Using simulation in clinical education

Patient simulation in all its forms is widely used in clinical education with the key aims of improving learners' competence and confidence, improving patient safety and reducing errors. Understanding its benefits, range of uses and limitations will help clinical teachers improve the learning experience.

This article discusses how simulation can be used in medical and health professions' education to develop and improve practical and team resource management skills and introduces the most common uses of simulation in clinical education settings.

Introduction

Simulations are a dress rehearsal of a real event where as many mistakes as possible can be made and lessons can be learned, but no one comes to harm.

People from many occupations (including athletes, actors and pilots) use simulation as part of their training. In these professions, in common with medicine, people have to perform skills in high pressure situations. The first recorded use of a medical simulator is that of a manikin created in the 17th century by a Dr Gregoire of Paris (Buck, 1991). He used a pelvis with skin stretched across it to simulate an abdomen, and with the help of a dead fetus explained assisted and complicated deliveries to midwives.

In spite of this early start, medical simulators did not gain widespread use in the following centuries, principally for reasons of cost, reluctance to adopting new teaching methods, and scepticism that what was learned from a simulator could be transferred to the actual practice. All of these reasons are still relevant today, but the combination of increased awareness of patient safety, improved technology and increased pressures on educators have promoted simulation as one option to address problems with traditional clinical skills teaching. Simulation has moved from the province of a few enthusiasts to a mainstream learning modality.

Dr Kirsty Forrest *is Honorary Clinical Senior Lecturer and Consultant Anaesthetist, Academic Unit of Anaesthesia, The General Infirmary at Leeds, Leeds LS1 3AX and Clinical Education Advisor, Yorkshire and Humber Deanery and* **Professor Judy McKimm** *is Associate Professor and Pro Dean, Health and Social Practice, Unitec, New Zealand, Visiting Professor in Medical Education at the University of Bedfordshire and Honorary Professor in Medical Education, Swansea University*

Correspondence to: Dr K Forrest

The American anaesthetist Gaba said:

'No industry in which human lives depend on the skilled performance of responsible operators has waited for unequivocal proof of the benefit of simulation before embracing it.' (Gaba, 1992)

Most junior clinicians will now be trained and assessed in simulators and the use of clinical skills or simulation laboratories is seen as routine in medical and health professions education. Advances in technology mean that there are very lifelike simulators for patients, surgery procedures and full-scale mock-ups of wards, theatre and emergency departments. Many include software so that the simulator's reactions depend on learners' actions. There are many advantages to simulator training. The most obvious is that trainees can practice as often as they like and whenever they want (within reason) without harming a patient.

Why simulation now?

The 2008 annual report of the Chief Medical Officer, *Safer Medical Practice* (Donaldson, 2009), spelled out the importance of simulator training to improve patient safety and clinicians' performance and to enable experience to be gained without practice on patients. Four key drivers for the widespread introduction of simulation are:

1. Public expectation. The public not only expect professionals to engage in appropriate skills and simulator training, they often believe that the profession already does. Patient groups are shocked to learn that doctors frequently perform a skill for the first time on a real patient.
2. Changes in working practice. The development of new professional roles, the growth of large and complex working environments, the widespread adoption of shift systems and the rapid pace of modern health care requires clinicians to develop high order leadership, team working and communication skills. Simulation has been at the forefront of the development (and assessment) of these skills.
3. Technological developments and opportunities. The technology available to support high fidelity and simulator training has progressed rapidly in recent years. Evidence exists that the educational value from low fidelity simulators can outweigh that of high fidelity simulators as long as they are embedded within an educationally sound training programme.
4. Reduced training time. A number of changes including the European Working Time Directive have reduced the time available for clinical training; to make the best possible use of available work-based time, trainees must have prepared effectively away from the work place.

Benefits of simulation

The use of simulation in health professions' education has benefits for learners, for development of clinical practice and skills, for patients and for health systems (Riley et al, 2003). There is now a significant and growing body of evidence that simulator training is educationally effective in developing technical skills (Ziv et al 2003). As well as facilitating the acquisition of routine skills, simulation also allows safe (for the learner and the patient) exposure to rare diseases, critical incidents, near misses and crisis situations that learners may not be exposed to during clinical training. Reflecting the experience of the airline, nuclear and other high risk industries, evidence is slowly accumulating in medicine that patient safety standards and non-technical skills improve following simulator training (Beyea, 2004; McGaghie et al, 2010).

How is simulation used?

Simulation training extends from part task trainers, or procedural training to the experience of full clinical situations. *Table 1* lists the range of low to high fidelity simulated experiences.

For example simulated parts of the body can be used for cannulation, catheterization and rectal examination. Some skills are practiced in a wet lab where animal and human tissue can be used, for example for suturing. Basic (low fidelity) manikins are used for teaching basic and advanced life support. High fidelity manikin simulators with a vast number of programmed interactions and physiological responses can be used for individual or team scenario training.

High fidelity simulators also include those that are used for laparoscopic and endoscopic skills where virtual reality is used. Some of these sophisticated simulators have 'forced feedback' (haptic) systems which enable the learner to 'feel' the endoscope going around the splenic flexure.

Despite the ready availability of simulated body parts and 'kit', the integration of technical and non-technical skills is paramount in developing professional practice. In addition, to ensure patient safety, non-technical skills are an aspect of training that should be emphasized. Analyses of adverse incidents indicates that the majority of causes of errors are in the non-technical skill domain, including communication failure, team failure, poor leadership or poor decision making (Gawande et al, 2003; Mallory et al, 2003). The Scottish Clinical Simulation Centre has looked at the integration of human factors into the medical curriculum and how to access the acquisition of those skills. They have developed behavioural markers for these skills in both the anaesthetic and surgical arenas.

Table 1. The range of simulated experiences
Games, classroom scenarios
Wet labs using human or animal tissue
Simulated patients, either actors or volunteers
Computer-generated virtual reality simulators
Manikins and models of varying complexity, from part task trainers, such as cannulation arms to 'complete' bodies such Simman
Mock hospital facilities including a simulated operating theatre, emergency departments and wards

Kneebone et al's (2003) research programme on the integration of technical and non-technical skills includes simulation training for rectal endoscopy which uses an endoscopy simulator with a simulated patient next to the simulator. A sheet covers the patient and the trainee has to perform the task while talking and explaining to the 'patient' what he or she is doing.

Scenario simulation provides an excellent opportunity for interprofessional education with the ability to train real teams from work environments. In addition, predetermined health-care groups deliver many of the skills required by patients during their care, but in the future who delivers these skills may well change. It is envisaged that simulation teaching will provide packages that any group could access and interact with other groups for relevant multidisciplinary situations.

Simulation and learning

The development and adoption of simulation training reflects development in theories of learning from more individually oriented activities to those that view learning as a social and cultural event. Simulations that focus on improving team performance are therefore becoming increasingly commonplace in high risk environments such as anaesthesia, surgery and emergency medicine (Gaba, 2006; Ker and Bradley, 2007; Nestel et al, 2008).

As simulation becomes an accepted part of everyday education and training for health professionals, attention is being paid to how simulation can best be used to develop technical and non-technical skills. Simulation appears to work most effectively when it is designed to meet curricular outcomes, includes realistic and relevant content, interesting and engaging learning methods and prepares learners for working in the clinical context in terms of activities, skills and competencies (Issenberg et al, 2005). *Table 2* lists the best practice features of simulation as identified in two systematic literature reviews.

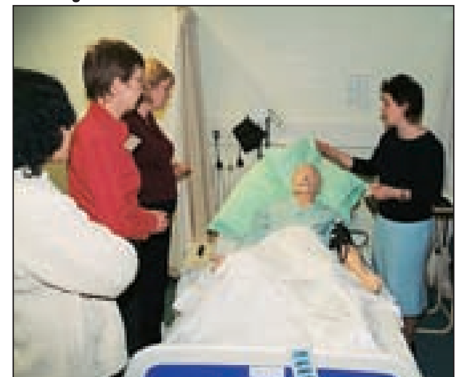
Simulation helps skills acquisition, maintenance and assessment in the move from 'novice to expert' (Dreyfus and Dreyfus, 1985). The key element is building simulation activities into learners' progression (*Figures 1* and *2*). For example medical students must practice and master the skills and pass an assessment before embarking on clinical rotations or trainees might have to provide evidence of competence in a simulator before interacting with patients. Learners can therefore have their first encounter with patients at a higher level of technical and clinical proficiency which protects patients (Ziv et al, 2003).

Clinicians can use simulated facilities to rehearse both challenging and routine procedures to reduce error (Yule et al, 2006). The philosophy is based on deliberate practise with appropriate feedback (both during and after the training event). Because simulation focuses primarily on skills acquisition (technical or non-technical), it is essential that learning activities

Table 2. Best practice features of simulation
Formative feedback during simulation
An opportunity for deliberate and repetitive practice
Curriculum integration
Outcome measurement
Simulation fidelity
Skills acquisition and maintenance
Mastery learning
Transfer to practice
Team training
High stakes testing
Instructor training
Educational and professional context
A variety of conditions and range of difficulties

From Issenberg et al (2005); McGaghie et al (2010)

Figure 1. Using a simulator for learning and teaching.



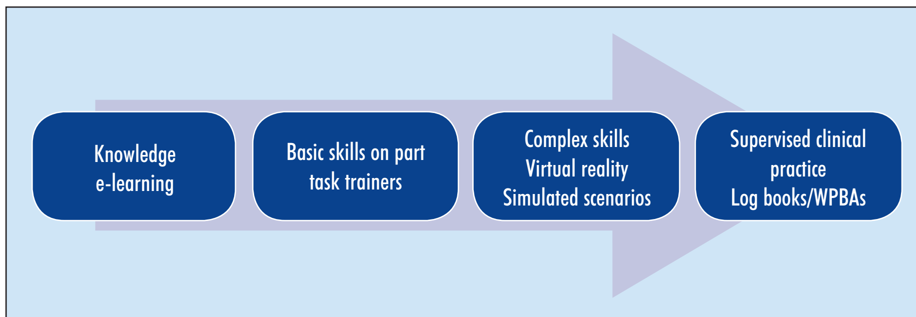


Figure 2. Simulation activities integrated into the learning programme. WPBA = workplace-based assessment.

are planned with clear learning outcomes and that a de-briefing or follow up stage is planned (Cumin et al, 2008).

The absence of learner feedback is the greatest single factor for ineffective simulation training. A lack of feedback may lead to:

1. Learning the wrong learning objective
2. Not realizing what the desired behaviours should be by not focusing on them
3. Not transferring skills to clinical practice
4. Spending increasing time on only one aspect of training.

A novel aspect of high fidelity simulation is the ability to play back videos of the simulated activity to an individual or team. Unlike verbal feedback from an observer there is tangible evidence of what the learner did or did not do or say. In addition insight into how the learner behaves under stress (getting angry, withdrawal, making mistakes) is a valuable and powerful learning tool.

Deliberate practice refers to time spent on a specific activity designed to improve performance in a particular aspect of practice. Deliberate practice is a better method of acquiring expertise than simple unstructured practice (Ericsson, 2004). There is a consistent association between the amount and the quality of deliberate practice and performance in domains as varied as chess, music and sport (Ericsson and Charness, 1994). Deliberate practice means that there is effort involved as well as some form of feedback, whether through self assessment, from the simulator or observation by another person.

Short-term training courses are not the same as deliberate practice and do not have the same beneficial effects on long-term performance. Research with laparoscopic equipment has shown that structured practice with feedback improves subsequent performance in the same real-life situation (Reznick and MacRae, 2006). Deliberate practice using simulation is particularly useful for new skills, rare events or emergencies.

A lack of opportunity for practice is associated with a poor educational outcome. This is often attributed to insufficient access to the simulator, as training sessions are usually time dependent, and the simulator is often a hotly-contested resource. In addition, each learner is different, and some learners inevitably need longer or more frequent sessions with the simulator to achieve the same educational results as their co-learners.

Simulation in practice

You have found a Simman (Laerdal, Orpington, Kent) manikin within your department and you think it would be a good way to teach trainees on how to deal with critical incidents. How would you start to prepare?

Be very specific about your educational goals – sometimes it is very easy to get carried away with the technology and forget what outcomes you are after. Once you have set out your aims and objectives, be very specific about your scenarios. It is helpful to write these down as flow diagrams as this is often what the computer programs for the manikins look like. Try to anticipate student replies; think outside the box as some replies or actions can be very surprising and have an appropriate reply or action from the manikin ready (*Figure 3*).

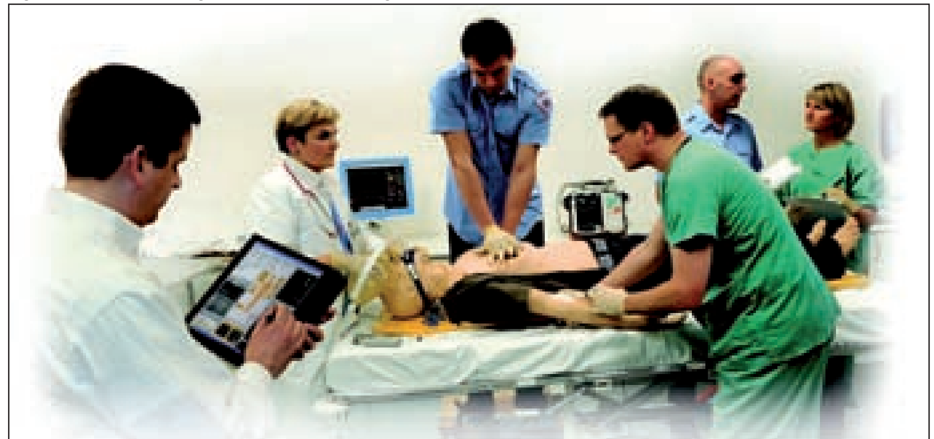
Practice running through the scenario on the manikin – this is when you find that the physical signs of the manikin that you expected sometimes are not present and you will have to adjust the scenario to maintain realism. You will be 'walking through' the scenario, gathering kit and turning the environment into a realistic set. Enrol the help of a colleague: often you need one person to run the scenario (and manikin) and the other to observe the trainee, especially when looking at non-technical skills.

Limitations of simulation

Although simulation is widespread, popular with learners and teachers and technological developments are leading to the availability of more and more complex simulators, much of the published work has been descriptive rather than grounded in evidence-based research (Issenberg et al, 2005). Contemporary research is now focussing on a more analytical, evaluative and inter-disciplinary perspective to identify how best, often costly, simulation can be used.

Simulation is not a substitute for health professionals learning with and from real patients in real clinical contexts, but is best used to teach practical or technical skills before working with patients and to replicate clinical scenarios in a safe and control-

Figure 3. Simman being used in team training.



led environment (Pratt and Sachs, 2006). Gaba (2004) notes that 'simulation is a technique, not a technology'. Although the technology can become confining for some users (Kneebone and ApSimon, 2001), others remind us that we must take care that the seductive powers of the technology do not lead to a use of simulation where it leads to dependency, becomes self-referential and produces a 'new reality' (Kneebone et al, 2005; Bligh and Bleakley, 2006). Kneebone et al (2004) note that simulation must not become an end in itself, disconnected from professional practice, leading to over-confidence in learners.

Simulation must be valid. Poor validity is associated with a lack of realism. In some simulators novices can out-perform an expert, which questions the validity of that simulation. Typically this would also lead to a lack of correlation with other outcome measures.

When considering simulation activities, teachers need to think how well they can be controlled (tractability), how well they match the real world (correspondence) and how well they involve learners meaningfully (engagement). A common misconception is that high fidelity simulation is better than low fidelity. High fidelity simulation is useful for skills involving complex interactions requiring integration of cognitive and psychomotor skills coupled with interaction with others in the health-care setting (Gaba, 2006). Maran and Glavin (2003) consider the progression from low to high fidelity simulation compared to the progression through medical education and conclude that the range of fidelity available is almost all potentially useful, but that many simulators are underused simply because of a lack of clear educational goals. Teachers therefore need to learn how to use simulation activities through faculty development and experience so as to make the most of resources and learning opportunities for their students or trainees and to integrate such activities into educational programmes, rather than being a bolt-on. Many simulation centres now offer training for teachers in the educational use of simulation.

Future directions

Policy agendas from government and professional bodies endorse, promote and fund patient simulation on a widespread scale (Donaldson, 2009). As well as helping to ensure patient safety and reduce error, simulation is also seen as an alternative means of learners acquiring clinical skills without spending time in an increasingly over-crowded clinical environment (Nursing and Midwifery Council, 2007). Educators must therefore be attentive to such agendas and ensure that simulation is complementary to learning in the clinical workplace and that learning in each context is relevant to achieving defined outcomes and developing safe, competent practitioners. It is likely that simulation will become more integrated into curricula and embedded into education and training programmes.

Opportunities for more interprofessional learning around non-technical skills and teamworking are likely to increase as more centres offer such learning opportunities although more evidence is required as to the efficacy of such training. Simulation has also been used to support new ways of working (McKimm, 2006). As health and social services change towards more integrated, patient-led approaches, we may see more use of simulation to support their introduction.

The biggest restraints to simulation training are cost and access. There are only a handful of centres across the country that can provide immersive high-fidelity simulations, the 'real' experience in mock clinical areas with all the appropriate equipment, manikins and faculty. One group has tried to address these issues by identifying the key aspects of the theatre environment that are needed for learning and then replicating these in a portable environment that can be set up in a short space of time and a small area. This ability has been coined 'distributed simulation' (Kneebone et al, 2010), where inflatable, portable theatres can be erected in places of work and simulations can be run. In addition to providing more easily accessible training, this kind of technology is much cheaper. This increasing emphasis on the ability to bring the simulation to the learner has also been replicated by other initiatives such as 'man in a van' or 'Simvan', where the equipment is mobile and taken to the learner and the simulation occurs in the van. However, both of these innovative developments still need trained faculty and a peripatetic educator to travel with the equipment.

Technological changes will also lead to much more integrated multimedia simulations such as the use of handheld devices, portable simulators and further development of virtual reality simulators.

Conclusions

Simulation is widely used to introduce and develop clinical skills and mould future behaviours in undergraduate and post-qualification education and training. There are benefits for patients and learners when simulation is used appropriately and effectively. As with any learning intervention, planning and preparation is vital, know your equipment and make sure technical support is available if required. Teachers need to ensure that simulation activities help learners to achieve defined learning outcomes, that the simulation and scenario is relevant to 'real world' learning, that feedback is built into the process and that learners are enabled to transfer the learning into the clinical context. There is no one size fits all and the wide range of simulators available mean that teachers can easily incorporate some sort of simulation activity into learning. Finally, particularly for high fidelity, complex simulations, make sure that the benefits of using simulation outweigh the costs of time for faculty, technical support, space and equipment purchases. BJHM

KEY POINTS

- Simulation is widely used in health professionals' education and training.
- Simulation can help reduce error, increase patient safety and develop more competent practitioners.
- It is most effective for training in technical or practical skills and for non-technical skills in team situations.
- Simulation experiences include simple models, simulated patients, computer-based virtual reality simulators and mock clinical facilities.
- Effective simulation includes preparation, link to clear learning outcomes, deliberate practice and feedback.

Figures 1 *and 3 are reproduced by kind permission of Laerdal.*
Conflict of interest: Professor J McKimm was commissioned by the London Deanery to lead on the development of the suite of e-learning modules from which these articles have been derived; Dr K Forrest – none.

Beyea SC (2004) Human patient simulation: a teaching strategy. *AORN Journal* **80:** 738–42
Bligh D, Bleakley A (2006) Distributing menus to hungry learners: can learning by simulation become simulation of learning? *Med Teach* **28:** 606–13
Buck GH (1991) Development of simulators in medical education. *Gesnerus* **48**(1): 7–28
Cumin D, Merry AF, Weller JM (2008) Standards for simulation. *Anaesthesia* **63:** 1281–7
Donaldson L (2009) *Annual Report of the Chief Medical Officer, 2008.* The Stationery Office, London
Dreyfus HL, Dreyfus SE (1985) *Mind over Machine: the Power of Human Intuition and Expertise in the Era of the Computer.* Free Press, New York
Ericsson KA (2004) Deliberate practice and the acquisition and maintenance of expert performance in medicine and related domains. *Acad Med* **79**(S10): S70–S81
Ericsson KA, Charness N (1994) Expert performance: its structure and acquisition. *Am Psychologist* **49:** 725–47
Gaba DM (1992) Improving anesthesiologists performance by simulating. *Anesthesiology* **76:** 491–4
Gaba DM (2004) The future vision of simulation in healthcare. *Qual Saf Health Care* **13:** i2–i10
Gaba DM (2006) *What does simulation add to teamwork training?* Agency for Healthcare Research and Quality, Rockville, Maryland (www.webmm.ahrq.gov/perspective.aspx?perspectiveID=20 accessed 7 May 2010)
Gawande AA, Zinner MJ, Studdert DM, Brennan TA (2003) Analysis of errors reported by surgeons at three teaching hospitals. *Surgery* **133:** 614–21
Issenberg SB, McGaghie WC, Petrusa E, Gordon D, Scalese RJ (2005) Features and uses of high-fidelity medical simulations that lead to effective learning: a BEME systematic review. *Med Teach* **27:** 10–28
Ker J, Bradley P (2007) *Simulation in Medical Education.* Association for the Study of Medical Education, Edinburgh
Kneebone RL, ApSimon D (2001) Surgical skills training: simulation and multimedia combined. *Med Educ* **35:** 909–15
Kneebone RL, Nestel D, Moorthy K, Taylor P, Baan S, Munz Y, Darzi A (2003) Learning the skills of flexible sigmoidoscopy – the wider perspective. *Med Educ* **37**(S1): 50–8
Kneebone RL, Scott W, Darzi A, Horrocks M (2004) Simulation and clinical practice: strengthening the relationship. *Med Educ* **38:** 1095–102
Kneebone RL, Kidd J, Nestel D et al (2005) Blurring the boundaries: scenario-based simulation in a clinical setting. *Med Educ* **39:** 580–7
Kneebone R, Arora S, King D et al (2010) Distributed simulation--accessible immersive training. *Med Teach* **32:** 65–70
Mallory S, Weller J, Bloch M, Maze M (2003) The individual, the system and medical error. *Br J Anaesth CEPD Reviews* **6:** 179–82
Maran NJ, Glavin RJ (2003) Low- to High fidelity simulation – a continuum of medical education. *Med Educ* **37**(S1): 22–8
McGaghie WC, Issenberg SB, Petrusa ER, Scalese RJ (2010) A critical review of simulation-based medical education research: 2003–2009. *Med Educ* **44:** 50–63
McKimm J (2006) *Report to the Ways of Learning Task Group: Assignment 5 - An assessment of the benefits of simulation-based training and of learning centres for simulation based training.* Department of Health, London
Nestel DF, Black SA, Kneebone RL, Wetzel CM, Thomas P, Wolfe JHN, Darzi AW (2008) Simulated anaesthetists in high fidelity simulators for surgical training: feasibility of a training programme for actors. *Med Teach* **30:** 407–13
Nursing and Midwifery Council (2007) NMC *Circular 36/2007: Supporting direct care through simulated practice learning in the pre-registration nursing programme.* Nursing & Midwifery Council, London
Pratt SD, Sachs BP (2006) Team training: Classroom training vs high fidelity simulation? Agency for Healthcare Research and Quality, Rockville, Maryland (www.webmm.ahrq.gov/perspective.aspx?perspectiveID=20 accessed 7 May 2010)
Reznick RK, MacRae H (2006) Teaching surgical skills - changes in the wind. *N Engl J Med* **355**(25): 2664–9
Riley RH, Grauze AM, Chinnery C, Horely RA, Trewhella NH (2003) Three years of 'CASMS': the world's busiest medical simulation centre. *Med J Aust* **179:** 626–30
Yule S, Flin R, Paterson-Brown S, Maran N (2006) Non-technical skills for surgeons in the operating room: A review of the literature. *Surgery* **139**(2): 140–9
Ziv A, Wolpe PR, Small DK, Glick S (2003) Simulation-based medical education: an ethical imperative. *Acad Med* **78:** 783–8