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Enhanced Surgical Safety Checklist Implementation Improves Safety Culture Among Surgical and Anesthesiology Residents: A Prospective Study in a Resource-Limited Tertiary Hospital

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Abstract

Background: The Surgical Safety Checklist (SSC) improves patient safety, but its impact on residents' perceptions of safety culture in resource-limited settings remains underexplored.

Objective: To evaluate an enhanced SSC implementation strategy, incorporating structured feedback and interdisciplinary mentorship, on safety culture perceptions among surgical and anesthesiology-intensive care residents (AIC) in a Romanian tertiary hospital.

Methods: A 6-month prospective cohort study (July–December 2024) was conducted at the Emergency Clinical Hospital of Constanta, Romania, enrolling 45 participants, including 25 general surgery residents and 20 AIC residents.

The intervention included SSC training, postoperative 3-item feedback forms, and biweekly mentorship sessions. Pre- and post-intervention Safety Attitudes Questionnaire (SAQ) scores were compared using Wilcoxon signed-rank tests; logistic regression identified predictors of improvement in perception.

Results: Of 45 residents, 42 (93%) completed the study. Teamwork climate scores increased from 67.8±11.9 to 82.9±9.5 ($p<0.001$) and safety climate from 69.5±12.1 to 81.7±10.3 ($p<0.01$). SSC compliance reached 90%. Feedback frequency was a key predictor of perception improvement (OR 2.4, 95% CI: 1.5–3.8). Limitations include the single-center design and lack of a control group or clinical outcome data.

Conclusion: An enhanced SSC strategy was associated with a significant improvement in residents' perceptions of safety culture, offering a scalable model for resource-limited settings. Multicenter studies with control groups and clinical outcomes are needed to confirm generalizability and practical impact.

The study was retrospectively registered with the ISRCTN registry (ISRCTN88241350) in accordance with WHO trial registration standards.

Introduction

Adverse surgical events contribute significantly to preventable harm globally, with communication breakdowns and poor teamwork implicated in up to 70% of cases [1]. The World Health Organization's Surgical Safety Checklist (SSC), introduced in 2009, has reduced perioperative morbidity and mortality by standardizing processes and fostering collaboration [2, 3]. However, its effectiveness depends on cultural acceptance and consistent implementation, particularly among residents who are both learners and frontline providers shaping future safety practices [4, 5].

In Romania, a transitional healthcare system faces distinct challenges, including resource constraints, inconsistent adherence to protocols, and hierarchical barriers that limit open communication in operating rooms [6, 7]. These issues are pronounced in tertiary facilities like the Emergency Clinical Hospital of Constanta, a regional referral center on Romania's Black Sea coast that provides medical

support to 655997 inhabitants and performs approximately 25 000 surgical procedures annually. This setting reflects broader Eastern European contexts, where training programs must balance clinical demands with safety education amidst limited infrastructure [6]. General surgery and AIC residents are pivotal in this ecosystem, yet their perceptions of safety tools like the SSC remain underexplored [4].

While seminal studies demonstrated the SSC's clinical efficacy [3], recent research has focused on implementation barriers and staff attitudes [5, 8]. Structured feedback and interdisciplinary mentorship have emerged as critical strategies for sustaining safety protocols [7, 9, 10]. Although studies on resident perceptions of safety culture exist [4, 9], only a few have integrated the above-mentioned improvements in resource-limited settings, making this an area ripe for innovation [8].

We hypothesized that an enhanced SSC implementation, combining structured postoperative feedback and interdisciplinary mentorship, would significantly improve residents' safety culture perceptions beyond standard checklist use. Conducted in the surgical block of the Emergency Clinical Hospital of Constanta, this study aimed to:

(1) quantify changes in Safety Attitudes Questionnaire (SAQ) scores [1],

(2) assess SSC compliance, and

(3) identify predictors of perception improvement.

Our approach offers a scalable, low-cost model for safety training in resource-constrained environments.

Methods

Study Design and Setting

A 6-month prospective cohort study was conducted from July to December 2024 in the General Surgery Department of the Emergency Clinical Hospital of Constanta, Romania, a tertiary referral center performing approximately 25 000 surgical procedures annually. The hospital's 10-bed operating theatre manages emergency and elective procedures, supported by a multidisciplinary team of surgeons, anesthesiologists, and nursing staff.

Participants

All general surgery (n = 25) and AIC residents (n = 20) rotating through the surgical block during the study period were eligible. Exclusion criteria included prior formal SSC training or fewer than 10 operating theatre shifts. Participants provided written informed consent. The study was approved by the Ethics Committee of the Emergency Clinical Hospital of Constanta (Approval No. 113/2024) and adhered to the Declaration of Helsinki.

Intervention

The World Health Organization's Surgical Safety Checklist (SSC) was adapted for local use (translated into Romanian, adjusted for workflow) [2]. The intervention comprised three components:

- **Training**: A 2-hour interactive session introduced the SSC's rationale, item-by-item completion, and case-based scenarios (e.g., emergency laparotomy). Role-playing simulated checklist use under time pressure, facilitated by senior surgeons and anesthesiologists.
- **Structured Feedback**: Post-procedure, residents completed a 3-item anonymous feedback form within 10 minutes ("How did SSC help?", "What barriers did you face?", "Suggestions for improvement?") to encourage reflection and identify implementation challenges. Forms were collected in a secure box and summarized weekly by a study coordinator.
- **Mentorship**: Biweekly 30-minute sessions paired residents with senior surgeons and anesthesiologists to discuss SSC integration, interdisciplinary communication, and barrier resolution. Mentors followed a 5-point structured guide (Supplementary Material S1) emphasizing practical examples.

Compliance was monitored via monthly audit logs reviewed by the study coordinator. To explore the intervention's specific effect, a sensitivity analysis compared residents with high (≥ 80%) versus low (< 80%) feedback form completion rates.

Outcome Measures

The primary outcome was change in safety culture perceptions, measured using the Safety Attitudes Questionnaire (SAQ), a 36-item validated tool assessing six domains: teamwork climate, safety climate, job satisfaction, stress recognition, perceptions of management, and working conditions [1]. Scores range from 0 to 100, with higher scores indicating improved perceptions. The Romanian SAQ version was pre-validated in a pilot with 10 staff to ensure cultural appropriateness. SAQ was administered at baseline and 6 months post-intervention. Perception improvement was defined as a ≥ 10-point increase in teamwork or safety climate scores, based on prior evidence of clinical relevance [1]. Starting from lower baseline scores proven in transitional healthcare systems, a 10-point increase on the SAQ scale was considered as a realistic and ambitious target for our 6-month intervention. In addition, this threshold is consistent with previous longitudinal studies admitting that a 5–10 points shift is both statistically and clinically significant and reflects a considerable improvement in safety culture [1].

Secondary outcomes included SSC compliance rates (percentage of procedures with completed checklists).

Data Collection and Analysis

Open-ended feedback form responses were analyzed using inductive thematic coding by two independent researchers, with themes quantified (e.g., percentage citing time constraints) and inter-rater reliability assessed (Cohen's kappa). SAQ data were analyzed using SPSS v.27. Shapiro-Wilk tests confirmed non-normal distribution, prompting Wilcoxon signed-rank tests to compare pre- and post-intervention SAQ scores.

Multivariable logistic regression identified predictors of perception improvement (e.g., feedback frequency [number of forms completed], training year, specialty), reported as odds ratios (OR) with 95% confidence intervals (CI). For multivariable logistic regression analysis, variables selection was performed according to purposeful selection process. Thus, candidate predictors were screened through univariate analysis and those demonstrating p□0.02 were entered into the multivariable model. The final model keeps only those variables with p□0.05 by a backward elimination procedure. Multicollinearity diagnostics were necessary to ensure the stability of the regression coefficients. On this line, Variance Inflating Factor (VIF) was calculated for all independent variables and the obtained values ranging from 1.1 to 1.8, (below the threshold of 2.5) emphasize lack of significant multicollinearity issues that could bias the model's stability.

Model fit was evaluated using the Hosmer-Lemeshow test and pseudo-R^2. A p-value < 0.05 was considered significant.

The sample size calculation was based on an expected mean improvement of SAQ score of 10 points and an estimated standard deviation of 15 points, as of similar studies in academic hospitals [3]. According to these parameters, a minimum of 38 participants was required to achieve 80% statistical power with significant difference of 0.05. Finally, we enrolled 45 participants, considering a potential 15–20% attrition rate. Considering the number of 42 responders and the objective improvement of 15.1 points in teamwork, the calculated post-hoc power of more than 95% proves the value of the findings.

A sensitivity analysis assessed the intervention's effect by comparing SAQ score changes between high- and low-feedback groups.

Results

Participants

Of 45 eligible residents, 42 (93%) completed the study, including 23 general surgery and 19 AIC residents. The mean age was 28.4±2.1 years, 55% were female, and the median training year was 3 (range: 1–5). Three residents dropped out due to insufficient shifts (<10). Baseline characteristics were balanced across specialties and training years (Table 1, Figure 1). No significant differences were observed in age (p=0.51), gender (p=0.79), or training year (p=0.33).

SAQ Outcomes

At baseline, mean Safety Attitudes Questionnaire (SAQ) scores for teamwork climate and safety climate were 67.8±11.9 and 69.5±12.1, respectively, with no specialty differences (p=0.41). Post-intervention, teamwork climate scores increased to 82.9±9.5 (+15.1 points, p<0.001) and safety climate to 81.7±10.3 (+12.2 points, p<0.01) (Table 2, Figure 2). Other domains showed modest improvements: job satisfaction (+7.2 points, p=0.03) and perceptions of management (+6.8 points, p=0.04). Surgical residents exhibited slightly greater gains in teamwork climate (+16.2 vs. +13.8 points, p=0.06), while AIC residents led in safety climate (+13.1 vs. +11.2 points, p=0.09). Senior residents (years 3–5) outperformed juniors (years 1–2) in teamwork climate (+16.8 vs. +12.1 points, p=0.04). The study achieved 92% power for teamwork climate and 87% for safety climate, confirming adequate power for primary outcomes.

Compliance

SSC completion rose from 62% at baseline to 90% by month 6, with monthly increments tracked (Figure 3). Compliance plateaued at 88–90% from month 4, indicating rapid adoption. The feedback form (Supplementary material S2) return rate was 85% (714/840 procedures), with consistent participation across specialties (surgical: 86%, AIC: 84%, p=0.72).

Predictors of Perception Improvement

Multivariable logistic regression identified feedback frequency (number of forms completed, mean: 17±4 per resident) as the strongest predictor of perception improvement (≥10-point SAQ increase) (OR 2.4, 95% CI: 1.5–3.8, p<0.01), followed by training year (OR 1.9, 95% CI: 1.2–3.1, p=0.02), (Table 3). The model showed adequate fit to the data (Hosmer-Lemeshow p=0.62) and accounted for 28% of the variance in perception improvement (pseudo-R^2=0.28).

Sensitivity Analysis

To address the absence of a control group, a sensitivity analysis compared residents with high (≥80%, n=30) versus low (<80%, n=12) feedback form completion rates. The high-feedback group exhibited greater SAQ improvements in teamwork climate (+16.5 vs. +10.2 points, p=0.03) and safety climate (+13.4 vs. +9.1 points, p=0.05), supporting the intervention's specific effect.

Qualitative Insights

Feedback form responses (n=714) were analyzed via inductive thematic coding (inter-rater reliability: Cohen's kappa=0.90). Key themes included improved role clarity (65%), reduced hierarchy (45%), enhanced communication (38%), and time constraints (28%) (Supplementary Material S3). Initial barriers included checklist fatigue (15%), which decreased to 4% by month 3, suggesting adaptation. Representative quotes highlighted practical benefits: "SSC clarified roles during emergencies" and "Mentors made me feel heard."

Discussion

Our enhanced Surgical Safety Checklist (SSC) implementation, integrating structured feedback and interdisciplinary mentorship, significantly improved safety culture perceptions among general surgery and AIC residents at the Emergency Clinical Hospital of Constanta. The observed improvements in teamwork climate (+ 15.1 points) and safety climate (+ 12.2 points) on the Safety Attitudes Questionnaire (SAQ) surpass those reported in standard SSC studies (typically + 5–10 points) [5, 8], underscoring the efficacy of our tailored approach. The 90% SSC compliance rate, exceeding global averages of 75–80% [8], further highlights the intervention's impact in a resource-limited setting.

Structured feedback was likely a key driver, fostering a reflective learning cycle consistent with evidence on debriefing's role in surgical safety [9]. Residents' ability to anonymously report barriers (e.g., time constraints in 28% of feedback responses) and propose solutions (e.g., "Add a pause for equipment checks") enhanced ownership and team accountability, as evidenced by the 85% feedback form return rate. Interdisciplinary mentorship mitigated hierarchical barriers, a persistent challenge in operating rooms [9]. By pairing surgical and AIC residents with dual-specialty mentors, the intervention reduced perceived seniority gaps, with 45% of feedback citing "reduced hierarchy" (e.g., "Mentors made me feel heard"). This aligns with calls for cross-specialty collaboration to strengthen safety culture [7, 10].

Senior residents (years 3–5) showed greater improvements (+ 16.8 vs. +12.1 points in teamwork climate, $p = 0.04$), likely due to their contextual understanding of safety risks, which amplified receptivity to structured interventions. Specialty differences—surgical residents excelling in teamwork (+ 16.2 vs. +13.8 points, $p = 0.06$) and AIC residents in safety climate (+ 13.1 vs. +11.2 points, $p = 0.09$)—may reflect distinct professional priorities (procedure focus vs. patient monitoring), warranting further exploration [4]. The low-cost model (feedback forms, mentor time) offers scalability for resource-constrained settings, where training programs can adopt our three-phase approach—education, reflection, mentorship—to embed SSC into curricula [6].

Compared to other studies, our 90% compliance rate outperforms reports from low- and middle-income settings, such as Palestine (71.1% adherence, 33% completion) [11], and aligns with high-resource contexts, like France (90.2% compliance, 61% completion) [11]. This suggests that our intervention bridged gaps between policy and practice, a critical need in Romania's evolving safety culture [6]. The decrease in reported checklist fatigue—defined as repetitive task overload—from 15% in month 1 to 4% by month 3 indicates successful adaptation, likely driven by mentorship and feedback loops [5].

The independence of feedback frequency as a predictor, regardless its conceptual link to mentorship, was confirmed by low VIF, thus suggesting that while mentorship provides the professional framework, the frequent feedback on checklist compliance is the main agent of behavioral change.

Limitations

Several limitations must be acknowledged. The absence of a control group hinders causal inferences, as improvements may stem from external factors, such as residency experience or concurrent safety initiatives [5].

The use of historical control was unfeasible in the context of Emergency Clinical Hospital of Constanta. The gap of standardized data collection before the implementation of SSC led to the lack of a reliable historical baseline to compare to the newly obtained results. Considering the stepped-wedge design, with only 45 participants enrolled in the study and 42 completers, there were not enough distinct „clusters" to divide into different timing steps without losing statistical power. On the other hand, it would be impossible to prevent residents in the control step from learning about SSC after seeing their peers use it, fact that would bias the results. However, alternative designs, such as historical controls or cluster randomization, could strengthen future studies.

A sensitivity analysis comparing high- versus low-feedback residents (≥ 80% vs. <80% form completion) showed greater SAQ gains in the high-feedback group (+ 16.5 vs. +10.2 points, p = 0.03), supporting the intervention's specific effect. The single-center design limits generalizability, as Constanta's context – 25 000 annual procedures, resource constraints, and pronounced hierarchical dynamics—differs from urban or high-resource settings (e.g., Western European hospitals with advanced infrastructure) [9]. Multicenter validation is needed to test scalability across diverse contexts. The small sample size (n = 42 completers) constrained subgroup analyses (e.g., surgical vs. AIC, junior vs. senior), though the study achieved 92% power for teamwork climate and 87% for safety climate, confirming adequacy for primary outcomes. The reliance on self-reported SAQ scores, while mitigated by the tool's psychometric robustness [1], lacks correlation with clinical outcomes, such as adverse event rates or readmissions [10]. Pilot data on near-miss events (Supplementary Material S4) suggest a potential link to safety improvements, but larger studies are needed. Finally, feedback responses may be influenced by social desirability bias, despite anonymity measures (secure box, anonymized summaries). Thematic coding with high inter-rater reliability (Cohen's kappa = 0.90) enhanced the qualitative analysis's rigor (Supplementary Material S3).

Future Directions

Future research should incorporate control groups and multicenter designs to validate the intervention's efficacy and generalizability. Measuring clinical outcomes (e.g., surgical site infections, mortality) alongside SAQ scores would clarify the intervention's practical impact, as prior studies link improved teamwork to reduced errors [1, 10].

Longitudinal studies could assess the sustainability of perception changes and compliance beyond 6 months. Exploring specialty-specific responses and integrating technology (e.g., digital feedback platforms) may further enhance the model's applicability. In Romania, where safety culture is evolving, this approach could inform national training curricula to standardize safety practices [8].

Conclusions

Our findings suggest that an enhanced Surgical Safety Checklist (SSC) implementation, combining structured feedback and interdisciplinary mentorship, would be associated with significantly improved safety culture perceptions among general surgery and AIC residents. The 15.1-point increase in

teamwork climate and 12.2-point increase in safety climate scores, coupled with a 90% SSC compliance rate, surpass typical SSC outcomes [8]. This low-cost, scalable model is particularly suited for resource-limited settings, offering a blueprint for integrating safety protocols into residency training. By fostering reflection and interdisciplinary collaboration, the intervention seems to be a valuable tool for overcoming educational and practical gaps in Romania's evolving safety culture. However, the single-center design and lack of clinical outcome data necessitate multicenter studies with control groups to validate generalizability and clinical impact. These findings underscore the potential of tailored strategies to enhance patient safety, with implications for training programs and policy in Romania and beyond.

Declarations

Ethics approval and consent to participate

The study was approved by the Ethics Committee of the Emergency Clinical Hospital of Constanta, Romania (Approval No. 113/2024). All participants provided written informed consent prior to participation. The study was conducted in accordance with the Declaration of Helsinki.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

IC and VG conceptualized and designed the study. IC, VG, and RP developed the methodology and supervised the intervention implementation. NL and IP contributed to data collection and management. AC and DOC performed the statistical analysis and contributed to data interpretation. VG and AS provided senior supervision. IC drafted the initial manuscript. VG, RP, NL, IP, AC, DOC, and AS critically revised the manuscript for important intellectual content. VG is the corresponding author. All authors read and approved the final manuscript.

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Tables

Table 1. Baseline Participant Characteristics

Variable	Surgical Residents (n=23)	AIC Residents (n=19)	p-value
Age (years, mean±SD)	28.6±2.0	28.2±2.2	0.51
Female (%)	56.5	52.6	0.79
Training Year (median range)	3 (1–5)	2 (1–5)	0.33

Note: p-values derived from t-tests (age), chi-square tests (gender), and Mann-Whitney U tests (training year).

Table 2. Pre- and Post-Intervention SAQ Scores

Domain	Pre (Mean±SD)	Post (Mean±SD)	Change	p-value
Teamwork Climate	67.8±11.9	82.9±9.5	+15.1	<0.001
Safety Climate	69.5±12.1	81.7±10.3	+12.2	<0.01
Job Satisfaction	71.2±10.8	78.4±9.9	+7.2	0.03
Perceptions of Management	65.4±12.3	72.2±11.1	+6.8	0.04

Note: p-values derived from Wilcoxon signed-rank tests.

Table 3. Multivariable regression analysis of predictors for SAQ score improvement

Variable	Odds ratio (OR)	95%CI	p-value	VIF
Feedback frequency	2.4	[1.5-3.8]	< 0.01	1.08
Training year	1.9	[1.2-3.1]	0.02	1.08

Figures

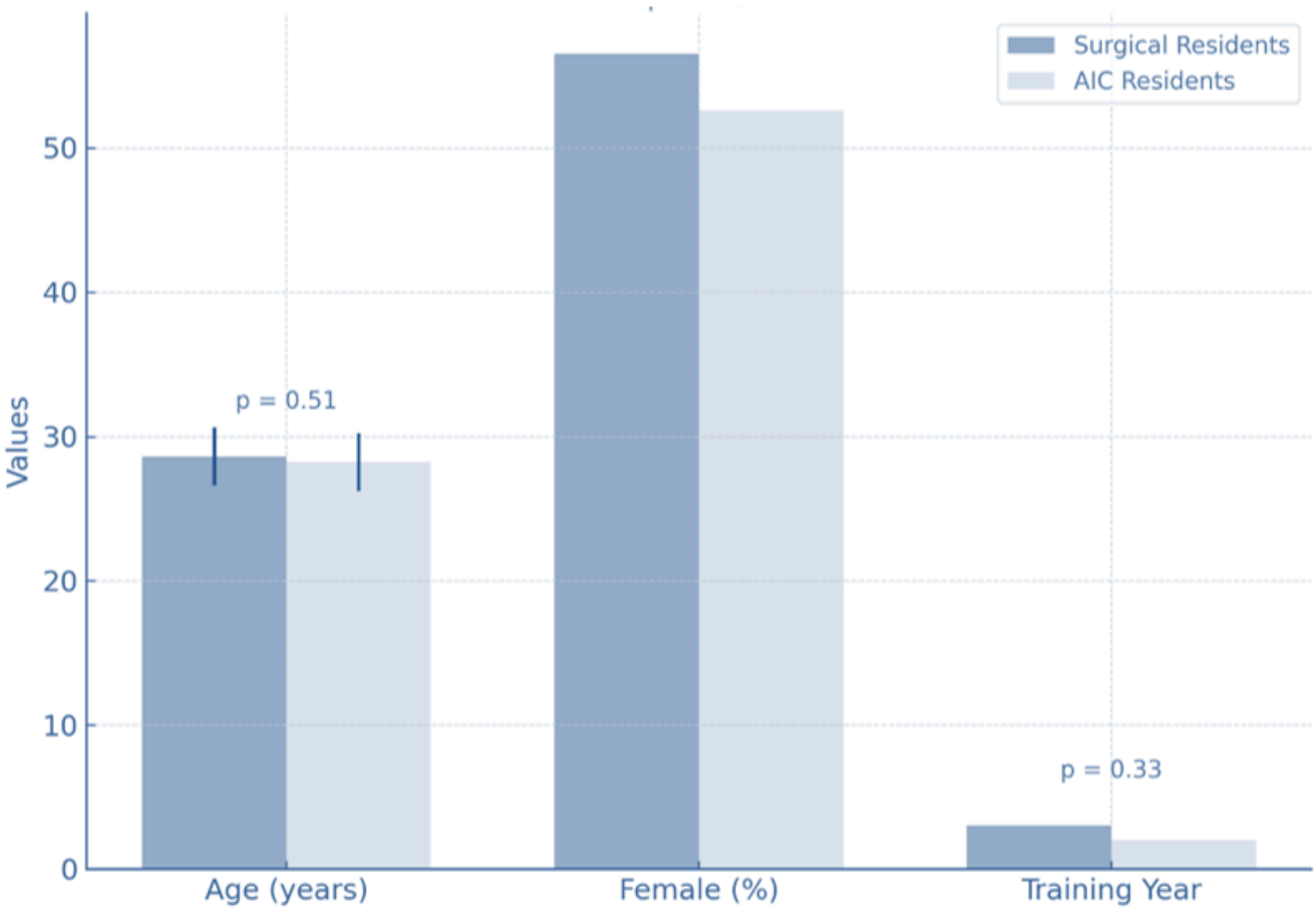


Figure 1

Baseline Participant Characteristics

Figure 1 shows the distribution of age, gender, and training year across surgical and AIC residents, confirming baseline balance ($p>0.33$ for all variables).

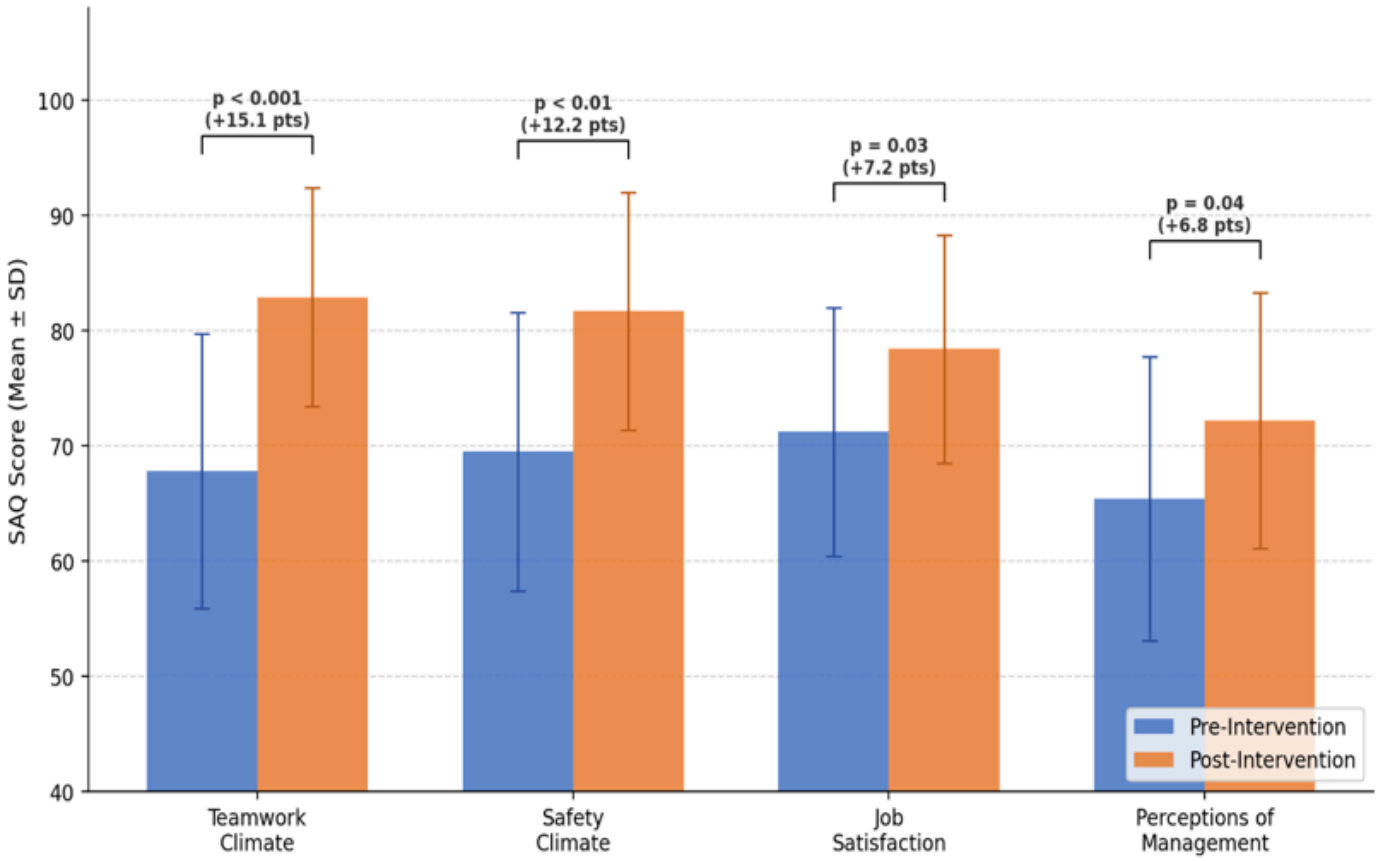


Figure 2

Pre- and Post-Intervention SAQ Scores by Domain

Figure 2 illustrates the significant increase in all SAQ domains post-intervention, with teamwork climate (+15.1 points, $p < 0.001$) and safety climate (+12.2 points, $p < 0.01$) showing the greatest improvements. Error bars represent standard deviations. Significance brackets with p-values and point changes are shown for each domain. For the SSC compliance trajectory, see Figure 3.

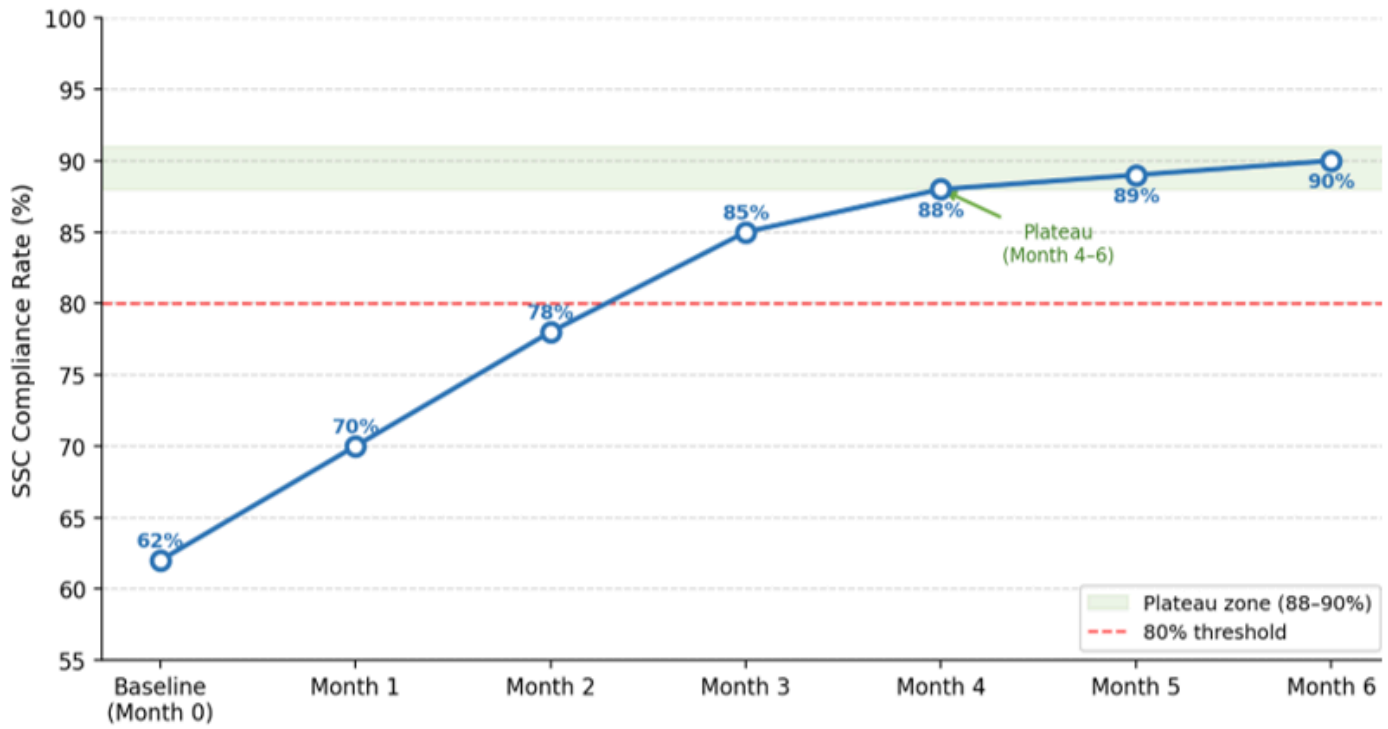


Figure 3

Monthly SSC Compliance Rates Over the 6-Month Study Period
Figure 3 shows the progressive increase in SSC compliance from 62% at baseline to 90% by month 6, with a plateau at 88–90% from month 4 onward. The dashed red line indicates the 80% threshold, surpassed by month 2.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SupplementaryMaterials.docx