

Systematic Review

Improving surgical outcomes through non-technical skills: the case for better training and national evaluation

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ABSTRACT

Effective communication and teamwork are as crucial as technical proficiency for achieving positive surgical outcomes. Non-technical skills (NTS)-including communication, leadership, decision-making, and situational awareness—enhance surgical performance by fostering awareness and capability among both trainees and experienced surgeons. Despite growing recognition of its importance, NTS training is not uniformly implemented in surgical education, leaving a significant gap. This study examines opportunities to expand NTS training within surgical practice. A survey at a local hospital assessed the availability of NTS training and perceived needs among 38 surgical trainees and professionals. The majority acknowledged the value of NTS in improving clinical performance but reported limited focus on human factors in daily practice. Complementing the survey, a literature review was conducted across Medline, EMBASE, and PsycINFO databases, identifying 414 relevant articles, 114 of which focused on clinical or educational contexts. Of these, 61 studies emphasized psychomotor skill assessment via direct observation, patient outcomes, and peer feedback, underscoring the critical role of effective evaluation methods. Findings indicate that while NTS training is appreciated, its effectiveness depends heavily on feedback quality and team dynamics, particularly in addressing challenging behaviors. The study highlights the need for enhanced training design and robust feedback mechanisms. Although current evidence linking NTS training to improved patient outcomes is largely anecdotal, there is strong professional support for broader implementation. The authors advocate for a systematic, nationwide evaluation to determine the true impact of NTS training on surgical performance and outcomes.

Keywords: Non-technical skills, Surgeon training, Communication, Leadership, Decision-making

INTRODUCTION

Acknowledging that human errors are inevitable in healthcare, particularly in the context of surgery, has driven efforts to minimize avoidable harm.¹ It's increasingly recognized that communication breakdowns and poor teamwork, rather than a lack of technical skill, are often at the root of clinical incidents and "NEVER events".² Research suggests that 5-10% of adverse events in surgical settings are preventable.³ The recognition that non-technical skill failures frequently lead to accidents has spurred the development of behavioural marker systems,

originally created for pilots (NOTECHS) and later adapted to other fields, including medicine.^{4,5} Although identifying core non-technical skills allows for structured competence assessments by surgeons, these assessments have not consistently translated into better clinical outcomes.⁶ This may be partly due to the small scale of the studies conducted, often involving fewer than 1500 patients.³ Despite the lack of a validated tool for assessing the impact of human-factors training on patient safety, there is still evidence to suggest its effectiveness. Feedback from surgeons, simulation training, and lessons from other industries all indicate that human-factors training can

contribute to safer patient care.⁷ This training covers important principles such as role clarity, effective communication, resource management, and situational awareness, all of which are critical for maintaining patient safety. Some training scenarios even include deliberate negative behaviour to enhance the authenticity and applicability of the lessons learned.⁷

In the UK, non-technical skills training has been incorporated into the intercollegiate surgical curriculum programme (ISCP), with work-based assessments designed to reduce clinical errors and adverse events. This study aims to explore the effect of non-technical skills training on surgical outcomes and to develop strategies for effectively implementing this training in local practice to improve surgical safety.

METHODS

Eligible studies were searched on Medline, EMBASE, and PsycINFO databases using the algorithm (exp non-technical skills training/ human factors or machine and Surgery and/or Surgeons and/or Training and outcomes and/or effectiveness) or derivatives thereafter by an experienced librarian in May 2023 (Supplementary Tables). The search was to identify articles in the last 30 years published in English. The studies were assessed at each stage including title, abstract and full text screening using the following criteria and the reasons for exclusion were recorded systematically (e.g., 'non-surgery related').

Two researchers participated in both titles, abstract and full-text screening stages (GS, NA), and where there was uncertainty in study eligibility, a consensus decision was made by at least two screeners. Endnote captured and managed the references at each stage of screening. The researchers (GS, NA) extracted the study design, intervention characteristics and details of outcomes assessed with an assessment of effectiveness and impact on surgical performance including avoidance of adverse events. The results were grouped into themes using a narrative synthesis method. The effectiveness of non-technical skills training was assessed by referencing them against the ACGME standards.^{8,9}

Assessing the impact of non-technical or human factors training within local hospitals

The survey was designed following principles outline by Glasgow 2005. It was predicted that non-technical skills training within the trust as part of formal education sessions within surgical training would improve behaviours and enable improved teamworking, safety and ultimately patient outcomes.¹⁰ An iterative process was undertaken both with trainers and trainees to develop sensitive enough questions that reflected the scope of lived experience, and this was scored using Likert scales to develop a rating of perceived human factors training. Descriptors were coded to identify themes to underpin learning for surgeons that would enhance surgical training.

A narrative synthesis methodology identifying themes that would facilitate the effective introduction of non-technical skills training and improve performance.

RESULTS

There was a total of 19 responses from a survey sent to 140 participants working within surgery a response rate close to 14% with only 2 not having undergone any form of non-technical skills training. Notably, varying degrees of training were observed across different skill domains, with leadership, communication, and team working skills being more commonly addressed in the training packages received (Figure 1).

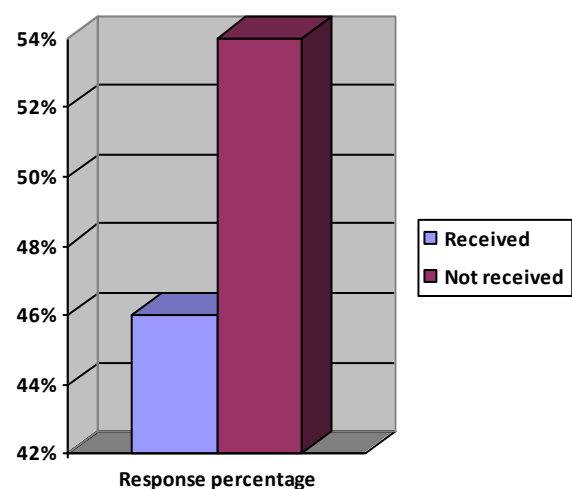


Figure 1: The results of participants who received NTS training.

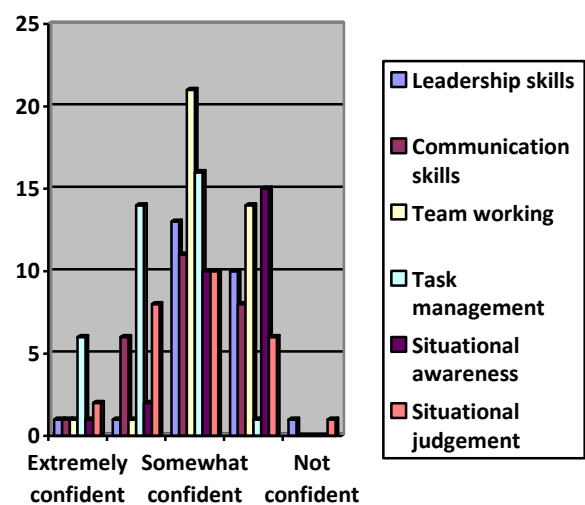


Figure 2: Self assessed proficiency by candidates based on confidence

Table 1: The search criteria for study.

Criteria	Inclusion	Exclusion
Population	Surgeons / Surgical Trainees / Anaesthetists (for triangulation)	Medical Specialties including Emergency Departments (although references were screened)
Intervention	Non-technical skills training	Technical training
Environment	Accessible either in hospital, or clinic or simulation	Outside the hospital or clinical environments simulated or real
Outcomes	Reported on outcomes related to surgical outcomes or results of surgery	No outcome data
Design	Reviews, randomised trials, and single cases	Did not report empirical data
Published	Papers published up until November 2022 from 1992 in English.	Not in English

Table 2: The results of type of NTS training received.

NTS skills	%
Leadership skills	21.3
Communication skills	19.7
Team working	8.5
Task management	6.5
Situational awareness	8.5
Situational judgement	8.5
Resource awareness and utilization	8.5
Other	8.5

Self-rating of skills

Respondents self-assessed their proficiency across diverse non-technical skills using a categorical scale ranging from extreme confidence to not at all confident (Figure 2). Communication, leadership, and task management skills seem to be the easiest to improve from the respondent's perspective. In contrast resource awareness, utilisation and situational judgement and leadership ranked more poorly. Situational awareness being somewhat in the middle in respondents perceived confidence of performance. Only 13% of respondents perceived the existing level of non-technical skills training within the National Health Service (NHS) as adequate within the surveyed sample. Non-

technical skills training centres around communication skills training and some simulation-based training. Qualitative data analysis revealed numerous improvement suggestions, including the incorporation of the wider multidisciplinary team (MDT) into training for enhanced communication, advocating for simulation-based training to improve current proficiencies, recommending regular or mandatory sessions in these topics –further highlighting its importance, and proposing this training as an addition to the core surgical training syllabus.

These findings underscore the current variability in training experience and self-rated competency across non-technical skill domains within the medical professional cohort surveyed, indicating several areas for potential improvement in training initiatives and program development.

DISCUSSION

Overview of research on non-technical skills

The literature search identified 1,614 articles related to non-technical skills (NTS). After reviewing the abstracts, 114 were found relevant to clinical practice or the performance of surgical trainees. Of these, 61 studies evaluated psychomotor skills through direct observation of surgeons and trainees, assessing performance outcomes. The remaining 53 studies were excluded as they focused on assessment tools for trainees without evaluating or detailing trainee performance. Only 31 of the papers provided sufficient data to be assessed according to the ACGME standards. A thematic analysis was conducted on those studies with outcome data relevant to surgical trainees' performance.

Enhancing clinical outcomes through non-technical skills training and assessment

National data on hospital clinical outcomes for surgical consultants, such as broad revision rates and mortality, are not always accurate indicators of clinical competence due to the many variables involved.¹¹ Although superior technical performance can improve patient outcomes, measuring or enhancing these skills in the operating theatre presents challenges.¹² The challenge is to enhance performance in these complex environments, which necessitates not only technical competence but also strong NTS.

Human factors training programs have proven reliable and valid when teaching NTS to surgical trainees in simulated environments.^{13,14} Trainee surgeons appreciate NTS training for its ability to enhance practical skills and boost confidence.¹⁵ The Department of health (DoH) has emphasized the importance of simulated human factors training in developing the essential skills for safe and effective patient care.⁷ Constructive feedback using NOTECHS observation tools has been applied in clinical settings for anesthetists, nurses, and surgeons in the

operating theatre.¹⁵ Some assessment systems have been adapted to provide more fluid formative feedback, as seen in delivery suites.¹⁶ The NOTSS tool has been piloted for surgical trainees and trainers since March last year as part of the intercollegiate surgical core programme (ISCP).

In one study, orthopaedic surgeons scored higher in NTS compared to plastic surgeons, although it was unclear whether this was due to the tool design, the procedure, or team dynamics.¹⁷ However, the variation in scores may be less significant than the learning outcomes. Feedback for underperformers does not always lead to behavioural changes, while capable surgeons and good team workers often anticipate problems and do not require feedback to achieve good surgical outcomes.^{18,19} Although NTS tools can differentiate between novice and expert clinicians, technically proficient clinicians do not always excel in communication and NTS.²⁰ Surgeon attitudes can influence outcomes and are linked to reoperation and readmission rates; modifying these attitudes can improve healthcare delivery.²¹ Including patient feedback can enhance the impact of suggestions and improve surgical performance and outcomes.²² NTS training has yielded unexpected benefits, such as the identification by student and trainee observers of the impact of minor interruptions on surgeons' performance in the operating theatre.²³ Implementing a "sterile cockpit" approach, similar to aviation, helps ensure safety by reducing interruptions and allowing surgeons to focus.²⁴ Staff attitude surveys show behavioural changes among those who work in the theatre following human factors training.²⁵ Team organization may have a more significant impact than individual performance.²⁶

However, measuring improvements from training is challenging due to other changes in routine surgical practice, such as the introduction of the World Health Organization (WHO) checklist. Teams with strong compliance to the WHO checklist and good teamwork skills have shown reduced morbidity and mortality, and high WHO compliance correlates with higher Oxford NOTECHS II scores.^{17,27} Crisis Resource Management (CRM) training has led to significant reductions in mortality ratios in healthcare facilities.²⁸ Improvements in attitudes and skills have been observed, aligning with psychomotor skill assessment levels, and similar results were found in the articles reviewed for NTS. However, changing behaviour is difficult and may require more time and cultural shifts.⁸

Effectiveness of non-technical skills assessment tools

NTS tools differ across specialties, with some integrating technical skill assessments to create hybrid tools, such as the CARDIOTEAM measure for resuscitation, which enhances relevance and focus.²⁹ However, this approach slightly diverges from the primary goal of improving human and non-technical skills. Modifications often reflect the increased complexity within specific clinical areas, such as minimal versus open access surgery, with

the former involving more complex equipment and the latter potentially leading to more human error.³⁰ Exploratory factor analysis of tools used in various workplace environments, such as the emergency department (TEAM), revealed that the "teamwork domain" accounts for most variability (63-80%) and may be the most valuable aspect of assessment, helping surgeons focus on specific skills that need improvement.³¹ Effective communication is essential for team function and is a core component of all non-technical skills.³² While communication techniques are taught at the undergraduate level, human factors training for formative assessment of postgraduate teams has only emerged in the past two decades.^{33,34}

Implementing non-technical skills training in the workplace

In Canada, a competency framework for resident's outlines NTS and technical skills using the objective structured assessment of technical skills (OSATS) to ensure that residents overall development as develop as skilled communicators, collaborators, and professionals early in their training.^{35,36} Human factors training enhances both technical and NTS competencies, although the relationship between the two is complex.³⁷ Various factors, such as experience and team familiarity, influence both competencies. Shared objectives and communication systems are crucial for improving performance.^{16,27,38} A shared mental model and standardized communication can lead to better outcomes.³⁹ Effective error management is achieved by maintaining open communication and cross-checking or actively monitoring each other.⁴⁰

Assessment and training are challenging to incorporate into regular surgical practices due to the constantly changing clinical situations and available resources, which create heterogeneity and complicate the assessment of interventions.⁴¹ The difficulty of a case is not fixed, and a trainee surgeon's opportunity to demonstrate leadership may be limited if the consultant takes over for clinical reasons or if other clinical commitments cause distractions.^{20,42} Communication is complex, as are the motivations of those involved, and both are influenced by chance factors.⁴³ However, observation and debriefing are encouraged at the end of each theatre list as part of the WHO checklist in many trusts.⁴⁴ This provides an opportunity for structured feedback from trained observers in the theatre, delivered in a non-confrontational manner during a hot debrief.⁴⁵ Only 9% of lists run longer when NTS training is implemented, so the impact on work efficiency is minimal.²⁰ More significant behaviour may require a cold debrief in a different setting.⁴⁶ Accurate observation in the theatre, coupled with the ability to provide meaningful structured feedback, requires skill.⁴⁷

Assessment outcomes can vary depending on the experience of the assessors, with novices often scoring more conservatively than experts. Thus, practice and calibration are needed to ensure reliability and accuracy.⁴⁸

The introduction of NTS assessment can generate a "Hawthorne effect," where teams may respond positively to being observed, which could limit the impact of the training itself.⁴⁹ The effectiveness of observers depends on how they integrate into the environment, as they can be perceived as a threat or may feel threatened themselves, leading to leniency.^{20,50} Assessors may be hesitant to challenge and could exhibit a halo effect when observing experts.⁵¹

The survey results indicate that while non-technical skills (NTS) training has become an integral part of surgical education, current programs do not comprehensively address all aspects of NTS. Enhancing situational awareness and judgment plays a key role in preventing communication breakdowns, which can lead to adverse events.⁷ For example, a study in Oxford found a significant negative correlation between the number of technical errors during laparoscopic cholecystectomy and the NTS performance score for team situational awareness ($p=0.009$).⁵² The strongest correlation was observed between technical errors and the situational awareness score of the surgical sub-team ($p<0.001$), indicating that despite being separate skill sets, technical and non-technical abilities are interconnected. This suggests that human factors training should be integrated with surgical skills training for surgeons. Moreover, reliable assessment of NTS cannot be performed solely by surgeons themselves and each surgical discipline requires tailored training, though it remains unclear whether all units implement this effectively.^{17,53} For example, applying NTS principles to a level one trauma unit may differ from their application in a level three unit that primarily handles elective surgeries.

Surgical trainees generally value NTS training, with over 90% reporting that it enhances their practice and self-confidence.⁷ Studies have shown that trainees at various experience levels demonstrate improvements in both technical skills and NTS with increased training exposure.²⁰ Non-technical skills training, by improving situational awareness, has been associated with a reduction in procedural errors.³⁷ According to cognitive load theory, as expertise develops, individuals create schemas that help them recognize and respond to specific situations, thereby freeing cognitive resources for more complex tasks.³⁷

However, there are concerns about the reliability of the assessment tools used for evaluating NTS, as different studies often modify the domains of these tools. For instance, adding "empathy and sensitivity" as a domain in an NTS tool used in anesthesiology did not improve the tool's ability to differentiate between trainees.⁵⁴ While the flexibility of these tools allows for better feedback, it complicates analysis due to the variability in data. There is a risk that modifying these tools for different environments could compromise their validity, especially for infrequently observed skills like decision-making in routine surgery. Furthermore, the introduction of NTS assessment can create a "Hawthorne effect," where teams

may perform better simply because they are being observed, making it difficult to discern whether improved teamwork is a result of the training itself or the observation process.⁴⁹ Observers may also be seen as a threat, potentially influencing team dynamics, or they may exhibit leniency, particularly when evaluating experts.^{20,50}

Training outside of the traditional classroom or simulator environment has not always been found to be effective, though trainees often perceive it as more realistic.^{55,56} Accurately observing cognitive skills like situational awareness and decision-making is challenging, as these are often inferred from behaviour rather than directly observed.²⁷ Communication can also be an issue, particularly between scrub nurses and surgeons, as nurses often need to make suggestions subtly, while surgeons can become overly focused on the procedure, leading to "inattention blindness".²⁷ The frequency and proficiency of demonstrating observable skills in both technical and non-technical areas can be procedure-specific or influenced by team composition. Detecting patient deterioration, for example, relies on situational awareness, and assertiveness may be necessary to refocus the surgical team's attention.⁵⁷

Since surgeons are still more likely to receive complaints compared to other healthcare professionals, there is a need to develop a standardized set of principles and behaviour for NTS to minimize errors and improve outcomes.⁵⁸ Basic NTS theory should be taught in classrooms or lectures, followed by simulation training and workplace observations.¹⁸ Poor behaviour must be identified and addressed through re-training or performance management pathways.⁴⁶ Structured feedback is crucial for guiding struggling trainees, and NTS assessments have proven effective in this regard.⁵⁹ In some cases, poorly performing teams may require external training.⁶⁰ It is essential that assessors are well-trained to deliver NTS effectively across different clinical areas, but resources to support this are currently lacking. A coordinated strategy for enhancing NTS training is needed at both national and local levels within the UK.

The involvement of two assessors improves the validity of NTS observations, and several training scenarios are required to ensure effective learning. However, this process can be costly, requiring a large faculty to facilitate.² Observers without clinical backgrounds must not only acquire technical knowledge but also be prepared to witness adverse events.¹⁴ While employing less expensive trainers may be possible, it could require a significant lead-in time. It is recommended that trusts adopt a strategic approach to building effective teams, as opposed to allowing teams to evolve naturally, to ensure better communication and outcomes.

CONCLUSION

To facilitate effective NTS training, improvements in feedback mechanisms and a carefully structured training

design are needed. While improved patient outcomes from NTS training are largely anecdotal at present, a systematic national study is required to evaluate its impact on surgical outcomes. Surgeons generally perceive this type of training as beneficial and effective.

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