

Discrepant perceptions of communication, teamwork and situation awareness among surgical team members

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Abstract

Objective. To assess surgical team members' differences in perception of non-technical skills.

Design. Questionnaire design.

Setting. Operating theatres (OTs) at one university hospital, three teaching hospitals and one general hospital in the Netherlands.

Participants. Sixty-six surgeons, 97 OT nurses, 18 anaesthetists and 40 nurse anaesthetists.

Methods. All surgical team members, of five hospitals, were asked to complete a questionnaire and state their opinion on the *current state* of communication, teamwork and situation awareness at the OT.

Results. Ratings for 'communication' were significantly different, particularly between surgeons and all other team members ($P \leq 0.001$). The ratings for 'teamwork' differed significantly between all team members ($P \leq 0.005$). Within 'situation awareness' significant differences were mainly observed for 'gathering information' between surgeons and other team members ($P < 0.001$). Finally, 72–90% of anaesthetists, OT nurses and nurse anaesthetists rated routine team briefings and debriefings as inadequate.

Conclusions. This study shows discrepancies on many aspects in perception between surgeons and other surgical team members concerning communication, teamwork and situation awareness. Future research needs to ascertain whether these discrepancies are linked to greater risk of adverse events or to process as well as systems failures. Establishing this link would support implementation and use of complex team interventions that intervene at multiple levels of the healthcare system.

Keywords: patient safety, quality of care, teamwork, communication, surgery

Introduction

Performing safe surgery relies on the ability of surgical team members to combine professional knowledge and technical expertise with non-technical skills (e.g. communication, teamwork, situation awareness, leadership, decision-making) [1]. Mastery of both types of skill is essential [2]. The surgical team is a dynamic, multi-disciplinary team and consists of

surgeons, anaesthetists, operating theatre (OT) nurses and nurse anaesthetists. Many errors that occur in the OT are attributed to the non-technical skills of the surgical team [1, 3–12]. In order to work safely and effectively in a surgical environment, with a minimum of technical errors, previous studies have identified that the non-technical skills of communication, teamwork and situation awareness are the most important [1, 6, 9, 11–14]. These non-technical skills are

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also important in other high-complex and high-risk industries such as aviation. In this industry, communication failures between team members, rather than a lack of technical skills or malfunctioning of the aeroplane, were responsible for ~70% of accidents [5–7, 9, 10].

In the context of the OT communication is defined as ‘skills for working in a team context to ensure that the team has an acceptable shared picture of the situation and can complete the tasks effectively’, and teamwork is defined as ‘skills for working in a group context, in any role, to ensure effective joint tasks completion and team member satisfaction’ [15]. Furthermore, situation awareness is defined as ‘developing and maintaining a dynamic awareness of the situation in theatre based on assembling data from the environment, understanding what they mean and thinking ahead what might happen next’ [15].

Procedures in the OT are complex and demand intense interaction between team members. Surgical teams should be cohesive and have similar perceptions of communication and teamwork to collaborate effectively, establish common goals for improving team performance, and ensure patient safety [9, 16]. Therefore, work processes should emphasize the interdependency of team members and support a good understanding of each team member’s tasks, roles and responsibilities within the surgical process. This facilitates effective teamwork, ensures that action is linked to reflection, and creates a culture that is open to change [6, 9, 13, 17, 18].

The aim of this study was to assess surgical team members’ perception of their non-technical skills, specifically communication, teamwork and situation awareness. Research questions were aimed at identifying the category or categories on which team members differed most and where these differences in perception existed. It is important to identify these discrepancies before introducing interventions for improvement and adjust implementation strategies accordingly [1, 3, 12, 13, 16, 19, 20].

Methods

This study was designed as a multiple case study among five Dutch hospitals, covering 6% of all hospitals in the Netherlands. The researchers (L.W., C.D.) visited each hospital and gave surgical team members oral and written information on the project and provided a questionnaire for all surgical team members to complete and elicit their opinion on the *current state* of communication, teamwork and situation awareness in the OT. Approximately 600 questionnaires were distributed by mail/email by the contact persons of the participating hospitals to the team members; surgeons, anaesthetists, OT nurses and nurse anaesthetists. In this article, the surgeon is defined as: ‘a medical specialist who performs surgery: a physician qualified to treat those diseases that are amenable to or require surgery’ [21].

Questionnaire

The questionnaire elicited background information, such as date and details on the respondent (age category, gender and

function within the hospital), and the respondent’s opinion on statements about communication, teamwork and situation awareness. The statements were based on two rating systems: the non-technical skills of surgeons and the anaesthetists’ non-technical skills [15, 22]. These rating systems are developed for use during observations to identify the main non-technical skills associated with good surgical practice of anaesthetists and surgeons that can be used for clear and transparent assessment of training needs [15]. The rating systems’ accompanying handbooks provided examples of good and poor behaviour for each category and subcategory, which were translated into statements. As these rating systems are validated instruments, and comparable to other validated instruments on team skills ([6, 23]), they provided a reliable source to develop the questionnaire used in this study. Table 1 presents the definitions of categories and subcategories used in the questionnaire.

The questions were randomly distributed over the questionnaire using a five-point Likert scale ranging from ‘1’ (strongly disagree) to ‘5’ (strongly agree) for each statement. The questionnaires were voluntary and anonymous to team member’s name, but not to team member’s function or hospital. All data were analysed confidentially.

Statistical analyses were performed using SPSS 16.0 for Mac. Comparisons between surgical team members per subcategory were performed using the Mann–Whitney *U*-test. Bonferroni adjustment was applied for multiple comparisons.

Results

Survey sample

The five hospitals that volunteered to participate comprised one university hospital, three teaching hospitals and one general hospital. In total, 235 questionnaires were returned. Response rates per hospital ranged between 29 and 60%, with an average response rate of 39% (Table 2).

The respondents represented all disciplines directly involved in surgical procedures: 66 surgeons (and residents), 18 anaesthetists (and trainee anaesthetists), 97 OT nurses and 40 nurse anaesthetists (for distribution between hospitals, see Table 2). Fourteen participants did not include their function and were therefore excluded from the study. Overall, 77% of surgeons were male, 58% of nurse anaesthetists were male and 85% of OT nurses were female. Within the anaesthetic disciplines, men and women were represented equally. No significant differences were seen for gender between hospitals. Within the surgical discipline most surgeons were between 36 and 45 years old. Within the other disciplines age categories were divided.

Table 3 presents the statements where at least half of the respondents per discipline rated the statement as inadequate (rating ‘1’ or ‘2’). Table 4 presents the mean ratings, standard deviation, median and missing data per subcategory. Table 4 shows a large amount of missing data for the surgeons for ‘Teamwork’ and ‘Situation awareness 1, 2 and 3’. This was

Table 1 Definitions for communication, teamwork and situation awareness [15, 22]

(Sub)categories and number of statements in questionnaire

Communication: skills for working in a team context to ensure that the team has an acceptable shared picture of the situation and can complete the tasks effectively

C1—Exchanging information: giving and receiving knowledge and information in timely matter to aid establishment of a shared understanding among team members ($n = 6$)

C2—Establishing a shared understanding: ensuring that the team not only has necessary and relevant information to carry out the operation, but that they understand it and that an acceptable shared ‘big picture’ of the case is held by team member ($n = 7$)

C3—Co-ordinating team activities: working together with other team members to carry out cognitive and physical activities in a simultaneous and collaborative manner ($n = 5$)

Teamwork: skills for working in a group context, in any role, to ensure effective joint tasks completion and team member satisfaction. The focus is particularly on the team rather than the task ($n = 11$)

Situational awareness: developing and maintaining a dynamic awareness of the situation in theatre based on assembling data from the environment (patient, team, time, displays and equipment): understanding what they mean and thinking ahead what might happen next

S1—Gathering information: seeking information in the OT from the operative findings, theatre environment, equipment and people ($n = 5$)

S2—Understanding information: updating one’s mental picture by interpreting the information gathered, and comparing it with existing knowledge to identify the match or mismatch between the situation and the expected state ($n = 2$)

S3—Projecting and anticipating future state: predicting what may happen in the near future as a result of possible actions, interventions or non-interventions ($n = 1$)

mainly attributable to the university hospital, where incomplete questionnaires, missing one page, were distributed. Mean ratings, standard deviation and median were calculated for the remaining data. Additionally, Table 5 presents the significant differences of the team members’ ratings per subcategory using the Mann–Whitney U -test. Here, application of the Bonferroni correction for multiple comparisons suggests an appropriate level of $P < 0.008$.

Communication

Within communication, three different subcategories are addressed, which will be elaborated in the following paragraphs.

C1 | *Exchanging information*. Surgeons rated this subcategory as adequate; the mean rating was 3.95 (Table 4). The other team

Table 2 Response to questionnaire

Hospital type	Questionnaires sent out (estimate)	Questionnaires received	Overall response rate (%)	Response per discipline		Surgeons (and residents)	Anaesthetists (and in training)	OT nurses	Nurse anaesthetists	Function unknown			
				Response, #	Gender								
University	180	78	43	33 (66)	26 M, 7 F	7 (18)	4 M, 3 F	27 (50)	3 M, 24 F	9 (24)	6 M, 3 F	2	2 M
Teaching 1	150	54	36	15 (34)	13 M, 2 F	4 (40)	2 M, 2 F	18 (30)	3 M, 12 F, 3 md	11 (37)	3 M, 8 F	6	1 M, 2 F, 3 md
Teaching 2	65	39	60	3 (25)	3 M	4 (44)	2 M, 2 F	18 (67)	1 M, 17 F	11 (79)	7 M, 3 F, 1 md	3	1 M, 2 F
General 1	130	38	29	8 (27)	5 M, 3 F	3 (25)	1 M, 2 F	21 (35)	1 M, 20 F	5 (19)	4 M, 1 F	1	1 M
General 2	78	26	33	7 (58)	4 M, 2 F, 1 md	—	—	13 (30)	4 M, 9 F	4 (29)	3 M, 1 F	2	2 F
Total	603	235	39	66 (45)	51 M (77) 14 F (21) 1 md (2)	18 (23)	9 M = 50%, 9 F = 50%	97 (40)	12 M = 12%, 82 F = 85%, 3 md = 3%	40 (34)	23 M = 58%, 16 F = 40%, 1 md = 2%	14	5 M = 36%, 6 F = 43%, 3 md = 21%
Age categories per discipline											C1: 3		
											C2: 7		
											C3: 15		
											C4: 8		
											C5: 11		
											md: 1		

M, male; F, female; md, missing data.
Age categories: C1, 18–25 years, C2, 26–35 years, C3, 36–45 years, C4, 46–55 years, C5, 56–65 years.

Table 3 Statements within communication, teamwork and situation awareness where at least half of the respondents per discipline rated the statement as inadequate

Statements	Percentage rated as inadequate per discipline			
	Surgeons	Anaesthetists	OT nurses	Nurse anaesthetists
C1 Exchanging information				
Anaesthetist/nurse anaesthetist keeping the surgeon informed on the administered medication during surgery	42	78	71	67
Surgeon communicating that surgery is not going according to plan	5	56	24	31
C2 Establishing a shared understanding				
Surgeon communicating planned procedure	5	51	49	49
Anaesthetist communicating planned procedure	20	6	61	18
Anaesthetist communicating planned actions	20	6	62	13
Pre-operative briefings with the whole team on the procedure	48	89	90	87
Debriefings with the whole team, discussing what problems occurred	27	83	84	72
C3 Co-ordinating team activities				
Surgeon checking pre-operatively whether the whole team is ready to start the procedure	12	59	73	49
Anaesthetist checking pre-operatively whether the whole team is ready to start the procedure	27	33	81	67
Stopping the procedure when asked by the OT nurse	38	53	72	68
T Teamwork				
Contentment with communication and teamwork in OT	6	44	72	36
Surgeon being a team player	4	27	51	38
S1 Gathering information				
Exchanging relevant patient data pre-operatively with the whole team	35	94	85	78
Surgeon asking the anaesthetic team for update on the patient's condition	6	78	37	58
S2 and S3 not applicable				

members rated this lower: mean 3.12–3.34. This difference of opinion between surgeons and other team members was significant ($P < 0.001$, Table 5). No significant differences were found between the OT nurses and anaesthetists ($P = 0.215$), between the OT nurses and nurse anaesthetists ($P = 0.011$), or between anaesthetists and nurse anaesthetists ($P = 0.677$).

The statement ‘anaesthetist/nurse anaesthetist keeping the surgeon informed on the administered medication during surgery’ was rated as inadequate by the anaesthetists (78%), OT nurses (71%) and nurse anaesthetists (67%, Table 3).

C2 | Establishing a shared understanding. Surgeons rated this subcategory as adequate: the mean was 3.68 versus a mean of 2.73 for the anaesthetists and 2.74 for the nurse anaesthetists. The OT nurses’ mean ratings were lowest: 2.35. The difference of opinion between surgeons and other team members, and between OT nurses and other team members was significant ($P < 0.001$). No significant difference was found between anaesthetists and nurse anaesthetists ($P = 0.811$).

Anaesthetists, OT nurses and nurse anaesthetists rated performing pre-operative briefings and debriefings as inadequate (72–90% of respondents). OT nurses (61–62%)

also rated communication of the planned procedure and actions by the anaesthetist as inadequate.

C3 | Co-ordinating team activities. Once more, these results showed the same overall pattern: the surgeons rated this subcategory highest (mean: 3.83), followed by the anaesthetists (3.33) and nurse anaesthetists (3.04). Again, the OT nurses’ ratings were lowest: 2.77. The difference of opinion between surgeons and other team members was significant ($P \leq 0.001$), as was the difference between OT nurses and anaesthetists ($P < 0.001$). No significant differences were found between the remaining team members.

Checking the readiness of the team pre-operatively by the surgeon as well as by the anaesthetist was rated as inadequate by OT nurses (73 and 81%, respectively). ‘Stopping the procedure when asked by the OT nurse’ was rated as inadequate by 53–72% of team members, except the surgeons.

Teamwork

Within this subcategory, the differences between all team members were significant ($P \leq 0.005$). Most surgeons and anaesthetists perceived ‘teamwork’ as adequate (group mean:

Table 4 Team members' ratings for the subcategories of communication, teamwork and situation awareness: mean (on 1–5 scale, higher score = higher quality), standard deviation (SD), median and missing data

Subcategory		Discipline					Total
		Surgeons	Anaesthetists	OT nurses	Nurse anaesthetists		
Communication	C1	Mean (SD)	3.95 (1.05)	3.26 (1.25)	3.12 (1.08)	3.34 (1.07)	3.41 (1.14)
		Median	4.00	3.00	3.00	3.00	
		% missing data	3	–	–	3	
	C2	Mean (SD)	3.68 (1.14)	2.73 (1.15)	2.35 (0.99)	2.74 (0.97)	2.85 (1.19)
		Median	4.00	3.00	2.00	3.00	
		% missing data	–	1	1	3	
	C3	Mean (SD)	3.83 (1.16)	3.33 (1.32)	2.77 (1.25)	3.04 (1.23)	3.18 (1.31)
		Median	4.00	3.00	3.00	3.00	
		% missing data	1	4	1	3	
Teamwork	T	Mean (SD)	3.78 (1.07)	3.47 (0.99)	3.06 (0.99)	3.26 (0.89)	3.32 (1.04)
		Median	4.00	4.00	3.00	3.00	
		% missing data	14 ^a	1	1	3	
Situation awareness	S1	Mean (SD)	3.84 (1.03)	2.84 (1.24)	3.15 (1.14)	3.14 (1.20)	3.30 (1.18)
		Median	4.00	2.00	4.00	3.00	
		% missing data	15 ^a	1	–	4	
	S2	Mean (SD)	4.35 (0.80)	4.11 (0.92)	3.91 (0.78)	4.05 (0.70)	4.07 (0.80)
		Median	4.00	4.00	4.00	4.00	
		% missing data	15 ^a	–	–	3	
	S3	Mean (SD)	3.41 (1.23)	2.67 (0.89)	3.74 (0.97)	3.28 (0.63)	3.51 (1.01)
		Median	4.00	3.00	4.00	3.00	
		% missing data	49 ^a	29	2	20	

^aFinal page of the questionnaire from the university hospital was not distributed.

3.78 and 3.47). The ratings of nurse anaesthetists and OT nurses were significantly lower (mean: 3.26 and 3.06).

All respondents perceived themselves as team players, felt comfortable about expressing their opinion, and perceived the OT nurse and nurse anaesthetist as team players. However, 51% of OT nurses did not see the surgeon as team player and 72% of OT nurses were not content with communication and teamwork in OT.

Situation awareness

Within situation awareness three subcategories are addressed, which will be elaborated in the following paragraphs.

S1 | Gathering information. The ratings for this subcategory showed similar results to most (sub)categories within communication and teamwork. Surgeons awarded this subcategory an average rating of 3.84; the average ratings for the OT nurses and nurse anaesthetists were 3.15 and 3.14. The anaesthetists' ratings were lowest: 2.84. The only

significant difference found was between the surgeons and other team members ($P < 0.001$).

Overall, 78–94% of anaesthetists, OT nurses and nurse anaesthetists rated exchanging relevant patient data pre-operatively with the whole team as inadequate, in contrast to the surgeon (35% rated this as inadequate). The surgeon asking the anaesthetic team for an update on the patient's condition was rated as inadequate by 58% of nurse anaesthetists and 78% of anaesthetists.

S2 | Understanding information. Most team members rated this subcategory as adequate: mean ratings for the groups ranged from 3.91 to 4.35. Significant differences were found only between the surgeons and OT nurses ($P < 0.001$), and between the surgeons and nurse anaesthetists ($P = 0.001$).

S3 | Projecting and anticipating future states. This subcategory entailed the statement 'during laparoscopic procedures, the instruments for a possible conversion are always present in OT'. Within this subcategory, a lot of missing data were found: 49% of surgeons, 29% of anaesthetists and 20% of

Table 5 Significant differences between surgical team members (Mann–Whitney *U*-test with Bonferroni correction)^a

Disciplines compared	Communication			Teamwork T	Situation awareness		
	C1	C2	C3		S1	S2	S3
Surgeons–OT nurses	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.170
Surgeons–anaesthetists	<0.001	<0.001	0.001	<0.001	<0.001	0.146	0.025
Surgeons–nurse anaesthetists	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.237
Anaesthetists –OT nurses	0.215	<0.001	<0.001	<0.001	0.023	0.074	<0.001
Anaesthetists–nurse anaesthetists	0.677	0.811	0.079	0.005	0.055	0.389	0.350
OT nurses–nurse anaesthetists	0.011	<0.001	0.013	0.001	0.919	0.174	0.002

^aBonferroni correction for multiple comparisons suggests an appropriate level of $P < 0.008$.

nurse anaesthetists did not answer this question. In contrast, the OT nurses showed a near full response (98%) and most nurses rated this item as adequate (mean 3.74). If rated at all, the surgeons rated this statement as adequate, the mean being 3.41, which was not significantly higher than the mean of 3.28 awarded by the nurse anaesthetists. The anaesthetists' ratings were lowest: mean 2.67.

Significant differences were found only between the OT nurses and anaesthetists ($P < 0.001$) and between OT nurses and nurse anaesthetists ($P = 0.002$).

Discussion

The purpose of this study was to analyse the discrepancies in team members' perception of communication, teamwork and situation awareness. Overall, this study showed a significant discrepancy between the surgical team members in all three categories. Throughout the questionnaire the surgeons rated most items as adequate (mean: 3.41–4.35) in contrast to all other team members where more differences in opinion were found. Within the communication category results showed a large variation in opinion between team members. The largest discrepancy in this study was found in 'establishing a shared understanding' (C2), which is an important factor when performing complex procedures, such as surgery [4]. The overall ratings concerning 'teamwork' also differed between surgical team members. Most surgeons and anaesthetists rated these as adequate. However, the majority of both OT nurses and nurse anaesthetists rated these as inadequate. Within the situation awareness category, the 'understanding information' subcategory was rated as adequate. However, all team members, except the surgeons, rated 'gathering information' as inadequate.

The discrepancies we found may have a negative effect on patient safety. A first step to improve patient safety is acknowledging that errors are made and discussing these errors. Although errors are inevitable, team members are often reluctant to discuss these failures, especially human errors. Surgeons might be hesitant to discuss failures because they are educated to 'do the right thing and do it right' and thus find it hard to acknowledge that errors are made [24].

Other team members might be discouraged to speak up because of traditional hierarchical structures, authority, social barriers or differences in professional training and responsibility [3, 17, 19, 24]. Also poor teamwork could lead to team members' withdrawal from discussions and could lead to decreased job satisfaction and efficiency, which in turn could result in communication failures and poor performance. Not taking time out to discuss complications as a team or to perform a thorough analysis of what went wrong and why results in poorly performing teams. Research in aviation shows that, regardless of workload, poorly performing teams spend only 5% of their time discussing possible complications compared with 33% of time spend by effective teams [25]. Research has also shown that similar perceptions of the *current situation* will result in effective collaboration and patient safety [7, 9, 16]. Similar perceptions of the *future state*, on what to improve and why, will support implementation of quality improvement initiatives and improve collective learning [1, 3, 12, 13, 16, 19, 20, 26]. All team members should understand and be well informed about the surgical procedure and about specific patient-related subjects, such as allergies or co-morbidity. A lack in this 'shared understanding' among team members might result in adverse events, such as wrong site surgery or wrong person surgery [7, 16, 20]. Many of our respondents experience a lack of shared perception both on the current and the future state, with the exception of the surgeons. One method to improve shared understanding is by means of pre-operative briefings. These create an opportunity, just before the start of the surgical intervention, to exchange information on the patient and on the surgical procedure with the whole team in order to prevent errors [20]. This establishes a shared mental model among team members.

The overall findings of this study are consistent with previous research, the most common pattern being that surgeons have a positive perception of communication and teamwork and that nurses have the most negative perception [3, 7, 8, 11, 16, 18, 19]. OT nurses who have a poor perception of communication sometimes have difficulty in speaking up, and are afraid of confrontation. This could also prevent other team members from correcting errors before patients are harmed and inhibit discussing and learning from errors as a team [5, 7, 17–19].

A limitation of this study was the number of centres involved; only five hospitals participated of the ~90 hospitals in the Netherlands (6%). However, these hospitals represent the whole spectrum of hospital types at a regional level and are comparable for quality of care. On the national list of quality indicators for patient care, the hospitals that volunteered ranked from average to good, but change positions annually when compared over the last 5 years [27].

Comparing response rates to similar studies is complicated because of the large differences in results/outcome measurements [3, 8, 16]. This study showed large discrepancies in response rate, both between hospitals and between disciplines. The surgeons' response rate was 45%, which is comparable to Flin *et al.* [8] (48%) and higher than Mills *et al.* [16] (12%). The OT nurses' response rate was higher: 40% versus 19% (Flin *et al.*) and 36% (Mills *et al.*). Makary *et al.* [3] showed a much higher response rate for all different disciplines (surgeons, anaesthetists, OT nurses, nurse anaesthetists). Future research should include results on differences between hospitals, and study which factors contribute to such high discrepancies in response rates.

The large amount of missing data for the surgeons (Table 4) was caused by human error. At the university hospital, the last page was not distributed, which resulted in unreliable answers for this discipline. To prevent errors like these, it is recommended that hard copies be distributed or to a web-based version (including required fields) used. The missing data concerning the statement about 'Projecting and anticipating future state' (S3) was directly related to a specific task: anticipating conversion. Apart from the high response from the OT nurses, being responsible for this task, most team members did not see this as part of their job, which might be the reason for the low response.

This study shows the differences in perception of surgical team members in relation to the non-technical skills communication, teamwork and situation awareness. Although these skills are considered the most important ones to work safely and effectively [1, 6, 9, 11–14, 28], skills such as leadership and decision-making are important as well. Therefore, a follow-up study was set up including these items in the questionnaire to get a more complete picture of the whole spectrum of non-technical skills.

Future research also needs to ascertain whether discrepancies of non-technical skills are linked to greater risk of adverse events or latent failures in the healthcare system. Establishing this link would support the use of complex team interventions that encompass the whole care process and support systems. Team interventions for improvement should support the dialogue between team members to create a shared mental model, and focus on team, process and system problems [1, 3–5, 7, 9, 12, 14, 17, 20, 29]. Additionally, research on patient safety should combine non-technical and technical skills. As surgical procedures are complex and error prone, mastering non-technical skills is as important as mastering technical skills in order to perform safe surgery [2, 30]. Although so far research shows very little quantitative evidence on positive results of team interventions on team effectiveness, there is emerging

evidence that team interventions that include technical as well as non-technical skills might lead to better outcomes [20, 31]. If teams strengthen their ability to reflect collectively on problems encountered, it will improve learning from experience and create a shared understanding between team members. These are all necessary preconditions to prevent adverse events [17]. Interventions like a pre-operative briefing and post-operative debriefing based on dialogue, discussing the surgery before and after performing the procedure with the whole team might be successful and improve team performance and patient outcomes [3, 7, 12, 14, 20]. Interventions to improve communication and teamwork should thus include multiple objectives related to the team and to the different organizational levels in the healthcare system.

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References

1. Yule S, Flin R, Paterson-Brown S *et al.* Non-technical skills for surgeons in the operating room: a review of the literature. *Surgery* 2006;**139**:140–9.
2. Mazzocco K, Petitti DB, Fong KT *et al.* Surgical team behaviors and patient outcomes. *Am J Surg* 2009;**197**:678–85.
3. Makary MA, Sexton JB, Freischlag JA *et al.* Operating room teamwork among physicians and nurses: teamwork in the eye of the beholder. *J Am Coll Surg* 2006;**202**:746–52.
4. Cuschieri A. Nature of human error. Implications for surgical practice. *Ann Surg* 2006;**244**:642–8.
5. Helmreich RL. On error management: lessons from aviation. *BMJ* 2000;**320**:781–5.
6. Mishra A, Catchpole K, Dale T *et al.* The influence of non-technical performance on technical outcome in laparoscopic cholecystectomy. *Surg Endosc* 2008;**22**:68–73.
7. Sexton JB, Makary MA, Tersigni AR *et al.* Teamwork in the operating room: frontline perspectives among hospitals and operating room personnel. *Anesthesiology* 2006;**105**:877–84.
8. Flin R, Yule S, McKenzie L *et al.* Attitudes to teamwork and safety in the operating theatre. *Surgeon* 2006;**4**:145–51.
9. Leonard M, Graham S, Bonacum D. The human factor: the critical importance of effective teamwork and communication in providing safe care. *Qual Saf Health Care* 2004;**13**(Suppl. 1): i85–90.

10. Flin R, Maran N. Identifying and training non-technical skills for teams in acute medicine. *Qual Saf Health Care* 2004;**13**(Suppl. 1):i80–4.
11. Flin R, Fletcher G, McGeorge P et al. Anaesthetists' attitudes to teamwork and safety. *Anaesthesia* 2003;**58**:233–42.
12. Makary MA, Mukherjee A, Sexton JB et al. Operating room briefings and wrong-site surgery. *J Am Coll Surg* 2007;**204**:236–43.
13. Undre S, Sevdalis N, Healey AN et al. Teamwork in the operating theatre: cohesion or confusion? *J Eval Clin Pract* 2006;**12**:182–9.
14. Lingard L, Regehr G, Orser B et al. Evaluation of a preoperative checklist and team briefing among surgeons, nurses, and anesthesiologists to reduce failures in communication. *Arch Surg* 2008;**143**:12–7; Discussion 8.
15. University of Aberdeen. *Non-technical Skills for Surgeons (NOTSS). System Handbook v1.2*. Aberdeen: University of Aberdeen, 2006, 17.
16. Mills P, Neily J, Dunn E. Teamwork and communication in surgical teams: implications for patient safety. *J Am Coll Surg* 2008;**206**:107–12.
17. Edmondson AC. Learning from failure in health care: frequent opportunities, pervasive barriers. *Qual Saf Health Care* 2004;**13**(Suppl. 2):ii3–9.
18. Nestel D, Kidd J. Nurses' perceptions and experiences of communication in the operating theatre: a focus group interview. *BMC Nurs* 2006;**5**:1.
19. Thomas EJ, Sexton JB, Helmreich RL. Discrepant attitudes about teamwork among critical care nurses and physicians. *Crit Care Med* 2003;**31**:956–9.
20. Haynes AB, Weiser TG, Berry WR et al. A surgical safety checklist to reduce morbidity and mortality in a global population. *N Engl J Med* 2009;**360**:491–9.
21. Merriam Webster's Medical dictionary, 2007.
22. University of Aberdeen. *Framework for Observing and Rating Anaesthetists' Non-Technical Skills. Anaesthetists' Non-Technical Skills (ANTS). System Handbook v1.0*. Aberdeen: University of Aberdeen, Industrial Psychology Research Centre & Scottish Clinical Simulation Centre, 2006, 18.
23. Healey AN, Undre S, Vincent CA. Developing observational measures of performance in surgical teams. *Qual Saf Health Care* 2004;**13**(Suppl. 1):i33–40.
24. Wu AW. Medical error: the second victim. The doctor who makes the mistake needs help too. *BMJ* 2000;**320**:726–7.
25. Sexton JB, Thomas EJ, Helmreich RL. Error, stress, and teamwork in medicine and aviation: cross sectional surveys. *BMJ* 2000;**320**:745–9.
26. Carroll JS, Edmondson AC. Leading organisational learning in health care. *Qual Saf Health Care* 2002;**11**:51–6.
27. Pons H, Lingsma H, Bal R. De ranglijst is een slechte raadgever. *Medisch Contact* 2009;**64**:1969–72.
28. Kohn LT, Corrigan JM, Donaldson MS. *To Err is Human: Building a Safer Health System*. Washington DC: National Academy Press, 2000.
29. World Health Organization. *WHO Draft Guidelines for Adverse Event Reporting and Learning Systems*, eds. World Health Organization, 2005, 1–80. www.who.int/entity/patientsafety/events/05/Reporting_Guidelines.pdf
30. Institute of Medicine. *Crossing the Quality Chasm: A New Health System for the 21st Century*. Washington, DC: National Academic Press, 2001.
31. Buljac-Samardzic M, Dekker-van Doorn CM, van Wijngaarden JDH et al. Interventions to improve team effectiveness: a systematic review. *Health Policy*, 2009;**94**:183–95.