Barriers and Facilitators in Implementing the Safety Climate Thermometer: A New Tool for Surgical Teams

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OBJECTIVE: To explore barriers and facilitators in implementing the Safety Climate Thermometer (SCT), a new tool designed to support team-level safety culture improvement in surgical settings. The SCT acts through visual insights into safety culture themes, acting as a conversation starter, and interdisciplinary team meetings about this topic. It aims to facilitate daily practice changes. The SCT has previously been developed using user-centered design methods, which consisted of a scoping literature review and international survey.

DESIGN: A qualitative implementation study using semi-structured interviews and observational data, guided by the implementation outcomes framework.

SETTING: Three surgical teams from Dutch hospitals of varying size participated between 2021 and 2023 and used the SCT's visual input and interdisciplinary team meeting structure for 7 months.

PARTICIPANTS: Seventeen healthcare professionals, including nurses, surgeons, and managers, took part in the SCT process and subsequent interviews.

RESULTS: The SCT facilitated an anonymous, online assessment followed by structured interprofessional discussions and goal-setting for safety improvement. Participants reported high usability and acceptability due to the tool's intuitive design and anonymity. The SCT was adaptable to different surgical contexts, though smaller teams with motivated champions and in-person facilitation appeared most suitable. Key barriers included high turnover and work pressure, competing priorities, lack of trust, and survey fatigue. Facilitators include in-person external facilitation and "protected time." Reported positive effects included strengthened team cohesion and a greater sense of being heard.

CONCLUSIONS: The SCT is a practice-oriented, user-friendly tool for improving safety culture through team-based reflection and dialogue. Future use should prioritize exploration of contextual factors. (J Surg Ed 83:103909. © 2026 The Author(s). Published by Elsevier Inc. on behalf of Association of Program Directors in Surgery. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/))

KEY WORDS: teams, teamwork, safety culture, quality improvement, survey

INTRODUCTION

Patient safety has significantly improved over the past 2 decades. Technological innovation, standardization of procedures, and advances in perioperative care have resulted in fewer surgical complications. Analysis of healthcare incidents in the Netherlands shows that

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avoidable harm numbers are not declining any further over the past years. Unfortunately, the incidence of healthcare-related harm has risen significantly from 9,9% to 14,6% nationally. Human factors (a term commonly used for human abilities and behaviors) were reported as the main cause. This included miscommunication, suboptimal collaboration between nurses and doctors, and deviations from protocol.[1] An additional national report from 2022 recommends the interprofessional team discussions to reduce avoidable harm.[2]

Moreover, human factors have a significant impact on safety and are commonly referred to as *safety culture.* Safety culture refers to the shared values, attitudes, and behaviors that shape how healthcare professionals perceive and act upon safety in daily practice.[3] Examples of these team behaviors that contribute to safety culture include teamwork and communication. Multiple studies indicate how safety culture affects complications, medication errors, patient satisfaction and length of stay, but also staff turnover, burnout, and job satisfaction among healthcare professionals.[4-8] However, there is no golden standard in Dutch healthcare for exploring nor improving safety culture. Nor is there a widely accepted standard format for multidisciplinary team meetings.

While several validated tools exist to *measure* safety culture, like the Safety Attitudes Questionnaire and Hospital Survey on Patient Safety Culture, their practical use is not integrated with team discussion nor does it entail team-focused improvement like the intensive TeamSTEPPS program.[9-11] Moreover, the true measurement of safety climate is complicated by the many contextual factors.[12] Therefore, we argue for a shift from measurement of safety culture to team-focused strategies for improvement. In addition, conventional surveys are often lengthy and were not designed user-centered while the importance of the latter was recently emphasized by Benishek et al.[13] As a result, these traditional measurement tools do not aid the timely translation of input and/or team dialogue into tangible improvements, reducing their impact and frequently failing to engage healthcare professionals.

The need for a quick-to-use, adaptive, and user-friendly tool was voiced by the Dutch Surgical Society. They wished for a tool that provides surgical teams with guidance to stimulate and structure team communication about safety culture and facilitates bottom-up improvement initiatives. To address this need, our research group designed the *Safety Climate Thermometer* (SCT), a brief, dialogue-oriented tool for surgical teams.[14] The SCT aims to go beyond static measurement by directly prompting interprofessional reflection, team discussion, and goal-setting on safety issues. By functioning as a catalyst for conversation, it is expected to facilitate a more dynamic and team-owned approach to safety improvement.

However, the success of such a tool depends not only on its design but also on its work floor performance. Implementation in healthcare is often challenged by contextual factors such as workload, leadership support, organizational culture, and resource availability. Understanding these barriers and facilitators is critical for determining whether and how an innovation can be sustainably integrated into daily practice. To date, little is known about how dialogue-based tools, such as the SCT, are used by surgical teams.

The present study reports on the first implementation of the SCT in 3 surgical teams across diverse hospital settings in the Netherlands. The study had 2 main aims: (1) to explore how surgical teams used the SCT to generate dialogue and improvement initiatives, and (2) to identify barriers and facilitators influencing its implementation. In doing so, we evaluate the acceptability and usability of the SCT and examine its adaptability across different teams. Insights gained from this pilot will inform recommendations for future use and contribute to the ongoing search for effective, practice-oriented, user-friendly approaches to strengthening safety culture in surgical teams.

METHODS

Study Design and Outcomes

This study was designed as a pilot implementation study, taking the form of immersive (naturalistic) action research in which surgical teams were actively engaged in the Safety Climate Thermometer tool in their own context. The approach reflects elements of participatory design, emphasizing responsiveness to local conditions during implementation and building on our previous experiences.[15,16] Start of the implementation (marked by start of online SCT input) followed a sequential approach to enable refinement of contents and design. In this immersive study, context is expected to be of great influence on implementation outcomes. Three surgical teams from Dutch hospitals of varying size participated in this multicenter study. Initial contact with local team members is marked by the first dot on each timeline (Fig. 3), followed by an exploratory phase. In these teams, an "expert team" consisting of team meeting (and subsequent interview) participants, was formed. All participants had no prior relationship with the research team and were purposively recruited during the exploratory phase via email, colleagues and face-to-face invitations.

Use of the SCT Tool

The practical use of the SCT involves 2 parts (Fig. 1). First, team members complete 2 anonymous, online survey rounds assessing safety climate (Fig. 2) across 8 themes: (1) Hazard detection and correction, (2) Reporting culture, (3) Communication, (4) Teamwork, (5) Organizational learning, (6) Safety conditions, (7) Leadership, and (8) Occupational wellbeing (Fig. 2, Table 1) using behavior-based descriptions. Adding free-text comments was possible. The authors visualized the results and presented them to expert team participants, who then selected 1 theme for deeper exploration. Team members then provided further input by scoring 8 behavior-based items, e.g. "Our team regularly provides feedback about safety concerns even if the team member has more authority."[14] Finally, an interprofessional team meeting was held to discuss survey results, define actions, and set measurable goals for the next 6 months. The SCT thus combines anonymous input with the benefits of team discussion.

Data Collection, Analysis, Storage, and Ethics

All expert team participants were invited for semi-structured interviews using open-ended questions (Appendix I), conducted by the first author between October 2022 and March 2023. Two participants (1 from Team 1 and 1 from Team 3) did not participate due to pregnancy leave and persistent scheduling issues. In total, 17 participants were interviewed once (in Dutch, for an average 24 minutes), privately via either Microsoft Teams ($n = 12$) or in-person at work ($n = 5$). Field notes were taken of remarkable answers and quotes, to aid research team discussion (see below). Because all participants were contacted for interview planning, data saturation was not applicable here. Interviews were recorded for the purpose of accurate transcription using Trint software. Therefore, accuracy was guaranteed and transcripts were not returned to participants before use. Recordings and transcripts are stored for at least 5 years in compliance with European law (GDPR). All participants provided informed consent and were informed of their participation in doctoral research of the first author. Due to the absence of patient involvement in this study, no ethical committee approval was needed under Dutch law. A deductive thematic analysis with open coding was performed by the first author following Creswell & Poth's data analyses spiral (p255).[17] Deduced themes were organized in Microsoft Excel and mapped onto the implementation outcomes framework by Bowen et al.[18] including acceptability, adaptability, practicality, demand, implementation resources and -ease. Our dataset is available upon reasonable request.[19] All interview quotations were translated from Dutch into English by the authors. Care was taken to preserve meaning and tone, and translations were reviewed for accuracy.

Reflexivity Statement

The first author (female), second author (female) and fourth author (male) are MD's with experience in safety culture research. The third author (male) holds a PhD in occupational health and the fifth author (female) holds an engineering degree, both providing experience with tool design and implementation in healthcare. The last author (female) has a background in nursing and management, and holds a PhD in team learning. All authors were involved in the development and implementation of the Safety Climate Thermometer.[14] While we feel this facilitative role was needed for this pilot implementation, it may have influenced data collection. Given our immersive action research approach, the authors' presence may have influenced team discussions and interview responses. To mitigate analysis bias, data analysis from the semi-structured interviews followed a deductive, framework-based approach. All interviews were coded and analyzed by 1 researcher with in-depth familiarity with the data due to presence during all implementation meetings. To enhance analytic rigor, multiple strategies were employed including deductive coding with constant comparison between teams and participants, reflexive memo-writing throughout analysis, regular discussion of deduced themes within the research team and mapping deduced themes onto the implementation outcomes framework. Preliminary findings were critically discussed within the research team to challenge assumptions and compare interpretations and experiences between researchers, but were not shared with the participants due to their sensitive nature and traceable origin. In addition, triangulation of interview data with our own observations supported the credibility of the findings.

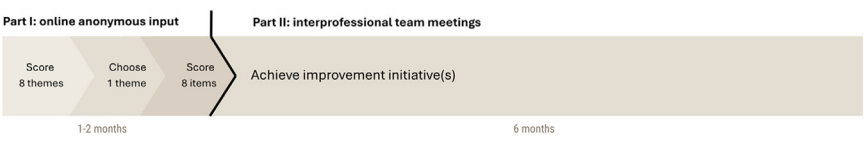

FIGURE 1. Successive steps of the safety climate thermometer methods.

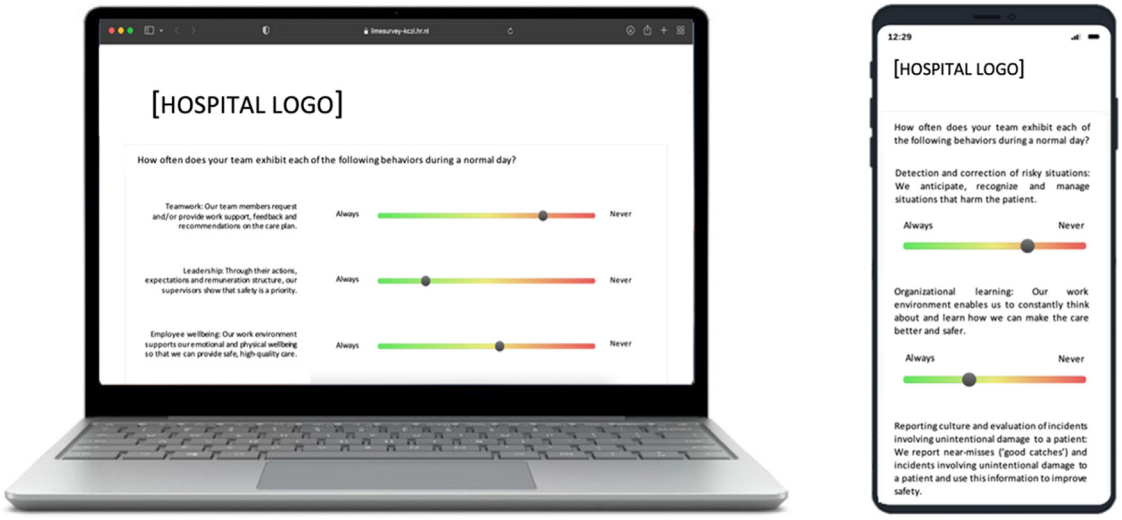

FIGURE 2. Visualization of providing input via the online safety climate thermometer tool. The behavior-based themes and items can be scored by using the gradient sliding bar (red = very poor, green = very good). The red-green gradient was chosen due to its common and intuitive association with positive and negative feelings during the design process.[14]

RESULTS

Participants

Table 1 presents a demographic composition per team. Expert team participants represented a range of professional roles, including nurses, surgeons, hospitalists, managers, physical therapists, and scrub nurses. Gender distribution varied per team, reflecting mostly female nurses and mostly male surgeons and managers. In total, 17 healthcare professionals from the 3 surgical teams participated in the interviews (Table 1).

Safety Climate Thermometer Scores and Local Improvement Initiatives

Table 2 reports Safety Climate Thermometer outcomes per team. In response, the 3 teams started improvement initiatives. In team 1, COVID-19 had negatively impacted nurses' ward overview and cohesion. They reformed the patient clustering model on the surgical ward, and subsequently improved night shift staffing to aid team cohesion. Team 2 shifted rounding-order responsibility to nurses instead of doctors and improved their resident on-boarding program to aid interprofessional collaboration in a high-turnover context. Team 3 aimed to

TABLE 1. Team Composition

	Hospital and Team Size					Expert Team Participants				
	Hospital Size*	**Nr. Beds**	**Staff Size**	**Department**	**Total Team Size**	**Expert Team Size**	**% Female**	**Type of Professional**	**Nr.**	**Inter Viewed**
Team 1	Medium	350	2285	General surgery, orthopedics, and gastroenterology	75	8	100	Nurse	8	7
Team 2	Medium	340	1850	Surgery	75	6	67	Nurse Surgeon Hospitalist Physical therapy	2 2 1 1	2 2 1 1
Team 3	Large	940	6800	OR floor	150	5	20	Manager Scrub nurse Surgeon	2 1 2	2 1 1

*Relative to national average.

TABLE 2. Online Safety Climate Thermometer Outcomes and Improvement Initiative(s) Per Team

	Team 1	Team 2	Team 3
Total team size	75	75	150
Distribution of link to online SCT	Email	Email	QR code posters
Online response	60% (n=44)	65% (n=49)	29% (n=44)
Average completion time	2 minutes		
Part I Theme with highest score (colour gradient transferred to %, 0 = very poor, 100% = very good)	Hazard detection and correction practices (73%)	Reporting culture and adverse event evaluation (68%)	Hazard detection and correction practices (62%)
Part II Theme that was chosen for in-depth review	Occupational wellbeing (52%)	Communication about safe health care (67%)	Occupational wellbeing (40%)
Highest item score	Our team members feel their jobs have a meaningful purpose (81%)	Our team members ask their colleagues for clarification if there is something they do not understand (70%)	N/A
Lowest item score	Our team members' well-being is an organisational priority (54%)	Our team regularly provides feedback to one another about safety concerns even if the team member has more authority (50%)	N/A

optimize OR staff deployment after the COVID-19 pandemic had decreased transparency and sustainability of staffing.

Implementation Timelines

Figure 3 presents the implementation timeline. Teams 1 and 2 completed their improvement initiatives in 8 and 7 months respectively. Which is slightly longer than the proposed 6 months, possibly due to both taking on a subsequent initiative (Table 2). Also note the difference exploration phase duration.

Implementation Framework

We report SCT acceptability (including content clarity and completeness), practicality, demand, implementation resources, and ease, and adaptability across teams. These results can be found in full detail in Table 3.

Acceptability

Participants seemed satisfied with content and design. They valued survey anonymity and felt that interprofessional team meetings added value to the SCT method. Usability was unanimously appreciated for the ease-of-scoring using the color gradient sliding bar, though 1

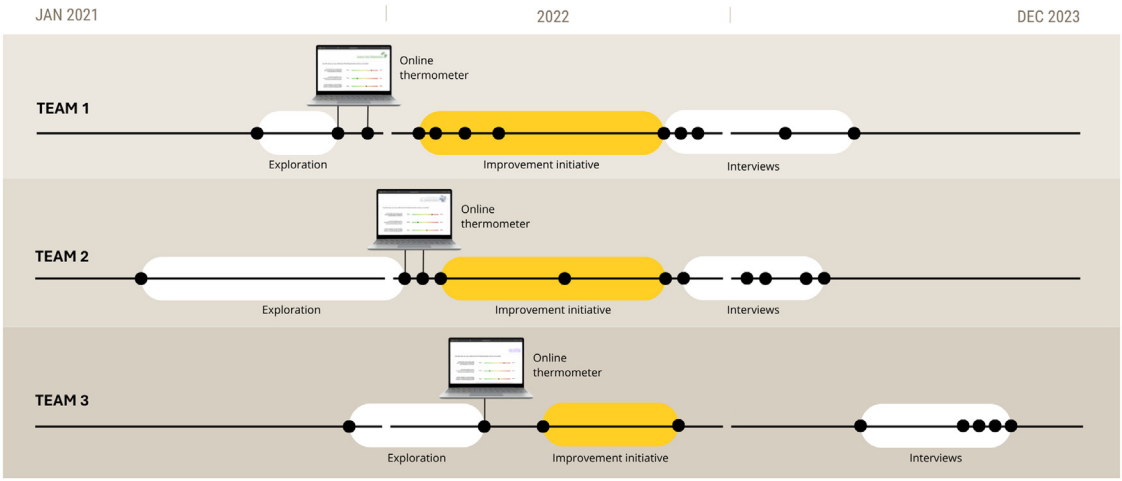

FIGURE 3. Project timeline (2021-2023) for team 1, 2, and 3 showing sequential start by online SCT tool use. Dots indicate expert team meetings. Exploration phases and post-implementation interview phases are marked white, improvement initiatives are marked yellow.

TABLE 3. Factors Influencing Implementation (Framework Adapted from Bowen et al.)[18]

Deductive Theme	Evaluated Aspects	Inductive Themes (Factors That Can Act as Barriers or Facilitators)	Illustrative Quotes P = Participant Number T = Team Number (Non-Correspondent With Table 1)	Suggested Changes to SCT Tool/ Methods for Future Use
Acceptability The extent to which the SCT tool's content and design are judged as satisfactory.	Completeness of themes and items	• Feels complete • Quality of care is not explicitly included • No superfluous/irrelevant themes or statements.	• "Yes, I think they're very nice. What you would want for a hospital––to have all them be optimal." (P 1, T 2) • "I thought the themes were good and substantiated, particularly since they clearly hadn't been drafted overnight." (P 2, T 3) • "When it came in initially, [I thought] yeah, maybe a bit too broad, but is it really? No. . ." (P 2, T 1) • "Uhm, maybe something about quality of care? On the ward." (P 5, T1)	• Consider adding a theme on quality of care to the online SCT tool.
	Clarity of phrasing	• Easily understood • Prompt reflection • Ambiguous	• "It's clear, it's well-structured, I know exactly what is meant." (P 5, T 2) • "I thought these [items] were quite striking questions, you know. Yeah, I thought they were good questions to really go in-depth and flex your brain muscles for a bit." (P 4, T 1) • "A question could sometimes be interpreted in multiple ways." (P 4, T 3)	• Reviewing phrasing of themes and items and rephrasing where necessary to avoid ambiguity.
	Overall impression	• User-friendly (clear, well-structured) • Ability to add free-text comments • Anonymity feels safe	• "Well, [was was] great was definitely the clarity and usability of the thermometer. Being able to add free-text comments, it wasn't too long or too short––enough to really get a good sense of the department and everyone's views on these safety topics. In retrospect, it just worked for the department." (P 4, T 1) • "Well, I think it's really valuable to sometimes be able to report things anonymously. [. . .] I think that is the safest feeling for fellow nurses." (P 3, T 1)	
	Usability of the online SCT tool (scoring ease)	• Convenience (practical, simple, easy-to-use) • Promptness • Reliability (absence of technical issues) • Allows one to score by intuition and feeling. • Risk of aggregation towards the middle area of the sliding bar. • Dependent on personality due to a lack of narrowly defined answer options • Heterogeneity in behaviors between team members can make scoring difficult	• "Scan [QR code], score, done!" (P 2, T 3) • "I found it a pleasant way to perform that kind of measurement. [. . .] Overall, I thought it was a nice way to express your feelings about certain topics." (P 5, T 1) • "I think it is a nice, easy-to-use instrument. It effectively combines color and personal perception in 1 tool." (P 1, T 3) • "Color quickly indicates a feeling." (P 6, T 1) • "So, where do you put it [the slider] then? And that's in the "we" aspect [of phrasing], which I don't really know how to handle." (P 6, T 2)	• The color gradient sliding bar was popular, but not user-friendly for persons with dyschromatopsia. We suggest the future use of a red-blue gradient instead.

(continued)

TABLE 3 (*continued*)

Deductive Theme	Evaluated Aspects	Inductive Themes (Factors That Can Act as Barriers or Facilitators)	Illustrative Quotes P = Participant Number T = Team Number (Non-Correspondent With Table 1)	Suggested Changes to SCT Tool/ Methods for Future Use	
Practicality The extent to which the use of the SCT tool could be carried out by participants with existing means.	Ability of participants to carry out intervention activities		• Presence of certain personality traits, like assertiveness • Urgency for improvement of safety culture	• "I think. . . you have to be assertive enough yourself to raise awareness to that issue." (Participant 5, team 1) • "Yeah, I think there has to be a certain sense of urgency." (P 4, T 2)	
	Usability of the SCT method	Clarity of online SCT tool results	• Clear (insightful) • Visualizes feelings • Allows for "safety II thinking" (understanding and reinforcing things that are going well) • Resonates amongst colleagues, building a sense of agreement • Directs towards improvement initiatives. • Response rates influence representativity and, in turn, the feeling of urgency for change • Quick result sharing is important, and real-time results might facilitate engagement even more	• "It ultimately makes implicit things explicit. That is what this [tool] does." (Participant 2, team 2) • "That you also kind of saw the positive things and not just immediately think, like, negatively. That you had good picture [in mind]. [. . .] You also know the things that are going well, so you can encourage these, or something." (5, T 1) • "Well, I also kind of liked seeing that you're not alone in a certain opinion. [. . .] This also makes those feelings visual." (P 6, T 1) • "I did think: Is that truly representative?" (P 2, T 3) • "Like I said, the feedback of the survey from March still hasn't happened. How are you supposed to maintain credibility in that [situation]?" (P 4, T 3) • "Yeah, that's kind of the novelty these days. Basically, immediately being able to see, guys, "How are we doing?" [. . .] That way you get feedback right away." (P 4, T 3)	• Using real-time results (almost like an entrance-poll) instead of presenting results after 2 wks might help to engage participants into the immediate team discussion even more. In addition, it highlights the cross-sectional aspect of the SCT and avoids giving the impression of safety climate measurement.

(*continued*)

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		Meeting frequency	• Frequent enough to keep engagement • Not too frequent • May be more frequent/ longer, since emotions take up considerable meeting time	• "The frequency was fine. What I did notice, is that sometimes [meetings] were a bit short, especially in the beginning, because, essentially… Because with so much going on, you basically need a sort of venting moment first where people can just tell their stories." (P 6, T 1)	• Meeting frequency should ideally be every 4-6 wks instead of 8-12.
		Guidance/ external facilitation by research team	• Ensures of psychological safety • Objective (impartial) • Open, explorative questioning by external facilitators created deeper understanding • Great service level • Fosters autonomy while guiding • Helps formulate actionable goals • Communication about meeting agenda, goals and actions can be improved	• "There was always a really nice safe atmosphere, I think, which made us dare to share everything. I really liked that a lot! Uh, yes, maybe that it could have been a bit more frequent." (P 5, T 1) • "Very open atmosphere, and I think that's the nice thing about it. […] I think that helped us to participate well and to bring things up, and that felt very safe. […] You kind of guided it, but you also let us take the lead, and sometimes you gave a bit of direction, and I think that was really nice." (P 4, T 1) • "So that's what you sometimes kind of missed: a line [of focus], so to say, in such a meeting. There often was an agenda, but it was gone within 5 min or so." (P 6, T 1) • "At times, I kind of missed clear assignment of actions. […] Like, who is responsible for what." (P 7, T 1)	• Increased communication beforehand about meeting agenda and goals, and firm chairmanship of meetings is advized, to better accommodate participants who benefit from clear steps and structure.
		Clarity of SCT steps	• Logical sequence of steps • Steps were clearly explained • Could be difficult to oversee at the start	• "I thought it was a logical structure" (P 4, T 2) • "Generally, yes, the main outlines were clear, but the precise details were not." (P 7, T 1)	• Having clear end goals early on in the process can create a horizon and engagement.

(*continued*)

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		Adherence to timeline	• Protected time*	• "If you don't have [protected time], it's a squeeze, I think. Then you have to fit it in alongside other things, and that's not really feasible on the ward." (P 6, T 1)	
Demand The extent to which the SCT tool is likely to be used (amount of demand).	Intent to continue use and reasons for this		• Quick • Good team indicator • Online SCT input is not necessary • Impartial (external) facilitation • Cyclic use is a key strength, but also a practical future challenge	"Yeah, because it's a good indicator for the whole team and it's quick. Being able to put your finger on a sore spot, in this way." (P 7, T 1) • "As long as there is a feeling of urgency. [. . .] But that could just as well have been, like, 4 or 5 separate interviews from you with a few team members, so to speak." (P 3, T 2) • "Yeah, but then also assessed by an impartial party." (P 6, T 1)	
	Perceived fit within team/ward culture and reasons for this		• Contents evoked recognition • Completely applicable to department • Color gradient and visually illustrative results resonate with practically oriented OR staff • Poor fit due to insufficient customization	• "When I read it now, I think: Oh yeah, that fits our ward!" (P 4, T 1) • "I think, when it comes to the safety themes, the questions that were asked, that it was just really completely applicable to our department. Not too much fuss. It was just. . . yeah, it just made sense." (P 4, T 1) • "I think that colors––in the OR we're all about practical things, solutions so to say, not about thinking for ages and only then doing [something], so the colors are very easy and striking so you think: 'This is good, that is wrong - Boom! Done." (P 3, T 3) • "The surgeons you determined the themes with aren't on the ward 24/7." (P 3, T 2)	• Customization of the SCT tool to a team with input from all expert team participants enables better fit.

(*continued*)

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Implementation The extent to which the SCT tool was used as intended and perceived resources for use.	Amount, type of resources needed to implement		• Time, specifically protected time*, was perceived to be crucial • Presence of a team "champion"	• "So you do need someone who keeps acting as a driving force, otherwise, uh, nothing will come of it." (P 4, T 2)	
	Factors affecting implementation ease or difficulty		• Traditional hierarchy and a lack of sense of belonging can prevent emergence of a "champion" • Staff turnover • Work pressure • Unsteady leadership (teams 1 and 3)	• "[. . .] but [even though] I have years of experience, I'm way down in hierarchy in this hospital." (P 1, T 2) • "For us, as [my profession], it felt a bit strange perhaps to take on a role in a team we feel not fully part of, because the team on the ward is not clearly defined. We don't have a team meeting where everyone participates." (P 3, T 2) • "Of course, the strength of this kind of thing is in the repetition and really actually implementing it in your systems. And that, with the high turnover of residents, hospital doctors, physicians, but especially also the pressure we're under——that we're just not very visible on the ward——that's a challenge." (P 2, T 2) • "It's rarely quiet, I tend to say." (P 3, T 3) • "Trust in [nurse team leader] has not fully returned for me yet." (P 6, T 1)	• Future implementation should focus more on cultivating a local champion who drives improvement.
Efficiency, speed, or quality of implementation		• Pre-existent team meeting structure • Attendance should be made less optional • Presence of team tension/ conflict or lack of trust • (Initial) resistance to (or endorsement of) change. • Presence of external facilitators, in-person vs. fully remote/digital. • Prioritization of implementation vs. other concurrent surveys/projects • Presence of survey and COVID-19 fatigue	• "That's also what I'm used to from other departments, that you either meet every 2 wks or at least monthly with a small group, just to sit down [and say]: [. . .] What needs to be addressed?" (P 6, T2) • "Thing is, you then notice how difficult it is to get everyone together." (P 2, T2) • "And then not, uh, optional, but just being present. [Having] a surgeon who doesn't have the on-call phone, but who really has an h to join in." (P 3, T 2) • "Culture is kind of a tricky 1 in our team [. . .] it's sometimes also, like: Yeah: what are they actually going to do with [these results]? And if that isn't clear, then they don't fill it out fully, or at all. . ." (P 3, T 3)	• Extend the exploration phase (3-9 mo in this study) before implementation start, to in-depth explore contextual factors including team composition, cohesion, turnover, trust, psychological safety, work pressure, concurrent projects/surveys, presence of change urgency and/or resistance better. • In-person external facilitation is recommended to better aid building trust and personal connection with participants.	

(*continued*)

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			• "And then that [physician] goes: Oh come on, why aren't we listening to the nurses? And *then* it is possible. And before, we also came up with good arguments——I think——and then it just wasn't possible." (P 7, T 1) • "If this had been an internal project, it would have died out, I can tell you that much." (P 4, T 2) • "I think it's a pity that it unfolded this way [digitally]. We also have learned from it." (P 4, T 3) • "On the other hand, we are also a bit survey-fatigued, because a new survey was started again without the previous 1 on patient safety having been fed back." (P 4, T 3)	

*Protected time refers to dedicated working hours formally set aside for non-clinical duties such as research, training, policy development, or quality improvement.

participant noted the survey's slider style might aggregate scores towards the center, and another found heterogeneous safety behaviors made some items difficult to score at a team level. Participants felt the intuitive nature of the color gradient aided their scoring. Table 3 includes multiple quotes about usability.

Practicality

Participants' ability to carry out improvement activities was influenced by the presence of personality trait assertiveness and urgency for change. Feedback of SCT results was considered insightful and might benefit from being real-time. Meeting frequency was satisfactory, but some felt it could be increased. The SCT steps were mostly logical and clear. Improvements could include increased communication about meeting agenda, goals, actions, and firm chairmanship. Lastly, "protected" time facilitated timeline adherence.

Demand

Overall demand was present but ambivalent. Ten out of 17 participants wanted to continue use, noting anonymity, external facilitation, results feedback, scoring ease, quickness, and being a good team indicator. One pressed the importance of cyclic tool use. Three participants (all from team 1) wanted to only continue interprofessional team discussions as the most valuable aspect, 1 did not have an opinion, 1 was opposed (while they recognized the possible visual benefits of the SCT) and 1 did not answer the question.

Concerning the SCT's fit within organizational/team culture, participants praised the applicability of content and the tool's visual nature. Nine out of 17 participants perceived the SCT to fit their team well, 1 was neutral, 1 did not have an opinion, 4 did not answer the question, 2 thought team fit was poor due to (1) insufficient customization of contents and (2) high turnover posing as a barrier for adoption.

Degree of Execution

Team 1 and 2 set actionable goals and achieved these (Table 2). Team 3 chose to only score themes, not items (survey round 2), and focus on immediate improvement opportunities. Their goals were not measurable and time-bound, inhibiting evaluation. Implementation of the SCT was discontinued preliminarily in team 3 (Fig. 3), due to unforeseen contextual factors elaborated upon in the discussion.

Implementation Resources

The most important resource for SCT implementation across all teams was time. Planning and attending interprofessional meetings and working on team goals required a few hours per week, with participants highlighting the value of "protected" time. Each team also needed at least 1 "champion" to facilitate implementation; this role could be taken by any professional

(manager, team leader, or healthcare professional). Without a driving force, implementation without external support seems infeasible. Moreover, implementation was influenced by a sense of urgency and presence of personality traits such as assertiveness in the expert team. Lastly, although the study budget allowed remuneration, participants did not use it. Improvement initiatives were performed during working hours, and extra hours were usually recorded as overtime. Remuneration or overtime were not mentioned as facilitators.

Factors Influencing Implementation Ease

To start, team 2 experienced how traditional hierarchy and a lack of sense of belonging can prevent the natural emergence of a team champion (reported under "implementation resources," Table 3). Moreover, staff turnover and unsteady/changing leadership can also be a barrier for implementation due to having to rebuild personal connection and trust. As a logical extension, presence of (dis)trust or absence of psychological safety were possible barriers too. Lastly, high work pressure was mentioned in relation to implementation ease.

Factors Influencing Implementation Efficiency, Speed or Quality

Pre-existing interprofessional team meetings facilitated implementation, possibly by familiarity with team discussion's or bypassing planning hurdles. One participant suggested mandatory attendance.

According to team 1 participants, tension after a conflict situation influenced implementation speed due to emotions taking up considerable meeting time. Moreover, (initial) resistance to change and lack of trust can also hinder implementation.

Many participants perceived external facilitation by an independent party to be pivotal. It was thought to be essential for psychological safety and impartial feedback of results. Participants' future concerns were (1) failure to anchor into local context and establish cyclic meetings will lead to de-implementation; and (2) high turnover hindering cyclic use or cultivation of a change urgency.

Lastly, in team 3, concurrence with (and prioritization of) other surveys/projects, and the presence of survey- and COVID-19 fatigue were major barriers:

> *"And people were a bit survey fatigued, because at that time we also [had] other surveys. At that time an employee satisfaction survey was done, and we also evaluated COVID then. I remember people were just tired due to COVID in the period we did this [SCT]. People weren't easily excited either. [. . .] It was an intersection of circumstances in which multiple things were happening at the same time."* (Participant 1, team 3)

Adaptability

Several observations are important when reviewing SCT adaptability. While all teams could customize the tool, only team 1 did so, including only nurses in the expert team to empower them; other professionals were involved later. Teams 2 and 3 noted in hindsight that further customization would have improved fit.

Team 1 purposefully decided to only include nurses in their expert team after discussion with other professions' representatives, to favor nurse empowerment. Other professionals were involved after formulating their improvement initiative, essentially shifting interprofessionality to a later stage in the process.

External facilitation was fully remote for team 3 due to COVID-19 restrictions, which complicated guidance and responsiveness. In contract, in-person facilitation in teams 1 and 2 fostered trust and personal connection.

Two content changes were made: (1) after team 1, the Leadership theme description was rephrased from "Our leaders. . ." to 'As a team, we demonstrate through our actions and expectations that safety is a priority' to avoid finger-pointing; (2) after team 2, an item from the Communication theme was simplified to avoid confusion.

Lastly, team size influenced implementation. Smaller teams (< 75 healthcare professionals) like team 1 and 2 were more easily informed, engaged, and motivated by the external facilitator, whereas team 3 (150 healthcare professionals) faced challenges due to remote guidance and a lack of personal connections.

Perceived Effects on the Team

In addition to the interview questions in Appendix I, some participants commented on additional effects. These do not directly relate to implementation outcomes nor the deductive implementation themes in Table 3 but provide insight into additional (positive) effects. No negative effects were mentioned.

First, several participants noted changes in team cohesion and atmosphere. Team 1 experienced marked improvement, while team 2 experienced ongoing division.

> *"I have the feeling that we have a really good work atmosphere. It also brought us something. . . That's what [nurse team leader] also said: You really are a team now."* (Participant 2, team 1)

> *"Although you are kind of part of the team, you're also still a bit on the outside."* (Participant 3, team 2)

In team 1, participants felt more heard by supervisors:

> *"I'm really happy with the project, because for myself I just notice that there are small changes. More openness anyway. I think we're just, unconsciously, being more and more involved by the supervisors. [. . .] They'll say: 'what is your input?' [. . .] I think that's really nice to see."* (Participant 3, team 1)

All teams valued the interprofessionality of the SCT tool without being prompted, reporting they work on improving culture together:

> *"[. . .] so I think that mirror sometimes just helps, like: Oh, where can I myself take steps to improve? And I think that really did help the team structure, sort of [. . .] In a way, you're kind of forced, but in a good way, to start working together and dealing with the issues at hand, which makes you grow closer to each other faster."* (Participant, team 1)

> *"You want to realise a certain culture change and for that you need all professionals in the team. So then you'll have to sit in a multidisciplinary team meeting."* (Participant 3, team 2)

> *"In the past one and a half, two years we've had quite a lot of changes in leadership, and so you also have to get used to each other again, make new agreements with a new team, and then carry that out to the rest of the workplace. And that means you also have to build up trust again, and connect with personnel. [. . .] So we've invested heavily in a speak-up culture."* (Participant 1, team 3)

DISCUSSION

This implementation study reports the practical use of the SCT tool by 3 surgical teams. Positive overall attitudes were reported and most importantly, the teams managed to organize multiple interprofessional team discussions dedicated to safety climate. This is important, since prior research on team-based reflection suggests that work floor feedback might be most effective when it is goal/action-oriented, repetitive, and sourced from peers rather than merely providing performance data and how it can contribute to organizational learning and innovation.[20,21,22] In this regard, the SCT's emphasis on cyclic interdisciplinary team dialogue mirrors mechanisms identified in the wider literature as essential for translating team safety insights into meaningful daily practice change.

The SCT was perceived to be acceptable and usable. Reasons for satisfactory usability included anonymity, quickness (less than 2 minutes on average), complete and clear content, and ease of scoring. This is consistent with prior usability and survey research, that reports how low time burden and anonymity are key determinants of response rates.[23,24] Demand and team fit were ambivalently perceived. Implementation resources, such as cultivation of a local champion and allocation of protected time were thought to be important. We recommend some changes to the SCT tool and delivery method for future use, which can be found in Table 3. Recommendations for future use of the SCT tool in surgical teams are summarized in the box below and include: e-mail distribution, cultivation of local champions that could serve as internal facilitators, allocation of protected time for participation by frontline professionals and in-person external facilitation.

When comparing overall implementation between teams, team 3 specifically faced challenges and was discontinued preliminarily. Interview data and our observations indicate the following causes: (1) prioritization of other surveys causing survey fatigue and meagre response, (2) a lack of change urgency due to questions doubts about representativeness, (3) post-COVID-19 fatigue and unstable leadership, causing reduced engagement, and (4) a possible lack of trust. Smaller teams (< 75 healthcare professionals) like team 1 and 2 appeared more suitable for SCT use due to better internal cohesion. Prior research has identified smaller teams to facilitate psychological safety and cohesion.[25,26] Remote facilitation in team 3 proved difficult, whereas on-site presence in teams 1 and 2 fostered connection, trust, and psychological safety. Our experiences in team 3 confirm known these remote leadership and facilitation challenges.[26,27] Lastly, we recommend distribution via email, which yielded a higher response rate than QR distribution.

Recommendations for future SCT use

- Most suitable for smaller teams (≤75 pers).
- Distribute via email.
- Cultivate a motivated team "champion."
- Allocate protected time for participants.
- Facilitate in-person (external) to build trust and psychological safety.
- Encourage customization to ensure team fit.
- Explore contextual factors in-depth before implementation.

The most important resource needed for implementation was time to attend and plan interprofessional team meetings. Participants reported "protected" time as key facilitator. This aligns with Benishek et al.[13] who recently highlighted how existing workloads should be considered before implementing safety interventions. Prior implementation research has identified time constraints as a recurrent challenge in the healthcare field.[28,29] Moreover, a growing body of literature shows that safety culture is closely intertwined with healthcare professionals' wellbeing. Associations have been reported between safety culture and stress, job satisfaction, turnover intentions, and psychological safety, while professional wellbeing itself has been linked to patient outcomes.[4-6,30,31] From this perspective, allocating protected time for safety reflection may not only support safety improvement efforts but also mitigate the workload-related strain that often undermines engagement with such interventions. We also argue that the relationship between patient safety and wellbeing of healthcare professionals deserves further consideration.

Facilitators of implementation were external facilitation, presence of a team "champion" that drives SCT use and improvement, and a pre-existing interprofessional meeting structure. Perceived barriers included contextual factors such as high turnover and work pressure, unsteady leadership, lack of trust, presence of survey fatigue and COVID-19 fatigue, (initial) resistance to change, presence of team tension or conflict, and prioritization of other surveys or projects. Survey fatigue remains a serious challenge in healthcare safety research.[24,32] In retrospect, our in-depth knowledge of team context proved to be insufficient to avoid said barriers. We therefore argue that external facilitators should focus on understanding contextual factors, consistent with earlier descriptions of external facilitation roles.[33,34]

Beyond the inductive and deductive themes (Table 3), some participants noted improved team cohesion, feeling heard, and moving towards a culture change, suggesting that SCT use may foster safety culture improvement through team-building. The next step is to study the impact of continuing SCT use on measurable safety culture outcomes beyond perceptions, ideally using longitudinal designs to assess behavioral changes as well as adoption and sustainability. However, safety culture behaviors in naturalistic settings are complicated by myriad confounding contextual factors, e.g. leadership changes or changes in work pressure.[12] Future research should also explore use of the SCT in non-surgical settings and the effects of team composition and patient population, to guide SCT application in diverse healthcare settings. Design wise, the response format using a sliding bar should be studied further. A comparative study could evaluate the SCT on user experience against other tools.

Lastly, this study highlighted the considerable influence of contextual factors on implementation success.[35] We therefore recommend to allow ample time before the start of implementation to in-depth explore team composition, cohesion, turnover, trust, psychological safety, work pressure, leadership, concurrent projects/surveys, presence of change urgency and/or resistance, and accommodate accordingly. Future studies should focus in-depth on the role of contextual factors in improving safety culture. Knowledge on how these contextual factors facilitate or hinder the translation of team dialogue into tangible improvements can strengthen the evidence base supporting non-technical, team-focused strategies for improving safety culture.

Strengths and Limitations

Implementation research is very contextual and due to the immersive nature of this study findings cannot be easily generalized to other groups or organizations. Since SCT tool's aims to aid interprofessional team discussion, we feel very confident the SCT can be effectively used for this purpose.

Our study design allowed for optimal flexibility during implementation. However, the naturalistic setting brought along some challenges considering bias. Firstly, the gender distribution was uneven in all 3 expert teams, largely influenced by the number of nurses per team. Since the ratio was skewed both ways for different teams, we do not expect this to have influenced our overall implementation results. Secondly, 2 participants could not be reached for the final interview due to pregnancy leave and scheduling issues. However unfortunate, we also do not expect this to have influenced the results. Thirdly and more importantly, as mentioned in the methods section, the author of this study also acted as interviewer and data analyzer. This may have influenced how participants chose to articulate their opinions, despite being assured that both positive and negative feedback was more than welcome. Therefore, participants' perceptions regarding the implementation might reflect a positive bias. However, local outcomes concerning interprofessional team discussions dedicated to safety climate and successful improvement initiatives cannot be disputed.

It is appropriate to briefly review the use of the color gradient sliding bar. The main argument for using a (color gradient) sliding bar is its engagement of respondents.[36,37] Our participants experienced it as a more intuitive way of scoring team climate than numerical scales and therefore it seems a more user-friendly option for exploration. Moreover, previous studies have

reported higher non-response rates and longer completion times with slider formats, possibly due to unfamiliarity.[38] To mitigate this, color was used to reduce cognitive effort (inspired by usability research) and no default starting position was shown to avoid false responses (actual non-responses by not moving from default starting position).[39] For future use, we recommend inclusion of a "prefer not to answer" option, consideration of device-specific usability and answering formats, and changing the color gradient from red-green to red-blue to improve accessibility for users with dyschromatopsia (red-green color blindness, accounting for up to 1 in 12 males).[40]

CONCLUSION

The Safety Climate Thermometer (SCT) was successfully implemented in 3 surgical teams, combining online anonymous input and interprofessional team discussion for safety culture improvement. Results demonstrate that anonymity, and quick, easy and intuitive scoring contribute to the SCT tool's usability. Implementation in smaller teams with a motivated champion guided by in-person external facilitation was most successful. Exploration of contextual factors is critical and warrants attention in implementation planning.

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SUPPLEMENTARY INFORMATION

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