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Trauma teams and time to early management during in situ trauma team training

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ABSTRACT

Objectives: To investigate the association between the time taken to make a decision to go to surgery and gender, ethnicity, years in profession, experience of trauma team training, experience of structured trauma courses and trauma in the trauma team, as well as use of closed-loop communication and leadership styles during trauma team training.

Design: In situ trauma team training. The patient simulator was preprogrammed to represent a severely injured patient (injury severity score: 25) suffering from hypovolemia due to external trauma.

Setting: An emergency room in an urban Scandinavian level one trauma centre.

Participants: A total of 96 participants were divided into 16 trauma teams. Each team consisted of six team members: one surgeon/emergency physician (designated team leader), one anaesthesiologist, one registered nurse anaesthetist, one registered nurse from the emergency department, one enrolled nurse from the emergency department and one enrolled nurse from the operating theatre.

Primary outcome: HRs with CIs (95% CI) for the time taken to make a decision to go to surgery was computed from a Cox proportional hazards model.

Results: Three variables remained significant in the final model. Closed-loop communication initiated by the team leader increased the chance of a decision to go to surgery (HR: 3.88; CI 1.02 to 14.69). Only 8 of the 16 teams made the decision to go to surgery within the timeframe of the trauma team training. Conversely, call-outs and closed-loop communication initiated by the team members significantly decreased the chance of a decision to go to surgery, (HR: 0.82; CI 0.71 to 0.96, and HR: 0.23; CI 0.08 to 0.71, respectively).

Conclusions: Closed-loop communication initiated by the leader appears to be beneficial for teamwork. In contrast, a high number of call-outs and closed-loop communication initiated by team members might lead to a communication overload.

Strengths and limitations of this study

- The trauma team training took place at the hospital's emergency room, providing an authentic setting for the team members to act within.
- All team members were professionals carrying out their own roles and executing their regular tasks.
- In situ trauma team training allowed for standardisation of the trauma case scenario by giving the trauma teams similar conditions.
- Organisational and structural hierarchies can differ depending on geographical and sociocultural settings.

INTRODUCTION

Time is a crucial factor for the patient's outcome during resuscitation after trauma.[1] Evidence suggests that early interventions minimise secondary injuries and reduces morbidity in severely injured patients, thus improving survival.[2–4] This provides a time frame for the trauma care. The first hour following trauma offers the highest possibility of reversing life-threatening conditions of the trauma patient and has, therefore, been designated as the 'Golden Hour'. One very important task for the trauma team is to minimise the time until definite management is established.[5 6]

The concept of trauma teams was initiated in the 1970s in the USA and was introduced in Europe about two decades later.[2 6] The team members work independently and simultaneously, and this 'horizontal' organisational approach provides rapid assessment of the critically injured patient.[6 7] Not only has the introduction of trauma teams been important for improvements in trauma care, but also the leader's role in the trauma team has been described as essential for the team's performance.[8–10] Necessary qualities for trauma team leaders include extensive skills and knowledge of trauma and trauma care, as well as having skills in various areas such as communication, leadership and cooperation.[8] These skills include the ability to change leadership style when the situation requires it, for example, when the team members lack experience.[11 12]

The collaboration in interdisciplinary teams is often described as a complex interactional process.[13–16] In healthcare, deficiencies in communication have been identified as a major contributor to errors in several different contexts.[14 17–20] These root-cause analyses gave rise to the development of Crisis Resource Management (CRM), a systematic educational programme designed to improve team performance based on knowledge from the aviation context to ensure the quality of teamwork.[21 22] Under the assumption that safe communication in emergency situations can be achieved by using standardised terminology and procedures,[9 23 24] closed-loop communication (CLC), a standardised scheme of communication has become a core component of CRM. CLC has been shown to reduce tensions between members of trauma teams, and has been suggested for routine use in these teams.[25 26] Therefore, CLC has been advocated and practiced in trauma team training in order to improve communication;[27 28] however, in healthcare there is only a little empirical evidence to show its effectiveness.

Apart from regular trauma team training, attendance at the structured trauma course is regarded as a practical and theoretical foundation for competent and skilled trauma teams.[6] The standardised and systematic principles described in ATLS[29] and also practiced in the European Trauma Course (ECT)[30 31] have been associated with improved trauma care.[32 33] It is essential to reduce both the time taken for complete assessment of the patient according to ATLS and the time taken to complete the diagnostic investigations.[34] However, although these trauma courses have resulted in early and more effective interventions in trauma care, the measured beneficial effects are weak.[35] It has been difficult to link the influence of team members' characteristics to the team members' performance on completed key tasks.[36 37] Still, in order to improve safety in trauma care and to optimise this care, it is important to identify key factors that influence the outcome of the team's performance. The hypothesis in the present study was that the time taken to make a decision to go to surgery is associated with team members' background characteristics, the use of CLC and leadership style.

Aim

Our aim was to investigate the association between the time taken to make a decision to go to surgery and gender, ethnicity, years in profession, previous educational experience and trauma in the trauma team, as well as use of CLC and leaders' position during the trauma team training.

METHODS

Participants

The participants were hospital staff involved in regular trauma team training. They were first randomly selected from staff lists, and then randomly allocated into teams. Initially, 19 teams were entered into the study, but two teams were excluded due to a fault in the recording equipment and one team was excluded because one team member was absent. Hence, 16 teams with a total of 96 participants were included in the study. Each team comprised of six participants: one surgeon/emergency physician (n=16), three of them attending; one anaesthesiologist (n=16), three of them attending; one registered nurse from the emergency department (n=16); one registered nurse anaesthetist (n=16); one enrolled nurse (nursing assistant in American English) from the emergency department (n=16); and one enrolled nurse from the operation ward (n=16). The participants with non-Scandinavian background were talking Swedish. There were no indications that the leaders did not understand the Swedish language.

Research setting

The trauma team training used in this study has been described elsewhere.[27 38] The training was performed in situ in the emergency room of the emergency department at an urban teaching hospital with 850 patient beds, classified as a Level 1 Trauma hospital in Northern Sweden. A patient simulator (SimMan 3G, Laerdal, Stavanger, Norway) was preprogrammed to represent a severely injured patient with an injury severity score of 25.[39] An automode programme was used to control the pathophysiology during the simulation. The pathophysiological state to be simulated was severe hypovolemia due to either blunt or penetrating trauma. The mechanism of injury was either a bicycle accident with the bicycle handlebar hitting the upper abdomen or a knife stabbing incident that had cut the left axillar artery. In order to maintain confidentiality of the case, the scenario could be either one of these incidents, but the simulation was run identically with regard to the physiological parameters.

Before the training session started, all members of the trauma teams were introduced to learning goals of the training session and also given a brief introduction to the patient simulator. The members of the trauma team were alerted via the hospital's paging system, and they gathered at the emergency department. On arrival at the emergency room, the team members started to prepare for the trauma case by checking the equipment and preparing the emergency room, all according to the hospital's standard operating procedures for trauma care (which are based on Advanced Trauma Life Support, ATLS). The designated leader, who was responsible for the team's performance in the emergency room, was either a surgeon or an emergency physician.

The scenario analysed in this study started after the handover by the ambulance personnel when the patient simulator was transferred from the ambulance stretcher to the stretcher in the emergency room. To ensure a standardised case and increase the reliability of the scenario, systolic blood pressure was decreased to 48 mm Hg at the start of the scenario, which induced apnoea and non-palpable pulses. The trauma team was then expected to immediately start their initial assessment to identify life-threatening injuries by following the hospital's standard operating procedures. The length of the trauma team training was designed to last for 15 min (900 s) before the instructor interrupted it.

Data collection

The trauma team training analysed in this study took place in 2009/2010. Video surveillance cameras were located in the emergency room, and individual wireless microphones attached to each team member were used to capture the communication. Vital parameters from the patient simulator were recorded and registered together with the recorded data in F-Rex, a software program developed by the Swedish Defence Research Agency (FOI, Linköping, Sweden), to allow reconstruction and investigation of the incident. Observations and field notes were made during the team training by the first author (MHm), and these were used as support material during the analysis. The participants' background characteristics were gathered from questionnaires answered by the team members before the start of the trauma team training.

Dependent variable

The outcome and dependent variable, the time taken to make a decision to go to surgery, was measured in seconds for each team from the time of transfer of the patient simulator to the stretcher in the emergency room until a decision to go to surgery was made. If no decision was taken within the duration of the team training (900 s), the outcome variable was censored.

Independent variables

The independent variables describing characteristics for each team were gender, ethnicity (Scandinavian country of origin=1 or not=0), experience of trauma (yes=1 or no=0), experience of trauma course (yes=1 or no=0), experience of trauma team training (yes=1 or no=0) and years in profession.

CLC was divided into three steps (figure 1). In the first step, call-out (CO), the sender transmits a message.

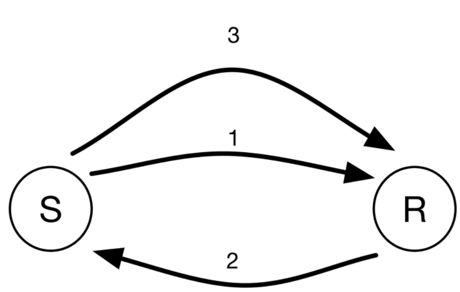

Figure 1 Closed-loop communication has three steps. (1) A sender (S) sends a message, (2) a receiver (R) receives the message and acknowledges the receipt of the message, and (3) the sender verifies that the message has been received and interpreted as intended. Modified from Wilson *et al*.[40]

In the second step, the receiver accepts the message and acknowledges its receipt. In the third step, the sender verifies that the message has been received and interpreted correctly. All three steps are needed to make a complete CLC according to the definition previously given by this and other research groups.[27 40] The number of CO and CLC initiated within the teams were determined by classifying the communications in the transcripts of the verbal communication, and then counting the numbers of CO and CLC.

Independent variables specific to the designated leader of each team were: leader's experience of trauma (yes=1 or no=0), leader's experience of trauma courses (yes=1 or no=0), leader's experience of trauma team training (yes=1 or no=0). Information about the leaders' CO and CLC, see description above of the definition of the variable. The number of CO and the number of CLC initiated by the leader were determined as described above. Leadership style was based on text analysis according to the conversation analysis[41 42] of the team leaders' communications and quantified in number of turn-constructional units (TCU).[38] A TCU is a piece of conversation which may comprise an entire turn. The end of a TCU marks a point where the turn may go to another speaker, or the present speaker may continue with another TCU. Leadership styles were then quantified in two variables: authoritarian and egalitarian, depending on the team leader's chosen communication strategy. Authoritarian leadership was the sum (n) of the educating (transferring knowledge) and coercive (orders, commands) TCU of the communication strategies used by the leader in each team training, while egalitarian leadership was the sum (n) of discussing and negotiating turn-constructional units of the leader's communication strategies.[38]

Statistical analysis

Descriptive statistics are presented for each of the teams. Age and years in profession are presented as medians (md) and quartiles (Q_1, Q_3). The categorical variables for each team—gender, experience of education (trauma courses and trauma team training), and experience of trauma—are presented as numbers (n) and percentages (%). Cox proportional hazards regression (HR) was performed to assess the impact of the independent variable on the outcome variable. The outcome variable was the time taken for the team to make a decision to go to surgery, including the possibility that the event did not occur during the observation period (ie, the team was censored). All 16 teams were included in the analysis process and contributed with information.

The proportional hazards assumption for the independent variables was tested with scaled Schoenfeld's residuals. Variables with p values below 0.2 in crude analyses were included in the Cox proportional hazards regression analysis. From this primary adjusted model, a stepwise elimination procedure was performed until only independent variables with p values below 0.05

were left in the final model. Most of the statistical analyses were performed using IBM SPSS (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, V.21 Armonk, New York, USA: IBM Corp.), but the test of the proportional hazards assumption for independent variables was performed in R V.3.0.2. (R Development Core Team. R: A language and environment for statistical computing. Vienna, Austria: R Foundation for statistical computing, 2015).

Ethical considerations

Individual informed consent was obtained before the start of the trauma team training. The participants were assured that they could leave the study whenever they wished to, and that the recorded material would be handled confidentially. The study was approved by the Regional Ethical Review Board in Umeå (9 June 2009, ref: 09-106M).

RESULTS

The teams' distribution of age, years in profession and gender are shown in table 1 together with educational experience (structured trauma courses and trauma team training) and experience of trauma. Team P consisted entirely of female team members, while by contrast only 1 of the members of team S was female. The team members' years in profession varied from 2 years to 18 years, with teams H, M and N having the lowest number of years in profession. Educational experience also varied between the teams. All members in teams A, B and E had experience of trauma team training, while in teams F, K and R, only three of six members had previous experience of team training. In team P, only one team member had completed a structured trauma course, while in teams R, N, H, F and D, three of six members had completed a structured trauma course (table 1). The teams with the highest number of initiated CO were teams C and P; however, only a few of these (3% and 7%, respectively) resulted in CLC. In contrast, in teams F and H about one-third (32% and 33%, respectively) of CO resulted in CLC (table 2).

In 8 of 16 teams (50%) a decision to go to surgery was made within the duration of the trauma team training. The time taken to make this decision varied from 239 to 770 s (table 2). The remaining eight teams were considered censored at the time of 900 s. There was no difference in time to make a decision to go to surgery between the two scenarios used: blunt (900 s (383, 900), n=7) (median (Q1, Q3)) versus penetrating trauma (770 s (434, 900), n=9), p=0.96.

Factors influencing the time to make a decision to go to surgery were analysed using Cox regression. The proportional hazards assumption was fulfilled for all independent variables. Crude proportional hazards regression analyses for all independent variables resulted in a primary adjusted model containing six independent variables: team experience of trauma courses, team ethnicity, authoritarian leadership style, leader's CLC, team's CO and team's CLC. A stepwise elimination of non-significant variables resulted in a final model where three of the independent variables remained significant. This final model showed that CLC initiated by the leader increased the likelihood of making a decision to go to surgery within 900 s (HR: 3.88, CI 1.02 to 14.69),

Table 1 Description of the teams' distribution of independent variables (age, years in profession, gender, ethnicity and experience of team training, structured trauma course, and trauma) for each team

Team (n=16)	Age, years median, (Q_1, Q_3)	Years in profession median, (Q_1, Q_3)	Ethnicity Non-Scandinavian (n)	Female gender(n)	Experience of team training (n)	Experience of structured trauma course (n)	Experience of trauma (n)
Team A	42 (31, 55)	12 (5, 26)		4	6	4	6
Team B	39 (32, 54)	8 (4, 24)		2	6	6	6
Team C	39 (32, 44)	10 (8, 24)	1	3	5*	4*	5*
Team D	44 (32, 51)	14 (4, 22)	1	5	5*	3	6
Team E	47 (32, 53)	11 (5, 18)	1	5	6	4	6
Team F	31 (30, 43)	8 (3, 19)	1	4	3	3	5
Team H	40 (30, 53)	2 (1, 22)		4	4*	3*	4*
Team J	37 (32, 48)	6 (4, 18)		3	4	4	6
Team K	41 (30, 57)	16 (5, 30)		2	3	5	6
Team L	34 (32, 43)	6 (4, 12)	1	5	4	4	6
Team M	38 (27, 44)	4 (1, 13)		2	5	4	5
Team N	39 (32, 49)	8 (1, 26)		3	4	3	6
Team O	45 (30, 55)	18 (2, 32)		4	4	4	5
Team P	38 (32, 52)	6 (2, 30)		6	4	1	5
Team R	34 (29, 39)	6 (1, 13)	2	3	3	3	6
Team S	40 (38, 48)	14 (8, 20)		1	5	6	6

Each team had six participants.
*Missing data, for this variable (n=5).

Table 2 Description of the teams' distribution of independent variables (CO, CLC and Leadership styles) for each team, and time in seconds to make the decision to go to surgery

Team (n=16)	CLC (n)	CO (n)	CLC/CO (Per cent)	Time to decision (seconds)	Decision within 15 min (yes)	Leadership: Authoritarian (n)	Leadership: Egalitarian (n)
Team A	1	19	11	394	Yes	20	12
Team B	3	15	20	770	Yes	2	6
Team C	2	30	7			7	8
Team D	2	22	9			0	2
Team E	2	26	8	475	Yes	6	16
Team F	7	22	32			0	9
Team H	7	21	33			5	13
Team J	1	9	11	239	Yes	9	11
Team K	5	25	20	524	Yes	3	7
Team L	1	14	7	361	Yes	2	2
Team M	1	15	7	405	Yes	0	3
Team N	1	15	7	383	Yes	4	3
Team O	3	14	21			1	5
Team P	1	35	3			5	4
Team R	3	16	19			3	5
Team S	5	26	19			5	6

Each team had six participants.
CLC, closed-loop communication; CO, call-out.

while CO (HR: 0.82, CI 0.71 to 0.96) and CLC (HR: 0.23, 0.08 to 0.71) initiated by team members decreased this likelihood (table 3).

DISCUSSION

The main finding in this study was that CLC initiated by the leader increased the probability of making a decision to go to surgery, which is in line with the assumption on which CRM was based that CLC is important for teams' efficiency.[9] This result puts communication in focus; more specifically, it emphasises the importance of CLC initiated by the leader for task completion. Secured communication has been described by Smith-Jentsch *et al*[43] to contain three components information exchanged, phraseology and the use of CLC. CLC contains three distinct steps: first the sender transmits a message; second, the receiver accepts the message and acknowledges its receipt; and finally, the sender verifies that the message has been received and interpreted correctly. The team leader's role has previously been identified as an important factor for the trauma team's performance,[8 10] with the key features being the leader's knowledge and experience of trauma.[8 9]

Communication has been found to be a key component in team building, and of importance for team performance.[9 18 44] As time will constrain what the trauma teams can accomplish in terms of life-saving treatments in emergency situations, effective and clear communication is essential to prioritise and to create common goals in the team. Using CLC in clinical practice may not be natural for the trauma team members. Factors such as time pressure and workload need to be taken into consideration, as well as factors due to open and hidden hierarchies. The impact of communication tools is also related to deliberate training. It has been shown that the number of miscommunications in surgical teams decreases when CLC is used.[20] In obstetric emergency

Table 3 Cox's proportional hazard regression with *Time to decision for surgery* as a dependent variable, adjusted and final model

	Adjusted model HR	p Value	Final model HR	95% CI	p Value
Teams' experience of trauma courses	6.41	0.606			
Ethnicity in teams	1.78	0.910			
Authoritarian leadership in teams	1.00	0.978			
Leader's CLC	3.30	0.099	3.88	1.024 to 14.690	0.046
Team's CLC	0.24	0.024	0.23	0.076 to 0.706	0.010
Team's CO	0.84	0.070	0.82	0.706 to 0.958	0.012

CLC, closed-loop communication; CO, call-out.

teams, clear statements of the critical situation and CLC were associated with more efficiency in task completion.[45] In another study based on the same material[27] as the present work, we found that CO and CLC were only used to a limited extent in trauma teams during trauma team training. We also found that having experience of two or more structured trauma courses was associated with more frequent use of CLC, compared to those with no such experience. A team leader with an egalitarian leadership style and of Scandinavian origin were associated with more frequent use of CLC.[27]

Encouraging team members to speak up and to voice their concerns are associated with improved safety.[46 47] In this study, we found a correlation between the amount of communication initiated by non-leaders in the team and a decreased efficiency measured as time taken to make a decision to go to surgery. Several, perhaps conflicting, commands may cause a communication overload that results in a delay before key tasks can be performed.[48 49] CRM guidelines underline and encouraged team members to speak up in the trauma team when there is a need to pay attention to important changes in the patient's status.[50] In an earlier study, we found that 14% of all CO resulted in a full CLC.[27] However, if all team members initiate CO and CLC, and actively and vividly discuss pros and cons of different strategies, a state of communication overload and also a lack of leadership might result, and thus the assessments and actions might be delayed. Communication overload may, therefore, be one of the explanations for the findings in this study that the more the CO and CLC initiated by the team members, the lesser the chance of reaching a decision to go to surgery within the allotted time.

Earlier studies have demonstrated that leaders' positions in trauma teams vary depending on the severity of the situation and the team members' experience.[11 12] The leaders were more active and took an authoritative role in emergency situations; when the condition of the patient stabilised, they stepped back and delegated more tasks. This is in line with the findings in a previous study[38] by our research group showing that not only did the leader's position vary depending on the situation and the interaction in the team, but so also did the leader's communication strategies. Having an authoritarian leader who used a coercive strategy (representing CO and CLC) with directed commands that only allowed short answers enabled the team to achieve their common goal. In contrast, leaders who invited the team members to discuss possible treatment alternatives and priorities shifted into an egalitarian leadership style.[38] One can assume that an invitation to discussion will prolong the time taken to make a decision to go to surgery even though a discussion will be necessary if there are doubts within the team about making the right decision or if the leader is inexperienced. When implementing a communication tool developed in another context, the tool may need to be modified to fit into an emergency context. One of the problems to avoid in the present context is communication overload.[28] CLC has previously been shown to be positively related to task distribution in emergency teams, but it is important to note that this result was based on a modified CLC that included only the acknowledgement part of CLC (ie, steps 1 and 2).[28] CLC with all three steps included can be perceived as inconvenient, and may lead to communication overload in emergency situations. This could be a possible explanation for the finding in our previous study that CLC was used only to a limited extent in trauma teams,[27] and also explain the findings in the present study that more CO and CLC initiated by the team members decreased the chance of making a decision to go to surgery.

The results in this study highlight the importance of providing team leaders and team members with possibilities to improve their communication skills. Simulation has grown in popularity as a training modality in healthcare, and CRM has become recognised as a framework for improving trauma teams' collaboration and communication. CLC is an essential part of CRM, and has been introduced to ensure safe and secure communication within the team. These concepts are now beginning to be included in courses such as ATLS,[29] ECT[30 31] and TeamSTEPPS.[51] If communication is to improve, this must be both deliberately trained and deliberately practiced. Factors, such as stress, distractions and interruptions, may compromise the team members' performance.[52 53] It is, therefore, necessary to train in emergency situations regularly and to integrate these into everyday work practices.[54 55]

Further studies would have to focus on the optimal relationship between leadership styles and the amount of CO and CLC initiated by different team members. There are most likely to be intercultural and contextual dependencies that need to be taken into account.

Methodological discussion

This study was based on a limited number of teams and therefore it carries a risk of not finding minor relationships. To increase the validity of the study, efforts were made to make the trauma scenario as authentic as possible: scripting the scenario, using in situ high-fidelity simulation, using existing equipment including pagers and radio communication to get an ambulance prewarning, and by letting the trauma team members perform their designated tasks in their usual job roles. For example, the study was not designed to analyse the differences between having an emergency physician and a surgeon as a leader, nor the differences in handling of sharp and blunt trauma with equal physiological models (ie, the same level of hypovolemia).

The training session's duration was limited to 15 min to allow time for prescenario preparation, the team training, and subsequent debriefing, as well as to minimise the time 'out of production'. It is likely that if the trauma team training had been extended in time, more teams would have reached a decision to go to surgery. Depending on the difficulty of the case, it could be argued that the time allocated for the team training was too short to allow them to complete their primary survey. However, a study of 387 video registrations of trauma teams' performance found that the average time to complete all steps of the primary survey was 5 min or less.[56]

In this study, we chose to use the time taken to make the decision to go to surgery as a measurement of team function rather than, for example, intubation. It is quite possible or perhaps more likely that specific parts of team communication are related to specific parts of the resuscitation. It would have been interesting to analyse the relation between CO and CLC versus, for example, time to intubation and time to established ventilation. The problem with doing these analyses is partly a problem of mass significance and partly a problem of sensitivity. The latter problem has to do with the fact that in a fully functional team, where all parts of the team are working at its full potential, the team knows what needs to be done and the need for communication decreases.

Our results might have been different if the team training had been an in-centre training. The participants could have been given more time for the scenarios and debriefing as Kobayashi *et al*[57] have discussed. However, a longer training session would have decreased the possibility for the team members to participate, as it would have been more difficult to disengage the participants from clinical duties. A recently published study found similarly high levels of teamwork in situ and in the trauma centre. In addition, there are advantages of being able to practice with authentic equipment, in a well-known environment and in their own roles, as has been thoroughly described previously.[58 59]

CONCLUSION

This study indicates the importance of the trauma team leader's CLC for reaching a decision to go to surgery, as well as a negative association with communication not initiated by the team leader. The communication tool used in this study, CLC, was developed in another context, and may need to be modified to fit into an emergency context. By focusing on the team leader's communication, more specifically on CLC, trauma team training might improve the decision process in these trauma teams.

Clinical implications

These results provide improved knowledge about trauma team communication, and can be used to improve training programmes for trauma teams. The findings emphasise not only the importance of communication in general but, more specifically, the importance of the leader's CLC. To improve safe and secure communication, deliberate practice of CLC might be necessary.

CLC may not come naturally to the professionals in the trauma team. The reasons for this might include time pressure and workload, as well as hierarchical and interpersonal factors. Establishing a routine helps to normalise the practice of closed-loop communication during emergencies, as does role modelling by team leaders. Convincing health professionals to adopt this formal mode for critical communications will depend on good evidence followed by training.

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