ORIGINAL ARTICLE

A Novel Method for Reproducibly Measuring the Effects of Interventions to Improve Emotional Climate, Indices of Team Skills and Communication, and Threat to Patient Outcome in a High-Volume Thoracic Surgery Center

Michael Nurok, MD, PhD; Stuart Lipsitz, ScD; Paul Satwicz, MD; Andrea Kelly, RN, JD; Allan Frankel, MD

Objective: To create and test a reproducible method for measuring emotional climate, surgical team skills, and threats to patient outcome by conducting an observational study to assess the impact of a surgical team skills and communication improvement intervention on these measurements.

Design: Observational study.

Setting: Operating rooms in a high-volume thoracic surgery center from September 5, 2007, through June 30, 2008.

Participants: Thoracic surgery operating room teams.

Interventions: Two 90-minute team skills training sessions focused on findings from a standardized safety culture survey administered to all participants and highlighting positive and problematic aspects of team skills, communication, and leadership. The sessions created an interactive forum to educate team members on the importance of communication and to role-play optimal interactive and communication strategies.

Main Outcome Measures: Calculated indices of emotional climate, team skills, and threat to patient outcome.

Results: The calculated communication and team skills score improved from the preintervention to postintervention periods, but the improvement extinguished during the 3 months after the intervention ($P<.001$). The calculated threat-to-outcome score improved following the team training intervention and remained statistically improved 3 months later ($P<.001$).

Conclusions: Using a new method for measuring emotional climate, teamwork, and threats to patient outcome, we were able to determine that a teamwork training intervention can improve a calculated score of team skills and communication and decrease a calculated score of threats to patient outcome. However, the effect is only durable for threats to patient outcome.

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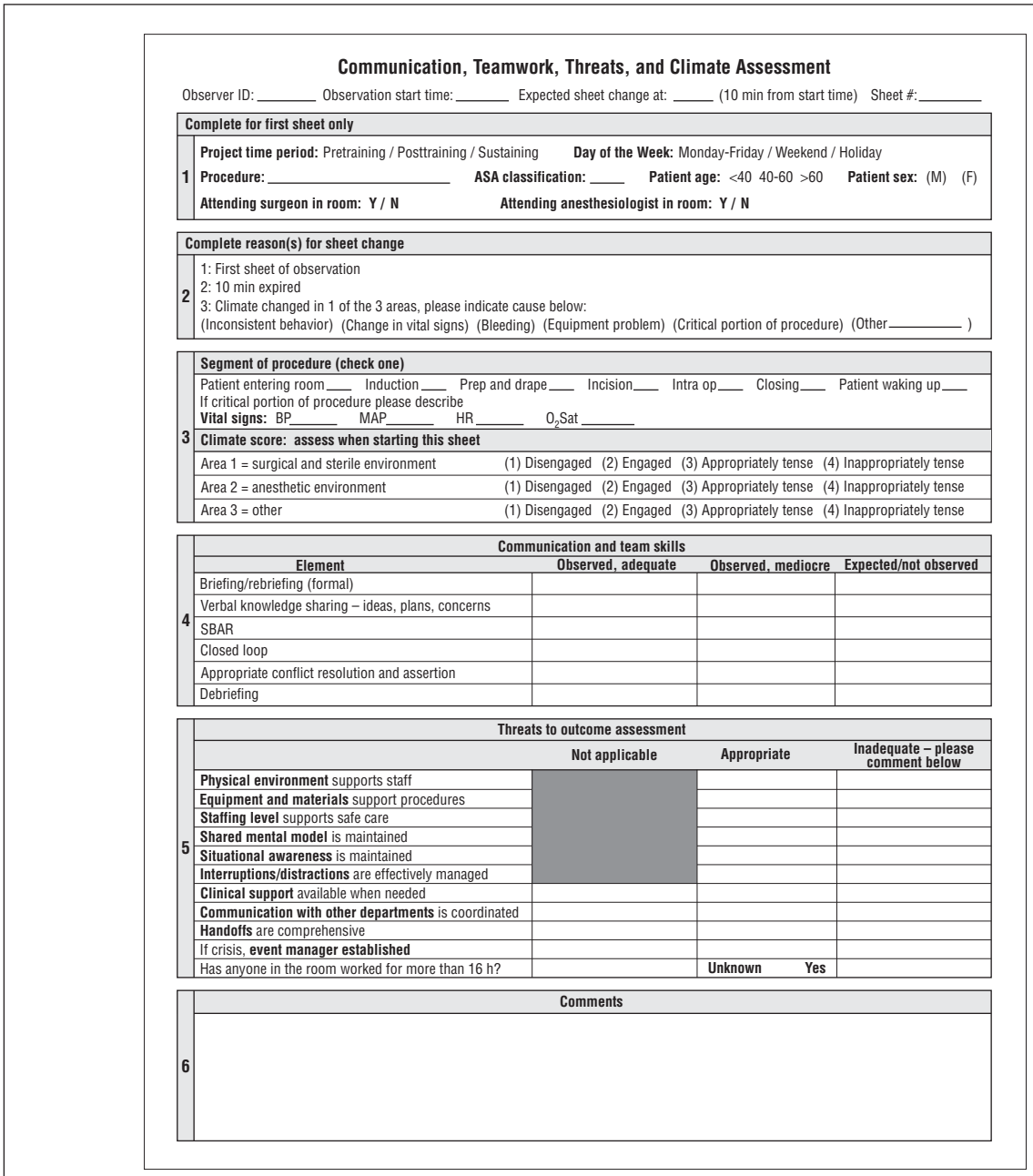
Author Affiliations: Divisions of Thoracic Anesthesia and Surgical Critical Care (Dr Nurok) and Division of General Internal Medicine and Center for Surgery and Public Health (Dr Lipsitz), Brigham and Women's Hospital, and School of Public Health (Dr Lipsitz), Harvard Medical School, and Patient Safety Program, Partners Healthcare (Ms Kelly and Dr Frankel), Boston, Massachusetts; and Department of Anesthesiology, Newton Wellesley Hospital, Newton Lower Falls, Massachusetts (Dr Satwicz). Dr Frankel is now with Pascal Metrics Inc, Washington, DC; Ms Kelly is now with Perioperative Services, Boston Medical Center.

STRATEGIES FOR IMPROVING team skills and communication are thought to increase safety in highly reliable organizations, including operating room teams. Previous work suggests that the safety climate may affect the ability of high-performance teams to function optimally.[1,2] Like the safety climate, the "emotional climate" of work may have consequences for team performance. There are no objective data using reproducible methods to support this assertion.

Thoracic surgical procedures are complex and usually undertaken by a dedicated group of anesthesiologists, nurses, and surgeons. Thoracic operations cause extreme abnormalities in ventilation and perfusion relationships, and these predictable perturbations provide an opportunity to study team behavior in the setting of stressful and changing patient conditions.

See Invited Critique at end of article

We created a reproducible, objective method of measuring emotional climate, indices of communication and team skills, and threats to patient outcome. In addition, we conducted an observational study to assess the impact of a defined team skills and communication improvement intervention on these measurements in a pod of thoracic surgery operating rooms in a high-volume thoracic surgery center.



Communication, Teamwork, Threats, and Climate Assessment

Observer ID: _____ Observation start time: _____ Expected sheet change at: _____ (10 min from start time) Sheet #: _____

Complete for first sheet only

1
Project time period: Pretraining / Posttraining / Sustaining **Day of the Week:** Monday-Friday / Weekend / Holiday
Procedure: _____ **ASA classification:** _____ **Patient age:** <40 40-60 >60 **Patient sex:** (M) (F)
Attending surgeon in room: Y / N **Attending anesthesiologist in room: Y / N**

Complete reason(s) for sheet change

2
1: First sheet of observation
2: 10 min expired
3: Climate changed in 1 of the 3 areas, please indicate cause below:
(Inconsistent behavior) (Change in vital signs) (Bleeding) (Equipment problem) (Critical portion of procedure) (Other_____)

3
Segment of procedure (check one)
Patient entering room___ Induction___ Prep and drape___ Incision___ Intra op___ Closing___ Patient waking up___
If critical portion of procedure please describe
Vital signs: BP_____ MAP_____ HR _____ O_2Sat _____

Climate score: assess when starting this sheet

Area 1 = surgical and sterile environment	(1) Disengaged (2) Engaged (3) Appropriately tense (4) Inappropriately tense
Area 2 = anesthetic environment	(1) Disengaged (2) Engaged (3) Appropriately tense (4) Inappropriately tense
Area 3 = other	(1) Disengaged (2) Engaged (3) Appropriately tense (4) Inappropriately tense

4
Communication and team skills

Element	Observed, adequate	Observed, mediocre	Expected/not observed
Briefing/rebriefing (formal)			
Verbal knowledge sharing – ideas, plans, concerns			
SBAR			
Closed loop			
Appropriate conflict resolution and assertion			
Debriefing			

5
Threats to outcome assessment

	Not applicable	Appropriate	Inadequate – please comment below
Physical environment supports staff			
Equipment and materials support procedures			
Staffing level supports safe care			
Shared mental model is maintained			
Situational awareness is maintained			
Interruptions/distractions are effectively managed			
Clinical support available when needed			
Communication with other departments is coordinated			
Handoffs are comprehensive			
If crisis, **event manager established**			
Has anyone in the room worked for more than 16 h?		**Unknown** **Yes**	

6
Comments

Figure 1. Front of data sheet. ASA indicates American Society of Anesthesiologists; BP, blood pressure; HR, heart rate; Intra op, intraoperative; MAP, mean arterial pressure; O_2Sat, oxygen saturation level; and SBAR, situation, background, assessment, and recommendation.

Our intervention consisted of two 90-minute team skills training sessions focused on findings from a standardized safety culture survey administered to all participants and highlighting positive and problematic aspects of team skills, communication, and leadership.[3] The sessions created an interactive forum to educate team members on the importance of communication and to role-play interactive and communication strategies designed to optimize safety. This format has been used by patient safety specialists previously, but the effect of the intervention on emotional climate, behavior, and threat to outcomes was unknown and, to our knowledge, had never been reproducibly measured. However, team member degree of engagement and levels of team tension are known to affect operational function in a variety of settings from nuclear power to aviation.[4] Our hypothesis was that improved team skills, communication, and emotional climate would correlate with fewer threats to patient outcome.

METHODS

SITE

This study was conducted in 4 thoracic surgery operating rooms at the Brigham and Women's Hospital, Harvard Medical School, from September 5, 2007, through June 30, 2008.

ENROLLMENT AND CONSENT

Approval for the study was obtained from the Partners Healthcare Human Research Committee. Information sessions were held to update thoracic surgery anesthesiologists, nurses, and surgeons concerning the study objectives, risks, and benefits. The study was authorized to begin after 70% of eligible nursing staff, surgical technicians, attending thoracic surgeons, and anesthesiologists voluntarily opted in by completing a deidentified patient safety climate survey during organized information sessions. From that point forward, anyone not wishing to participate had the ability to opt out by informing the principal investigator (M.N.). No one opted out.

PRIMARY AND SECONDARY AIMS

The primary aim of this study was to create a reproducible method for measuring emotional climate, communication and team skills, and threats to patient outcome. The secondary aim was to evaluate the impact of a standardized intervention aimed at improving team skills and communication.

STUDY PROCEDURES AND RANDOMIZATION

This study was developed in consultation with a steering group consisting of 2 thoracic surgeons, 2 anesthesiologists, 2 nurses, and 3 safety specialists. Observers included 2 anesthesiologists (M.N. and P.S.), 2 nurses (including A.K.), and 3 safety specialists (including A.F.). Two surgeons were approved investigators and observers but did not participate in observations because of scheduling conflicts. A standardized observation form was used, with definitions of the specific emotional climate and behaviors printed on the back of each form (**Figure 1** and **Figure 2**). Observations focused on behavioral interactions in 3 environments of the operating room: the surgical field including surgeons and scrub nurses, the anesthesia environment, and the circulating environment.

Before initiation of the project, pilot observations were performed to desensitize subjects to being observed and to develop and test the operability of behavioral definitions to be used in the study. Definitions were refined in consultation with observers and the project steering group. Analyzed communications and team skills were refined from a standardized observational template that the patient safety group had used for previous studies. Definitions of threats to outcome were based on information from a group at Kaiser Permanente involved in an ongoing study analyzing threats to outcome.[5] Once definitions were finalized, 30 paired observations of thoracic surgical procedures were performed to ascertain whether interrater reliability and agreement were acceptable. One new observer (P.S.) joined the team midway through the study, and he was required to perform paired observations until his interrater reliability matched that of the core group.

A randomization list of operating rooms was used to decide where to observe. After randomization, a single observer entered the room and stood adjacent to the doorway in a position where he or she could observe the operating field, anesthesia environment, and circulating environment. Patient vital signs present on entry into the operating room were recorded from the overhead display along with other demographic data. After this, observers assessed the emotional climate as disengaged, engaged, appropriately tense, or inappropriately tense in each of the 3 environments.

Observers then rated 6 behavioral team skills elements across all 3 environments as adequate, mediocre, or expected but not observed. Each instance of the behavior was recorded as a tick mark. Observation periods lasted 10 minutes. At the end of an observation period, observers identified any threats to outcome seen during the previous 10 minutes. These included adequacy of staffing, physical environment supportive of staff, readiness of equipment, availability of relevant information, interruptions, supervision, fatigue, communication with other services, and handoffs.

Definitions of behavior markers for assessment

Climate score:
Disengaged: staff in room seem bored, inattentive, distracted
Engaged: staff seem alert, interested, and engaged; appropriate for patient's acuity
Appropriately tense: staff seem tense but it is appropriate for what is happening in the case
Inappropriately tense: staff seem inappropriately anxious or tense

Briefing/rebriefing (formal):
Goals: (must accomplish both for "expected and observed")
1. Create a shared mental model by discussing pertinent clinical information and an anticipated plan of action
2. Set the tone for collaboration and information sharing by creating an atmosphere of safety to speak up

Rebriefing (a shortened briefing that occurs if there is a significant change in team members or significant change in the procedure)

SBAR
Situation
Background
Assessment
Recommendation

Closed loop communication
Speaking back at teammate's request
Confirms that the request was heard correctly and is being acted on
Includes any verbal response, including instrument requests met with a verbal response
Helps the team to maintain a shared mental model

Debriefing
Expected during closed segment of case – for scoring purposes only score adequate or mediocre if debriefing occurs during a different segment of case
Team members are informally assembled after a procedure or activity
Discuss relevant information for the purpose
Identifying:
What went well?
What could have been done differently?
What was learned?

Verbal knowledge sharing: ideas, plans, concerns
Any verbal knowledge sharing that is audible to the team or work group and helps to maintain situational awareness and a shared mental model; may include teaching

Appropriate conflict resolution and assertion
Appropriate assertion of ideas or concerns
Appropriate negotiation of issues
Appropriate escalation of concerns, including requesting external consultation

Figure 2. Back of data sheet.

Data sheets were changed at the end of every 10-minute observation period or if the emotional climate changed and remained changed for 1 minute. A new set of patient vital signs was obtained within the first minute of using a new data sheet. All deidentified data were entered into the project database.

Data were collected in the following 3 periods: preintervention (11 consecutive weeks after the beginning of the study), postintervention (12 consecutive weeks after a training intervention), and a sustaining period. The intervention consisted of two 90-minute multidisciplinary team skills training sessions for surgeons, anesthesiologists, technicians, and nurses, during which a team training expert (A.F.) created an interactive forum to educate team members on the importance of communication and to role-play interactive and communication strategies designed to optimize safety. The session included a discussion of findings from a standardized safety culture survey administered to all participants and highlighting positive and problematic aspects of team skills, communication, and leadership.[3] This standardized safety culture survey was administered before the implementation of the study and again at the study completion.

Scoring of different elements was as follows. Patient vital signs were categorized as abnormal if the mean arterial pressure was less than 55 mm Hg, the heart rate was more than 100 or less than 49 beats/min, or the oxygen saturation level was less than 88%. Communication and team skills were scored for

Table 1. Interrater Reliability of Emotional Climate and Communication and Teamwork Skills During 30 Initial Paired Observations in Pilot Period

Element	κ Coefficient (95% CI)
Climate score	
Surgical and sterile environment	0.99 (0.85-1.00)
Anesthetic environment	0.99 (0.86-1.00)
Circulating environment	0.51 (0.15-0.86)
Team skills	
Briefing/rebriefing	0.71 (0.21-0.96)
Verbal knowledge sharing	0.53 (0.33-0.73)
Structured problem solving (SBAR)	0.77 (0.01-1.00)
Closed loop communication	0.41 (0.05-0.90)
Conflict resolution and assertion	0.86 (0.01-1.00)
Debriefing[a]	. . .

Abbreviations: CI, confidence interval; ellipses, not applicable; SBAR, situation, background, assessment, and recommendation.
[a] No data sheets were scored with this behavior.

Table 2. Test of Agreement of Threat-to-Outcome Assessment During 30 Initial Paired Observations in Pilot Period

Threat-to-Outcome Assessment	Proportion Who Agree	95% Confidence Interval
Physical environment supports staff	1.00	0.86-1.00
Equipment and materials support procedures	0.92	0.73-0.99
Staffing level supports safe care	1.00	0.86-1.00
Shared mental model is maintained	0.92	0.73-0.99
Situational awareness is maintained	0.75	0.53-0.90
Interruptions and distractions are effectively managed	0.96	0.79-1.00
Clinical support available when needed	1.00	0.29-1.00
Communication with other departments is coordinated[a]	. . .	. . .
Handoffs are comprehensive	1.00	0.21-1.00
Event manager established in crises[a]	. . .	. . .

[a] No data for this behavior.

each data sheet by weighting elements that were expected but not observed as 0, mediocre as 0.5, and adequate as 1; a weighted average for each skill was calculated, and these skill scores were then averaged together to calculate communication and team skills scores. A threat-to-outcome score was calculated as the total number of threats marked on each data sheet.

RESULTS

Interrater reliability and agreement for the 30 initial paired observations are reported in **Table 1** and **Table 2**, respectively. The κ coefficients were greater than 0.70 for all but 3 of the communication and team skills observations. Agreement on threats to outcome exceeded 90% with the exception of 1 element for which there was 75% agreement. A total of 305 data sheets (91 preintervention, 165 postintervention, and 49 sustaining) were collected during the study period, representing approximately 50 hours of observation.

There were statistically significant differences in patient age, sex, abnormal vital signs, and whether the attending anesthesiologist was in the room between the pre-

Table 3. Baseline Operating Room Information

	Times Scored, No. (%)[a]			*P* Value
	Preintervention	Postintervention	Sustaining[b]	
Patient age, y				
<40	11 (12.2)	10 (6.3)	16 (33.3)	.01
40-60	33 (36.7)	63 (39.6)	19 (39.6)	
>60	46 (51.1)	86 (54.1)	13 (27.1)	
Patient sex				
Male	50 (56.8)	92 (60.9)	22 (45.8)	.02
Female	38 (43.2)	59 (39.1)	26 (54.2)	
Abnormal vital signs				
Yes	12 (13.5)	16 (9.9)	17 (35.4)	<.001
No	77 (86.5)	146 (90.1)	31 (64.6)	
Attending surgeon in the operating room				
Yes	47 (56.6)	93 (59.6)	24 (50.0)	.49
No	36 (43.4)	63 (40.4)	24 (50.0)	
Attending anesthesiologist in the operating room				
Yes	52 (65.8)	103 (66.5)	21 (43.8)	.02
No	27 (34.2)	52 (33.5)	27 (56.2)	

[a] Data are missing for some variables. There was a total of 91 preintervention observations, 165 postintervention observations, and 49 sustaining observations.
[b] Indicates durability of training effect.

intervention, postintervention, and sustaining observation periods (**Table 3**). There were no statistically significant differences in the presence of the attending surgeon in the room during observations (Table 3). Because of these differences, we calculated values adjusted for these variables and found similar results unless specified. Herein we report the unadjusted values. All patients observed were classified as having American Society of Anesthesiologists scores of 2 or 3.

There was a trend toward the surgical environment being more frequently engaged and less frequently disengaged or appropriately tense from the preintervention to postintervention to sustaining periods, but this did not reach statistical significance ($P=.06$) (**Table 4**).

The communication and team skills score improved from the preintervention period to the postintervention period but then returned to a level not statistically different from the preintervention period (**Table 5**) ($P<.001$). The threat-to-outcome score improved following the team training intervention and remained statistically improved from the preintervention score, although the score indicated a decrease in improvement from the immediate postintervention period (**Table 6**) ($P<.001$).

Not all elements of team behavior improved after the intervention (Table 5). Specifically, the intervention had no effect on the adequacy of observed briefings, debriefings, or structured problem solving. There was a trend toward increased adequacy of verbal knowledge sharing after the intervention, but this did not reach statistical significance.

Not all elements of threats to outcome improved following the intervention (Table 6). Specifically, there was no improvement in the physical environment supporting staff, handoffs being comprehensive, or an event man-

Table 4. Emotional Climate in Surgical, Anesthetic, and Circulating Environments

	Times Scored, No. (%)[a]			*P* Value
	Preintervention	Postintervention	Sustaining[b]	
Surgical environment				
Disengaged	5 (5.6)	8 (5.0)	0	.06
Engaged	77 (85.6)	148 (91.9)	46 (95.8)	
Appropriately tense	8 (8.9)	5 (3.1)	1 (2.1)	
Inappropriately tense	0	0	1 (2.1)	
Anesthetic environment				
Disengaged	1 (1.1)	5 (3.0)	0	.37
Engaged	82 (90.1)	151 (92.1)	47 (97.9)	
Appropriately tense	8 (8.8)	8 (4.9)	1 (2.1)	
Inappropriately tense	0	0	0	
Circulating environment				
Disengaged	3 (3.7)	4 (2.5)	0	.36
Engaged	76 (92.7)	157 (96.3)	46 (95.8)	
Appropriately tense	3 (3.7)	2 (1.2)	2 (4.2)	
Inappropriately tense	0	0	0	

[a] Data are missing for some variables. Because of rounding, percentages may not total 100. There was a total of 91 preintervention observations, 165 postintervention observations, and 49 sustaining observations.
[b] Indicates durability of training effect.

ager being established in crises. There was a trend toward improved staffing levels supporting safe care.

COMMENT

PRINCIPAL FINDINGS

To our knowledge, this is the first study to develop, define, and use reproducible objective methods to measure emotional climate, team skills and communication, and threats to patient outcome. We demonstrated that an intervention focused on teamwork and communication improved a calculated score of team skills and communication and decreased a calculated score of threats to patient outcome. The durability of this effect was only observed for the calculated score of threats to patient outcome. In addition, we observed that the intervention was associated with a trend toward a more appropriately engaged surgical environment. This is the first study of which we are aware that has demonstrated a relationship between observational measurements of emotional climate and team skills behaviors known to be manifest in high-reliability organizations and an assessment of a calculated score of threats to patient outcome.

The team skills training intervention improved the team skills and communication score, and then this effect extinguished as the period of training became more remote. The threat-to-outcome score remained statistically improved during the sustaining period of the study but at a lower level, suggesting that this effect may have also extinguished had the study continued longer. These

Table 5. Communication and Team Skills

Item Scored	No. of Data Sheets With ≥1 Tick for Observed Behavior	Mean (SD) Score Weighted for Adequacy of Behavior[a]	*P* Value
Briefing/rebriefing			
Preintervention	29	0.45 (0.43)	.28
Postintervention	11	0.64 (0.38)	
Sustaining[b]	11	0.64 (0.39)	
Verbal knowledge sharing			
Preintervention	88	0.90 (0.17)	.07
Postintervention	153	0.94 (0.13)	
Sustaining[b]	46	0.81 (0.27)	
Structured problem solving (SBAR)			
Preintervention	18	0.51 (0.35)	.29
Postintervention	14	0.70 (0.24)	
Sustaining[b]	13	0.65 (0.32)	
Closed loop			
Preintervention	85	0.78 (0.21)	.01
Postintervention	123	0.72 (0.23)	
Sustaining[b]	39	0.63 (0.27)	
Appropriate conflict resolution			
Preintervention	15	0.80 (0.30)	<.001
Postintervention	68	0.86 (0.21)	
Sustaining[b]	8	0.42 (0.32)	
Debriefing			
Preintervention	5	0.10 (0.22)	.71
Postintervention	3	0.33 (0.58)	
Sustaining[b,c]	0	. . .	
Communication and team skills score[d]			
Preintervention	91	0.77 (0.17)	<.001
Postintervention	156	0.85 (0.14)	
Sustaining[b]	48	0.70 (0.21)	

Abbreviations: ellipses, not applicable; SBAR, situation, background, assessment, and recommendation.
[a] Zero indicates expected but not observed; 0.5, mediocre; and 1, adequate. For example, for 3 ticks for a behavior under mediocre and 2 ticks under expected but not observed, the score is $([3 \times 0.5] + [2 \times 0])/(3 + 2) = 0.3$.
[b] Indicates durability of training effect.
[c] No data sheets were scored with this behavior.
[d] Calculated from the average of the weighted averages for each skill.

data suggest that ongoing team skills training might sustain improvements in communication indices.

We observed a trend toward the surgical environment being classified as more engaged after the team training intervention; however, this did not reach statistical significance. Previous data have shown relationships between emotional environment and a team's ability to perform. Bowles et al[6] demonstrated that perceived stress reported by flight crews in simulated emergencies was lower in high-performance crews than in low- and medium-performance crews. The study suggested that the personality style of the captain affected crew member performance, with captains demonstrating an active, warm, confident, competitive personality commanding the most highly performing crews. Lingard et al[7] demonstrated the negative impact of tension on other operating room team members.

We used threats to outcome as a presumptive surrogate for patient outcome. Other authors have looked di-

Table 6. Threat and Threat-to-Outcome Scores

Item Scored	No. of Data Sheets Scored	Mean (SD) Weighted Score[a]	*P* Value
Physical environment supports staff			
Preintervention	82	0.02 (0.16)	
Postintervention	158	0.02 (0.16)	.98
Sustaining[b]	48	0.02 (0.14)	
Equipment and materials support procedures			
Preintervention	82	0.08 (0.28)	
Postintervention	159	0.00 (0.00)	<.001
Sustaining[b]	48	0.12 (0.33)	
Staffing level supports safe care			
Preintervention	81	0.05 (0.22)	
Postintervention	160	0.01 (0.08)	.09
Sustaining[b]	47	0.02 (0.15)	
Shared mental model is maintained			
Preintervention	77	0.14 (0.35)	
Postintervention	156	0.03 (0.16)	<.001
Sustaining[b]	48	0.17 (0.38)	
Situational awareness is maintained			
Preintervention	78	0.20 (0.41)	
Postintervention	158	0.01 (0.11)	<.001
Sustaining[b]	47	0.02 (0.15)	
Interruptions/distractions are effectively managed			
Preintervention	78	0.12 (0.32)	
Postintervention	162	0.01 (0.08)	<.001
Sustaining[b]	48	0.02 (0.14)	
Clinical support available when needed			
Preintervention	18	0.11 (0.32)	
Postintervention	1	0.00 (. . .)	.87
Sustaining[b,c]	0	0.00 (. . .)	
Communication with other departments is coordinated			
Preintervention	17	0.06 (0.24)	
Postintervention	13	0.00 (. . .)	.43
Sustaining[b,c]	0	0.00 (. . .)	
Handoffs are comprehensive			
Preintervention	14	0.21 (0.43)	
Postintervention	13	0.00 (0.00)	.20
Sustaining[b]	1	0.00 (. . .)	
Event manager established in crises			
Preintervention	9	0.11 (0.33)	
Postintervention	1	0.00 (. . .)	.11
Sustaining[b,c]	0	0.00 (. . .)	
Threat-to-outcome score[d]			
Preintervention	83	0.68 (1.16)	
Postintervention	162	0.08 (0.31)	<.001
Sustaining[b]	48	0.38 (0.64)	

Abbreviation: ellipses, not applicable.

[a] Threat scores were weighted with a 1 for inappropriate management and 0 for appropriate management and averaged by the number of threats scored. For example, if there were 2 responses checked inappropriate and 6 responses checked appropriate, the score is $([2\times1]+[6\times0])/(2+6)=0.25$.

[b] Indicates durability of training effect.

[c] No data sheets were scored with this behavior.

[d] Calculated from total number of weighted threats marked on each data sheet.

rectly at the relationship between operating room behavior and outcome. Carthey et al[8] demonstrated that in a group of 16 pediatric cardiac surgeons, those with the best outcomes were more likely to demonstrate behavioral markers of excellence seen commonly in high-reliability organizations. Mazzocco et al[5] demonstrated that less frequent briefings during handoff periods and less frequent information sharing during intraoperative and handoff periods increased the odds ratio for complication or death.

Another observational study by Christian et al[9] in general surgery operating rooms demonstrated that communication breakdown had a negative influence on patient safety. The same group more recently showed that communication breakdown was a frequent feature of malpractice claims.[10] Our data are consistent with this body of literature.

LIMITATIONS

This study has multiple limitations. Definitions of emotional climate, communication and teamwork skills, threats to outcome, communication and teamwork skills score, and threat-to-outcome score were developed during this study, and the adequacy of these definitions has not been tested. The extent to which emotional climate or threats to patient outcome are directly observable has not been tested. Although surgeons did help refine the observation template during the pilot portion of the study in which they participated, there were no surgeon-observers during the formal portion of this investigation. Surgeons may have assessed the emotional climate and behaviors differently to nonsurgeon observers. We cannot exclude that individual behavior improved when observers were in the operating room. The study took place from the beginning to the end of an academic year, and we cannot exclude that observed improvements resulted from an increase in team skills by trainees. The indices of interrater reliability were not identical, and this may have affected our results. Although interrater reliability was assessed before the observations, it was never rechecked, and it is possible that during the course of the study interobserver variation became greater. Some of the behaviors taught during the team training were observed at a lower frequency, albeit often with greater adequacy when they did occur. This finding deserves further research to determine which behaviors in particular, and whether the adequacy or frequency of a behavior specifically, is most important for improving team performance and decreasing threats to patient outcome.

IMPLICATIONS

This study uses a new method for measuring emotional climate, indices of teamwork, and threats to patient outcome. A teamwork training intervention improved calculated indices of team skills and communication and decreased calculated indices of threats to outcome; however, the effect was only durable for calculated indices of threats to patient outcome. These data also suggest that team behaviors extinguish over time unless appropriately supported; this might include continuous highlighting during department meetings, open support by leadership, practice, role-play, and simulation. These and other methods to improve team skills and decrease threats to outcome

should be prospectively tested using the methods described in the present study.

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Correspondence: Michael Nurok, MD, PhD, Divisions of Thoracic Anesthesia and Surgical Critical Care, Brigham and Women's Hospital, 75 Francis St, Boston, MA 02115 (mnurok@partners.org).
Author Contributions: *Study concept and design:* Nurok, Lipsitz, Kelly, and Frankel. *Acquisition of data:* Nurok, Satwicz, Kelly, and Frankel. *Analysis and interpretation of data:* Nurok, Lipsitz, Satwicz, and Frankel. *Drafting of the manuscript:* Nurok, Kelly, and Frankel. *Critical revision of the manuscript for important intellectual content*: Nurok, Lipsitz, Satwicz, and Frankel. *Statistical analysis:* Lipsitz. *Obtained funding:* Nurok and Frankel. *Administrative, technical, and material support:* Nurok, Lipsitz, Satwicz, and Kelly. *Study supervision:* Nurok, Kelly, and Frankel.
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REFERENCES

1. Singer SJ, Falwell A, Gaba DM, Baker LC. Patient safety climate in US hospitals: variation by management level. *Med Care.* 2008;46(11):1149-1156.
2. Singer SJ, Gaba DM, Falwell A, Lin S, Hayes J, Baker L. Patient safety climate in 92 US hospitals: differences by work area and discipline. *Med Care.* 2009;47(1):23-31.
3. Sexton JB, Helmreich RL, Neilands TB, et al. The Safety Attitudes Questionnaire: psychometric properties, benchmarking data, and emerging research. *BMC Health Serv Res.* 2006;6:44. doi:10.1186/1472-6963-6-44.
4. Klein G. *Sources of Power: How People Make Decisions.* Cambridge, MA: MIT Press; 1998.
5. Mazzocco K, Petitti DB, Fong KT, et al. Surgical team behaviors and patient outcomes. *Am J Surg.* 2009;197(5):678-685.
6. Bowles S, Ursin H, Picano J. Aircrew perceived stress: examining crew performance, crew position and captain's personality. *Aviat Space Environ Med.* 2000;71(11):1093-1097.
7. Lingard L, Reznick R, Espin S, Regehr G, DeVito I. Team communication in the operating room: talk patterns, sites of tension, and implications for novices. *Acad Med.* 2002;77(3):232-237.
8. Carthey J, De Leval MR, Wright DJ, Farewell VT, Reason JT. Behavioural markers of surgical excellence. *Saf Sci.* 2003;41(5):409-425. doi:10.1016/S0925-7535(01)00076-5.
9. Christian CK, Gustafson ML, Roth EM, et al. A prospective study of patient safety in the operating room. *Surgery.* 2006;139(2):159-173.
10. Greenberg CC, Regenbogen SE, Studdert DM, et al. Patterns of communication breakdowns resulting in injury to surgical patients. *J Am Coll Surg.* 2007;204(4):533-540.

INVITED CRITIQUE

Patient Safety Is Evolving

Patient safety is evolving—from a social movement rich in theory but short on data to a new science grounded in objective methods and evidence. This study by Nurok et al is a step in this evolution. The aim was to create a reproducible method for measuring emotional climate, communication and team skills, and threats to patient outcome. The study is based on the hypothesis that improved team skills, communication, and emotional climate would correlate with fewer threats to patient outcomes.

The study has several methodologic concerns. Nurok et al generated observational measures in 3 categories: (1) threats to outcome, (2) communication and team skills, and (3) emotional climate. Some of the measures in the category of threats to outcome assess factors (physical environment, equipment and materials, and staffing levels) usually determined at higher organizational levels that may not respond to frontline, team-level interventions. Certain measures bundled as threats to outcome are like other measures bundled as communications and team skills. It would be helpful to understand more about the authors' reasoning regarding category assignments. Emotional climate is assessed by a single measure that may not adequately describe nuanced differences in team context. Because measures are collected only if certain events occur during the observations, composite category scores calculated across measures may not weigh each measure appropriately, and this could influence results. Interrater reliability was variable for key measures, even among the small observer group that worked together to develop the study. Despite these concerns, this study advances understanding of assessing and improving teamwork in health care.

The study found that benefits of teamwork training extinguished after several months. This raises an interesting question: Is there a better way to improve teamwork other than by training? My own understanding, increasingly, is that teamwork is structural and emerges from optimum preconditions rather than training.

Paul N. Uhlig, MD, MPA

Author Affiliation: Central Plains Cardiothoracic Surgery, Wichita, Kansas.
Correspondence: Dr Uhlig, Central Plains Cardiothoracic Surgery, 1990 N 143rd St E, Wichita, KS 67230 (paul.uhlig@centralplainsheart.com).
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