Cogn Tech Work (2008) 10:251–254
DOI 10.1007/s10111-007-0090-z

EDITORIAL

Enhancing surgical systems

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Published online: 26 July 2007

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The new millennium was a turning point for the scrutiny of quality and safety in healthcare. An increasing number of studies, investigations, reports and audits worldwide acknowledge that there is a significant risk of unintentional harm to surgical patients. The reasons for this are complex, but, in broad terms, surgical systems are to some degree failing to establish equilibrium in balancing service demands with systems development. In order to resolve this, healthcare must adopt a systems approach to performance. This means addressing the current tensions and discordance that exist between innovation, service efficiency, working hours, training periods, skill development, assessment and safety. There is a clear ethical and financial rationale for healthcare to invest more heavily in a systems approach to performance and safety research. Not only would it improve the service to patients, it may reduce the escalating cost of litigation and provide secondary benefits from the research it needs, more transparency of roles and responsibilities, better working conditions, training and service efficiency. The overall goal is to design surgical systems so they evolve to meet both the medical demands of society and the demands of reliable operational safety.

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From within and without, surgical systems continue to experience disturbance and change. There is relentless innovation in new technology affording new ways of working but producing new constraints and unorthodox demands on professional skill. The introduction of the European Working Time Directive now limits the hours of time for learning during a surgical career, and the UK Modernising Medical Careers programme has condensed training to allow faster routes to qualification. There are simply less clinical opportunities for surgeons to become expert; they along with other professionals in surgery must gain a range of skills that are increasingly complex yet under-specified. For instance, surgeons acknowledge the fact that higher order cognition contributes to skilful surgery, but there has been little attention paid to the cognitive processes that underpin surgical performance. Likewise, teamwork is highly relevant to a successful surgical career, but it does not feature highly in surgical training. Communication has risen to prominence more recently, but assessments tend to focus almost entirely on the surgeon's interaction or interface with the patient, at the exclusion of the wider system of work. Only the Accreditation Council for Graduate Medical Education explicitly demands that resident trainee surgeons obtain specific knowledge, skills and attributes to demonstrate 'systems-based practice', which they define as, "Manifested by actions that demonstrate an awareness of and responsiveness to the larger context and system of healthcare and the ability to effectively call on system resources to provide care that is of optimal value". In short, professional skills training are not meeting the demands of modern surgery.

A reliance on individual skills alone, however, will not achieve safety. There are many components to the system; we must design each optimally to integrate to the whole.

Both safety and skills depend on an understanding of how the system operates and what causes or affects system performance. To achieve this, we need to measure and model the many different aspects of surgical systems. In a sense, we need to reverse engineer surgical systems, to then forward engineer toward reliability. There are many obstacles to meeting these aims. Theoretically, it is difficult to delineate a sociotechnological system into neat units that we might control at will, as there are very many interacting variables and non-linear processes. Practically, we cannot treat operational surgery as a laboratory, or stop all surgery while we run experiments; it is impossible to control all variables and very likely unethical. However, despite the obstacles, we can identify the main performance-shaping factors: the key professional skills, elements of team performance, technology design, environment design and so on. We can build models and measures of performance to fit the context, use traditional physical measures of the environment and of work, and simulate various tasks, environments and situations for developing and testing models of performance. There is much that healthcare can learn from other domains of a high-risk nature such as aviation and the nuclear industry. This does not mean that we should adopt methods and measures without critical appraisal; we should translate, not transplant them. After all, the cockpit is not the operating theatre and, unlike flight control, computers are unlikely to control surgical action for some considerable time.

To achieve the research aims, we need both retrospective and prospective methods. There are pros and cons to both. Those whom work in the system and their records of work are a great resource in retrospective research. However, the complexity of the system is such that those involved in it may be unable to view the many factors that cause performance at any one time. Self-reporting of past events are somewhat subjective, and prone to prejudice and hindsight bias. Similarly, retrospective accident investigation or error-analysis techniques are somewhat arbitrary in the depth and scope of their analysis, and they can only be as effective as the information archived, on record or in memory for past events and conditions and the current understanding of tasks and human performance. Many aspects of the system may influence performances that we may not be able to measure retrospectively. Prospective research, on the other hand, offers objective analysis of events and conditions through targeted sampling, ethnographically, and the opportunity to test intervention. Observational research is, however, necessarily selective for the limit on observer resources, who are also prone to bias in preference perhaps for one view or another. Furthermore, observation itself may inadvertently alter conditions or performances observed.

One view is that if measures of system performance or condition do not predict clinical outcome, in terms of mortality and morbidity, they are not valid or worth considering. However, many factors can affect clinical care but do not necessarily manifest as a serious adverse event. Some factors or conditions may indirectly influence patient outcome, but very occasionally and only in concert with other factors. Indeed, factors such as the work interruption and workload have subtle effects on human performance, and can raise workers' stress levels, making the chance of error more likely. The consequence of these and other social and psychological factors can permeate a work system and ultimately affect safety. Regardless of whether there is evidence of their relationship to some absolute outcome, if conditions negatively affect performance, or if there is a consensus among personnel to that effect this must be sufficient evidence to consider appropriate intervention and to reduce risk to as low as practicably possible. Safety research should address the full scope of surgical systems; there is no justifiable reason to ignore any parts and every reason to examine the whole.

A systems approach to safety will demand a range of measures and methods. Measures of course need to be valid and reliable, though the demand for their testing will vary in degree, depending on how subjective-objective they are. For instance, measures may apply to some construct of cognition or behaviour, such as awareness or leadership, respectively and demand considerable work to ensure that they are valid and reliable. On the other hand, if the measures apply to behaviours or properties, such as the duration of a break in task activity their testing will be more straightforward.

This special issue reflects a cross-section of research addressing potential ways of enhancing surgical systems, with a particular emphasis on improving safety. These include test interventions, such as briefing and ethnographical observational studies sampling surgical systems to measure factors that might enhance or impair performance. Teamwork, particularly communication, may help steer a work system in one direction or another. Unsurprisingly, therefore this special issue covers communication in some depth and breadth, in terms of methods and arrangement, content, measurement and effects on team performance. The first half section of this special issue concentrates on that which personnel in the operating theatre might gain from training and briefing interventions in the real and virtual operating theatre. The second half more broadly focuses on the factors affecting behaviour and performance in surgical systems, with an emphasis on observational measurement and research. This research area is of course new. It has clearly not matured, so the studies comprising this special issue mainly report developmental and explorative work. Perhaps the problems and challenges experienced or raised by the researchers are as noteworthy for the reader as much the findings within.

Guerlain and colleagues report on crew-resource management techniques transferred to surgeons in practice. Specifically they show that training surgeons on briefing, with debriefings led to a significant increase in intra-operative communications, along with some suggestion that such practice enhance future surgical performances. Yule and colleagues describe the process of observing and debriefing surgical trainees using their structured system. They found that surgeons who participated in their trials reported that debriefing trainees provided a common language to discuss skills, such as decision-making and communication. They also found that interpersonal skills were more difficult to rate than cognitive skills, but overall evidence suggested performance might improve with training. Interventions, such as briefing and debriefing may have a positive effect on performance. Simulation, a proven research and training methodology in aviation, offers considerable potential for the surgical domain for the testing of briefing and other intervention or training. Koutantji and colleagues report on their attempts to show whether it is feasible to implement intra-disciplinary and interdisciplinary team training in simulation. They point out that while they achieved some success, there are considerable challenges ahead, in developing valid measures and methods of training. Skills training and sound protocol alone may not be sufficient to deal with all the performance shaping factors in surgery and moreover training ought to account for some of the research emerging about different aspects of the system in which they work. For example, encouraging a cultural shift toward interdisciplinary teamwork is a challenge. Whyte and colleagues also show positive associations between briefings and the quality of communication in the operating room, with a reduction in communication failure and enhanced team knowledge and practice. However, the authors also found paradoxical effects of briefing in some cases team briefings could mask gaps in knowledge, inhibit positive communication, reinforce professional divisions and create tension. Clearly, there are many issues to consider in implementing and testing interprofessional team interventions, including culture, professional boundaries, resource allocation, cooperation and objective measurement of the range of effects.

The second section of this special issue considers measurement instruments, which might reveal aspects of the system that potentially threaten or enhance performance in practice. Catchpole and colleagues report their developmental observation techniques designed to measure the interactions among the surgical team or between the team and their broader work environment. They examined operations using a framework derived from aviation, seeking to classify observed events in terms of their threats and rate certain systems-related skills. They found that their measures of a surgeon's skill correlated positively with the number of threats and errors identified and with operative duration. Healey and colleagues also report developmental observational measures of teamwork and intra-operative interference, as inferred from observed distraction and interruption in the operating theatre. The initial results of piloting support previous findings showing interference derived from equipment failures, external staff and uncoordinated communications. The authors attributed some of this to a lack of pre-operative preparation and a general lack of control over the team environment. Observational measures, such as Catchpole and Healey's may be helpful in improving the reliability of surgical systems by means of debriefing and feedback to management levels of the organisation.

So, this special issue addresses surgical 'systems' which converge in the operating theatre and it is important that we attempt to confine a system this way, to have some common frame of reference or unit of analysis for the range of research needed. However, this issue also raises problems relating to the wider system, beyond the operating theatre, which are important issues for safety, such as training in simulation. Xiao and colleagues, in particular, consider the extended system by focusing on the distribution of information, which different surgical cases depend on. They emphasise that artefacts and technology mediate the teamwork needed to organise and manage surgery within and between operations. They also highlight some of the opportunities and challenges regarding the means by which information for surgery transfers across sub-systems or departments.

There are many background factors that affecting performance in surgery, which this special issue does not cover, particularly regarding the organisational context. Therefore, Benn and colleagues conclude with an overview of this special issue and an attempt to compare the research within to the concept and theory of high-reliability organisations. They emphasise that to achieve safety organisations need different mechanisms of regulation operating at different timelines and organisational levels, which they illustrate by mapping the work reported within to a conceptual model of safety operating within the organisation. A major lesson for healthcare domains to learn from highly reliable organisations is that safety is not just a static condition or outcome it is an integral process of the organisation. Therefore, while healthcare needs to learn from past failure, it also needs to prevent future failures. We can achieve this by shifting the balance of focus away from individual error towards models that emphasise optimal design of surgical systems.

The benefits of these developments will not be immediately felt—indeed, the road to safer surgical systems will be arduous. Scientific evidence of the highest order underpins Healthcare practice, with systemic and educational changes requiring a sound evidence base. This makes generating clinically relevant safety data a vital goal. Without such evidence, it will be difficult to convince practitioners and managers that sustaining the necessary changes is justified, or perhaps even ethical. Meanwhile, it is important to communicate the rationale for certain developmental research in the first instance, and necessary to convince healthcare for the need for such work. As in other high-risk domains, safety science in healthcare will constantly change, increasing in complexity, and moderated by a resource-conflicted environment. However, healthcare will almost certainly remain, perhaps beyond all other high-risk industries, reliant on people and therefore demand input from human factors researchers. Developing the theory, skills, tools, methods, and evidence base that is necessary for improving safety and quality has never been of such central importance; nor, perhaps, of such potential benefit.