A Human Factors Intervention in Hospital - Evaluating Outcome of a TeamSTEPPS Program in a Surgical Ward

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Abstract
Background Patient safety in hospitals is being jeopardized, as too many patients experience adverse events. Most of the adverse events arise from human factors, such as inefficient teamwork and communication failures, and the incidence of adverse events is greatest in the surgical area. Previous research has shown the effect of team training on patient safety culture and on different areas of teamwork. Limited research has investigated teamwork in surgical wards. The aim of the study was to evaluate the outcome of a team training intervention among healthcare professionals in a surgical ward after 6 and 12 months. The Systems Engineering Initiative for Patient Safety 2.0 was used as a conceptual framework for the study.

Methods This study had a pre-post design with measurements at baseline, after 6 months and 12 months of intervention. The intervention was conducted in a urology and gastrointestinal surgery ward in Norway, and study site was selected based on the leaders’ willingness to participate in the project. Survey data from healthcare professionals, measured by the TeamSTEPPS Teamwork Perceptions Questionnaire, the Collaboration and Satisfaction about Care Decisions in Teams, and the unit-based sections of the Hospital Survey of Patient Safety Culture Questionnaire, were used to evaluate the intervention. A paired t-test, a Wilcoxon signed-rank test, a generalized linear mixed model and linear regression analysis were used to analyze the data.

Results After six months, improvements were found in organizational outcomes in two patient safety dimensions. After 12 months improvements were found in both organizational and professional outcomes, that was in three patient safety culture dimensions and three teamwork dimensions. The generalized linear mixed model estimates demonstrated that physicians had effect on two patient safety culture measures. Furthermore, results showed that teamwork was associated with the organizational outcome Patient Safety Grade.

Conclusion These results demonstrate that the team training program had an effect after 12 months of implementation. Future studies are recommended to examine the causal effect of a team training intervention in this context, preferably with studies with larger sample sizes and stronger study designs.
Trial registration number:
ISRCTN13997367 (retrospectively registered)

Background
Patient safety in hospitals is being jeopardized, as too many patients experience adverse events [1, 2]. The risk of adverse events in surgical care is higher than in other areas of hospitals [3, 4]. Most adverse events arise not from the solitary actions of individuals but from systems of which they are a part and with which they interact [5]. Root cause analyses have revealed that human factors, as poor teamwork and communication failures are the underlying factors for the majority of adverse events in hospitals [2, 6]. Focusing on patient safety culture is crucial for minimizing adverse events and improving patient safety [7]. An organization’s patient safety culture is the product of individual and group values, beliefs, attitudes, perceptions, competencies, and patterns of behavior that determine the organization’s commitment to quality and patient safety [8]. Patient safety requires that healthcare professionals have the right competencies and tools to perform their tasks. It is therefore crucial to examine patient safety interventions that focus on healthcare professionals and work system factors that contribute to safe care [9]. In this study, we conducted a team training intervention in a surgical ward.

The surgical ward is a microsystem within a hospital organization and a unit type with a high degree of complexity [10]. The interdependency among healthcare professionals contributes to this complexity [1]. Healthcare professionals working in wards are generalists. The clinical work requires a broad spectrum of competencies, and healthcare professionals are often working under high time pressure [11]. The physician members of the surgical ward teams are often in the operating room [12], making interprofessional teamwork extra challenging.

Human factors is a multidisciplinary science at the intersection of psychology and engineering [13] and is commonly described as a discipline devoted to studying and improving the interactions among humans and other elements of a system (within a given environment) [14]. Human factors interventions are about improving system performance and preventing accidental harm, which for healthcare means supporting the cognitive and physical work of healthcare professionals and
promoting high-quality, safe care for patients [15]. Human factors interventions, as team training, is regarded as an innovative approach for improving patient safety [16-18]. Team training is described as applying a set of instructional strategies that rely on well-tested tools (e.g., simulation, lectures, videos) to accomplish specific team competencies [19, 20].

Previous research on team training interventions has shown improvements in different areas of teamwork [21, 22] and safety culture [23, 24], reductions in surgical harm [25], and reductions in surgical mortality [26]. However, most of the team training research has been conducted in specialty units, and limited research has investigated teamwork in surgical wards [27] or investigated teamwork over long time frames [28]. Few studies have examined the associations between perceptions of teamwork and patient safety culture after a 12-month team training intervention.

Observational studies have found that interprofessional teamwork was associated with organizational culture [29] and that event reporting, communication, and leadership were predictors of patient safety culture [30].

In this study, we implemented Team Strategies and Tools to Enhance Performance and Patient Safety (TeamSTEPPS™) in a surgical ward. TeamSTEPPS is a generic program based on research [31, 32] and is built on five key principles: “Team Structure” and the four team competencies “Leadership”, “Situation monitoring”, “Mutual support” and “Communication” [32]. “Team decision-making” is an additional team competency [2, 33, 34] that is not included in the TeamSTEPPS program but was included in this study. The four team competencies of TeamSTEPPS have 17 associated tools and strategies that are meant to be implemented in clinical practice to improve performance and patient safety [35].

Since the need to implement team training programs in the surgical ward context is being increasingly recognized, an interprofessional teamwork intervention was initiated. The aim of the study was to evaluate the outcome of a team training intervention among healthcare professionals in a surgical ward after 6 and 12 months. The research questions were as follows:

1. Did healthcare professionals’ perceptions of teamwork and patient safety culture improve from baseline after 6 and 12 months of intervention?
2. Did patient safety culture related to the TeamSTEPPS intervention vary by profession group and by time, demonstrating an effect of the intervention?
3. Were perceptions of teamwork dimensions associated with patient safety culture in the unit after 12 months?

Conceptual framework

Teamwork and patient safety may be explained on the basis of a structure-process-output (SPO) framework that describes the impact of input in the structure on process and output, as in classic system theory [20, 33, 36]. The human factors model “The Systems Engineering Initiative for Patient Safety 2.0” (SEIPS 2.0) is a SPO model developed for innovative patient safety research in healthcare [5, 37]. The model emphasizes structural elements in the work system with a person at the center. The person may be patients, healthcare professionals or healthcare teams as in this study. The team members perform a range of tasks using various tools and technologies in an internal and external environment and under specific organizational conditions, which all influence the care processes and which in turn influence the outcomes [5, 37]. Unlike most of the SPO models, the SEIPS model differentiates the outcomes. In addition to 1) patient outcomes, the model includes 2) professional outcomes and 3) organizational outcomes [37]. The interrelatedness of the elements (person, tasks, tools and technology, organization, internal and external environment) in the work system, and between the work system, process and outcome, illustrates the complexity of the system [37].

In this study, we used the SEIPS 2.0 model to conceptualize the intervention and the outcomes of the study from a system perspective [38]. Implementation of a team training program was regarded as an input in the organization element to strengthen the work system by attempting to improve healthcare professionals’ team competencies and patient safety culture [20, 36]. The outcomes in this study were healthcare professionals’ perceptions of teamwork (professional outcome) and patient safety culture (organizational outcome). See Fig. 1.

Please insert Fig. 1 here

Methods

Study design

We conducted a study with a pre-post design with measurements at baseline, after 6 months and 12
months of intervention.

Setting and sample

The intervention was conducted in a 20-bed urology and gastrointestinal surgery ward in a 180-bed hospital in Norway. The study site was selected based on the leaders’ willingness to participate in the project, motivated by patient safety incidents in the ward. The profile of the surgical ward at the three timepoints for data collection is displayed in Table 1. No major changes in the unit profile occurred during the study period, except for changes in leadership positions. All 43 frontline healthcare professionals (12 physicians, 24 registered nurses, and 7 nursing assistants) were invited to participate in the study.

| Table 1  | Unit profile data |
|---------|------------------|
|         | Baseline | 6 months | 12 months |
| Beds and nurse/bed ratio | | | |
| Number of patient beds | 20 | 20 | 20 |
| Nurse/bed ratio | 1.16 | 1.16 | 1.16 |
| Full-time equivalent positions | | | |
| Physicians | 13 | 12 | 12 |
| Registered nurses | 17.25 | 19.25 | 20.25 |
| Nursing assistants | 4.95 | 3.1 | 2.1 |
| Unit nurse director | 1.0 | 1.0 | 1.0 |
| Clinical nurse specialist | 1.0 | 1.0 | 1.0 |
| Change in positions | | | |
| Clinical nurse specialist | - | No | No |
| Unit nurse manager | - | No | Yes |
| Physician leader gastrointestinal surgery | - | No | No |
| Physician leader urology | - | No | Yes |
| Chair of the surgical department | - | No | Yes |
| Patient data and sick leave (previous 6 months) | | | |
| Number of patient admissions per month | 192 | 174 | 173 |
| Length of stay (mean days) | 3.46 | 3.63 | 3.62 |
| Occupied beds | 87% | 96% | 89% |
| Emergency admissions | 64% | 65% | 66% |
| Sick leave nursing staff | 13.22% | 5.05% | 7.58% |
| Sick leave physicians | 3.55% | 1.47% | 2.58% |
| Adverse events | 2015 | 2016 | 2017 |
| Numbers of reported adverse events | 38 | 42 | 52 |

Please insert Table 1 here

The intervention

The intervention was conducted according to the TeamSTEPPS implementation plan [32], which comprises three phases and aligns with the Clinical Human Factors Group recommendation for team training interventions [39].

Phase 1. Set the stage and decide what to do - Assessment and planning
A site assessment was conducted. After the leaders of the surgical ward had decided that their unit was ready for the TeamSTEPPS program, an intervention plan was developed jointly by the researchers and the leaders of the ward.

**Phase 2. Make it happen - Training, planning and implementation**

The onset of the intervention was a mandatory six-hour interprofessional TeamSTEPPS training that included simulation training (41 participants over 3 days). The training was conducted in a simulation center at the university and delivered by the master trained nurse -and physicians leaders in the unit. Safety issues in the ward were identified by the frontline healthcare professionals at the training. After the training, an interprofessional change team was established. The change team consisted of 12 members from all levels in the organization, in addition to a former patient and one of the researchers (ORA). Based on the identified safety issues, the change team developed an action plan, according to which they implemented tools and strategies into daily practice. Five tools were implemented during the first five months of the implementation phase (Closed-loop, SBAR, Briefs, Huddles, and Cross-monitoring). Refresher training for the nursing staff (75 minutes) and physicians (20 minutes) was held after 5 months.

**Phase 3. Make it stick - Sustainment**

The implementation of tools and strategies continued. Five more tools were implemented (Debriefs, Task assistance, STEP, Two challenge rule, and I-PASS) during the last five months of the 12-month study period. After 11 months, another refresher training session was held for the nursing staff (75 minutes). Further details of the intervention are described elsewhere [40].

**Measurements**

Three questionnaires were used to evaluate the intervention. The TeamSTEPPS Teamwork Perceptions Questionnaire (T-TPQ) [41, 42] is a 35-item questionnaire that measures individuals’ perception of the level of teamwork that exists in their work unit. Participants responded using a 5-point Likert scale of agreement (5 = strongly agree to 3 = neutral to 1 = strongly disagree). The T-TPQ measures five teamwork dimensions addressed in the TeamSTEPPS program; there are seven items for each of the following five dimensions: “Team structure”, “Leadership”, “Mutual Support”, “Situational Monitoring”
The Collaboration and Satisfaction about Care Decisions in Team (CSACD-T) is a questionnaire measuring clinical decision making in teams. It is composed of seven items with statements about collaboration in team decision making about patient care and two items about satisfaction with decision making. The participants responded by using a 7-point Likert scale of agreement (from 1 = strongly disagree to 7 = strongly agree), global collaboration (from 1 = no collaboration to 7 = complete collaboration), and satisfaction about care decisions (from 1 = not satisfied to 7 = very satisfied). The questionnaire was developed from the original nurse-physician “Collaboration and Satisfaction about Care Decisions” questionnaire [43].

The Hospital Survey of Patient Safety Culture Questionnaire (HSOPS) [44] is a questionnaire that assesses the extent to which healthcare professionals’ organizational culture supports patient safety. It is recommended for evaluating the cultural impact of team training and patient safety interventions [44]. The full HSOPS comprises 2 single items and 12 patient safety culture dimensions. Each dimension is composed of three or four items [44]. The two single items (“Number of Events Reported” and “Patient Safety Grade”) and two of the dimensions (“Overall Perceptions of Patient Safety” and “Frequency of Events Reported”) are regarded as outcome measures. Three dimensions are regarded as hospital level measures [45]. Because we only studied one unit, we excluded the hospital-level section of the questionnaire (11 items – 3 dimensions) and used the 2 single items and the remaining 33 items of the nine unit-level dimensions: “Teamwork Within Unit”, “Manager’s Expectations & Actions Promoting Patient Safety”, “Organizational Learning - Continuous Improvement”, “Feedback and Communication About Error”, “Communication Openness”, “Staffing”, “Nonpunitive Response to Errors”, “Overall Perceptions of Patient Safety”, and “Frequency of Events Reported” [45]. The participants responded by using a 5-point Likert scale of agreement (from 1 = strongly disagree to 5 = strongly agree), with neither in the middle, or how often (from 1 = very seldom to 5 = very often). The single item: “Patient Safety Grade”, which asks participants to provide an overall grade on patient safety for their unit, has the following five response options: A = Excellent, B = Very Good, C = Acceptable, D = Poor, E = Failing. The single item “Number of Events Reported”,

and “Communication”.
which indicates the number of adverse events the participants have reported over the past 12 months, has six response options: 1 = No events, 2 = 1 to 2 events, 3 = 3 to 5 events, 4 = 6 to 10 events, 5 = 11 to 20 events, 6 = 21 events or more [44].

All three questionnaires were translated into Norwegian and psychometrically tested [46-48]. In addition to the questionnaires, participants’ background information was asked for (sex, age group, profession group, employee time in the unit).

Data collection
An electronic survey (SurveyXact) was distributed by email to the healthcare professionals to evaluate the effect of the TeamSTEPPS program. Data collection was conducted at baseline (February-March 2016) and after 6 months (November -December 2016) and 12 months of intervention (June 2017). Unit profile data were collected from the unit nurse manager.

Statistical analyses
To test for statistically significant changes between baseline and 6 months and between baseline and 12 months, a paired t-test was applied on the healthcare professional’s mean scores of the T-TPQ and HSOPS dimensions and the total score of the CSACD-T, and a Wilcoxon signed-rank test was applied on the two single items of the HSOPS [49]. A generalized linear mixed model (GLMM) [50] was used to investigate the outcome of TeamSTEPPS by estimating the associations among the nine HSOPS dimensions used as dependent variables and “Profession group” (nursing staff and physicians) and “Time” (baseline, after 6 and 12 months of intervention) as the two independent variables. A GLMM is a generalization of traditional linear regression that adjusts for the correlation between repeated measurements within each subject and finds the best linear fit to the data across all individuals. The model maximizes power by utilizing all data despite missing observations in some subjects [51, 52]. The GLMM was applied to the total sample (n = 98), and the results are reported as estimates with 95% confidence intervals. To test whether any of the three significant improved teamwork dimensions of the T-TPQ were associated with two of the patient safety culture outcomes (“Overall patient safety” and “Patient Safety Grade”) after 12 months of intervention, a multiple linear regression analysis was performed on all healthcare professionals (n = 31) who responded after 12 months of intervention.
A p-value < .05 was considered to be statistically significant for all analyses. Statistical Package for Social Sciences (SPSS) version 24 (Armonk, New York) and R 3.1.1 were used to analyze the data. The study adheres to the TREND guidelines [54].

Results
Of the 43 invited healthcare professionals in the ward, 35 of them (81%) responded to the survey at baseline. After six months of the intervention, 32 (76%) healthcare professionals responded, of which 28 had also responded at baseline. After twelve months of the intervention, 31 (78%) healthcare professionals responded, of which 25 had responded at baseline. A total of 98 responses from all respondents were collected at the three time points. See Table 2 for an overview. The characteristics of the respondents are displayed in Table 3.

| Table 2                          | The number of respondents |
|----------------------------------|---------------------------|
|                                  | n                         |
| Baseline                         | 35                        |
| After 6 months of intervention   | 32                        |
| After 12 months of intervention  | 31                        |
| In total                         | 98                        |
| Baseline and after 6 months      | 28                        |
| Baseline and after 12 months     | 25                        |

| Table 3                          | Characteristics of the respondents |
|----------------------------------|-----------------------------------|
|                                  | n = 28                            |
|                                  | 6 months                          |
| n (%)                            |                                   |
| Gender                           |                                   |
| Female                           | 23 (82)                           |
| Male                             | 5 (18)                            |
| Profession                       |                                   |
| Physicians                       | 6 (21)                            |
| Assistant nurses                 | 4 (14)                            |
| Registered nurses                | 18 (64)                           |
| Age                              |                                   |
| ≤ 30 years                       | 6 (22)                            |
| 31–50 years                      | 12 (44)                           |
| ≥ 51 years                       | 9 (33)                            |
| Missing                          | 1                                 |
| Time employed in the unit        |                                   |
| 0–5 years                        | 6 (25)                            |
| 6–15 years                       | 11 (46)                           |
| ≥ 16 years                       | 7 (29)                            |
| Missing                          | 4                                 |

Please insert Table 2 here

| Table 2                          | The number of respondents |
|----------------------------------|---------------------------|
|                                  | n                         |
| Baseline                         | 35                        |
| After 6 months of intervention   | 32                        |
| After 12 months of intervention  | 31                        |
| In total                         | 98                        |
| Baseline and after 6 months      | 28                        |
| Baseline and after 12 months     | 25                        |

The mean scores on the T-TPQ, CSACD-T and HSOPS for those answered two times (baseline and after 6 months or baseline and after 12 months) are displayed in Table 4. None of the teamwork dimensions of the T-TPQ showed significant changes after six months. After 12 months of
intervention, significant improvements were found in three teamwork dimensions: “Situation Monitoring”, “Mutual Support”, and “Communication”. No significant changes were found in team decision making (CSACD-T) during the study period.

Table 4
Healthcare professional perceptions of teamwork and patient safety culture from baseline to 6 and 12 months of intervention

|                         | n = 28 |                             |                             | n = 25 |                             |                             |
|-------------------------|--------|------------------------------|------------------------------|--------|------------------------------|------------------------------|
|                         | baseline mean | 6 months mean | change from baseline to 6 months | baseline mean | 12 months mean | change from baseline to 12 months |
| T-TPQ² dimensions       |         |         |                            |         |         |                            |
| Team Function           | 3.93 (.40) | 3.96 (.44) | .48 | .638 | 3.95 (.43) | 4.08 (.44) | 1.71 | .100 |
| Leadership              | 4.24 (.40) | 4.21 (.49) | -.39 | .700 | 4.16 (.39) | 4.15 (.63) | -.09 | .926 |
| Situation Monitoring    | 3.79 (.47) | 3.98 (.56) | 1.74 | .094 | 3.70 (.43) | 4.06 (.54) | 4.70 | .001 |
| Mutual Support          | 3.85 (.44) | 3.93 (.51) | .89 | .382 | 3.83 (.44) | 4.03 (.50) | 1.04 | .027 |
| Communication           | 3.84 (.40) | 3.94 (.50) | 3.34 | .345 | 3.81 (.39) | 4.02 (.53) | 2.66 | .015 |
| CSACD-T³ dimensions     |         |         |                            |         |         |                            |
| Team Decision Making    | 4.73 (.89) | 5.02 (1.09) | 1.29 | .207 | 4.69 (.92) | 4.95 (.03) | 1.32 | .20  |
| HSOPS⁴ dimensions       |         |         |                            |         |         |                            |
| Teamwork Within Unit    | 3.87 (.54) | 4.08 (.52) | 1.80 | .084 | 3.78 (.52) | 4.05 (.51) | 2.39 | .025 |
| Manager Expect. & Actions Promoting Pat. Safety | 4.18 (.60) | 4.29 (.50) | .91 | .370 | 4.11 (.56) | 4.39 (.52) | 2.72 | .012 |
| Organizational Learning - Cont. Improvement | 3.82 (.51) | 4.05 (.61) | 1.8 | .001 | 3.76 (.51) | 3.97 (.65) | 1.78 | .087 |
| Feedback & Communication About Error | 3.71 (.62) | 3.85 (.70) | .04 | .965 | 3.65 (.58) | 3.90 (.60) | 1.84 | .078 |
| Communication Openness  | 3.80 (.57) | 3.80 (.62) | 2.37 | .025 | 3.77 (.59) | 3.97 (.49) | 2.58 | .017 |
| Staffing                | 3.83 (.49) | 4.07 (.60) | -1.08 | .292 | 3.81 (.49) | 4.07 (.53) | .06 | .955 |
| Nonpunitive Response to Errors | 2.90 (.69) | 3.14 (.83) | 1.38 | .178 | 2.86 (.66) | 3.01 (.84) | .97 | .342 |
| Frequency of Events Reported⁵ | 3.52 (.46) | 3.39 (.52) | 1.98 | .059 | 3.49 (.45) | 3.50 (.66) | 1.09 | .287 |
| Overall Perceptions of Patient Safety⁵ | 4.12 (.51) | 4.28 (.50) | .90 | .375 | 4.13 (.49) | 4.27 (.62) | 1.94 | .065 |
| HSOPS⁴ single items      |         |         |                            |         |         |                            |
| Number of Events Reported⁵ | 2.11 (.83) | 2.00 (.80) | -.63 | .527 | 2.24 (.78) | 2.24 (.78) | -.78 | .439 |
| Patient Safety          | 3.67 (.56) | 3.79 (.59) | -.82 | .414 | 3.67 (.57) | 3.67 (.57) | -.19 | .059 |
The patient safety culture results (HSOPS) showed significantly improved scores in two dimensions after six months of intervention: “Organizational Learning & Continuous Improvement” and “Communication Openness”. The three dimensions “Communication Openness”, “Teamwork Within Unit” and “Manager`s Expectations & Actions Promoting Patient Safety” were significantly improved after 12 months.

The results of the GLMM estimates suggest an effect of time on the TeamSTEPPS regarding “Organizational Learning & Continuous Improvement” and “Communication Openness” after six months (compared to baseline). The estimates also suggest that physicians had an effect on the TeamSTEPPS intervention regarding “Frequency of Events Reported” and “Patient Safety Grade” (Table 5).
Table 5
Estimated Patient Safety Culture by “Time” and “Profession group” (n = 98).

| Parameter                                      | Estimate | 95% Confidence Interval | p     |
|------------------------------------------------|----------|-------------------------|-------|
| **Organizational Learning and Continuous Improvement** |          |                         |       |
| Intercept                                      | 3.80     | 3.60 - 4.00             | .000  |
| Baseline                                      | .0b      |                        |       |
| 6 months of intervention                      | .33      | .05 - .60              | .020  |
| 12 months of intervention                     | .18      | -.09 - .46             | .193  |
| Nursing staff                                 | 0b       |                        |       |
| Physicians                                    | -.27     | -.54 - .00             | .051  |
| **Communication Openness**                    |          |                         |       |
| Intercept                                      | 3.80     | 3.63 - 4.02             | .000  |
| Baseline                                      | .0b      |                        |       |
| 6 months of intervention                      | .29      | .02 - .55              | .035  |
| 12 months of intervention                     | .21      | -.05 - .48             | .116  |
| Nursing staff                                 | 0b       |                        |       |
| Physicians                                    | -.12     | -.38 - .14             | .366  |
| **Frequency of Events Reported**              |          |                         |       |
| Intercept                                      | 2.73     | 2.46 - 3.00             | .000  |
| Baseline                                      | .0b      |                        |       |
| 6 months of intervention                      | .26      | -.11 - .63             | .164  |
| 12 months of intervention                     | .13      | -.25 - .51             | .500  |
| Nursing staff                                 | 0b       |                        |       |
| Physicians                                    | .56      | .19 - .93              | .003  |
| **Patient Safety Grade**                      |          |                         |       |
| Intercept                                      | 3.60     | 3.41 - 3.79             | .000  |
| Baseline                                      | .0b      |                        |       |
| 6 months of intervention                      | .11      | -.16 - .38             | .410  |
| 12 months of intervention                     | .25      | -.02 - .52             | .074  |
| Nursing staff                                 | 0b       |                        |       |
| Physicians                                    | .40      | .14 - .66              | .003  |

1A mixed effects model with individual mean scores
2Baseline and nursing staff were set to zero

Please insert Table 5 here.

The multiple linear regression analysis of all respondents after 12 months (n = 31) found that the three improved teamwork dimensions “Situational Monitoring”, “Mutual Support” and “Communication” (independent variables) explained 31.6% of the variance in the “Patient Safety Grade” after 12 months of intervention. The model reached statistical significance (p = .012). When analyzing which of the three independent variables contributed to the prediction of “Patient Safety Grade”, the model showed that “Mutual Support” had the largest β coefficient (β = .76) and that the
effect was significant (p = .036). When testing with the “Overall Perceptions of Patient Safety” as the dependent variable, the model reached statistical significance (p = .021). The three teamwork dimensions explained 24.3% of the variance in the “Overall Perceptions of Patient Safety” after 12 months of intervention but with a low β-coefficient and without statistical significance.

Discussion
Regarding organizational outcomes as related to the SEIPS 2.0 model, improvements were found in two patient safety culture dimensions after the first six months of this comprehensive intervention. No improvement was found in professional outcome after the first six months, as measured by perceptions of teamwork. After the full 12 months, however, improvements were found in both professional and organizational outcomes. Improvement in professional outcomes were shown in three out of four perceptions of teamwork dimensions. Regarding organizational outcomes, improvements were found in three patient safety culture dimensions. These results indicate that the team training program had an effect after 12 months of implementation. The GLMM estimates demonstrated an effect of time on the patient safety culture dimensions (organizational outcome) “Organizational Learning and Continuous Improvement” and “Communication Openness” after 6 months, and the estimates also demonstrated that physicians had an effect on the patient safety culture dimensions “Frequency of Events Reported” and “Patient Safety Grade”. Furthermore, the teamwork dimension “Mutual Support” was associated with “Patient Safety Grade” after 12 months of intervention.

No significant improvement in T-TPQ measures after six months may be explained by the fact that few of the TeamSTEPPS tools had been implemented by that point. We expected to find improvement in “Communication” after 6 months since the tools Closed-loop and SBAR (Situation, Background, Assessment, Request or Recommendation) were implemented in the work system in an early phase of the intervention. After 12 months of intervention, however, the results showed improvement in three teamwork dimensions (“Situation Monitoring”, “Mutual Support”, and “Communication”). The Cross monitoring strategy was implemented after five months, and the STEP tool was implemented after nine months [40], so the improvement in “Situation Monitoring” may be due to the implementation of
these tools. “Situation Monitoring” is about continuously scanning the environment for important information, watching out for other team members, exchanging relevant information, and jointly reevaluating patient goals [41]. The improved scores in “Mutual Support” may be a result of the “Task Assistance” and “Two Challenge Rule” strategies that were implemented in the work system during the study period [40]. “Mutual Support” is about cautioning each other about potentially risky patient safety situations and about assisting one another during high workloads [41]. When seeing these improvements in teamwork dimensions from a system perspective, they are seen as improved professional outcomes (see Fig. 1). Previous studies from the context of surgical wards that have measured self-reported teamwork have produced ambiguous results [55–57]. Paull et. al [57] found improvement in all scores in their multicenter study when the scores were measured immediately after the training. Study results collected a short time after a team training may benefit from the positive experience the participants have just had and can be seen to reflect a strong Hawthorne effect [58]. The reason why we did not see improvements in team decision making in our study may be due to the time points for measuring. Previous studies that showed enhanced scores in decision making measured two weeks and two months after simulation training [59, 60]. Our results for team decision making may also be explained by the fact that the TeamSTEPPS program does not emphasize decision making, and therefore, there was not a focus on this important aspect of teamwork in the intervention.

The organizational outcome measured by the patient safety culture results (HSOPS) showed improvement in “Organizational Learning & Continuous Improvement” and “Communication Openness” after six months of intervention, and the improvement in the latter was also sustained after 12 months, both of which are interesting results. “Communication Openness” is a measure of whether staff freely speak up if they see something that may negatively affect a patient and if they feel free to question those with more authority than themselves [61]. This result is therefore of importance regarding the patient safety culture in the ward, as it may contribute to catching an adverse events before it reaches a patient. Regarding whether the healthcare professionals reported diverse types of adverse events in our study, the average answer was “sometimes” at all data
collection times, while the registered adverse events increased during the study period. An increase in adverse events is not desirable but may be seen as an improvement in the reporting culture. The main purpose of reporting is to learn from adverse events [62], and learning is an important part of the human factors approach to patient safety. After six months, improvements were found in organizational outcomes (in two patient safety dimensions). After the full 12 months, improvements were found in both organizational outcomes (three patient safety culture dimensions) and professional outcomes (three teamwork dimensions). The mixed model estimates demonstrated that physicians had effect on two patient safety culture measures. Furthermore, results showed that teamwork was associated with Patient Safety Grade [63]. The improvement in the HSOPS dimension “Organizational Learning – Continuous Improvement” (organizational outcome) may indicate that the healthcare professionals perceived their ward as a learning unit. This result also supports the mixed model estimate, which demonstrated that the time had an effect on “Organizational Learning & Continuous Improvement” after six months. The estimates also demonstrated that the healthcare professional’s perceptions of “Communication Openness” were affected by time (six months), which corresponds with the results from the t-test analyses, where “Communication Openness” showed significant improvements after both 6 and 12 months. The “Frequency of Events Reported” and “Patient Safety Grade” were affected by the physicians which is an interesting finding since it is often challenging to involve physicians in interprofessional interventions in wards [64]. All professions were trained together, which may have influenced the professional and organizational outcomes in a positive way. In addition to the sustained improvement in “Communication Openness”, two more dimensions of HSOPS were improved after 12 months: “Teamwork Within Unit” and “Manager’s Expectations & Actions Promoting Patient Safety”. Management and leadership are important enablers in achieving effective teamwork and patient safety in complex organizations [65], and improvement in these three dimensions of the patient safety culture may enable further work and future improvement in the other patient safety culture dimensions in the surgical ward. Our improved patient safety culture results in three dimensions of the HSOPS (organizational outcome) are in line with those from previous research in diverse hospital contexts. Two multicenter
studies found improvement in three HSOPS dimensions when measured after 12 months [66, 67], and Thomas and Galla [64] found improvements in three HSOPS dimensions after 2 years. Schwartz, Welsh [67] found a decrease from 6 to 12 months in their multicenter study, a decrease they explained with a need for early refresher training.

The professional outcome “Mutual Support” was associated with “Patient Safety Grade” at the end of the study period, which is interesting from a human factors perspective since this T-TPQ dimension encompasses items focusing on patient safety and emphasizes the strong patient safety aspect of the TeamSTEPPS program.

The use of the conceptual framework contributed to an enhanced understanding of the system approach in our study, which is important to implement and sustain innovations [68]. When implementing teamwork tools such as SBAR, Closed-loop, and Cross-monitoring [40] in the work system, the use of the tools and strategies in the clinical work processes have influenced professional outcomes indicating that the teamwork competencies of the healthcare professionals improved during the study period. Transfer of the learning from team training is crucial to patient safety and interesting from a human factors perspective, as outcomes are influenced by the learning-to-transfer pathway [69]. The improvement in organizational outcomes (patient safety culture) may be due to the TeamSTEPPS intervention in the work system (see Fig. 1). In this study, the implementation was conducted by the master trained leaders and the champions on the change team, which may have contributed to the transfer and sustainment of this human factors innovation initiative.

Study limitations
The study has some limitations. The lack of randomization and controls may have threatened the internal validity, although a pre-post design is useful where there are practical barriers to a randomized design [70]. The study samples were small, but the response rates were satisfying, without risk of response bias. Because of the uncontrolled design, we cannot conclude that the improvements were due to the intervention. There are always secular trends that might be occurring at the same time in a surgical ward, and which may have influenced our results [71]. Because of the study limitations, caution must be taken in generalizing the results.
Conclusions
This study showed the effect of a human factors team training intervention after 12 months of implementation in a surgical ward, an effect that was demonstrated by both professional and organizational outcomes in the SEIPS 2.0 model. More work needs to be done to investigate the effect of TeamSTEPPS interventions in surgical wards, and studies with larger sample sizes and stronger designs are preferred. Future studies testing the causal pathways identified by SEIPS 2.0 will be of special interest.

Abbreviations
CSACD-T Collaboration and Satisfaction with Care Decisions in Team
GLMM Generalized Linear Mixed Model
HSOPS The Hospital Survey of Patient Safety Culture Questionnaire
SBAR Situation, Background, Assessment, Request or Recommendation
SEIPS Systems Engineering Initiative for Patient Safety
TeamSTEPPS Team Strategies and Tools to Enhance Performance and Patient Safety
T-TPQ TeamSTEPPS Teamwork Perceptions Questionnaire

Declarations
Ethics approval and consent to participate
The study protocol was reviewed by the “Regional Committees for Medical Research Ethics - South East Norway” (ref. 2016/1013 C). The study was approved by the “Norwegian Center for Research Data# (ref. no. 46323), and conducted in accordance with the Helsinki Declaration [72]. Written information about the study was sent to all participants via SurveyXact with reference to the principle of autonomy addressed by confidentiality and voluntariness. Although the team training and implementation activities were compulsory during work hours, participating in the surveys was voluntary. Completion of the surveys was regarded as informed consent. For ethical reasons, we did not collect data about the non-responders.

Consent for publication
“Not applicable”
Availability of data and materials

All data generated or analyzed during this study that are not included in this published article may be found in the supplementary files.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

ORA, MLHL, SEH, and RB contributed to the conception and design and the writing and critical revision of the manuscript and approved the final version published.

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Figures

![Figure 1](image_url)

A modified SEIPS 2.0 model adapted from Holden et al. (2013). The components with the bold lines illustrate this study from a human factors system perspective. Used with permission from Richard Holden.

Supplementary Files
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