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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, earlier 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 style during a trauma team training.

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

Setting: An emergency room in a Scandinavian level one trauma center.

Participants: A total of 96 participants 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: Hazard ratios (HR) with confidence intervals (CI 95%) 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: 1.02-14.69). Only eight of 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: 0.71-0.96 and HR: 0.23; CI: 0.08-0.71, respectively).

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

Key words: closed-loop communication, leadership, trauma, trauma team training, time

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Article summary

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 acting in their own roles and executing their regular tasks.
- In-situ trauma team training allowed standardization of the trauma case scenario giving the trauma teams similar conditions.
- Organizational and structural hierarchies can differ depending on geographical and sociocultural settings.

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Competing interests

The authors have read and understood the BMJ policy on declaration of interests and declare no competing interests.

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Introduction

Time is crucial factor for patient outcome during resuscitation after trauma (1). Evidence suggests that early interventions minimize 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 minimize the time until definite management is established (5, 6).

The concept of trauma teams was initiated in the 1970s in the US and was introduced in Europe about two decades later (2, 5). The team members work independently and simultaneously, and this 'horizontal' organizational approach provides rapid assessment of the critically injured patient (5, 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 team members lack experience (11, 12).

The collaboration in interdisciplinary teams is often described as a complex interactional process (13-16). In health care, 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 program 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 standardized terminology

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and procedures (9, 23, 24), closed-loop communication (CLC), a standardized 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), but in healthcare there are little empirical evidence showing its effectiveness.

Apart from regular trauma team training attendance at structured trauma course is regarded as a practical and theoretical foundation for competent and skilled trauma teams (5). The standardized and systematic principles described in ATLS (29) have been associated with improved trauma care (30, 31). 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 (32). However, although these trauma courses have resulted in earlier and more effective interventions in trauma care, the measured beneficial effects are weak (33). It has been difficult to link the influence of team members' characteristics to the team members' performance on completed key tasks (34, 35). Still, in order to improve safety in trauma care, and to optimize 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 closed-loop communication, 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, earlier experience of trauma team training,

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experience of structured trauma courses and trauma in the trauma team, as well as use of closed-loop communication, and leadership style during a trauma team training.

Methods

Participants

The participants were hospital staff involved in regular trauma team training. They were firstly 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 six participants; one surgeon/emergency physician (n=16), one anaesthesiologist (n=16), one registered nurse from the emergency department (n=16), one registered nurse anaesthetist (n=16), one enrolled nurse from the emergency department (n=16), and one enrolled nurse from the operating theatre (n=16).

Research setting

The trauma team training used in this study has been described elsewhere (36) (27). The training was performed in-situ in the emergency room of the emergency department at a hospital in Northern Sweden. A patient simulator (SimMan 3G, Laerdal, Stavanger, Norway) was pre-programmed to represent a severely injured patient with an injury severity score of 25 (37) suffering from hypovolemia. The members of the trauma team were alerted via the hospital's paging system, and 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

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operating procedures for trauma care (which are based on 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 from the ambulance personnel when the patient simulator was transferred from the ambulance stretcher to the stretcher in the emergency room. To ensure a standardized case and increase the reliability of the scenario, systolic blood pressure was decreased to 48 mmHg at 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, following the hospital's standard operating procedure. The length of the trauma team training was designed to last for 15 minutes (900 seconds) before the instructor interrupted.

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). The participants' background characteristics were gathered via from questionnaires filled in by the team members before the trauma team training.

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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 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 seconds), 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), years in profession. Closed-loop communication was divided into CO (step one) and CLC (steps one, two, and three), defined according to the definition of CLC previous given by this and other research groups (27, 38). The number of CO and the number of CLC initiated within the teams were analysed.

Independent variables specific to the 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 above. The number of CO and the number of CLC initiated by the leader were analysed. Leadership was analysed as described in an earlier study (36) and defined in two variables: authoritarian and egalitarian. Authoritarian leadership was the sum of educating (transferring knowledge) and coercive (orders, commands) turn-constructional units of the communication strategies used by the leader in each team training, while egalitarian leadership was the sum of discussing and negotiating turn-constructional units of the leader's communication strategies (36). .

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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 (hazard ratio, 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. If no decision was taken within 900 seconds, the team was censored. 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, version 21 Armonk, NY: IBM Corp.), but the test of the proportional hazards assumption for independent variables was performed in R version 3.0.2.

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).

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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 one 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 1).

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Table 1. Description of the teams' distribution of independent variables and time in seconds to decision to go to surgery.

Team n=16	Age	Years in profession	Female gender	Experience of			CLC		CO		CLC/CO		Time to decision	Decision reached within 900 s	Leadership	
				Trauma team training	Structured trauma course	Trauma	Team	Leader	Team	Leader	Team	Leader			Authoritarian TCU	Egalitarian TCU
	median, (Q_1, Q_3)	median, (Q_1, Q_3)	n	n	n	n	n	n	n	n	%	%	seconds	yes	n	n
Team A	42 (31, 55)	12 (5, 26)	4	6	4	6	1	1	19	15	11	7	394	yes	20	12
Team B	39 (32, 54)	8 (4, 24)	2	6	6	6	3		15	4	20		770	yes	2	6
Team C	39 (32, 44)	10 (8, 24)	3	5*	4*	5*	2		30	10	7				7	8
Team D	44 (32, 51)	14 (4, 22)	5	5*	3	6	2		22	2	9				0	2
Team E	47 (32, 53)	11 (5, 18)	5	6	4	6	2	2	26	16	8	12	475	yes	6	16
Team F	31 (30, 43)	8 (3, 19)	4	3	3	5	7	4	22	10	32	40			0	9
Team H	40 (30, 53)	2 (1, 22)	4	4*	3*	4*	7	5	21	11	33	45			5	13
Team J	37 (32, 48)	6 (4, 18)	3	4	4	6	1	1	9	7	11	14	239	yes	9	11
Team K	41 (30, 57)	16 (5, 30)	2	3	5	6	5	2	25	17	20	12	524	yes	3	7
Team L	34 (32, 43)	6 (4, 12)	5	4	4	6	1	1	14	12	7	8	361	yes	2	2
Team M	38 (27, 44)	4 (1, 13)	2	5	4	5	1		15	4	7		405	yes	0	3
Team N	39 (32, 49)	8 (1, 26)	3	4	3	6	1		15	6	7		383	yes	4	3
Team O	45 (30, 55)	18 (2, 32)	4	4	4	5	3	1	14	4	21	25			1	5
Team P	38 (32, 52)	6 (2, 30)	6	4	1	5	1	1	35	14	3	7			5	4
Team R	34 (29, 39)	6 (1, 13)	3	3	3	6	3		16	7	19				3	5
Team S	40 (38, 48)	14 (8, 20)	1	5	6	6	5	3	26	12	19	25			5	6

*missing data, for this variable (n=5); TCU = turn-constructional units

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In eight 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 seconds (Table 1). The remaining eight teams were considered censored at the time of 900 seconds.

Factors influencing the time to decision to go to surgery were analyzed 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 seconds (HR; 3.88, CI 1.02-14.69), while CO (HR; 0.82, CI 0.71-0.96) and CLC (HR 0.23, 0.08-0.71) initiated by team members decreased this likelihood (Table 2).

Table 2. Cox's proportional hazard regression with *Time to decision for surgery* as a dependent variable, adjusted and final model.

	Adjusted model		**Final model**		
	HR	p	HR	95 % CI	p
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 - 14.690	0.046
Team's CLC	0.24	0.024	0.23	0.076 - 0.706	0.010
Team's CO	0.84	0.070	0.82	0.706 - 0.958	0.012

HR = hazards ratio; CI = confidence interval

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 upon which CRM

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was based: that CLC is important for teams' efficiency (9). This result puts communication in focus; more specifically, the importance of the leader's communication for task completion. 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, 39). 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 prioritize 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 teams, clear statements of the critical situation and CLC were associated with more efficiency in task completion (40). 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. Having a Scandinavian origin and a team leader with an egalitarian leadership style were associated with more frequent use of CLC (27).

Several, perhaps conflicting commands may cause communication overload that results in a delay before key tasks can be performed (41, 42). Communication overload may thus be an explanation for the finding in this study that the more CO and CLC initiated by the team members, the less chance of reaching a decision to go to surgery within the allotted time.

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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, and when the condition of the patient was stabilized they stepped back and delegated more tasks. This is in line with the findings in a previous study (36) by our research group showing that not only the leader's position varied depending on the situation and the interaction in the team, but also the leader's communication strategies. Having an authoritarian leader that 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 shifted into an egalitarian leadership style (36). One can assume that an invitation to discussion will prolong the time taken to make a decision to go to. When implementing a communication tool developed in another context, the tool may need to be modified to fit into an emergency context. The problem 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 which included only the acknowledgement part of CLC (i.e. steps one and two) (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 highlights 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 recognized as a framework for improving trauma teams' collaboration and communication. CLC is an

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essential part of CRM, and has been introduced to ensure safe and secure communication within the team. If communication is to improve, this must be both deliberately trained and deliberately practiced. Factors as stress, distractions, and interruptions may compromise the team members' performance (43, 44). It is therefore necessary to train in emergency situations regularly and to integrate them into everyday work practices (45, 46).

Methodological discussion

This study was based on a limited number of teams, which 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 pre-warning and by letting the trauma team members perform their designated tasks in their usual job roles.

The training session's duration was limited to 15 minutes to allow time for pre-scenario preparation, the team training, and subsequent debriefing, as well as to minimize 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 five minutes or less (47).

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Conclusion

This study indicates the importance of the trauma team leader's CLC for reaching a decision to go to surgery, as well as the negative association with communication not initiated by the team leader. It can be assumed that communication overload during trauma resuscitation may prolong the time taken to make a decision to go to surgery. 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 the knowledge about trauma team communication, and can be used to improve the training programs for trauma teams. The findings emphasize 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 closed-loop communication is necessary.

Closed-loop communication may not come naturally to the professionals in the trauma team. The reasons for this include time pressure and workload, but also hierarchical and interpersonal factors. Establishing a routine helps to normalize the practice of closed-loop communication during emergencies, as does role modeling 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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Author contributions

MHm, CB and MHn designed the initial study. MHm, ML, and MHn drafted the manuscript. All authors contributed to the data analysis and to critical revision of the manuscript. All authors have approved the final manuscript and agreed to be accountable for all aspects of the work including the accuracy and integrity of all parts of the work.

Data Sharing Statement

No additional data is available

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References

1. Driscoll PA, Vincent CA. Variation in trauma resuscitation and its effect on patient outcome. Injury 1992;23:111-5.
2. Adedeji OA, Driscoll PA. The trauma team--a system of initial trauma care. Postgrad Med J 1996;72:587-93.
3. Gerardo CJ, Glickman SW, Vaslef SN, Chandra A, Pietrobon R, Cairns CB. The rapid impact on mortality rates of a dedicated care team including trauma and emergency physicians at an academic medical center. J Emerg Med 2011;40:586-91.
4. Cornwell E, Chang D, Phillips J, Campell K. Enhanced trauma program commitment at a level I trauma center: effect on the process and outcome of care. Arch Surg 2003;138:838-43.
5. Tiel Groenestege-Kreb D, van Maarseveen O, Leenen L. Trauma team. Br J Anaesth 2014;113:258-65.
6. Rainer TH, Cheung NK, Yeung JH, Graham CA. Do trauma teams make a difference? A single centre registry study. Resuscitation 2007;73:374-81.
7. Georgiou A, Lockey DJ. The performance and assessment of hospital trauma teams. Scand J Trauma Resusc Emerg Med 2010;18:66.
8. Hjortdahl M, Ringen AH, Naess AC, Wisborg T. Leadership is the essential non-technical skill in the trauma team--results of a qualitative study. Scand J Trauma Resusc Emerg Med 2009;17:48.
9. Salas E, Sims DE, Burke CS. Is there a "big five" in teamwork? Small Group Research 2005;36:555-99.
10. Cole E, Crichton N. The culture of a trauma team in relation to human factors. J Clin Nurs 2006;15:1257-66.
11. Yun S, Faraj S, Sims HP, Jr. Contingent leadership and effectiveness of trauma resuscitation teams. J Appl Psychol 2005;90:1288-96.
12. Klein KJ, Ziegert JC, Knight AP, Xiao Y. Dynamic delegation: Hierarchical, shared and deindividualized leadership in extreme action teams. Adm Sci Q 2006;51:590-621.
13. Undre S, Sevdalis N, Healey AN, Darzi A, Vincent CA. Observational teamwork assessment for surgery (OTAS): refinement and application in urological surgery. World J Surg 2007;31:1373-81.
14. Lingard L, Espin S, Whyte S, Regehr G, Baker GR, Reznick R, Bohnen J, Orser B, Doran D, Grober E. Communication failures in the operating room: an observational classification of recurrent types and effects. Qual Saf Health Care 2004;13:330-4.
15. Bristowe K, Siassakos D, Hambly H, Angouri J, Yelland A, Draycott TJ, Fox R. Teamwork for clinical emergencies: interprofessional focus group analysis and triangulation with simulation. Qual Health Res 2012;22:1383-94.
16. Miller D, Crandall C, Washington C, 3rd, McLaughlin S. Improving teamwork and communication in trauma care through in situ simulations. Acad Emerg Med 2012;19:608-12.
17. Sutcliffe KM, Lewton E, Rosenthal MM. Communication failures: an insidious contributor to medical mishaps. Acad Med 2004;79:186-94.
18. Rabol LI, Andersen ML, Ostergaard D, Bjorn B, Lilja B, Mogensen T. Descriptions of verbal communication errors between staff. An analysis of 84 root cause analysis-reports from Danish hospitals. BMJ Qual Saf 2011;20:268-74.
19. Nagpal K, Arora S, Vats A, Wong HW, Sevdalis N, Vincent C, Moorthy, K. Failures in communication and information transfer across the surgical care pathway: interview study. BMJ Qual Sa. 2012;21:843-9.

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20. Gillespie BM, Chaboyer W, Fairweather N. Factors that influence the expected length of operation: results of a prospective study. BMJ Qual Saf 2012;21:3-12.
21. Rall M, Gaba D. Patients simulators. In: Miller RD, Afton-Bird G, editors. Anesthesia. Vol 2. 6. ed. New York: Elsevier/Churchill Livingstone; 2005. p. xviii, 1617-3203 s., lix.
22. Helmreich RL, Merritt AC, Wilhelm JA. The evolution of crew resource management training in commercial aviation. Int J Aviat Psychol 1999;9:19-32.
23. Velji K, Baker GR, Fancott C, Andreoli A, Boaro N, Tardif G, Aimone E. Sinclair, L. Effectiveness of an Adapted SBAR Communication Tool for a Rehabilitation Setting. Healthc Q 2008;11:72-9.
24. Lingard L, Espin S, Rubin B, Whyte S, Colmenares M, Baker GR, Doran D, Grober E, Orser B, Bohnen J, Reznick R. Getting teams to talk: development and pilot implementation of a checklist to promote interprofessional communication in the OR. Qual Saf Health Care 2005;14:340-6.
25. Burke CS, Salas E, Wilson-Donnelly K, Priest H. How to turn a team of experts into an expert medical team: guidance from the aviation and military communities. Qual Saf Health Care 2004;13:I96-I104.
26. Salas E, Wilson KA, Murphy CE, King H, Salisbury M. Communicating, coordinating, and cooperating when lives depend on it: tips for teamwork. Jt Comm J Qual Patient Saf 2008;34:333-41.
27. Hargestam M, Lindkvist M, Brulin C, Jacobsson M, Hultin M. Communication in interdisciplinary teams: exploring closed-loop communication during in situ trauma team training. BMJ open 2013;3:e003525.
28. Schmutz J, Hoffmann F, Heimberg E, Manser T. Effective coordination in medical emergency teams: The moderating role of task type. Eur J Work Organ Psy 2015:1-16.
29. American College of Surgeons Committee on Trauma. ATLS: Advanced Trauma Life Support Program for Doctors. 7th ed. Chicago, IL: American College of Surgeons; 2004. xiv, 391 p. p.
30. van Olden GD, Meeuwis JD, Bolhuis HW, Boxma H, Goris RJ. Clinical impact of advanced trauma life support. Am J Emerg Med 2004;22:522-5.
31. van Olden GD, Meeuwis JD, Bolhuis HW, Boxma H, Goris RJ. Advanced trauma life support study: quality of diagnostic and therapeutic procedures. J Trauma 2004;57:381-4.
32. Tsang B, McKee J, Engels PT, Paton-Gay D, Widder SL. Compliance to advanced trauma life support protocols in adult trauma patients in the acute setting. World J Emerg Surg 2013;8:39.
33. Zwarenstein M, Goldman J, Reeves S. Interprofessional collaboration: effects of practice-based interventions on professional practice and healthcare outcomes. The Cochrane database of systematic reviews. 2009:CD000072.
34. Siassakos D, Draycott TJ, Crofts JF, Hunt LP, Winter C, Fox R. More to teamwork than knowledge, skill and attitude. Br J Obstet Gynaecol 2010;117:1262-9.
35. Siassakos D, Fox R, Crofts JF, Hunt LP, Winter C, Draycott TJ. The management of a simulated emergency: better teamwork, better performance. Resuscitation 2011;82:203-6.
36. Jacobsson M, Hargestam M, Hultin M, Brulin C. Flexible knowledge repertoires; communication by leaders in trauma teams. Scand J Trauma Resusc Emerg Med 2012;20:44.
37. Baker SP, O'Neill B, Haddon W, Jr., Long WB. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. J Trauma 1974;14:187-
38. Wilson KA, Salas E, Priest HA, Andrews D. Errors in the heat of battle: taking a closer look at shared cognition breakdowns through teamwork. Hum Factors 2007;49:243-56.

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39. Gillespie BM, Chaboyer W, Lizzio A. Teamwork in the OR: enhancing communication through team-building interventions. ACORN: the Journal of Perioperative Nursing in Australia 2008;21:14.
40. Siassakos D, Bristowe K, Draycott TJ, Angouri J, Hambly H, Winter C, Crofts JF, Hunt LP, Fox R. Clinical efficiency in a simulated emergency and relationship to team behaviours: a multisite cross-sectional study. Br J Obstet Gynaecol 2011;118:596-607.
41. Woloshynowych M, Davis R, Brown R, Vincent C. Communication patterns in a UK emergency department. Ann Emerg Med 2007;50:407-13.
42. Andersen PO, Jensen MK, Lippert A, Ostergaard D. Identifying non-technical skills and barriers for improvement of teamwork in cardiac arrest teams. Resuscitation 2010;81:695-702.
43. Sevdalis N, Undre S, McDermott J, Giddie J, Diner L, Smith G. Impact of Intraoperative Distractions on Patient Safety: A Prospective Descriptive Study Using Validated Instruments. World J Surg 2014;38:751-8.
44. Wheelock A, Suliman A, Wharton R, Babu E, Hull L, Vincent C, Sevdalis N, Arora S. The Impact of Operating Room Distractions on Stress, Workload, and Teamwork. Ann Surg 2015;261:1079-84.
45. Shapiro MJ, Morey JC, Small SD, Langford V, Kaylor CJ, Jagminas L, Suner S, Salisbury ML, Simon R, Jay GD. Simulation based teamwork training for emergency department staff: does it improve clinical team performance when added to an existing didactic teamwork curriculum? Qual Saf Health Care 2004;13:417-21.
46. Steinemann S, Berg B, Skinner A, DiTulio A, Anzelon K, Terada K, Oliver C, Ho HC, Speck C. In situ, multidisciplinary, simulation-based teamwork training improves early trauma care. J Surg Educ 2011;68:472-7.
47. Lubbert PH, Kaasschieter EG, Hoorntje LE, Leenen LP. Video registration of trauma team performance in the emergency department: the results of a 2-year analysis in a Level 1 trauma center. J Trauma 2009;67:1412-20.

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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 a trauma team training.

Design: In-situ trauma team training. The patient simulator was pre-programmed 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 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: Hazard ratios (HR) with confidence intervals (CI 95%) 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: 1.02-14.69). Only eight of 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: 0.71-0.96 and HR: 0.23; CI: 0.08-0.71, respectively).

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

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Article summary

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 acting in their own roles and executing their regular tasks.
- In-situ trauma team training allowed standardization of the trauma case scenario giving the trauma teams similar conditions.
- Organizational and structural hierarchies can differ depending on geographical and sociocultural settings.

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Introduction

Time is crucial factor for patient outcome during resuscitation after trauma [1]. Evidence suggests that early interventions minimize secondary injuries and reduces morbidity in severely injured patients, thus improving survival [2, 3, 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 minimize the time until definite management is established [5, 6].

The concept of trauma teams was initiated in the 1970s in the US and was introduced in Europe about two decades later [2, 6]. The team members work independently and simultaneously, and this ‘horizontal’ organizational 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, 9, 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 team members lack experience [11, 12].

The collaboration in interdisciplinary teams is often described as a complex interactional process [13, 14, 15, 16]. In health care, deficiencies in communication have been identified as a major contributor to errors in several different contexts [14, 17, 18, 19, 20]. These root cause analyses gave rise to the development of Crisis Resource Management (CRM), a systematic educational program 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 standardized

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terminology and procedures [9, 23, 24], closed-loop communication (CLC), a standardized 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], but in healthcare there are little empirical evidence showing its effectiveness.

Apart from regular trauma team training, attendance at structured trauma course is regarded as a practical and theoretical foundation for competent and skilled trauma teams [6]. The standardized 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 earlier 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 optimize 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 closed-loop communication, 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

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trauma in the trauma team, as well as use of closed-loop communication, and leaders' position during trauma team training.

Methods

Participants

The participants were hospital staff involved in regular trauma team training. They were firstly 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 pre-programmed to represent a severely injured patient with an injury severity score of 25 [39]. An auto-mode program was used to control the pathophysiology during the simulation. The

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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 cutting the left axillar artery. In order to maintain confidentiality of the case, the scenario could be either one, but the simulation was run identically regarding 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 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 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 from the ambulance personnel when the patient simulator was transferred from the ambulance stretcher to the stretcher in the emergency room. To ensure a standardized case and increase the reliability of the scenario, systolic blood pressure was decreased to 48 mmHg at 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, following the hospital's standard operating procedure. The length of the trauma team training was designed to last for 15 minutes (900 seconds) before the instructor interrupted.

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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 were used as support material during the analysis. The participants' background characteristics were gathered from questionnaires answered by the team members before the trauma team training.

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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 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 seconds), 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.

Closed-loop communication was divided into three steps (Fig 1). In the first step, call-out (CO), the sender transmits a message. 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 previous given by this and other research groups [27, 40]. The number of CO and CLC initiated within the teams were determined by classifying the communication 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 above. 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 conversations analysis [41, 42] of the team leaders' communication 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 leaders chosen communication strategy. Authoritarian leadership was the sum (n) of 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

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regression (hazard ratio, 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. If no decision was taken within 900 seconds, 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, version 21 Armonk, NY: IBM Corp.), but the test of the proportional hazards assumption for independent variables was performed in R version 3.0.2 [43].

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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 one 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).

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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. Each team had 6 participants.

Team n=16	Age 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

*missing data, for this variable (n=5)

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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. Each team had 6 participants.

Team	**CLC**	**CO**	**CLC/CO**	**Time to decision**	**Decision within 15 min**	**Leadership**	
n=16	*n*	*n*	*%*	*seconds*	*yes*	Authoritarian *n*	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

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In eight 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 seconds (Table 2). The remaining eight teams were considered censored at the time of 900 seconds.

Factors influencing the time to 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 seconds (HR; 3.88, CI 1.02-14.69), while CO (HR; 0.82, CI 0.71-0.96) and CLC (HR 0.23, 0.08-0.71) initiated by team members decreased this likelihood (Table 3).

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

	Adjusted model		**Final model**		
	HR	p	HR	95 % CI	p
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 - 14.690	0.046
Team's CLC	0.24	0.024	0.23	0.076 - 0.706	0.010
Team's CO	0.84	0.070	0.82	0.706 - 0.958	0.012

HR = hazards ratio; CI = confidence interval

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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 upon which CRM was based: that CLC is important for teams' efficiency [9]. This result puts communication in focus; more specifically, the importance of CLC initiated by the leader for task completion. Secured communication has by Smith-Jentsch el al [44] been described to contain three components; information exchanged, phraseology and the use of CLC. CLC contains three distinct steps; first the sender transmits a message, secondly the receiver accepts the message and acknowledges its receipts, 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, 45]. 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 prioritize 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 teams, clear statements of the critical situation and CLC were associated with more efficiency in task completion [46]. 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

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experience of two or more structured trauma courses was associated with more frequent use of CLC, compared to those with no such experience. Having a Scandinavian origin and a team leader with an egalitarian leadership style were associated with more frequent use of CLC [27].

Several, perhaps conflicting commands may cause communication overload that results in a delay before key tasks can be performed [47, 48]. 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 patient status [49]. 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 pro's and con's 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 thus be one of the explanations for the findings in this study that the more CO and CLC initiated by the team members, the less 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, and when the condition of the patient was stabilized 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 the leader's position varied depending on the situation and the interaction in the team, but also the leader's communication strategies. Having an authoritarian leader that 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

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decision to go to even though a discussion will be necessary if there are doubts in the team of 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 and the researchers argue that this result was based on a modified CLC that included only the acknowledgement part of CLC (i.e. steps one and two) [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 recognized 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 as ATLS [29], ECT [30, 31] and TeamSTEPPS [50], If communication is to improve, this must be both deliberately trained and deliberately practiced. Factors as stress, distractions, and interruptions may compromise the team members' performance [51, 52]. It is therefore necessary to train in emergency situations regularly and to integrate them into everyday work practices [53, 54].

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

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Methodological discussion

This study was based on a limited number of teams, which 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 pre-warning and by letting the trauma team members perform their designated tasks in their usual job roles.

The training session's duration was limited to 15 minutes to allow time for pre-scenario preparation, the team training, and subsequent debriefing, as well as to minimize 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 five minutes or less [55].

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 e.g. intubation. It is quite possible, or perhaps 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 those 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.

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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 discuss [56]. 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-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 [57, 58].

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 programs for trauma teams. The findings emphasize 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 closed-loop communication is necessary.

Closed-loop communication may not come naturally to the professionals in the trauma team. The reasons for this include time pressure and workload, but also hierarchical and interpersonal factors. Establishing a routine helps to normalize the practice of closed-loop communication during emergencies, as does role modelling by team leaders. Convincing

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health professionals to adopt this formal mode for critical communications will depend on good evidence followed by training.

Author contributions

MHm, CB and MHn designed the initial study. MHm, ML, and MHn drafted the manuscript. All authors contributed to the data analysis and to critical revision of the manuscript. All authors have approved the final manuscript and agreed to be accountable for all aspects of the work including the accuracy and integrity of all parts of the work.

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Competing interests

The authors have read and understood the BMJ policy on declaration of interests and declare no competing interests.

Data sharing

No additional data is available.

Refences

1 Driscoll PA, Vincent CA. Variation in trauma resuscitation and its effect on patient outcome. *Injury* 1992;23:111-5.
2 Adedeji OA, Driscoll PA. The trauma team--a system of initial trauma care. *Postgrad Med J* 1996;72:587-93.

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3 Gerardo CJ, Glickman SW, Vaslef SN, et al. The rapid impact on mortality rates of a dedicated care team including trauma and emergency physicians at an academic medical center. *J Emerg Med* 2011;40:586-91.
4 Cornwell EE, Chang DC, Phillips J, et al. Enhanced trauma program commitment at a level I trauma center: effect on the process and outcome of care. *Arch Surg* 2003;138:838-43.
5 Rainer TH, Cheung NK, Yeung JH, et al. Do trauma teams make a difference? A single centre registry study. *Resuscitation* 2007;73:374-81.
6 Tiel Groenestege-Kreb D, van Maarseveen O, Leenen L. Trauma team. *Br J Anaesth* 2014;113:258-65.
7 Georgiou A, Lockey DJ. The performance and assessment of hospital trauma teams. *Scand J Trauma Resusc Emerg Med* 2010;18:66.
8 Hjortdahl M, Ringen AH, Naess AC, et al. Leadership is the essential non-technical skill in the trauma team--results of a qualitative study. *Scand J Trauma Resusc Emerg Med* 2009;17:48.
9 Salas E, Sims D, Burke C. Is there a big five in teamwork? *Small Group Research* 2005;36:555-99.
10 Cole E, Crichton N. The culture of a trauma team in relation to human factors. *J Clin Nurs* 2006;15:1257-66.
11 Yun S, Faraj S, Sims HP. Contingent leadership and effectiveness of trauma resuscitation teams. *J Appl Psychol* 2005;90:1288-96.
12 Klein KJ, Ziegert JC, Knight AP, et al. Dynamic delegation: Shared, hierarchical, and deindividualized leadership in extreme action teams. *Administrative Science Quarterly* 2006;51:590-621.
13 Undre S, Sevdalis N, Healey AN, et al. Observational teamwork assessment for surgery (OTAS): refinement and application in urological surgery. *World J Surg* 2007;31:1373-81.
14 Lingard L, Espin S, Whyte S, et al. Communication failures in the operating room: an observational classification of recurrent types and effects. *Qual Saf Health Care* 2004;13:330-4.
15 Bristowe K, Siassakos D, Hambly H, et al. Teamwork for Clinical Emergencies Interprofessional Focus Group Analysis and Triangulation With Simulation. *Qualitative health research* 2012;22:1383-94.
16 Miller D, Crandall C, Washington C, et al. Improving teamwork and communication in trauma care through in situ simulations. *Acad Emerg Med* 2012;19:608-12.
17 Sutcliffe KM, Lewton E, Rosenthal MM. Communication failures: an insidious contributor to medical mishaps. *Acad Med* 2004;79:186-94.
18 Rabøl LI, Andersen ML, Østergaard D, et al. Descriptions of verbal communication errors between staff. An analysis of 84 root cause analysis-reports from Danish hospitals. *BMJ Qual Saf* 2011;20:268-74.
19 Nagpal K, Arora S, Vats A, et al. Failures in communication and information transfer across the surgical care pathway: interview study. *BMJ Qual Saf* 2012;21:843-9.
20 Gillespie BM, Chaboyer W, Fairweather N. Factors that influence the expected length of operation: results of a prospective study. *BMJ Qual Saf* 2012;21:3-12.
21 Rall M, Gaba D. Patient simulators. In: Miller R, Afton-Bird G, eds. *Miller's Anaesthesia*. New York: Elsevier Churchill Livingstone 2005.
22 Helmreich RL, Merritt AC, Wilhelm JA. The evolution of crew resource management training in commercial aviation. *The international journal of aviation psychology* 1999;9:19-32.

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23 Velji K, Baker GR, Fancott C, et al. Effectiveness of an Adapted SBAR Communication Tool for a Rehabilitation Setting. *Healthc Q* 2008;11:72-9.
24 Lingard L, Espin S, Rubin B, et al. Getting teams to talk: development and pilot implementation of a checklist to promote interprofessional communication in the OR. *Qual Saf Health Care* 2005;14:340-6.
25 Burke CS, Salas E, Wilson-Donnelly K, et al. How to turn a team of experts into an expert medical team: guidance from the aviation and military communities. *Qual Saf Health Care* 2004;13 Suppl 1:i96-104.
26 Salas E, Wilson KA, Murphy CE, et al. Communicating, coordinating, and cooperating when lives depend on it: tips for teamwork. *Joint Commission Journal on Quality and Patient Safety* 2008;34:333-41.
27 Härgestam M, Lindkvist M, Brulin C, et al. Communication in interdisciplinary teams: exploring closed-loop communication during in situ trauma team training. *BMJ Open* 2013;3:e003525.
28 Schmutz J, Manser T, Keil J, et al. Structured performance assessment in three pediatric emergency scenarios: a validation study. *J Pediatr* 2015;166:1498-504.e1.
29 American College of Surgeons Committee on Trauma. *ATLS : advanced trauma life support : student course manual*. Chicago, IL: American College of Surgeons 2012.
30 Thies K, Gwinnutt C, Driscoll P, et al. The European Trauma Course--from concept to course. *Resuscitation* 2007;74:135-41.
31 Thies KC, Deakin CD, Voiglio EJ, et al. The European Trauma Course: trauma teaching goes European. *Eur J Anaesthesiol* 2014;31:13-4.
32 van Olden GD, Meeuwis JD, Bolhuis HW, et al. Advanced trauma life support study: quality of diagnostic and therapeutic procedures. *J Trauma* 2004;57:381-4.
33 van Olden GD, Meeuwis JD, Bolhuis HW, et al. Clinical impact of advanced trauma life support. *Am J Emerg Med* 2004;22:522-5.
34 Tsang B, McKee J, Engels PT, et al. Compliance to advanced trauma life support protocols in adult trauma patients in the acute setting. *World J Emerg Surg* 2013;8:39.
35 Zwarenstein M, Goldman J, Reeves S. Interprofessional collaboration: effects of practice-based interventions on professional practice and healthcare outcomes. *Cochrane Database Syst Rev* 2009:CD000072.
36 Siassakos D, Draycott TJ, Crofts JF, et al. More to teamwork than knowledge, skill and attitude. *BJOG* 2010;117:1262-9.
37 Siassakos D, Fox R, Crofts JF, et al. The management of a simulated emergency: better teamwork, better performance. *Resuscitation* 2011;82:203-6.
38 Jacobsson M, Härgestam M, Hultin M, et al. Flexible knowledge repertoires; communication by leaders in trauma teams. *Scand J Trauma Resusc Emerg Med* 2012;20:44.
39 Baker SP, O'Neill B, Haddon W, et al. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *J Trauma* 1974;14:187-96.
40 Wilson KA, Salas E, Priest HA, et al. Errors in the heat of battle: taking a closer look at shared cognition breakdowns through teamwork. *Hum Factors* 2007;49:243-56.
41 Schegloff EA. Confirming allusions: Toward an empirical account of action. *American journal of sociology* 1996:161-216.
42 McLaughlin ML. *Conversation : how talk is organized*. Beverly Hills: Sage Publications 1984.
43 R Development Core Team. R: A language and environment for statistical computing. Vienna, Austria: R Foundation for statistical computing 2015.
44 Smith-Jentsch KA, Zeisig RL, Acton B, et al. Team dimensional training: A strategy for guided team self-correction. In: Cannon-Bowers JA, Salas E, eds. *Making*

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BMJ Open: first published as 10.1136/bmjopen-2015-009911 on 29 January 2016. Downloaded from http://bmjopen.bmj.com/ on June 10, 2025 at Agence Bibliographique de l Enseignement Superieur (ABES) .
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decisions under stress: Implications for individual and team training. Washington, DC, US: American Psychological Association 1998:271-97.
45 Gillespie BM, Chaboyer W, Lizzio AJ. Teamwork in the OR: enhancing communication through team-building interventions. *ACORN The Official Journal of Perioperative Nursing in Australia* 2008;21:14-9.
46 Siassakos D, Bristowe K, Draycott TJ, et al. Clinical efficiency in a simulated emergency and relationship to team behaviours: a multisite cross-sectional study. *BJOG* 2011;118:596-607.
47 Woloshynowych M, Davis R, Brown R, et al. Communication patterns in a UK emergency department. *Ann Emerg Med* 2007;50:407-13.
48 Andersen PO, Jensen MK, Lippert A, et al. Identifying non-technical skills and barriers for improvement of teamwork in cardiac arrest teams. *Resuscitation* 2010;81:695-702.
49 Rall M, Dieckmann P. Crisis resource management to improve patient safety. *Euroanesthesia 2005*. Vienna, Austria: European Society of Anaesthesiology 2005:107-12.
50 TeamSTEPPS. Agency for Healthcare Research and Quality 2009.
51 Sevdalis N, Undre S, McDermott J, et al. Impact of intraoperative distractions on patient safety: a prospective descriptive study using validated instruments. *World J Surg* 2014;38:751-8.
52 Wheelock A, Suliman A, Wharton R, et al. The Impact of Operating Room Distractions on Stress, Workload, and Teamwork. *Ann Surg* 2015;261:1079-84.
53 Shapiro MJ, Morey JC, Small SD, et al. Simulation based teamwork training for emergency department staff: does it improve clinical team performance when added to an existing didactic teamwork curriculum? *Qual Saf Health Care* 2004;13:417-21.
54 Steinemann S, Berg B, Skinner A, et al. In situ, multidisciplinary, simulation-based teamwork training improves early trauma care. *J Surg Educ* 2011;68:472-7.
55 Lubbert PH, Kaasschieter EG, Hoorntje LE, et al. Video registration of trauma team performance in the emergency department: the results of a 2-year analysis in a Level 1 trauma center. *J Trauma* 2009;67:1412-20.
56 Kobayashi L, Patterson MD, Overly FL, et al. Educational and research implications of portable human patient simulation in acute care medicine. *Acad Emerg Med* 2008;15:1166-74.
57 Miller KK, Riley W, Davis S, et al. In situ simulation: a method of experiential learning to promote safety and team behavior. *J Perinat Neonatal Nurs* 2008;22:105-13.
58 Nunnink L, Welsh AM, Abbey M, et al. In situ simulation-based team training for post-cardiac surgical emergency chest reopen in the intensive care unit. *Anaesth Intensive Care* 2009;37:74-8.

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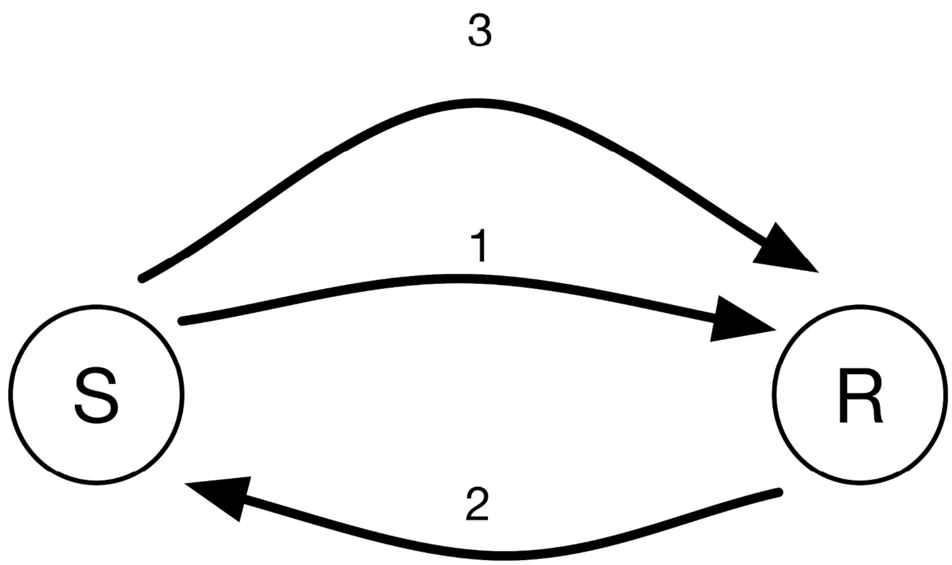

Fig 1. Closed-loop communication has three steps.
(1) A sender (S) sends a message, (2) a receiver (R) receives the message and acknowledges the reception, and (3) the sender verifies that the message has been received and interpreted as intended. Modified from Wilson et al [40].
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Trauma teams and time to early management

during in-situ trauma team training

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Key words: closed-loop communication, leadership, trauma, trauma team training, and time

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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 a trauma team training.

Design: In-situ trauma team training. The patient simulator was pre-programmed 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 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: Hazard ratios (HR) with confidence intervals (CI 95%) 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: 1.02-14.69). Only eight of 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: 0.71-0.96 and HR: 0.23; CI: 0.08-0.71, respectively).

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

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Article summary

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 acting in their own roles and executing their regular tasks.
- In-situ trauma team training allowed standardization of the trauma case scenario giving the trauma teams similar conditions.
- Organizational and structural hierarchies can differ depending on geographical and sociocultural settings.

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Introduction

Time is crucial factor for patient outcome during resuscitation after trauma [1]. Evidence suggests that early interventions minimize secondary injuries and reduces morbidity in severely injured patients, thus improving survival [2, 3, 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 minimize the time until definite management is established [5, 6].

The concept of trauma teams was initiated in the 1970s in the US and was introduced in Europe about two decades later [2, 6]. The team members work independently and simultaneously, and this ‘horizontal’ organizational 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, 9, 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 team members lack experience [11, 12].

The collaboration in interdisciplinary teams is often described as a complex interactional process [13, 14, 15, 16]. In health care, deficiencies in communication have been identified as a major contributor to errors in several different contexts [14, 17, 18, 19, 20]. These root cause analyses gave rise to the development of Crisis Resource Management (CRM), a systematic educational program 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 standardized

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terminology and procedures [9, 23, 24], closed-loop communication (CLC), a standardized 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], but in healthcare there are little empirical evidence showing its effectiveness.

Apart from regular trauma team training, attendance at structured trauma course is regarded as a practical and theoretical foundation for competent and skilled trauma teams [6]. The standardized 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 earlier 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 optimize 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 closed-loop communication, 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

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trauma in the trauma team, as well as use of closed-loop communication, and leaders' position during trauma team training.

Methods

Participants

The participants were hospital staff involved in regular trauma team training. They were firstly 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 pre-programmed to represent a severely injured patient with an injury severity score of 25 [39]. An auto-mode program was used to control the pathophysiology during the simulation. The

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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 cutting the left axillar artery. In order to maintain confidentiality of the case, the scenario could be either one, but the simulation was run identically regarding 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 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 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 from the ambulance personnel when the patient simulator was transferred from the ambulance stretcher to the stretcher in the emergency room. To ensure a standardized case and increase the reliability of the scenario, systolic blood pressure was decreased to 48 mmHg at 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, following the hospital's standard operating procedure. The length of the trauma team training was designed to last for 15 minutes (900 seconds) before the instructor interrupted.

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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 were used as support material during the analysis. The participants' background characteristics were gathered from questionnaires answered by the team members before 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 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 seconds), 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.

Closed-loop communication was divided into three steps (Fig 1). In the first step, call-out (CO), the sender transmits a message. 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

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received and interpreted correctly. All three steps are needed to make a complete CLC according to the definition previous given by this and other research groups [27, 40]. The number of CO and CLC initiated within the teams were determined by classifying the communication 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 above. 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 conversations analysis [41, 42] of the team leaders' communication 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 leaders chosen communication strategy. Authoritarian leadership was the sum (n) of 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

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regression (hazard ratio, 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 (i.e. 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, version 21 Armonk, NY: IBM Corp.), but the test of the proportional hazards assumption for independent variables was performed in R version 3.0.2 [43].

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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 one of the members of team S was female. The team members' years in profession

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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).

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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. Each team had 6 participants.

Team n=16	**Age** 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

*missing data, for this variable (n=5)

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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. Each team had 6 participants.

Team	CLC	CO	CLC/CO	Time to decision	Decision within 15 min	Leadership	
						Authoritarian	Egalitarian
n=16	*n*	*n*	*%*	*seconds*	*yes*	*n*	*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

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In eight 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 seconds (Table 2). The remaining eight teams were considered censored at the time of 900 seconds. 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 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 seconds (HR; 3.88, CI 1.02-14.69), while CO (HR; 0.82, CI 0.71-0.96) and CLC (HR 0.23, 0.08-0.71) initiated by team members decreased this likelihood (Table 3).

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

	Adjusted model		**Final model**		
	HR	p	HR	95 % CI	p
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 - 14.690	0.046
Team's CLC	0.24	0.024	0.23	0.076 - 0.706	0.010
Team's CO	0.84	0.070	0.82	0.706 - 0.958	0.012

HR = hazards ratio; CI = confidence interval

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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 upon which CRM was based: that CLC is important for teams' efficiency [9]. This result puts communication in focus; more specifically, the importance of CLC initiated by the leader for task completion. Secured communication has by Smith-Jentsch el al [44] been described to contain three components; information exchanged, phraseology and the use of CLC. CLC contains three distinct steps; first the sender transmits a message, secondly the receiver accepts the message and acknowledges its receipts, 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, 45]. 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 prioritize 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 teams, clear statements of the critical situation and CLC were associated with more efficiency in task completion [46]. 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

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experience of two or more structured trauma courses was associated with more frequent use of CLC, compared to those with no such experience. Having a Scandinavian origin and a team leader with an egalitarian leadership style 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 [47, 48]. 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 to make a decision to go to surgery. Several, perhaps conflicting, commands may cause communication overload that results in a delay before key tasks can be performed [49, 50]. 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 patient status [51]. 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 pro's and con's 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 thus be one of the explanations for the findings in this study that the more CO and CLC initiated by the team members, the less 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, and when the condition of the patient was stabilized 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 the leader's position varied depending on the situation and the interaction in the team, but also the leader's communication strategies. Having an authoritarian leader that used a coercive strategy (representing CO and CLC) with directed commands that only allowed short answers enabled

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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 even though a discussion will be necessary if there are doubts in the team of 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 and the researchers argue that this result was based on a modified CLC that included only the acknowledgement part of CLC (i.e. steps one and two) [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 recognized 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 as ATLS [29], ECT [30, 31] and TeamSTEPPS [52], If communication is to improve, this must be both deliberately trained and deliberately practiced. Factors as stress, distractions, and interruptions may compromise the team members' performance [53, 54]. It is therefore necessary to train in emergency situations regularly and to integrate them into everyday work practices [55, 56].

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

Methodological discussion

This study was based on a limited number of teams, which 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 pre-warning and by letting the trauma team members perform their designated tasks in their usual job roles. For example, 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 (i.e. the same level of hypovolemia).

The training session's duration was limited to 15 minutes to allow time for pre-scenario preparation, the team training, and subsequent debriefing, as well as to minimize 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 five minutes or less [57].

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 e.g. intubation. It is quite possible, or perhaps likely, that specific parts of team communication are related to specific parts of the

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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 those 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 discuss [58]. 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-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 [59, 60].

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 programs for trauma teams. The findings emphasize not only the importance of communication in general, but more specifically the importance of the leader's

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CLC. To improve safe and secure communication, deliberate practice of closed-loop communication might be necessary.

Closed-loop communication may not come naturally to the professionals in the trauma team. The reasons for this might include time pressure and workload, but also hierarchical and interpersonal factors. Establishing a routine helps to normalize 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.

Author contributions

MHm, CB and MHn designed the initial study. MHm, ML, and MHn drafted the manuscript. All authors contributed to the data analysis and to critical revision of the manuscript. All authors have approved the final manuscript and agreed to be accountable for all aspects of the work including the accuracy and integrity of all parts of the work.

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Competing interests

The authors have read and understood the BMJ policy on declaration of interests and declare no competing interests.

Data sharing

No additional data available.

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Refences

1 Driscoll PA, Vincent CA. Variation in trauma resuscitation and its effect on patient outcome. *Injury* 1992;**23**:111-5.
2 Adedeji OA, Driscoll PA. The trauma team--a system of initial trauma care. *Postgrad Med J* 1996;**72**:587-93.
3 Gerardo CJ, Glickman SW, Vaslef SN, et al. The rapid impact on mortality rates of a dedicated care team including trauma and emergency physicians at an academic medical center. *J Emerg Med* 2011;**40**:586-91.
4 Cornwell EE, Chang DC, Phillips J, et al. Enhanced trauma program commitment at a level I trauma center: effect on the process and outcome of care. *Arch Surg* 2003;**138**:838-43.
5 Rainer TH, Cheung NK, Yeung JH, et al. Do trauma teams make a difference? A single centre registry study. *Resuscitation* 2007;**73**:374-81.
6 Tiel Groenestege-Kreb D, van Maarseveen O, Leenen L. Trauma team. *Br J Anaesth* 2014;**113**:258-65.
7 Georgiou A, Lockey DJ. The performance and assessment of hospital trauma teams. *Scand J Trauma Resusc Emerg Med* 2010;**18**:66.
8 Hjortdahl M, Ringen AH, Naess AC, et al. Leadership is the essential non-technical skill in the trauma team--results of a qualitative study. *Scand J Trauma Resusc Emerg Med* 2009;**17**:48.
9 Salas E, Sims D, Burke C. Is there a big five in teamwork? *Small Group Research* 2005;**36**:555-99.
10 Cole E, Crichton N. The culture of a trauma team in relation to human factors. *J Clin Nurs* 2006;**15**:1257-66.
11 Yun S, Faraj S, Sims HP. Contingent leadership and effectiveness of trauma resuscitation teams. *J Appl Psychol* 2005;**90**:1288-96.
12 Klein KJ, Ziegert JC, Knight AP, et al. Dynamic delegation: Shared, hierarchical, and deindividualized leadership in extreme action teams. *Administrative Science Quarterly* 2006;**51**:590-621.

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13 Undre S, Sevdalis N, Healey AN, et al. Observational teamwork assessment for surgery (OTAS): refinement and application in urological surgery. *World J Surg* 2007;**31**:1373-81.
14 Lingard L, Espin S, Whyte S, et al. Communication failures in the operating room: an observational classification of recurrent types and effects. *Qual Saf Health Care* 2004;**13**:330-4.
15 Bristowe K, Siassakos D, Hambly H, et al. Teamwork for Clinical Emergencies Interprofessional Focus Group Analysis and Triangulation With Simulation. *Qualitative health research* 2012;**22**:1383-94.
16 Miller D, Crandall C, Washington C, et al. Improving teamwork and communication in trauma care through in situ simulations. *Acad Emerg Med* 2012;**19**:608-12.
17 Sutcliffe KM, Lewton E, Rosenthal MM. Communication failures: an insidious contributor to medical mishaps. *Acad Med* 2004;**79**:186-94.
18 Rabøl LI, Andersen ML, Østergaard D, et al. Descriptions of verbal communication errors between staff. An analysis of 84 root cause analysis-reports from Danish hospitals. *BMJ Qual Saf* 2011;**20**:268-74.
19 Nagpal K, Arora S, Vats A, et al. Failures in communication and information transfer across the surgical care pathway: interview study. *BMJ Qual Saf* 2012;**21**:843-9.
20 Gillespie BM, Chaboyer W, Fairweather N. Factors that influence the expected length of operation: results of a prospective study. *BMJ Qual Saf* 2012;**21**:3-12.
21 Rall M, Gaba D. Patient simulators. In: Miller R, Afton-Bird G, eds. *Miller's Anaesthesia*. New York: Elsevier Churchill Livingstone 2005.
22 Helmreich RL, Merritt AC, Wilhelm JA. The evolution of crew resource management training in commercial aviation. *The international journal of aviation psychology* 1999;**9**:19-32.
23 Velji K, Baker GR, Fancott C, et al. Effectiveness of an Adapted SBAR Communication Tool for a Rehabilitation Setting. *Healthc Q* 2008;**11**:72-9.
24 Lingard L, Espin S, Rubin B, et al. Getting teams to talk: development and pilot implementation of a checklist to promote interprofessional communication in the OR. *Qual Saf Health Care* 2005;**14**:340-6.
25 Burke CS, Salas E, Wilson-Donnelly K, et al. How to turn a team of experts into an expert medical team: guidance from the aviation and military communities. *Qual Saf Health Care* 2004;**13 Suppl 1**:i96-104.
26 Salas E, Wilson KA, Murphy CE, et al. Communicating, coordinating, and cooperating when lives depend on it: tips for teamwork. *Joint Commission Journal on Quality and Patient Safety* 2008;**34**:333-41.
27 Härgestam M, Lindkvist M, Brulin C, et al. Communication in interdisciplinary teams: exploring closed-loop communication during in situ trauma team training. *BMJ Open* 2013;**3**:e003525.
28 Schmutz J, Manser T, Keil J, et al. Structured performance assessment in three pediatric emergency scenarios: a validation study. *J Pediatr* 2015;**166**:1498-504.e1.
29 American College of Surgeons Committee on Trauma. *ATLS : advanced trauma life support : student course manual*. Chicago, IL: American College of Surgeons 2012.
30 Thies K, Gwinnutt C, Driscoll P, et al. The European Trauma Course--from concept to course. *Resuscitation* 2007;**74**:135-41.
31 Thies KC, Deakin CD, Voiglio EJ, et al. The European Trauma Course: trauma teaching goes European. *Eur J Anaesthesiol* 2014;**31**:13-4.
32 van Olden GD, Meeuwis JD, Bolhuis HW, et al. Advanced trauma life support study: quality of diagnostic and therapeutic procedures. *J Trauma* 2004;**57**:381-4.

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33 van Olden GD, Meeuwis JD, Bolhuis HW, et al. Clinical impact of advanced trauma life support. *Am J Emerg Med* 2004;**22**:522-5.
34 Tsang B, McKee J, Engels PT, et al. Compliance to advanced trauma life support protocols in adult trauma patients in the acute setting. *World J Emerg Surg* 2013;**8**:39.
35 Zwarenstein M, Goldman J, Reeves S. Interprofessional collaboration: effects of practice-based interventions on professional practice and healthcare outcomes. *Cochrane Database Syst Rev* 2009:CD000072.
36 Siassakos D, Draycott TJ, Crofts JF, et al. More to teamwork than knowledge, skill and attitude. *BJOG* 2010;**117**:1262-9.
37 Siassakos D, Fox R, Crofts JF, et al. The management of a simulated emergency: better teamwork, better performance. *Resuscitation* 2011;**82**:203-6.
38 Jacobsson M, Härgestam M, Hultin M, et al. Flexible knowledge repertoires; communication by leaders in trauma teams. *Scand J Trauma Resusc Emerg Med* 2012;**20**:44.
39 Baker SP, O'Neill B, Haddon W, et al. The injury severity score: a method for describing patients with multiple injuries and evaluating emergency care. *J Trauma* 1974;**14**:187-96.
40 Wilson KA, Salas E, Priest HA, et al. Errors in the heat of battle: taking a closer look at shared cognition breakdowns through teamwork. *Hum Factors* 2007;**49**:243-56.
41 Schegloff EA. Confirming allusions: Toward an empirical account of action. *American journal of sociology* 1996:161-216.
42 McLaughlin ML. *Conversation : how talk is organized*. Beverly Hills: Sage Publications 1984.
43 R Development Core Team. R: A language and environment for statistical computing. Vienna, Austria: R Foundation for statistical computing 2015.
44 Smith-Jentsch KA, Zeisig RL, Acton B, et al. Team dimensional training: A strategy for guided team self-correction. In: Cannon-Bowers JA, Salas E, eds. *Making decisions under stress: Implications for individual and team training*. Washington, DC, US: American Psychological Association 1998:271-97.
45 Gillespie BM, Chaboyer W, Lizzio AJ. Teamwork in the OR: enhancing communication through team-building interventions. *ACORN The Official Journal of Perioperative Nursing in Australia* 2008;**21**:14-9.
46 Siassakos D, Bristowe K, Draycott TJ, et al. Clinical efficiency in a simulated emergency and relationship to team behaviours: a multisite cross-sectional study. *BJOG* 2011;**118**:596-607.
47 Okuyama A, Wagner C, Bijnen B. Speaking up for patient safety by hospital-based health care professionals: a literature review. *BMC Health Serv Res* 2014;**14**:61.
48 Katakam LI, Trickey AW, Thomas EJ. Speaking up and sharing information improves trainee neonatal resuscitations. *J Patient Saf* 2012;**8**:202-9.
49 Woloshynowych M, Davis R, Brown R, et al. Communication patterns in a UK emergency department. *Ann Emerg Med* 2007;**50**:407-13.
50 Andersen PO, Jensen MK, Lippert A, et al. Identifying non-technical skills and barriers for improvement of teamwork in cardiac arrest teams. *Resuscitation* 2010;**81**:695-702.
51 Rall M, Dieckmann P. Crisis resource management to improve patient safety. *Euroanesthesia 2005*. Vienna, Austria: European Society of Anaesthesiology 2005:107-12.
52 TeamSTEPPS. Agency for Healthcare Research and Quality 2009.
53 Sevdalis N, Undre S, McDermott J, et al. Impact of intraoperative distractions on patient safety: a prospective descriptive study using validated instruments. *World J Surg* 2014;**38**:751-8.

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54 Wheelock A, Suliman A, Wharton R, et al. The Impact of Operating Room Distractions on Stress, Workload, and Teamwork. *Ann Surg* 2015;**261**:1079-84.
55 Shapiro MJ, Morey JC, Small SD, et al. Simulation based teamwork training for emergency department staff: does it improve clinical team performance when added to an existing didactic teamwork curriculum? *Qual Saf Health Care* 2004;**13**:417-21.
56 Steinemann S, Berg B, Skinner A, et al. In situ, multidisciplinary, simulation-based teamwork training improves early trauma care. *J Surg Educ* 2011;**68**:472-7.
57 Lubbert PH, Kaasschieter EG, Hoorntje LE, et al. Video registration of trauma team performance in the emergency department: the results of a 2-year analysis in a Level 1 trauma center. *J Trauma* 2009;**67**:1412-20.
58 Kobayashi L, Patterson MD, Overly FL, et al. Educational and research implications of portable human patient simulation in acute care medicine. *Acad Emerg Med* 2008;**15**:1166-74.
59 Miller KK, Riley W, Davis S, et al. In situ simulation: a method of experiential learning to promote safety and team behavior. *J Perinat Neonatal Nurs* 2008;**22**:105-13.
60 Nunnink L, Welsh AM, Abbey M, et al. In situ simulation-based team training for post-cardiac surgical emergency chest reopen in the intensive care unit. *Anaesth Intensive Care* 2009;**37**:74-8.

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Figure legends

Fig 1. Closed-loop communication has three steps.

(1) A sender (S) sends a message, (2) a receiver (R) receives the message and acknowledges the reception, and (3) the sender verifies that the message has been received and interpreted as intended. Modified from Wilson et al [40].

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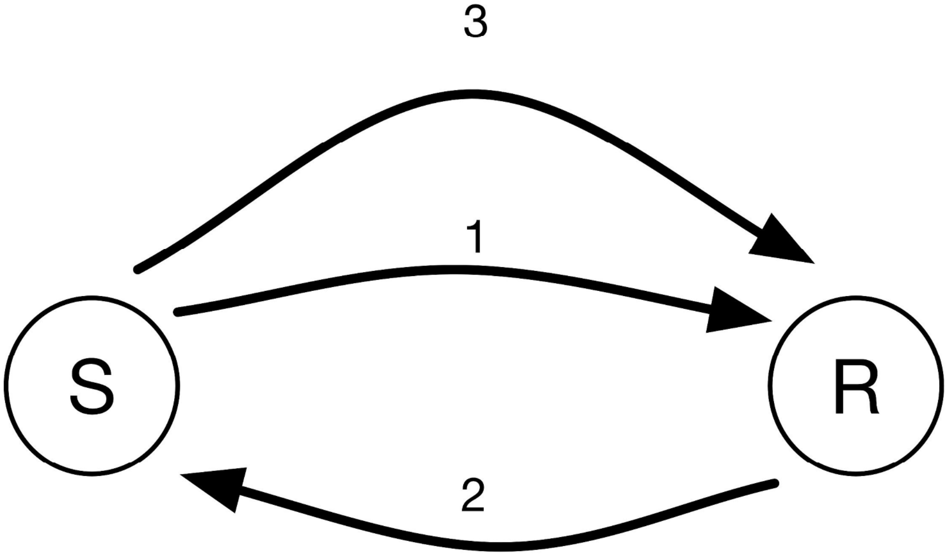

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