), and the establishment of clear channels of communication (Initiate closed-loop communication, the call-out) (Burke et al., 2006). The main function of these set of leadership behaviors are initiating structure within the resuscitation through commands. We found that in our sample, over 76% of the commands were given in T1. The reduction of structuring behaviors over time could be explained by the fact that new composed teams benefit from being giving commands early in the CPR (H5), while teams benefit from less directive behavior while making collectively the right diagnosis and selecting the treatment. This implies that the team leader should adapt his leadership behavior to the different phases of the CPR. Early in the CPR, there is more likely time pressure and information overload, requiring more directive behavior than later in the CPR when team structure is established.

Tschan et al. (2006) found when structure was established in the team, directive leadership seems unrelated to team performance. When the team is making a diagnosis, team composition is less likely to change and it is likely that basic tasks are distributed. As in our sample, team composition was not going to change. We found that students received a CPR simulation instruction video with the focus on the behavior of the team leader. The students showed the same team leader behaviors as the team leader in the instruction. Implying that directive leadership from the team leader, as mentioned earlier, seems more a formality than a necessary need in the CPR. When basic tasks are distributed, team leader's responsibilities shift from structuring the team and initiating tasks, to secure that the guidelines are followed and the resuscitation is not interrupted (Tschan et al., 2014). This suggest that directive leadership is not always necessary during resuscitations (Wacker & Kolbe, 2014).

This arises the question whether teams in our education context benefits more from empowering leadership behavior. Empowering leadership behaviors emphasizes the development of team member self-leadership skills, whereas team members take mutual leadership responsibility (Pearce & Sims, 2002). Ford et al. (2016) and Yun et al. (2005) states that empowering leadership is more effective with team members who possess the clinical knowledge to make their own decisions. We found that some team leaders, especially in T2 spent more time on external communication (talking to instructors, bystanders or other clinical professionals). At that moment, we saw that most of the students showed excellent knowledge of the procedures and were able to work almost autonomous without direction from the team leader. It seems that teams in our sample shifted after basic tasks were distributed to a more a more empowering approach. This can be particular be beneficial in a simulation within an education setting such as an University ALS course, empowering leadership facilitates learning by allowing the team members to make their own decisions and discussing this with the team leader (Ford et al., 2016; Yun et al., 2005).

6.4. Closed-loop communication in CPR simulation

We found a strong correlation with team leader behavior and closed-loop communication. This result was not surprising, since a response on the team leader was coded as the check-back, and a confirmation from the team leader as closing-the-loop. We found that 45% (mean rate behaviors per minute, M = 3.62; check-backs, M = 1.62) of the call-outs resulted in check-backs, and only 14% (mean rate behaviors per minute, M = 3.62; closing the loop, M = .49) of the call-outs resulted in closing the loop, thus complete CLC. This is in line with Hargestam et al. (2013), who found that only one out of seven call-outs (14%) became complete CLCs and no more than three CLCs were completed per training session. In our observations we found that some of the team leaders had the habit to answer most of the check-backs with a short "ok". Because the limited use of completed CLC, we hypothesized that the quantity of check-backs would be significant higher in high performing teams. Our analysis show that high performing teams did not differ significant in the quantity of check-backs, but on average (see Table 5), high performing team had 6% (low, 40%; high, 46%) more check-backs in the first few minutes and 13% (low, 43; high, 56%) more in the last few minutes than lower performing teams (H8). An explanation can be the more effective call-outs receive more often a check-back than call-outs that are not clear. However, this study found no relation between check-backs or closing the loop with team performance.

We found that closed loop communication was used more early in the simulation when team structure had to be established and the confirmation of verbal statements was important (Soar et al., 2015). Depending on the situation, a check-back or confirmation by the team leader may not always be beneficial. For example, as the CPR evolves, the same team members provide compression to the patient. The team leader can observer direct if immediate action is taken, making the check-back or closing the loop unnecessary. This is in line with Schmutz et al. (2015), which did not assess the last step (closing the loop) because it occurs very seldom. Moreover, it could contribute to communication overload given that there is often more than one line of conversation in an emergency team (Schmutz et al., 2015). We therefore suggest that CLC should complement effective communication, as a tool to coordinate the team during critical moments to assure the confirmation of important statements such administering a medicine, and is in essence not the goal.

In line with other studies (Cole & Crichton, 2006; Cooper & Wakelam, 1999; Hughes et al., 2014; Roberts et al., 2014), analysis showed that team leaders in high performing teams made more use of directed call-outs than team leaders in low performing teams (H7). This effect was found in the first few minutes, not in the last few minutes because directed call-outs reduced over time in our study. This can be explained by the example that the two first members who gave basic life support, did this throughout the whole simulation. It seems that name calling may not be necessary when basic tasks are distributed. Furthermore, directing call-outs reduces the cognitive load of other members in the team (Fernandez Castelao et al., 2015). By not directing a command towards an specific member, it is likely that the team leader has to repeat the command and delays the execution of the task.

7. Limitations, furture research and conclusion

7.1. Limitations and future research

The present study provided relevant information on effective team function in an CPR simulation. Studying the relation between team leader behavior and CLC with team performance makes this paper a valuable contribution to recent literature in the field of medical emergency simulation. Nevertheless, this research comes with inevitable limitations.

To begin with, we did not monitor how much teams spend exercising both technical skills and team dynamics. Each team had five practice simulations. Students and teams were able to practice technical skills in their free time, which may increase the performance of the team. Furthermore, most teams knew each other well, since they were able to choose their own team members. Some teams existed of individual that did not know each other. According to Pittman, Turner, and Gabbott (2001), team dynamics should not be developed for the first time at a resuscitation. The process of team-building should be deliberately payed attention to during practice. Thus, future research should try to measure how much teams spend practicing of the record and monitor existing team dynamics.

The small sample size (*n*=22) limited the statistical power of the analysis. We used a median-split analyses, therefore assuming that every value above or below the median was equal. Due to the small sample size, we did not decide to split the sample in three groups. Therefore, this research has a more descriptive character and results should be interpreted with caution. More reliable results could emerge from a similar study with a bigger sample.

Team performance was scored by two instructors. Both received instruction and spend time discussing the scoring scale. Duo to practical reason, each instructor was only able to rate half of the teams. This meant that we were not able to do an inter-rater reliability analyses and look at the inter-rater agreement between both raters. Moreover, more extensive training should be done to prepare the instructors for rating the team performance scales.

Furthermore, the current study did not took knowledge and experience in account. Greater experience among team members may decrease the amount of input needed from the team leader, but remain present to monitor team member behavior (Künzle et al., 2010). Kim et al. (2016) state that the success of cardiac arrests can be influenced by the healthcare providers' knowledge of resuscitation science and their level of skill in CPR. Furthermore, Ackermann (2009) studied the effect of the acquisition for both CPR knowledge and skills. The study showed that on the pretest both control and experimental groups indicated no statically differences in the mean scores. However, students who had additional experience with the simulation demonstrated statistically significant higher scores for CPR knowledge and skills. Therefore future studies should take knowledge in account when relating it to CPR performance.

Our study showed that the team leader becomes less involved in the team when the resuscitation shifts from structuring the team to making a diagnosis. Empowering leadership could be more beneficial then. Empowering leadership facilitates learning by allowing the team members to make their own decisions and discussing this with the team leader (Ford et al., 2016; Yun et al., 2005). Klein et al. (2006) refers to this as dynamic delegation, wheares the active leadership role is passed to less experienced team members. Furhermore, the interplay of features of team members can affect leadership patterns (Künzle et al., 2010). There is done little research on the influence how team members affect leadership. In future research, it would be interesting to investigate how members influence the leadership in the team.

It must be taken into account that the present study did focus on a simulated setting and was part of an universities ALS course, with the goal of improving future simulation training. Therefore, the results of this study are not generalizable to real-life CPR scenarios

7.2. Practical implications

Resuscitation simulations are the key to prepare upcoming clinical experts to be able to give high quality CPR and train their skills without harming real patients. The simulations today are able to create real challenges and provide learners with similar problems that might be encountered in hospitals. Simulation can be designed in almost unlimited ways. However, the current simulation had some limitations. For example, each member was assigned to a role, therefore demanding less structuring behavior from the team leader. Furthermore, the team leader did not have to monitor the individual performance of the team members. Because the predefined roles and the included tasks, the team leader did not had to took individuals members knowledge, preference and skills into account. We are aware that the goal of the simulation in our sample was to "enable students to adequately assess and treat a patient in resuscitation setting according to protocolled guidelines by making use of a systematic clinical approach and medical technology", because it is less likely that they will encounter a real scenario in the nearby future. However, simulations still could benefit from an less structured simulation, enabling the team leaders fully potential to assign roles and distribute tasks. An assignment during the simulation could be, "You're team consist of five team members, assign the roles and tasks effectively". This would clearly demand more structuring behaviors from the team leader, and probably, it would take longer before basic tasks are distributed and structure is established.

Furthermore, the current study suggests that complete CLC cycles are not mandatory for effective communication. We therefore suggest that more focus should be on clear and comprehensible communication instead of CLC. The CLC can only be as effective as initiated call-out. For example:

Team leader: "Mark, can you push the button?"
Team member: "Which red button, do you mean this one on the patient monitor?".
Team leader: "Yes, to silence the sound"

As result, we are? not further in the CLC cycle than the original call-out. A check-back on the initial call-out was still not given. In contrast to the following example:

Team leader: "Mark, can you push the red button on the patient monitor?"
Team member: "Yes and done"

Moreover, it show also how simultaneous lines of conservation can be reduced and the chance of communication overload. Furthermore, the second example ensures faster action. This example can also explain why not every call-out has to result in a check-back. When the team member pressed the button, the sounds stops and gave the team leader immediately a check-back. The team member did not have to give any confirmation. Clear communication should be the main focus in ALS courses so no confusion can occur. Especially when the team leader distributes tasks, so the team leader can take immediately action without delay.

7.3. General conclusion

The goal of the study was to examine which behaviors and CLC by team leaders increase team performance and if the behaviors from the team leader change over time. Therefore, the following research question was posed; *How are team leader behaviors and closed loop communication from Technical Medicine students, participating as team leader in resuscitation simulations, associated with simulated resuscitation team performance?*

The current research shows some interesting results. First, by providing commands, team leaders in our sample were able to build a structure of responsibilities through communicating what needs to be done and how it should be done. Second, when it comes to CLC, we found that a great portion of the team members were able to work autonomous, since "charge" was enough instruction for the member to not only charge, but also to stand clear to give a shock. This can reduce the simultaneous lines of conversation during the simulations and the chance of communication overload. Third, when the basic tasks were distributed, team leader's responsibilities shifted from structuring the team and initiating tasks, to securing that the guidelines are followed and the resuscitation is not interrupted. This suggest that more directive forms of leadership were not always necessary during the simulation. It implies that simulations in the same context could benefit from more empowering leadership behavior while making diagnosis and selecting furture treatments. Fourth, closing the loop occurred very seldom. It could contribute to communication overload given that there is often more than one line of conversation in a team. We therefore suggest that CLC should complement effective communication, as a tool to coordinate the team during critical moments to assure the confirmation of important statements such administering a medicine, and is in essence not the goal. Finally, our analysis showed that team leaders in high performing teams made more use of directed call-outs than team leaders in low performing teams. By not directing a command towards an specific member, it is likely that the team leader has to repeat the command and delays the execution of the task. Furthermore, directed call-outs reduce over time in our study. This can be explained by the example that the two first members who gave basic life support, did this throughout the whole simulation. It seems that name calling may not be necessary when basic tasks are distributed. Hence, we were able to show here that investigating leader micro-behavior and CLC at 2 different times in CPR simulations provides promising guidelines on what enhances the effectiveness of the team. More study needs to be done in real-life medical teams to further substantiate our results.

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Appendix I: Learning goals and course content

Goal

The course Advanced Life Support enables students to adequately assess and treat a patient in resuscitation setting according to protocolled guidelines by making use of a systematic clinical approach and medical technology.

The following learning objectives are pursued:

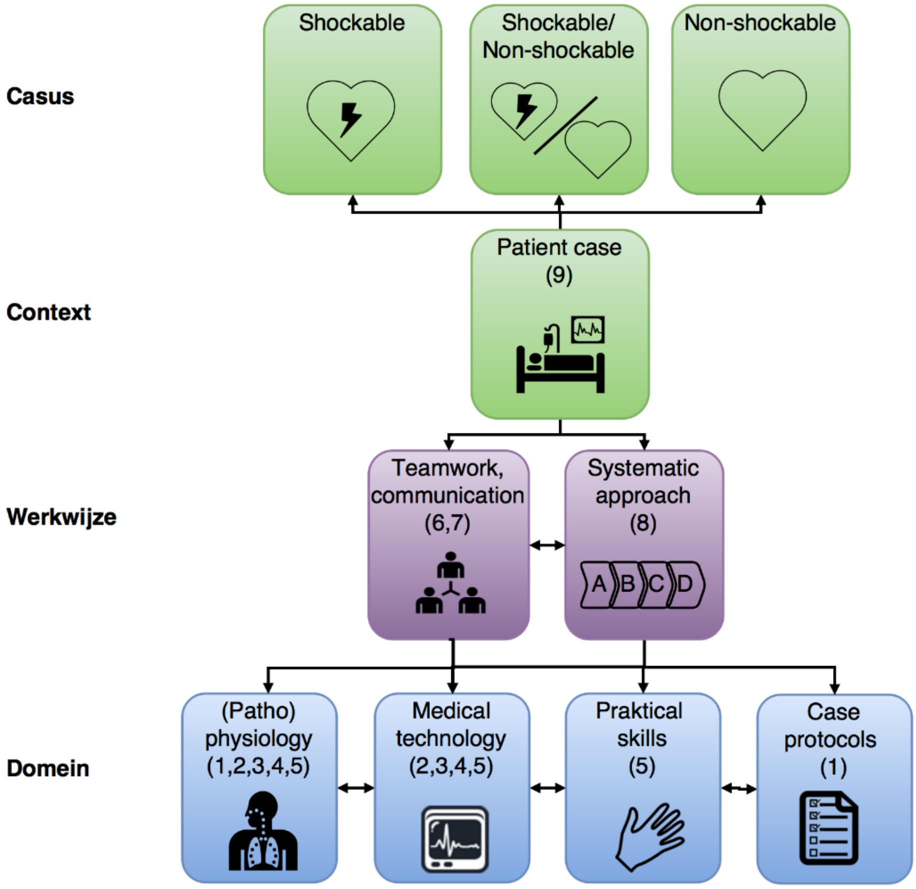
1. The student can describe the underlying principles of therapies that are commonly used in a resuscitation setting
2. The student can describe the possibilities and limitations of diagnostic technologies that are commonly used in a resuscitation setting
3. The student is able to relate information derived from the anamnesis, physical examination, arterial blood gas values, venous laboratory values, echography, X-thorax and the patient monitor to an individual patient case.
4. The student can perform resuscitation in a team according to the protocol of shockable and non-shockable rhythms in a simulated resuscitation setting.
5. The student can adequately perform chest compressions, non-invasive ventilation techniques, medication administration, and electrical therapies that are part of the resuscitation protocol in a simulated resuscitation setting.
6. The student can adequately communicate and collaborate in a team in a simulated resuscitation setting.
7. The student can handover patients in a structured way according to the SBAR methodology.
8. The student can analyze a patient in a structured way according to the ABCDE methodology.
9. The student can propose an adequate diagnostic and therapeutic strategy based on the available clinical and contextual information of a patient case.

Content

In the course Advanced Life Support, we will follow the guidelines provided by the European Resuscitation Council. Yet, we do not intend to train resuscitation teams or to provide any certifications, but to create insight in medical technologies and procedures that are relevant in the management of patients witch a circulatory arrest.

During the course, students will practice and become acquainted with medical technologies and skills, in which the underlying therapeutic and diagnostic principles are underlined. Next, specific attention is given to the clinical approach of patient assessment and the interpretation of critical body functions. The major part of the course consists of sessions in which knowledge and skills have to be integrated and applied on a simulated patient case in a resuscitation setting.

	Cognitieve vaardigheden (kennis)	Praktische vaardigheden (handelingen)	Interactieve vaardigheden (samenwerking, communicatie)	Intellectuele vaardigheden (Integratie)
Leerdoelen	1, 2, 3, 4	5	6,7	3, 5, 8, 9
Voorkennis	Basis kennis	BLS Injecteren	N.v.t.	N.v.t.
Onderwijs	Hoorcollege, Zelfstudie, Groepsopdracht	Skills practicum	Werkgroep	Groepspracticum
Toetsing individu	Theorietoets	BLS toets	N.v.t.	Theorietoets
Toetsing groep	Casus assessment (geïntegreerd in context)			



Appendix II: Team effectiveness and performance scales

Team effectiveness and performance scales

Groep:	________
Datum:	___/___
Practicum:	________
Rater:	________

Hieronder volgen enkele uitspraken. Geef aan in hoeverre je het eens of oneens bent met de uitspraak of item. Teken daarvoor een kruis in de desbetreffende cirkel. Noteer ook je voorletters in de rechterbovenhoek van deze bladzijde.

Geef bij elke uitspraak een antwoord, zelfs als je niet helemaal zeker van je antwoord bent. Belangrijk om te weten: er is <u>geen goed of fout antwoord</u>. Alle gegevens worden enkel ten behoeve van dit onderzoek gebruikt.

Team performance

	Erg inaccuraat 1	2	3	4	5	6	Erg accuraat 7
1. Dit team is een consistent goed presterend team	◯	◯	◯	◯	◯	◯	◯
2. Dit team is effectief	◯	◯	◯	◯	◯	◯	◯
3. Dit team maakt weinig fouten	◯	◯	◯	◯	◯	◯	◯
4. Dit team verzet kwalitatief hoog werk	◯	◯	◯	◯	◯	◯	◯

ALS performance

1 = onvoldoende, 5 = uitstekend

	- - 1	- 2	+/- 3	+ 4	+ + 5
5. ALS-protocol	◯	◯	◯	◯	◯
6. Uitvoering handelingen	◯	◯	◯	◯	◯
7. Diagnostiek en klinisch redeneren	◯	◯	◯	◯	◯
8. Therapeutisch plan	◯	◯	◯	◯	◯
9. Werkwijze	◯	◯	◯	◯	◯

Leadership effectiveness

	1 Volledig mee oneens	2	3	4	5 Volledig mee eens
10. Vergeleken met andere leidinggevenden is deze leidinggevende <u>**niet**</u> erg efficiënt	◯	◯	◯	◯	◯
11. De manier waarop deze leidinggevende functioneert is een goed voorbeeld voor andere leidinggevenden	◯	◯	◯	◯	◯
12. Deze leidinggevende slaagt er vaak <u>**niet**</u> in doelen te halen	◯	◯	◯	◯	◯
13. Deze leidinggevende heeft succes binnen het team	◯	◯	◯	◯	◯

	Zeer ineffectief				Zeer effectief
14. Ik vind deze leidinggevende: zeer ineffectief (1) - zeer effectief (5)	◯	◯	◯	◯	◯

Handleiding en uitleg effectiveness & performance scales

Team performance (Vertaald uit Gibson, Cooper, & Conger, 2009)

1. Met een consistent goed presterend team wordt bedoeld: Een team dat gedurende het hele reanimatie- scenario goed presteert.
2. Een effectief team wordt gedefinieerd als team dat doeltreffend werkt, zijn doelen behaalt, in de algemene zin. Een doel kan bijvoorbeeld zijn: het komen tot de juiste diagnose. De nadruk wordt hierbij gelegd op het behalen van het doel, en in mindere mate op het proces.
4. Met kwalitatief werk doelt men zowel op de technische als de niet-technische aspecten van het werk.

Origineel:
1 = very inaccurate, 7 = very accurate

1. *"This team is consistently a high performing team."*
2. *"This team is effective."*
3. *"This team makes few mistakes."*
4. *"This team does high quality work."*

ALS performance (ALS scorelijst, TG)

5. ALS protocol

Weging: 20%
Onder ALS protocol wordt verstaan:

   a. primaire diagnose: De patiënt aanspreken, schudden, respons afwachten, in mond kijken en/of voelen, chinlift, look/listen/feel (≥ 7 sec.), en pols voelen (≥ 4 sec) voor start compressies.
   b. Reanimatie cyclus: directe start na primaire diagnose, minimale interruptie, 30:2 ratio compressies: beademingen
   c. Snelle ritmecheck: vroeg en juiste interpretatie
   d. Indicatie defillibratie: shock vs. non-shock
   e. Opvolging handelingen protocol: aanhouden 2 min. cycli

6. Uitvoering handelingen

Weging: 20%
Onder uitvoeringen handelingen wordt verstaan:

   a. Compressie techniek: juiste handplaatsing, frequentie (100/min)
   b. Kap beademing techniek: correcte mayo tube maat selectie + plaatsing, en correcte handpositie + teugtoediening.
   c. Ritmecheck methodiek: onderbreken compressies, pols voelen, en gezamelijke interpretative ritme.
   d. Defillibratie techniek: correct gebruiken defillibrator, waarschuwing omgeving ("*bed vrij*").
   e. Intubatie techniek: material selectie en controle, juiste intubatie techniek (max. 12 sec), en controle via look/listen/feel techniek.
   f. Medicatie toedieningswijze en dosis: juiste concentratie en juiste toegangsroute.

7. Diagnostiek en klinisch redeneren

Weging: 40%
Onder diagnostiek en klinisch redeneren wordt verstaan:

   a. ABCDE systematiek: volgorde en compleetheid
   b. Inzet anamneses: relevantie en compleetheid (algemene, speciële, aanvullende anamnese)
   c. Inzet lichamelijk onderzoek: relevantie en compleetheid (volgens ABCDE)
   d. Inzet diagnostische technieken: relevantie en compleetheid (monitor, lab, ECG, echo, X-thorax)
   e. Interpretatie diagnostische informatie: juiste interpretatie diagnostische uitslagen (anamnese, lichamelijk onderzoek, monitor, lab, ECG, echo, X-thorax)
   f. Diagnostische conclusie: correcte diagnose stelling
   g. Reassessment: herevaluatie bij verandering status

8. Therapeutisch plan

Weging: 10%

Onder dit item wordt verstaan:

a. Behandeling onderliggende oorzaak: passende behandeling
b. Post-resuscitation care: overdracht naar passende afdeling/specialist, en adequate follow-up strategie

9. Werkwijze

Weging: 20%

Onder werkwijze wordt verstaan:

a. Closed loop communicatie: naam benoemen, bevestigen, heldere communicatie
b. Onderling overleg en samenwerking: overleg en samen besluit nemen, en elkaar helpen bij onzekerheid.
c. Overdracht volgens SBAR: SBAR componenten aanwezig

Leadership effectiveness (adapted from Hooijberg, 1996)

10. Met efficiënt wordt bedoeld: de doelen worden op de meest economische manier behaald. In deze context betekent het dat de leidinggevende handelt en zijn/haar doelen bereikt op de meest zuinige/nuttige/verstandige manier wat betreft tijd, inspanning en middelen.
11. Hier wordt gevraagd of de leidinggevende als een rolmodel voor zijn teamleden functioneert, zodat zij er in de toekomst een voorbeeld aan kunnen nemen wanneer zij in een leidersrol moeten staan.
12. Onder doelen wordt verstaan: de doelen die een leidinggevende moet behalen, zoals op een correcte manier communiceren, het protocol volgen, etc.
13. Met succes wordt bedoeld zowel op sociaal/emotioneel vlak, als succes in het redeneren, actie ondernemen etc.
14. Voor een definitie van effectiviteit: zie punt 2.

Appendix III: Encryption research data

Plan versleuteling data onderwijskundig onderzoek ALS (febr – aug 2017)

De data zou verzameld worden op basis van studentnummer. Dit valt onder de categorie persoonsgegevens, en wordt alleen toegestaan indien er geen andere mogelijkheid is om de data beschermd te verzamelen. We geloven dat dit inderdaad bij ons onderzoek van toepassing is, om de volgende redenen:

1. Het videomateriaal is gekoppeld aan studentnummer binnen een beschermde omgeving.
2. Indien elke student een ander nummer zou krijgen, zou
   a. Elke student zijn eigen nummer moeten onthouden: hier bestaat het risico dat studenten het nummer vergeten. Mogelijke gevolgen: De procedure wordt vertraagd of studententeams worden ge-excludeerd.
   b. De persoon met de versleuteling telkens aanwezig moeten zijn om de juiste nummers aan de juiste studenten te geven, onder andere tijdens snelle groepswissels. De studenten, noch de onderzoekers kunnen de nummers checken. Mogelijke gevolgen: studentnummers worden verwisseld (data is dan niet meer betrouwbaar), de procedure loopt vertraging op.

   Hierdoor moeten we concluderen dat dataverzameling op basis van geanonimiseerde nummers de betrouwbaarheid van het onderzoek in het gedrang kunnen brengen.

   Daarnaast beschikken de onderzoekers niet over de tijd, noch de middelen om data volledig geanonimiseerd te kunnen verzamelen.

Om deze reden stellen we het volgende voor, zoals te zien in het verzoek voor de Ethische Commissie:

Met alle data zal vertrouwelijk worden omgegaan. Omdat het videomateriaal en teams gekoppeld zijn aan studentennummers, zal initieel alle data verzameld worden op basis van dit studentennummer. Wanneer data binnenkomt, wordt elk studentnummer zo snel mogelijk omgezet naar een nieuw nummer door middel van een versleuteling. Dit document zal zich gescheiden van de onderzoeksgegevens, op een fysiek andere plek bevinden. Enkel de hoofdonderzoeker krijgt inzage in de sleutel. Onderzoekers kunnen de data pas analyseren wanneer deze versleuteld is, met uitzondering van het videomateriaal. Deze kan namelijk niet losgekoppeld worden van het studentnummer, omdat de onderzoekers slechts inzage krijgen in de video's die gedeeld werden aan de betreffende studententeams op een beschermd platform. Alle informatie blijft binnen het onderzoeksteam, en derden zullen geen informatie over individuele respondenten kunnen ophalen.

Enkel het geel gemarkeerde zal anders geïnterpreteerd/aangepast moeten worden:

Onder hoofdonderzoekers zal moeten worden verstaan: Jolien van Sas en Tom Swinkels. Onderzoekers zijn Simon Rijsemus en Maschja Baas.

Toegang tot de versleuteling zal vergrendeld worden door middel van een paswoord die alleen Tom en Jolien kennen. Daarnaast zal –indien mogelijk- een verbod voor printen in het document worden gezet. Na afronding van het onderzoek krijgt de coördinator van het onderzoek (Maaike Endedijk?) toegang tot het document, en wordt de toegang voor Tom en Jolien verboden.

In de praktijk:

Alle analoge data zal de studentnummers bevatten, de respondenten vullen deze zelf in. Op digitale data (met uitzondering van het videomateriaal) zullen geen persoonsgegevens (naam of studentnummer) terug te vinden zijn. Het omzetten van studentnummer naar een geanonimiseerd nummer zal gebeuren tijdens het handmatig invoeren van analoge data in een digitaal bestand. Hiervoor zal een beschermde sleutellijst aangemaakt worden, waar enkel de hoofdonderzoekers toegang tot zullen hebben.

We zijn ons ervan bewust dat deze manier van data verzamelen risico's met zich meebrengt. Wegens tijdgebrek en gebrek aan middelen was het niet mogelijk data volledig geanonimiseerd te verzamelen. Echter zal erg voorzichtig met de data worden omgegaan, en zal alles achter slot en grendel (digitaal en analoog) bewaard worden.

	Categorie:	Locatie:	Inzicht door:
Studentnummers	Persoonsgegevens	Analoog	T. Swinkels & J. van Sas
Nieuwe nummers	Geanonimiseerd	Digitaal	Onderzoekers team ALS

Uit het goedgekeurde verzoek Ethische Commissie BMS:

23. OPSLAG EN VERWERKING GEGEVENS

23a. Worden gegevens van het onderzoek vertrouwelijk behandeld en anoniem opgeslagen en verwerkt?

Nee

23b. Indien Nee: Waarom niet?

Met alle data zal vertrouwelijk worden omgegaan. Omdat het videomateriaal en teams gekoppeld zijn aan studentennummers, zal initieel alle data verzameld worden op basis van dit studentennummer. Wanneer data binnenkomt, wordt elk studentnummer zo snel mogelijk omgezet naar een nieuw nummer door middel van een versleuteling. Dit document zal zich gescheiden van de onderzoeksgegevens, op een fysiek andere plek bevinden. Enkel de hoofdonderzoeker krijgt inzage in de sleutel. Onderzoekers kunnen de data pas analyseren wanneer deze versleuteld is, met uitzondering van het videomateriaal. Deze kan namelijk niet losgekoppeld worden van het studentnummer, omdat de onderzoekers slechts inzage krijgen in de video's die gedeeld werden aan de betreffende studententeams op een beschermd platform. Alle informatie blijft binnen het onderzoeksteam, en derden zullen geen informatie over individuele respondenten kunnen ophalen.

24. INZAGE GEGEVENS

24a. Hebben proefpersonen achteraf inzage in hun eigen gegevens?

Nee

24b. Worden de mogelijkheden tot inzage vooraf bekend gemaakt aan de proefpersonen? Op welke wijze?

Ja, dit zal bij de mondelinge uitleg over het onderzoek vermeld worden. Studenten krijgen geen inzage in hun eigen gegevens, tenzij ze na afronding van het onderzoek een afspraak maken met de hoofdonderzoeker die via de versleuteling gegevens van die persoon kan laten inzien. Een proefpersoon kan enkel zijn/haar eigen gegevens inzien. Deze mogen niet gekopieerd of digitaal verzonden worden.