



SAFER MEDICAL PRACTICE: MACHINES, MANIKINS AND POLO MINTS

Tomorrow's healthcare professionals will benefit from a much wider range of training techniques and scenarios than has been the case in the past.

KEY POINTS

- Using simulation to constantly practise skills and rehearse emergency situations is a vital part of air safety.
- Air safety has improved greatly because the skills of pilots (particularly in dealing with crises) and the ability of teams to work together are regularly reinforced through simulator-based training and assessment.
- Skills in medicine have traditionally been learnt and practised with real patients, but simulation methods (both low and high technology) are increasingly available.
- Studies of simulation training for surgical skills have shown that surgeons trained in this way make fewer errors and carry out technically more exact procedures.
- While simulations and simulated tasks to develop skills are established in many medical training centres in this country, some other parts of the world are far ahead of us.
- Many doctors attending simulation courses (including those for life-saving resuscitation) are now having to pay for them out of their own pockets and struggle to be released from service commitments to attend.
- Simulation offers an important route to safer care for patients and needs to be more fully integrated into the health service.



Elaine Bromiley went into hospital in 2005 for a routine nose operation. Her two young children eagerly awaited her homecoming. The operation was minor and she had few concerns. For her husband, Martin, a pilot and human factors expert, that day was to change his life forever.

Elaine walked into the anaesthetic room and was put to sleep. The anaesthetist then started to put in the breathing tube, which is necessary when someone is anaesthetised. It is rare to encounter problems. On that day, intubation was not routine. The anaesthetist could not insert the tube. No oxygen was getting into Elaine's lungs, and it was proving impossible to pass a tube into her throat. The surgeon and another anaesthetist joined him. Even between the three of them, they were not able to place the breathing tube.

This emergency situation is well known to anaesthetists. It has a name: 'Can't intubate, can't ventilate'. There is a clear emergency procedure to deal with it. There is a simple emergency mantra for dealing with this eventuality: 'Oxygenate not intubate'. The protocol for the urgent management of this situation escalates rapidly, including the early abandonment of attempts to intubate in favour of pursuing oxygenation by any means, and culminating in the use of a piece of equipment to reach the windpipe via the

front of the neck. This provides oxygen to the lungs, bypassing the throat entirely. The percutaneous tracheostomy kit was available in the room, but the three doctors did not use it. What should have been a habit was not. Instead, they focused on repeatedly trying to insert the standard throat tube, despite the fact that this was not working. As they concentrated on doing this, they did not realise how much time had passed. Over the next 20 minutes, as their attempts repeatedly failed, Elaine's brain was starved of oxygen. By the time a breathing tube was finally put in place, it was too late. Elaine's brain had been irreparably damaged by the lack of oxygen. She remained in a coma and died two weeks later.

On 16 January 2009, US Airways flight 1549 took off from La Guardia airport in New York City. Minutes after take-off, the plane

"Simulation is a technique – not a technology – to replace or amplify real experiences with guided experiences that evoke or replicate substantial aspects of the real world in a fully interactive manner."

Professor David M Gaba
Stanford University, USA

ploughed into a flock of birds. The right engine caught fire and shut down, followed moments later by the left engine. A total of 155 lives hung in the balance. Captain Chesley Sullenberger, calmly, professionally and with formidable skill, landed the plane on the Hudson River – a feat never before achieved. The audio recording of the captain's conversation with air traffic control is remarkable. There is an absolute sense of calm, of someone retaining control in the face of such a dire situation.

A similar incident involving total engine failure had occurred exactly a year earlier in London. British Airways flight 38, arriving from Beijing, lost power to both engines as it came in to land at Heathrow. The co-pilot expertly navigated the plane, carrying 152 passengers, to the ground just short of the runway. It sustained extensive damage on landing, but nobody on the plane was seriously injured.

Engine failure is an emergency for pilots. 'Can't intubate, can't ventilate' is an emergency for anaesthetists. Yet while more than 300 passengers on the two aircraft survived, Elaine Bromiley died. On both flights, there was potential for panic. Instead, the unfamiliar was familiar because it had been encountered many times before, not in real life but in a simulator. Although it is a rare occurrence, pilots regularly rehearse engine failure in simulators. So when faced with a real situation, habit takes over. And even in a scenario so rare that it's a surprise, pilots have developed mental strategies that allow them to prioritise and make crucial decisions rapidly and successfully. Habits are developed and reinforced by continual exposure in the simulator.

Not all anaesthetists, by contrast, regularly rehearse the 'Can't intubate, can't ventilate' scenario. They learn the theory of what to do and they learn the practical skill. But they do not routinely practise the scenario, even though simulated methods are available.

Simulation enables people to train for rare events that will not occur often enough for experiential learning to be of real benefit.

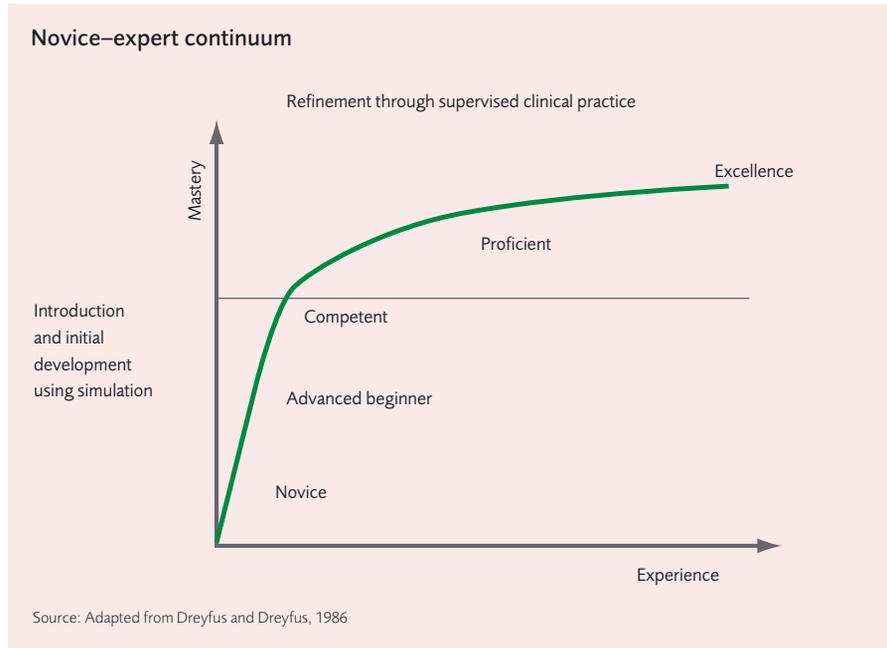
Unfavourable comparisons between medicine and other high-risk industries have been made before. When a person steps on a plane, their risk of dying in an air crash is one in 10 million. When a person is admitted to hospital, their risk of dying or being seriously harmed by medical error is one in 300.

"In one study, surgeons trained on a simulator were twice as fast and twice as accurate as those who had not been."

One way in which high-risk industries reduce risk from rare events is through simulation. Simulation allows people to prepare for such risky events in a safe environment. It recreates conditions that closely resemble reality, while removing any danger. It means that when people confront a real emergency situation, they do so with the experience of detailed rehearsal. It is widely used in aviation and in the military. It is slowly being adopted in medicine. Simulation of rare events does not create automaticity; rather, by using simulation 'over-learning' occurs. People can be prepared to manage rare events without panic and disorganisation.

Improving skills

Medical education has been caricatured as 'see one, do one, teach one'. This describes a process in which learners observe the teacher undertaking a technique; then they perform the technique themselves once under supervision; and then they are deemed capable and safe to perform the technique unsupervised and, indeed, to teach others. Medical schools have generally realised that such a model is not



appropriate for the 21st century. Most medical students now learn to take blood from a plastic arm before attempting to take it from a real arm. They learn to sew two pieces of plastic together before suturing any real skin. For these and other basic skills, simulation is now used routinely.

Simulation can also be used to teach more complex skills. Junior surgeons can attend courses to learn to perform laparoscopic (keyhole) surgery. They often use the same equipment that they will use in the operating theatre. They develop their fine coordination skills by using the equipment to stack Polo mints, put matches through hoops, and chop chicken. Honing clinical skills requires constant practice. Attending courses and classes is important but so too is practising.

Malcolm Gladwell, in his recent book *Outliers*, suggests that the key to perceived genius is really often devoted practice. It is crucial to learn the right way and then practise these habits. Incorrect methods do not sneak in and become habit by accident. Simulation allows this to happen because learning is accompanied by assessment and feedback, unlike learning from real surgery, where all too often the only feedback is from adverse events. Breaking complex new tasks

into small chunks, which can be repeated with assessment until learnt, is a technique developed by the father of deliberate practice Anders Ericsson. To allow junior doctors to do this, local access to such tools is required at times that suit the trainee.

Simulation improves performance. Research at Imperial College London has shown that simulation improves the skills of surgeons in training. One study observed surgeons operating on pigs to remove the gallbladder. Some surgeons had received simulation training for this; others had not. Compared with surgeons who had not completed simulation training, the surgeons who had done so were twice as fast at completing the task (2,165 seconds compared with 4,590 seconds) and twice as accurate (requiring 1,029 movements rather than 2,446 movements).

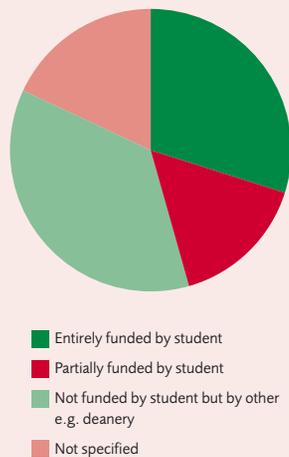
Simulation reduces errors. A trial in Sweden demonstrated that junior surgeons who had been given virtual reality training for keyhole surgery made significantly fewer errors than their peers who had not. Their colleagues made, on average, three times as many errors and took 58% longer to carry out an operation.

Table 1: Types of simulator by earliest identified date of reference

Simulator	Date of first publication
Fibre endoscopy	1987
Endoscopic retrograde cholangiopancreatography (ERCP)	1988
Colonoscopy	1990
Endoscopic trainer	1993
Laparoscopic surgery	1994
Hysteroscopy	1994
Hollow organ closure	1994
Total hip replacement	1995
Ophthalmic simulator of laser photocoagulation	1995
Ophthalmic surgery	1995
Intravenous catheter insertion	1996
Otolaryngology	1996
Laparoscopic surgery	1997
Abdominal aortic aneurysm (AAA)	1998
Inferior vena cava filter placement	1998
Sigmoidoscopy	1998
Shoulder arthroscopy	1999
Surgical suturing	1999
Breast biopsy	1999
Transurethral prostatic resection	1999
Computer-based interventional cardiology	2000
Bronchoscopy	2001
Upper gastrointestinal endoscopy	2003

Source: Cooper and Taqueti, 2004

Figure 1: Funding for compulsory basic surgical skills courses



Source: Royal College of Surgeons of Edinburgh electronic logbook records

Changes in the structure of medical training have resulted in a reduction in junior doctors' hours. As a result, doctors complete fewer hours of training in total before becoming consultants. Today's doctors are exposed to fewer patients than their predecessors. Modern training provides fewer opportunities for doctors to practise practical procedures. Some have expressed concern that this may result in lower clinical standards. Simulation-based training will be an important part of bridging this skills gap in the future.

Access to simulation is patchy. Despite their proven effectiveness, junior surgeons usually have to pay to attend these laparoscopy courses from their own pocket (see **Figure 1**). Senior doctors struggle to be allowed out of service commitments to attend these courses and increasingly have to pay for them out of their own pocket. Course prices have increased significantly:

the average price of a paediatric resuscitation course in 1997 was £300; now it is around £500. Given the critical nature of these courses, the rationale for making doctors pay for courses themselves is unclear.

Use of a simulator to learn practical skills occurs mainly on an ad hoc basis. Whether or not a junior surgeon has access to simulation largely depends on which hospital they are working in at the time.

Strengthening team-work

Gone are the days of the lone hero doctor. Delivery of safe, high-quality healthcare requires many different professionals to work together as a team. When a sick patient is rushed into hospital, paramedics, nurses and doctors must be able to work together quickly and effectively. When an emergency occurs in childbirth, the team includes midwives, obstetricians, paediatricians, nurses and anaesthetists. Vulnerable patients need occupational therapists, physiotherapists, pharmacists and social workers to work together with doctors and nurses to ensure a safe discharge from hospital. However good each individual's technical skills are, avoiding tragedy depends on them working together as a team.

Highly realistic training environments, such as operating theatres or wards that authentically replicate actual clinical environments, can be used to train and develop clinical teams, especially when linked to audio-visual recording and behavioural debriefing. Clinical teams can be put through their paces managing complex, rare or serious clinical scenarios.

Some people inherently work well in teams, but everyone can improve their skills. Team-working is best learnt from experience. The usefulness of full-immersion, clinical team-based simulation is that it allows people to work on these skills in a controlled and safe

environment. Elaine Bromiley may have been alive today if the theatre team had had better insight into crisis resource management skills and if they had had regular emergency simulation training to refine these skills.

Learning to debrief

Simulated scenarios give adequate time to encourage reflection and to identify what could be done better. The team is debriefed. Many of the best simulations involve the participant being filmed, so that later they can watch and critique their own performance. Once acquired, debriefing techniques learnt in simulation should be applied to real clinical situations. Learning to learn from real events makes for safer healthcare. After finally placing Elaine Bromiley's breathing tube, the team looking after her continued with their day. They did not have the opportunity at the time to reflect on and learn from the traumatic events.

Unlike the situation in other high-risk industries, debriefing after a critical event is not routine in medicine.

Assessing skills

Simulation forms an important part of skills assessment for both medical students and doctors. In many schools of medicine, communication skills are tested in mock scenarios using actors in place of patients. Medical school examinations may include observation of students taking blood from a plastic arm, or suturing a rubber pad. Complex manikins can mimic heart conditions that can be discovered only through careful clinical examination. In some parts of the world, testing using simulation has become mandatory. For example, since 2004 all newly qualified doctors in Israel must participate in a national simulation-based training course lasting five days. In order to complete their training, anaesthetists in Israel have to successfully complete a practical assessment using simulation.

Figure 2: Examples of high-fidelity simulation centres



Simulation allows researchers to identify common mistakes caused by gaps in clinicians' knowledge. Once found, training can be altered to make sure that these gaps are filled. By watching how teams function in a variety of simulated settings, specialist observers can alter the protocols, improving usability, safety and effectiveness. Observers can determine how teams respond to changes in the environment, such as lighting or noise levels. New medical devices can be trialled before being distributed. Simulation may allow many types of problem to be highlighted and put right long before any risk to patients can occur. Many complex clinical procedures have now been standardised. Teams carrying out these tasks can follow predetermined pathways to make sure that they are achieving best practice. This is essential in time-critical activities such as resuscitation, where teams must work rapidly and consistently to achieve a good outcome. Simulation can be used to develop and assess these procedures.

Simulation in the United Kingdom

Since the mid 1960s, courses have been run to rehearse emergency conditions in both medicine and trauma, for example where patients have stopped breathing, have collapsed or have suffered major blood loss.

These courses are based on a simple principle – that in difficult, taxing conditions, people revert to routine and habit. To ensure safe practice, good habits need to be a reflex action. That means rehearsing simple, standardised techniques for performing complex procedures. This approach has made a fundamental difference to how acute medicine operates in the United Kingdom. At the heart of these courses is simulation. This often requires little in the way of technology, but much in the way of time and effort from both trainers and trainees. Currently, junior doctors are expected to undergo simulated resuscitation training once every four years. Airline pilots are required to show proficiency in simulated emergencies every six months.

Figure 3: Comparison of medicine and aviation high-fidelity simulation availability

British Airways	NHS in England
	
<p>3,200 pilots</p>	<p>34,000 consultants and 47,000 doctors in training, including 12,000 surgeons</p>
<p>14 high-fidelity simulators</p>	<p>Fewer than 20 high-fidelity simulators</p>

Resuscitation training courses are considered mandatory for junior doctors. However, the NHS is not able to provide such training routinely throughout a medical career. Upon reaching senior grades, doctors no longer need to demonstrate resuscitation competence under simulated conditions.

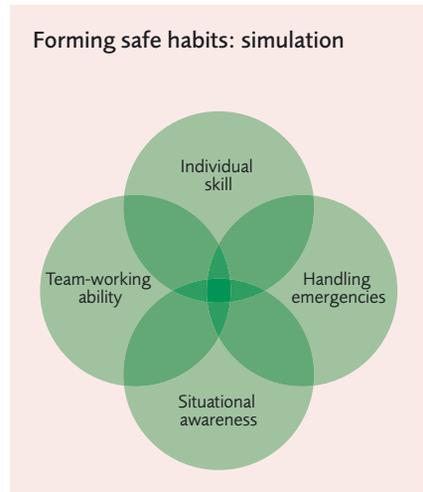
The NHS has yet to embrace simulation widely as a mechanism to objectively identify those doctors suitable for certain specialties, although some specialties – such as ophthalmology and cardiac surgery – have started to do this. Procedure-specific simulation (for example planning the operation about to be carried out) is also possible and enhances team-work dramatically, as well as ensuring that the correct equipment is in place.

Teaching and learning by simulation need not necessarily involve complex technology. Situational learning can often be achieved with only basic resources. However, high-fidelity simulation, using advanced technology to artificially replicate reality, provides a unique opportunity to immerse practitioners in a highly realistic environment. Access for doctors to these technologies is still limited (see **Figure 2**).

Admittedly, high-fidelity simulators are not yet applicable to all fields of medicine, but their availability is much lower than in the airline industry (see **Figure 3**).

The international standard

MSR, the Israel Center for Medical Simulation founded by Dr Amitai Ziv, simulates settings including an emergency department, operating theatres, clinics, a pharmacy and more. Every one of its patients is made of plastic or is an actor. It is a world leader in using simulation to train healthcare professionals. Every year, more than 7,000 doctors and other healthcare professionals pass through its doors. It has some of the most advanced medical simulation technology that exists.



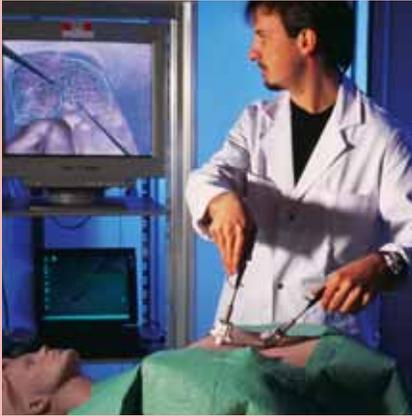
In England, the current picture is less promising. Simulation is regarded as a useful add-on rather than a compulsory and core part of training. However, some NHS organisations have started to take a more organised approach to simulation. Over the last two years, the London Deanery and NHS London have invested £11 million to provide simulation facilities to hospitals throughout London. Every acute hospital trust in London now has them.

Lessons from the aviation industry show that learning increases if the training is designed and taught by pilots. Training pilots teach in the simulators and 'fly the line' – fly as normal commercial pilots. This ensures that they can spread their knowledge to others during routine flights. It also means that training is respected and appreciated. These positions are highly sought after. It is important that senior doctors become trainers in medical simulation and that the role is not just left to more junior enthusiasts.

Although there are examples of excellent practice, there is not yet the national capacity or coordination that is needed. Simulation does not yet form a sufficient part of medical training and assessment. Furthermore, too great a burden is placed on individuals to fund such training themselves, compared with other industries where mandating the training has meant that funding is provided by employers.

Simulation works. Simulation is important to medicine. The NHS must be able to provide the type of simulation that would make a difference to patients like Elaine Bromiley.

ACTION RECOMMENDED



"Simulation training in all its forms will be a vital part of building a safer healthcare system."

- Simulation-based training should be fully integrated and funded within training programmes for clinicians at all stages.
- Simulation-based training needs to be valued and adequately resourced by NHS organisations.
- A skilled faculty of expert clinical facilitators should be developed to deliver high-quality simulation training.
- The importance of human factors training to safe care should be widely communicated.
- A national centre for simulation techniques should be established to maintain and disseminate leading-edge methods and new developments.
- Each medical Royal College should identify a lead for simulation training.
- National Patient Safety Agency serious incident reports should be made available to simulation centres to embrace learning to prevent such incidents in the future.