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CLINICAL PRACTICE

Improving patient safety in the operating theatre and perioperative care: obstacles, interventions, and priorities for accelerating progress

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Editor's key points

- Human factors are major contributors to errors in healthcare that can impact patient safety.
- Improvements in the safety and outcomes of hospitalized patients have been slower than expected.
- Healthcare team-based approaches, including simulation, standardization, and training, could further improve patient safety.

Summary. The publication of *To Err Is Human* in the USA and *An Organisation with a Memory* in the UK more than a decade ago put patient safety firmly on the clinical and policy agenda. To date, however, progress in improving safety and outcomes of hospitalized patients has been slower than the authors of these reports had envisaged. Here, we first review and analyse some of the reasons for the lack of evident progress in improving patient safety across healthcare specialities. We then focus on what we believe is a critical part of the healthcare system that can contribute to safety but also to error—healthcare teams. Finally, we review team training interventions and tools available for the assessment and improvement of team performance and we offer recommendations based on the existing evidence-base that have potential to improve patient safety and outcomes in the coming decade.

Keywords: communication; education; healthcare quality; healthcare team; leadership; patient safety

In the past 10 years, healthcare has changed dramatically. Major reports have highlighted human error and adverse events that patients, particularly those admitted to hospitals, suffer—including the Institute of Medicine's (IoM) report *To Err Is Human* published in 1999 in the USA[1] and the Department of Health's (DH) *An Organisation with a Memory* published in 2000 in the UK.[2] These reports followed a number of pioneering retrospective studies in the USA, Australia, and the UK that documented average error rates of 10% in hospital admissions—that is, that one in 10 hospital inpatients was likely to suffer an error during hospital stay.[3–5] These publications brought about a sharp focus on patient safety issues in healthcare.

As a result of this publicity and a growing body of scientific and medical literature, patient safety has become a permanent part of the health policy and wider political agenda. Numerous changes have since been advocated to improve patient safety, including mandating minimum nurse-to-patient ratios,[6] reducing working hours of trainee/resident doctors,[7] introduction of 'care bundles' that improve patient outcomes,[8,9] introduction of safety checklists,[10,11] and advances to the science of simulation and teamwork training.[12–15] Significant funding has been spent to develop and promote such interventions and to produce the evidence-base, via large-scale primary studies, that would

help make the case for the efficacy of interventions such as checklists[10,11] and team training[16] in improving care processes and patient outcomes.

Where are we now? Despite numerous studies, policy reports, and (literally) hundreds of interventions to improve patient safety, progress has overall been slower than initially envisaged. A recent large-scale study from the USA found that the rates of error have remained relatively constant over the past few years.[17] Similar analyses from the UK have arrived at a mixed conclusion, with some safety indicators improving, others deteriorating, and yet others showing no change.[18] Although a lot of effort has been put into improving the safety of hospitalized patients, one might argue that in some ways, the results have been less than impressive.

Our aim in the present article is three-fold. First, we review and analyse reasons for the lack of evident progress in improving patient safety across healthcare specialities. Secondly, we focus on what we believe is a critical part of the healthcare system that can contribute to safety but also to error—healthcare teams. Finally, we review team training interventions and tools currently available for the assessment and improvement of team performance and team skills that can be used in operating theatres and intensive care units (ICUs). We conclude with a number of recommendations for healthcare team improvement.

Is healthcare becoming safer?

Measurement concerns

Although the question of whether hospital-based care has become safer for patients is straightforward, it has become increasingly evident that the answer is complex—for many reasons.[18] A first problem that we still face is that safety indicators are often not readily available. Hospital systems worldwide rely on a wide range of coding schemes for diseases, treatments, and complications. These are often non-standardized in their entries and hence very difficult to meaningfully compare across sites, countries, and often even across time.[19] To add to the complexity, the concept of 'patient safety indicators' is rather novel; developing and validating indicators is a field of scientific enquiry within the patient safety discipline.[19] A second concern is that large-scale safety reporting systems as a means to gauge levels of patient safety have their own limitations. Such systems became popular and many were implemented as a result of the IoM and DH reports—the UK's 'National Reporting and Learning System' (NRLS) was a direct recommendation of the report *An Organisation with a Memory*.[20] First introduced in 2003, the NRLS database currently contains more than 6.5 million incidents (data publicly available at www.nrls.npsa.nhs.uk). However, reporting has been voluntary, it has typically been carried out by nursing personnel without much physician involvement, and it has never captured the true incidence of errors; recent studies have shown that incident reporting captures ∼6% of errors found via retrospective review of the patient record.[21] Reporting levels tend to increase when a 'safety alert' of some sort gets published—as the reporters become more sensitized to the specific topic of the alert. For these reasons, incident reporting appears to be a surrogate marker of safety culture—such that hospitals that report higher levels of incidents have higher levels of safety awareness and culture among their frontline personnel.[22] The general public reading a 'report card' (available in the USA) evaluating a hospital with higher incident levels than its competitor hospitals might, however, think differently.

Implementation concerns

The efficacy of patient safety interventions depends heavily on the quality of their implementation (perhaps even more so than biomedical interventions, e.g. a new drug). An obvious example of this is the introduction of safety checklists.[23] Transplanted into healthcare from other high-risk industries (most notably aviation), safety checklists are currently becoming increasingly popular. An ever-expanding evidence-base, including high-profile studies such as the Michigan Keystone ICU project,[24] the WHO Surgical Safety Checklist international pilot evaluation,[10] and the SURPASS checklist randomized controlled trial (RCT) in the Netherlands,[11] suggests that introduction of a checklist can improve outcomes in many acute clinical areas. Checklists, however, are not a panacea. Social scientists and the

Michigan research group have argued that the success story of the 'simple checklist' that seems to be making healthcare headlines is somewhat deceptive.[25] A checklist is not more than a technical solution: if used properly, it ensures that certain things will be reviewed at certain times. If the underlying problem, however, involves poor attitudes and lack of a culture of safety then it is doubtful that any checklist will make a positive impact on safety. That the checklists are not a 'cheap and cheerful' solution for the publicly funded UK National Health Service (NHS) was revealed by the early experiences of using the WHO Checklist in a London teaching hospital.[26] The use of the WHO Checklist was highly variable among its three constituent parts (SIGN IN, TIME OUT, SIGN OUT) and also over time. The research team observed the checklist being done only partially (e.g. SIGN OUT omitted), with key participants not present in the operating theatre (e.g. senior surgeon not present), or in a dismissive manner. Checklists are not unique in the complexity of their implementation—care bundles, performance monitoring and feedback, team training, and other interventions aimed at enhancing patient safety can all fail at the implementation stage. We argue, therefore, that this is an additional explanation for the lack of robust evidence for wide-scale safety improvements—if safety interventions are poorly implemented their potential for a positive impact on patient outcomes will be limited.[23]

Healthcare teams

Individual clinicians vs healthcare teams

Healthcare is a team sport; teams take care of patients.[27 28] Healthcare teams operate in an environment characterized by acute stress, heavy workload, often high stakes decision-making (e.g. a laparotomy cannot be undone if later proven unnecessary) and very consequential errors.[29] Individuals have limited capabilities. In his classic review of how human factors impact on adverse events, the psychologist Reason[30] has suggested that human rather than technical failures represent the greatest threat to complex and potentially hazardous systems, including healthcare. When human limitations are combined with organizational and environmental complexity, 'production pressures' and the naturally occurring stress of managing very sick patients, human error becomes virtually inevitable.[31 32] The following determinants have been shown to affect the quality of clinical performance within healthcare settings.

Individual healthcare providers' skills and competencies

Within interventional specialities, like anaesthesia and surgery, these are often split between 'technical skills' and 'non-technical skills'.[33–37] The former include the psychomotor dexterity and coordination that are required to carry out complex psychomotor tasks (e.g. to intubate a patient or successfully place an epidural catheter). The latter include the skills that allow a healthcare provider to work well as a member of a team (e.g. communication, leadership).

Teamworking and team effectiveness

As care is being delivered by teams, the quality and effectiveness of team communication,[27][38] team monitoring/situation awareness,[39] and team coordination[40] are important—not just for safety but also from the perspective of efficiency.

Clinical environments

The hospital environment is often not conducive either to individualized work or to teamworking. Distractions and interruptions (e.g. during medication administration, during the induction, maintenance and emergence from anaesthesia, or during a surgical procedure) have been analysed in detail in the past few years and have been shown to contribute to the loss of concentration and deterioration of safety.[41–45]

Taken together these three determinants of good (or poor) performance and safety comprise what is known as a 'Systems Approach' to patient safety[46–49]—which recognizes that human operators are fallible and when under extreme pressure, errors will almost inevitably occur. Indeed, lapses and problems in one or more of these three categories have been consistently identified as 'latent risk factors' within healthcare units and organizations where errors subsequently occur.[50]

Teamwork and team performance

Patient safety is 'predicated on trust, open communication, and effective interdisciplinary teamwork'.[51] Teamwork can be defined as a 'set of interrelated behaviours, actions, cognitions and attitudes that facilitate the required task work that must be completed'.[52] There is a vast literature outside healthcare and increasingly within it on what makes teams work well together and be effective. Team communication and information sharing are critical for optimizing team performance.[53] According to Baker and colleagues,[54] to work together effectively team-members must possess specific knowledge, skills and attitudes such as the skill to monitor each other's performance and correct errors before they become adverse events or cause harm, knowledge of their own and team-mates' task responsibilities, and a positive disposition towards working in a team. Behaviours found in effective teams include team leadership, mutual performance monitoring, backup behaviour (i.e. mutual support), adaptability, communication, team orientation, and mutual trust.[54] These behaviours have also been found relevant to operating theatre[55] and ICU[56] contexts. Moreover, an important cognitive characteristic of effective teams is that they have shared and accurate 'mental models'—which means that the team-members hold an accurate and shared understanding of the task at hand, their equipment, and their team-mates—including who is responsible and able to carry out which task at what point in time.[39][57] Thomas and colleagues[58] conducted a qualitative assessment of teamwork and suggested that factors that influence the ability of a group of individuals to work together as a team include the following:

- Team-members' characteristics: their personal skills and attributes, reputation, expertise.
- Workplace factors: staffing levels, work organization, work environment.
- Group influences: communication, behaviours, and inter-relationships within the team.

Team effectiveness is in itself a key endpoint—the question is 'what is an effective team'? Within the healthcare literature, this has sometimes been treated as a 'black box'—the emphasis has traditionally been on patient outcomes and clinical processes because these endpoints are evidently relevant to patients and can also be assessed more objectively. However, simply stating, for instance, that a good theatre team is one whose patients always get antibiotics on time and deep venous thrombosis (DVT) prophylaxis before an operation masks a number of issues of relevance to how teams are assembled and developed—and also a range of team-related outcomes that are often ignored. Although necessary, objective clinical metrics of team effectiveness are not sufficient because they tell us little in terms of how to improve a team. From the perspective of team science, Hackman[59] has analysed three critical aspects of a team's peformance:

(i) Whether or not the team accomplishes its goals: this reflects the examples above, that is, whether a theatre team ensures that antibiotics and DVT prophylaxis have been administered on time.

(ii) Team-member satisfaction with the team and commitment to team goals: this is a longitudinal team outcome, mostly neglected in healthcare teams. It refers to whether frontline staff are happy to be part of their team—which in turn can be linked to the morale of the team, a range of behaviours mentioned above (e.g. trust in each other, mutual support and back up, etc.), and also to team-members' turnover (as unhappy team-members are more likely to leave the team/organization when an opportunity arises).

(iii) The ability of the team to improve their team effectiveness over time: just like individuals, teams have learning curves. As with Olympic athletes, a team of experts that has just been put together does not necessarily make an expert team—teams develop their expertise over time, learn from their mistakes, and improve their processes and skills.

Team leadership

An important aspect of team performance is how it is led. Team leadership is a complex function—a recent review across industries proposed that it involves the three core activities of *Leading* (over years), *Managing* (over months), and *Coaching* (daily) (Table 1).[60] Even though this list is likely not exhaustive, it makes immediately apparent the fact that many aspiring or current clinical team leaders rarely engage in such tasks or do so in an ineffective manner. A first problem for healthcare is that such tasks are rarely

formally included or appraised as part of the team leader's performance. It follows that many senior doctors do not have the relevant skills—nor is training available to them to assist them in acquiring these skills. This is not a problem peculiar to healthcare—across numerous industries, leaders often find themselves being promoted to leadership positions on the basis of their excellent operational or technical performance—however, they are then left on their own to take on the task of effectively managing a new and typically bigger team that is looking up to them for leadership. Within the healthcare industry, clinical seniority alone is not a sufficient criterion for leadership. The tasks and responsibilities of a leader (Table 1) suggest that some clinical leaders should be actively engaged with the entire healthcare organization (i.e. the hospital and its management) in order to promote the work of the team that they lead. Understanding of management structures and knowledge of organizational targets (often decided by central policy-making bodies) are prerequisites for the effective clinical leader.

Team training and simulation

Team training: when and why?

The previous two sections suggest that improving patient safety requires a concerted effort to change our current systems and attitudes, such that safety interventions become better embedded within healthcare organizations and are used more effectively by expert teams that have clear understanding of their tasks and roles and show adequate team behaviours. Improvements in the human factors and teamworking aspects of healthcare are expected to bring about significant improvement in patient outcomes—over and above improvements associated with biomedical advances.[61]

Why train anaesthetists in communication, teamwork, and situational awareness? Anaesthetists providing care to patients must be prepared to deal with unexpected events and emergencies—including anaphylaxis, myocardial infarction, unexpected profound blood loss, embolism, and numerous other intraoperative crises that arise without warning. Nowhere is the stress greater than in the stressful and rapidly changing environment of high-risk surgery, including the realms of obstetrics, cardiothoracic, neurosurgery, and trauma.[62] Where do medical/nursing students, trainees/residents, consultant/attending doctors, midwives, and a range of other allied health professionals learn to work together as team-members? In recent years, medical training has made significant progress in incorporating problem-based learning in undergraduate medical education.[62] However, incorporation of such modules into the curriculum can be challenging[62]—and often the teaching occurs within single-speciality groups. Formal training and assessment of team skills (using validated metrics that could potentially be included in a portfolio or personal appraisal system; see the Priority 2 section) is also typically not carried out as

part of specialist training on the doctor's way to becoming a consultant/attending physician.

We take the view that systematic team training is a key part of the change required of healthcare organizations in order to achieve higher levels of patient safety. Team training within healthcare environments is not a new concept. The IoM report *To Err Is Human* strongly recommended translating concepts of aviation team training and 'Crew Resource Management' to improve patient safety.[1] The IoM reiterated the same recommendation in their follow-up report *Crossing the Quality Chasm*.[63] The Agency for Healthcare Research and Quality (AHRQ) and the Joint Commission have also supported this position.

The original training model of the aviation industry has historically been the main source of inspiration in relation to team training for the healthcare industry. In the late 1970s and early 1980s, aviation developed a team training model termed 'Crew Resource Management' (CRM).[64] Key characteristics of CRM-based training include:

- extensive use of simulators, within which crisis scenarios can be enacted and operators' performance observed and assessed;
- focus on 'non-technical' skills—which are social (e.g. communication), cognitive (e.g. situation awareness), and resource management (e.g. coping with stress) skills, which complement technical/psychomotor proficiency;[65]
- standardization in the form of (i) assessment instruments that capture non-technical skills systematically (e.g. NOTECHS),[66 67] (ii) assessor training and certification,[68] and (iii) regular simulation-based training and certification sessions for operators.

Anaesthesia was one of the first healthcare specialities to embrace this model—by developing 'Anaesthesia Crisis Resource Management' (ACRM) training modules between the late 1980s and the mid-1990s.[69 70] These early efforts were subsequently followed by other specialities and there has been a significant surge in the development and availability of CRM-styled team and 'non-technical' skills training courses. Several studies have reported use of team training modules in Emergency Medicine departments,[71 72] ICU environments,[73] and surgical services.[74–77]

Does team training work?

Whether a team training intervention is effective should be evaluated at the following four levels:[78]
- Level 1: Reactions: participants who attend team training sessions should find them useful in performing their jobs.
- Level 2: Learning and attitudes: post-training participants should acquire new knowledge and their attitudes to teamworking/safety/related concepts should improve.
- Level 3: Skills and behaviours: post-training participants should be able to do things that they were not able

Table 1 Key elements of team leadership[60]

Element of leadership	Definition	Time horizon	Tasks for the team leader
Leading	Provision of a strategic direction and vision to the team	Long-term: years	– Create a real 'team' – Communicate a direction for the team's work (team vision) – Design the team so that it can achieve its vision – Negotiate and gain organizational support for the team – Use team interventions judiciously
Managing	Planning and clarifying the team's objectives	Medium-term: months	– Set clear team objectives – Clarify team-members' roles/responsibilities – Manage team-members so they each have an individual role within the team – Evaluate individuals' contributions – Provide feedback on team's performance – Periodically review team's processes and objectives
Coaching	The leader's daily (often informal) interactions with team-members	Short-term: days	– Listen what the team-members have to say – Recognize and address emotions within the team – Provide individual feedback – Agree goals with individual team-members

to do pre-training (e.g. their communications skills should improve).

- Level 4: Organizational outcomes: regular team training should improve organizational effectiveness (e.g. fewer accidents or near misses, better safety processes).

Recent reviews and meta-analyses show that team training within aviation does achieve positive effects at levels 1–3, but there is no evidence for the 'holy grail' of fewer accidents at level 4.[64 79 80]

Within healthcare, there have been multiple reviews on the impact of team training.[81 82] Overall, until recently, the findings mirrored those of the aviation industry—healthcare providers who attended team training sessions found them beneficial and relevant to their work, showed learning and improved attitudes post-training, and learned some additional skills.[83–86] The biggest study, to our knowledge, to evaluate the impact of team training on level 4 outcomes within perioperative care is that by Neily and colleagues[87] published in 2010. This was a large-scale RCT across 108 Veterans Affairs Hospitals in the USA (74 in the team intervention arm and 34 in the control arm), which documented an overall 18% reduction in postoperative mortality in the intervention hospitals. The intervention was substantial and clearly costly—including a 2 month preparation period per site, 1 day on-site training sessions[87] with theatres closed on the day, and quarterly telephone follow-ups with the local lead for 12 months. The impressive findings of that study suggest that team training can improve outcomes. 'Light-touch' team training sessions—for example, including introduction to human factors and teamworking concepts—can be beneficial. However, their impact will likely be limited

to level 1 or 2. This does not mean that they are not useful—but they are a first of many steps that need to be carried out to improve patient outcomes in the long run.

Where next? Healthcare teams for the 21st century

The preceding discussion shows that over the past few years, with the advent of early simulators and CRM-styled training, healthcare has made some steps towards improving team effectiveness and team skills. Here we identify what we believe are some critical priorities for the healthcare industry in the coming 5–10 years to consolidate and accelerate progress.

Priority 1: Embedding simulation into training and practice

Traditional medical and nursing education has relied on the treatment of real patients in actual clinical settings. In the light of the expanding evidence-base that simulation-based practice of technical and team skills improves performance and safety and with increasing availability of simulators, there is a paradigm shift occurring in many universities and training programmes internationally. Numerous simulators are currently available across all interventional specialities—including anaesthesia, surgery, and obstetrics. These range from simple bench-top models to task simulators, entire procedure simulators (e.g. virtual reality simulators), and simulated operating or labour suites for training and assessment of entire clinical teams. Many, if not most, medical and nursing schools and hospitals have purchased simulators and there are various attempts to use them in undergraduate and postgraduate education.[88 89] Although these are

positive steps, we believe that much remains to be done. Implementation of simulation-based education and training is often person-driven and hence at risk of collapsing when the interested and knowledgeable faculty member changes institution or job role. Institutions often see their involvement with simulation-based training limited to purchasing the equipment—whereas in fact this is only the first of many steps, most of which involve the human resource that is required to run simulations that are regular, systematic in their assessment and feedback processes, and thus meaningful to clinical learners.[90]

We propose that all invasive procedures, whenever feasible, should first be routinely practiced on a simulator before a physician or nurse performs them on a patient. Advances in simulation technologies have rendered simulation-based training an 'ethical imperative'—as Ziv and colleagues[91] commented a decade ago 'patients are not commodities to be used as conveniences of training'. Our own view (which remains to be supported by evidence) is that no doctor or nurse should perform an invasive procedure on a patient before showing successful completion of their learning curves on a well-validated simulator. Simulation allows the development of personalized, proficiency-based (rather than time-based) training curricula—in fact curricula for the training of complex laparoscopic procedures have been developed and validated and are currently available.[92] [93] Laparoscopic surgeons are setting the tone in this field—as of October 2012, the 'Fundamentals of Laparoscopic Surgery' (FLS) course, endorsed by the American College of Surgeons and a prerequisite in many surgical training programmes in North America, will require recertification every 10 years (i.e. including laparoscopic experts; see www.flsprogram.org).

We advocate a multi-stage approach, where trainees start from bench-top and task trainers, followed by procedural simulation of more complex procedures appropriate for their level of training/proficiency.[88] [89] Such simulation-based training should be integrated into clinical work: an emerging evidence-base is showing that 'warm up' physical and mental practice just before a procedure may be beneficial for trainees,[94] [95] who can use the equipment within the hospital but more so in their home environment at relatively minor cost.[96] The next step in this evolution of medical training will involve actual members of multi-disciplinary teams (e.g. nurses, surgeons, anaesthetists) training together in a simulated operating theatre environment, where effective responses to catastrophic and/or rare crises can be rehearsed and perfected and novel interventions like the WHO Checklist can be introduced.[74–77] Many anaesthetic emergencies (e.g. failed intubation, anaphylaxis, embolism) require practiced actions not only of the anaesthetist, but of the entire theatre team. Practice as a team, therefore, is essential.

Priority 2: Improving and standardizing assessment

The increased focus on non-technical and team skills to reduce errors and improve patient safety has triggered the development of numerous assessment tools designed to capture these skills. Efforts have concentrated on ensuring that these tools are psychometrically robust (i.e. reliable and valid)—a selection of tools with psychometric evidence is presented in Table 2. While this is a critical step in embedding training and improving these skills, at present any standardization of assessment is lacking. This is in stark contrast to the training and assessment of such skills in other high-risk industries, most notably the aviation industry.[68] The lack of standardized assessment in healthcare presents a significant challenge; although there is a large degree of overlap between the available assessment tools in relation to the core skills assessed the rating scales vary considerably, and there is no systematic benchmark against which to assess or compare performance. We advocate that evidence regarding the psychometric robustness of assessment tools and the aims of the assessment process should guide tool selection (Box 1). Further research within clinical settings on optimal application of assessment tools to improve performance and on developing performance benchmarks is needed.

Priority 3: Training and quality assurance of faculty

Many of the assessment measures that have been developed are widely available, via peer-reviewed publications and online resources, and thus are available to any individual that desires to access them. The potential problem here is that non-technical and team skill assessment tools appear deceptively simple and straightforward to use. Such assessments, however, require training to be done well, otherwise they are unreliable.[97] [98] Thus, a crucial factor in implementing such assessments into healthcare is the formal, structured training of faculty that provide assessments. The lack of guidelines regarding assessment tool application is in stark contrast to the regulations enforced by other industries. Such regulations are in place to ensure that assessments are fair, reliable, valid, and feedback is provided in an effective and sensitive manner. Faculty and trainers are required to undertake extensive training, demonstrate a minimum level of proficiency, and hold an accreditation to apply these measures in practice. For example, the aviation and military industries have long recognized the need for training faculty to assess and debrief non-technical performance as a key characteristic of high-reliability operations. Specific faculty training programmes have been developed that focus on teaching 'novice' faculty to identify and assess non-technical performance in the same way as highly experienced assessors.[68] Thus, integrating effective and robust non-technical and team skills training and assessment is dependent on the development of programmes targeted at faculty to ensure that they are competent to train and assess such skills.

A recent expert-consensus study established guidelines for such faculty training programmes (Box 2)[99]—which can now be developed with the aim of improving how team skills and performance are assessed and trained, and ultimately of creating highly performing teams.

Table 2 Non-technical skills and teamwork assessment tools

Tool	Elements assessed	Clinical speciality	Reliability evidence	Validity evidence	Notes on practical implementation
Observational Teamwork Assessment for Surgery (OTAS)[112–115]	Global operating theatre team performance 1. Communication 2. Cooperation/back up behaviour 3. Coordination 4. Leadership 5. Team monitoring/situation awareness	It can be used for surgical, anaesthetic, and nursing personnel It can be used to evaluate individual's skills and behaviour and also global team performance It captures performance at three stages: before operation, intraoperatively, and after operation	Inter-rater reliability	Content, concurrent, and construct validity	OTAS can be used by both clinical and non-clinical assessors It assesses/debriefs team performance in routine and crisis situations It captures performance and skills of professional subteams within the operating theatre and also of the global theatre team OTAS comes with validated training programmes for novice users
Revised Non-Technical Skills (Revised NOTECHS)[75 116 117]	Non-technical skills 1. Communication/interaction 2. Situation awareness 3. Cooperation/team skills 4. Leadership/managerial skills 5. Decision-making	It can be used for surgical, anaesthetic, and nursing personnel It captures performance intraoperatively	Internal consistency	Construct validity	Revised NOTECHS can be used by both clinical and non-clinical assessors The tool is particularly applicable to assessing/debriefing behaviours in crisis situations
Oxford Non-Technical Skills (Oxford NOTECHS)[118 119]	Non-technical skills 1. Communication/interaction 2. Situation awareness 3. Cooperation/team skills 4. Leadership/managerial skills 5. Decision-making	It can be used for surgical, anaesthetic, and nursing personnel It captures performance intraoperatively	Inter-rater reliability	Predictive, concurrent, and convergent validity	Oxford NOTECHS can be used by both clinical and non-clinical assessors The tool captures team performance in routine and non-routine situations
Trauma Non-Technical Skills (T-NOTECHS)[120 121]	Non-technical skills during trauma calls 1. Communication/interaction 2. Situation awareness/coping with stress 3. Cooperation/resource management 4. Leadership 5. Assessment/decision-making Assessed skills based on OTAS and revised NOTECHS	It can be used for any speciality attending a trauma call It captures performance during the trauma call	Inter-rater reliability Internal consistency	Construct validity	T-NOTECHS can be used by clinical (doctors and nurses) and non-clinical assessors (researchers) The tool assesses/debriefs performance during simulated and real-life trauma calls

Continued

Table 2 *Continued*

Tool	Elements assessed	Clinical speciality	Reliability evidence	Validity evidence	Notes on practical implementation
Non-Technical Skills for Surgeons (NOTSS)[122–124]	Non-technical skills 1. Communication/teamwork 2. Leadership 3. Situation awareness 4. Decision-making	Designed to be used only for surgical personnel It captures performance intraoperatively	Inter-rater reliability	Convergent validity	NOTSS is designed to be used by senior surgeons It focuses on the operating surgeon
Anesthesiologists' Non-Technical Skills (ANTS)[125–127]	Non-technical skills 1. Teamworking 2. Task management 3. Situation awareness 4. Decision-making	Designed to be used only for anaesthetic personnel It captures performance intraoperatively	Inter-rater reliability	Content validity	ANTS is designed to be used by senior anaesthetists It focuses on the anaesthetist in charge of the patient
Scrub Practitioners' List of Intra-operative Non-Technical Skills (SPLINTS)[36 128]	Non-technical skills 1. Communication/teamwork 2. Task management 3. Situation awareness	Designed to be used only for scrub nurses or scrub practitioners It captures performance intraoperatively	Inter-rater reliability	Content validity	SPLINTS is designed to be used by senior nursing/related personnel It focuses on the scrub nurse/practitioner in charge; it does not address other nursing personnel (i.e. circulating nurse)
Ottawa Crisis Resource Management Global Rating Scale (Ottawa GRS)[129]	Non-technical skills and global CRM performance 1. Problem solving 2. Situational awareness 3. Leadership 4. Resource utilization 5. Communication	Designed for use across medical and surgical specialities It captures CRM-related non-technical skills during a training episode	Inter-rater reliability Internal consistency	Construct validity	The Ottawa GRS is not specific to the OR environment; it is broadly applicable to healthcare teams in acute settings It has been evaluated in the context of resuscitation and management of critically ill patients It is aimed at assessing the effect of simulation-based training modules on participants' relevant skills

Mayo High Performance Teamwork Scale (MHPTS)[130]	8 compulsory and 8 elective items that reflect CRM-related non-technical skills	Designed based on anaesthesia CRM training modules	Inter-rater reliability	Construct validity	The MHPTS is not specific to the operating theatre environment; it is broadly applicable to healthcare teams in acute settings
	Compulsory items	It captures CRM-related non-technical skills of doctors and nurses during a training episode	Internal consistency		It has been evaluated in the context of CRM training (pre-training *vs* post-training scores)
	1. A leader is clearly recognized by all team members				It is aimed at assessing the effect of CRM training modules on participants' relevant skills
	2. The team leader assures maintenance of an appropriate balance between command authority and team member participation				
	3. Each team member demonstrates a clear understanding of his or her role				
	4. The team prompts each other to attend to all significant clinical indicators throughout the procedure/intervention				
	5. When team members are actively involved with the patient, they verbalize their activities aloud				
	6. Team members repeat back or paraphrase instructions and clarifications to indicate that they heard them correctly				
	7. Team members refer to established protocols and checklists for the procedure/intervention				
	8. All members of the team are appropriately involved and participate in the activity				
Observational Skill-based Clinical Assessment tool for Resuscitation (OSCAR)[131 132]	Non-technical skills and global performance of a resuscitation team	It can be used for anaesthetic, medical, and nursing personnel who make up a resuscitation team	Inter-rater reliability	Content and convergent validity	OSCAR can be used by doctor and resuscitation officer assessors
	(1) Communication	It can be used to evaluate individual's skills and behaviour and also global team performance during a resuscitation episode			It assesses/debriefs individual and global performance during a resuscitation
	(2) Cooperation/back up behaviour				
	(3) Coordination				
	(4) Leadership				
	(5) Team monitoring/situation awareness				
	(6) Decision-making				
	Assessed skills based on OTAS, ANTS, and Revised NOTECHS				

Box 1 Characteristics of a good non-technical/team assessment tool[133]

Validity: in relation to performance outcome/s (e.g. patient outcomes)

Reliability: inter-rater reliability, internal consistency

Sensitivity: in relation to levels of performance (i.e. distinguishing poor from good performers)

Transparency: people assessed understand the performance criteria against which they are being rated; availability of reliability and validity data

Usability: simple framework, easy to train, easy to understand, easy to observe, domain-appropriate language, sensitive to rater workload

Can provide a focus for training goals and needs

Baselines for performance criteria are available and can be used appropriately by raters

Minimal overlap between assessment components

Priority 4: Selection

Healthcare is rather unique among many industries, in that little effort goes into job-person fit. The key premise of selecting clinicians or nurses using scientific methods is that selection affords the organization the opportunity to select new recruits who have the technical competencies but also team skills to fit into existing teams, and thus expand operations successfully. Organizational and team leadership involves significant investment in developing personnel to take on roles of increasing complexity and responsibility internally, but also to select new people/talent to join the team/organization externally. In healthcare, selection is minimal in some specialities and totally absent in others, whereas new trainee/residents recruits change-over *en masse* at certain time points potentially without enough time to get integrated into their new teams/organizations. Furthermore, selection procedures typically involve an interview—which has the worst predictive validity of all selection methods (although it is the least expensive). 'Assessment/selection centres', where candidates are assessed on a series of tasks and simulations that reflect the duties that they will be carrying out (if selected) for an organization, have better predictive validity for future on-the-job performance, but they are the most expensive personnel selection method.[100]

These practices are not without consequences. In the UK, a recent large-scale epidemiological study carried out using data from 175 acute hospitals between 2000 and 2008 found that emergency patients admitted in these hospitals during the so-called 'change-over week' (i.e. the first week of August when the new trainees arrive) had 6–8% higher mortality risk than patients of the same disease/sociodemographic profile admitted to the same hospitals during the previous week.[101] The year-end change-over has also been reported from American hospitals where it has been reported that mortality increased and efficiency decreases because of year end change-overs—termed the 'July effect'.[102] Further,

Box 2: Expert-derived recommendations for training faculty to assess non-technical and team skills[99]

1. Trainers: Who should deliver the 'Train-the-Trainers' programme?
   - Multi-disciplinary team consisting of clinicians and psychologists/human factors experts.
2. Faculty: Who should receive the 'Train-the-Trainers programme?
   If the aim is to provide performance feedback within clinical practice:
   - Senior clinicians (consultant/attending-level surgeons/anaesthetists, senior theatre nurses)
   - Clinicians and psychologists/human factors experts (alongside clinicians)
   If the aim is to provide high-stakes assessments (e.g. selection or revalidation/recertification):
   - Senior clinicians (consultant/attending level surgeons/anaesthetists and senior theatre nurses)
   - Clinicians that regularly provide training and assessment
3. Proficiency/revalidation
   Proficiency
   - *To provide performance feedback within clinical practice:* Minimum intra-class correlation coefficients with expert's scores of 0.61–0.70
   - *To provide high-stakes assessments:* Minimum intra-class correlation coefficients of 0.71–0.80
   Revalidation: Faculty should be reassessed annually if providing high-stakes assessments
4. Training programme content
   - Theoretical background on non-technical skills and human factors applied to healthcare/surgery
   - Introduction to non-technical/team skill assessment tools
   - Training in the recognition of non-technical/team skills
   - Practice in skill rating
   - Training in providing feedback/debriefing following assessment
   - Limitations of skill assessments (e.g. biases and errors in assessment)
   - Implications of skill assessments
5. Training programme delivery
   - Methods: Video clips for practicing skills observation and rating
   - Duration: Two full-days, proficiency/competency-based training, support after initial training, and refresher course(s)

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the lack of team stability in theatres has been reported as a key stressor for theatre personnel[103] and also as a key reason contributing to the inability of the theatre team to reach expert status—as with constant new team-members the team restarts their learning curve far too often.

Evidence-based selection, using appropriately validated tasks and the concept of assessment/selection centres, is feasible across specialities, including acute care,[104] surgery,[105] [106] and anaesthesia.[107] [108] Gale and colleagues,[107] specifically, have shown correlations between performance within the assessment centre setting and job performance over the first year of the candidate's clinical appointment. Such efforts should be expanded—appropriate skill anchors and performance benchmarks can be developed for a number of key tasks/procedures depending on the seniority of the position. Candidates can then be tested on a range of these and scored in relation to the normative data. This scoring can be assisted by further psychometric evaluation of the candidate, using a range of psychometric tests that cover personality as well as ability aspects that contribute to effective, high-quality performance.[109] Within such a context, interviews can be utilized to screen candidates, or at a later stage of the selection process to evaluate the candidate within the context of face-to-face interaction. Although there is no single perfect method to assess and select healthcare providers, we believe that a combination of well-validated, evidence-based methods is likely to provide a better outcome in terms of quality and person-job/team/organization fit, and also fairness and transparency of the process.[100] In the long term, such an approach would have the potential of significant return on investment, with more stable, more satisfied, and more expert teams making up the clinical workforce of a modern acute hospital.

Conclusion

In the past decade, patient safety has entered the clinical and policy agenda—and for the anaesthesia profession, the commitment to safety was recently reaffirmed with the 'Helsinki Declaration on Patient Safety in Anaesthesiology' in June 2010.[110] [111] For all this attention, however, more can be done to improve care processes and patient outcomes in hospitals. Following our review of the recent evidence on patient safety interventions, healthcare teams and team training, we specifically advocate (i) embedding simulation into clinical training and practice, (ii) standardization of skills and team assessment processes, (iii) investment in training and quality assurance of senior faculty to train and mentor skills and teams, and finally (iv) a more thoughtful and evidence-based approach to healthcare provider selection. In the light of the available evidence, we believe that all of these improvements in the 'human element' of care provision have the potential to further improve patient safety and outcomes in the next 10 years.

Declaration of interest

None declared.

Funding

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