Use of simulators in paediatric and neonatal training

Simulators are being increasingly used in medical education. They vary from simple 'low-fidelity' models used to teach specific skills such as venepuncture and cannulation, to mannequins attached to complex computer systems that mimic physiological responses to illness and treatment. The low frequency of presentation of infants and young children with critical illness makes simulation of particular benefit for paediatric training, providing the opportunity for risk-free practice of clinical management and non-clinical skills such as communication, situational awareness and leadership.

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Key points

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1. Simulators provide interactive learning without risk to patients.
2. Non-clinical skills are very important for staff performance in critical situations – simulation is an excellent tool for developing these skills.
3. Simulation training is most effective with defined educational objectives and good feedback.
4. Simulation has the potential for use in many areas of paediatric and neonatal training.

What is a simulator?

Simulators are designed to reproduce an aspect of the working environment, to allow a risk-free setting where learners can master the relevant skills. They can be utilised for anything from teaching simple technical skills such as cannulation to the replication of a full resuscitation designed to challenge a team and develop non-clinical skills. Situational awareness, decision making and team working are critical to good patient care, but difficult to assess and teach in the clinical setting – simulation provides a way to focus on these aspects of critical care without compromising patient management.

Simulators are not a new concept – Edward Link presented his homemade flight simulator, which became commonplace in military and civil aviation, in 1922. However, they have developed and diversified hugely in recent years, to the level of integrated simulators which are preprogrammed with complex mathematical models of cardiovascular and respiratory physiology to produce appropriate responses to interventions without ongoing input from instructors.

Hi-fidelity patient simulators such as the Laerdal 'Simbaby' (**FIGURE 1**) are full body ALS-type mannequins coupled with computer programmes which mimic the anatomy and physiology of a myriad of pathological states. Participants are able to interact with it in a realistic fashion similar

FIGURE 1 The simulation set-up showing the Laerdal Simbaby and the computers used to programme and control the simulation.

to human-human interactions. The mannequin can be programmed to reproduce many clinical findings such as pulse, heart sounds and breath sounds, which are elicited in the usual way by palpation and auscultation. They have the capability to produce a range of monitoring signals and allow clinical interventions ranging from insertion of cannulae to intercostal drain placement. Any intervention by the participant results in real-time changes in the 'patient' condition. The baby even cries! Scenarios can be preset but are often run by an instructor who changes physiological parameters to reflect the patient response to interventions.

Why use simulation training?

> "No industry in which human lives depend on skilled performance has waited for unequivocal proof of the benefits of simulation before embracing it" *Dr D M Gaba*

Balancing the training needs of students and junior doctors with our aim to provide patients with the best possible care has been challenging the medical community for many years. For a large number of the clinical skills required, 'hands on' is the only way to learn.

Simulators provide us with the opportunity for interactive learning in a clinical setting without patient risk. We know that human factors and our ability to function as a team impact on outcomes in critical situations, and simulation training has been shown to improve performance of non-clinical skills. Simulation is learner-orientated and non-threatening. As part of a planned teaching programme with clear objectives set, simulation has great potential to expand learning opportunities and improve individual and team performance in managing the critically ill infant or child.

Simulators are particularly useful for training our responses to high-risk, low-frequency events, where exposure is low but critical decision making will significantly impact on outcome. Fortunately, critically ill infants and children present relatively rarely, certainly in comparison to adults. Schoenfield et al[1] found that of 80,000 paediatric emergency department admissions, only 0.23% required treatment in a resuscitation room. However, this means that exposure to paediatric resuscitation in 'real life' is poor.

In one study from the US[2], 44% of paediatric trainees had never had the opportunity to lead a resuscitation by the end of their training. With recent changes to medical training in the UK leading to fewer hours worked per week, fewer years of training and therefore less clinical exposure, the chance of this occurring can only increase. Use of simulators has been proposed as one method of addressing the problems faced by paediatric trainees in the UK[3].

Such infrequent exposure enhances the fear factor, making critical situations dealing with children even more stressful. While some stress may be good in a crisis, we know that excessive stress levels impact on performance and increase human error.

In addition, clinicians initially managing a critically ill infant or child may not be paediatric specialists. For those not used to dealing with small patients, unwell babies and neonates produce even greater levels of stress than older children. The spectrum of clinical presentation in infants and small children is different to that of adults, or even older children, as are their physiological responses to both illness and therapies. Fear of 'doing it wrong' may delay decision-making and initiation of treatment in situations where a rapid response needed.

There is a body of evidence, particularly in surgery, which strongly supports that 'practice makes perfect' and high volume is often associated with better outcome. This relationship is particularly true of infrequent high-risk procedures, and is often used to support centralisation of clinical services. This may result in teams with limited support having even less exposure to critical situations, yet being expected to perform when an incident occurs.

Simulation in the form of critical illness and resuscitation scenarios, provides the opportunity to recognise and evaluate potentially life-threatening situations, choose appropriate interventions and perform the required technical skills in real time. Performance of both clinical and non-clinical skills can be evaluated subsequently with constructive feedback in a blame-free environment.

Simulation is an excellent tool for team training, in addition to training for individuals. Resuscitation of the critically ill infant or child is an emotionally charged situation wherever it occurs, putting an additional stress on people who, due to a lack of exposure, already feel under confident and under pressure. Team communication and performance can be explored and developed in a simulated environment, allowing preparation for the non-clinical as well as clinical challenges.

One of the greatest strengths of simulation training is in the assessment and practice of 'non-clinical' skills. We all know that errors occur in medicine, having a variable effect on outcome. Patient harm often results from a series of errors rather than one in isolation[4]. We know that error results from the physiological and psychological limitations of humans. Causes include fatigue, workload and fear as well as cognitive overload, poor interpersonal communications, imperfect information processing and flawed decision-making. Simulation training can address many of these causes and provide opportunities to practise and improve performance.

- Avoids risks to patients and learners
- Reduces undesired interference
- Scenarios/tasks can be created to demand
- Skills can be practised repeatedly
- Training can be tailored specifically for individual requirements
- Retention and accuracy are improved
- Transfer from classroom to real life is enhanced
- Standards for evaluation of performance and assessment of educational need are enhanced

FIGURE 2 Advantages of simulators. Adapted from Maran NJ, Glavin RJ. Low to high fidelity simulation – a continuum of medical education? *Medical Education* 2003; **37**(suppl. 1):22-28.

Non-clinical skills

Non-clinical (also termed non-technical) skills are those cognitive and social skills that pull together a group of clinically and technically competent individuals and allow them to function as an effective team in critical situations.

The US Institute of Medicine estimates that between 44,000 and 98,000 patients a year die as a result of medical errors, and it is recognised that communication failures are one of the leading causes of patient harm. Their report *To Err is Human* states

> "most care delivered today is done by teams of people, yet training often remains focused on individual responsibilities, leaving practitioners

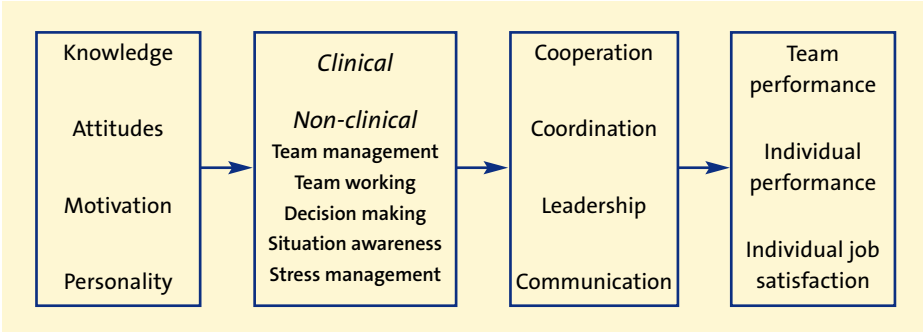

FIGURE 3 Factors influencing team performance. Adapted from Flin R, Maran N. Identifying and training non-technical skill for teams in acute medicine. *Qual Saf Health Care* 2004; **13** (suppl 1):i80-i84.

- Feedback is provided during the learning experience
- Learners engage in repetitive practice
- Simulator is integrated into overall curriculum
- Learners practise with increasing levels of difficulty
- Adaptable to multiple learning strategies (large and small groups etc)
- Allows clinical variation
- Controlled environment allows practise without consequences
- Individualised learning
- Clear outcomes/benchmarks identified
- Validity (realism) of simulator

FIGURE 4 Conditions facilitating effective learning. Adapted from Issenberg SB, McGaghie WC, Petrusa ER et al. Features and uses of high fidelity medical simulations that lead to effective learning: a BEME systematic review. *Med Teacher* 2005; **27**(1): 10-28.

inadequately prepared to enter complex settings."

Within the aviation industry in the 1980s[5] it was recognised that high technical proficiency in pilots was not enough to guarantee safety, and that the root cause of many aeroplane accidents was poor team performance rather than lack of expertise. Research by NASA has shown that 70% of aviation accidents involve human error[5].

Crew resource management (CRM) was developed in response to this finding, aiming to enhance the use of non-technical skills in order to improve safety-critical behaviour on the flight deck[6]. These programmes are extensively used in aviation, as well as in other high-risk industries. Due to low accident rates, it is difficult to objectively measure their effectiveness, but there is evidence that they have positively influenced attitudes and behaviour[7-9].

It is recognised that the dynamic decision-making in critical situations in medicine is similar to that faced by flight crew in crisis situations in the cockpit. In addition, as with critical care areas in medicine, the individuals making up the team vary from shift to shift, resulting in the need for individuals to learn portable skills that allow them to integrate rapidly into an effective unit.

Crisis resource management was developed in response to the recognition of such problems facing medicine, with the aim of allowing individuals from different specialties who may never have met, and have no knowledge of each other's skills, to form a cohesive team who can work towards a common goal.

Anaesthesia was the first specialty to adopt these principles, developing the Anaesthetists' Non Technical Skills (ANTS) system to provide a framework for teaching and assessment of non-clinical skills using simulators to run scenarios of critical events[10]. Simulation is now used for training, at both undergraduate and postgraduate level, in an increasing number of specialties including critical care, emergency medicine, trauma, paediatrics and neonates.

With simulators, clinicians from the different specialties involved in caring for critically ill children can learn and practise together, allowing an opportunity for pooling of knowledge, experience and approaches to problem solving. If individuals never work together as part of the same team again, knowledge of another specialty coupled with the non-clinical skills they develop give the next team they form a better chance of effective performance.

Should we get one?

Intuitively it seems to make sense that practising in an environment where we can make mistakes without harming patients is a good thing – we can practise, which we know is good for outcome, and develop our non-clinical skills when it doesn't have huge implications if we get it wrong.

As with many interventions in both medicine and education, our intuitive sense that this is a good thing is not so well supported by good evidence. The body of work has been described as scattered, inconsistent, anecdotal, variable in methodological rigor and largely qualitative in nature[11-13].

In a recent review of 109 studies, Issenberg et al[12] found that high fidelity medical simulations are educationally effective and simulation-based education complements medical education in patient care settings. However, they also identified a set of conditions that facilitate effective learning (**FIGURE 4**) of which the most critical condition for success is robust reflection and feedback.

A survey of medical students and educators[14] by Gordon et al in 2001 found that the responses of both to hi-fidelity patient simulation were very positive. The majority of both students and educators rated the sessions as excellent and felt they should be a mandatory part of training, citing realism and a sense of urgency, exposure to clinical situations requiring problem solving and critical thinking, opportunity for reflection and the ability to make mistakes in a safe environment.

Simulation-based training has been shown to be superior to problem-based learning for acquisition of critical assessment and management skills[11] and effective in the improvement of non-technical skills of anaesthesia residents[15,16], in evaluating management of sepsis[17], in improving performance of emergency teams[18], in neonatal resuscitation[19], paediatric resuscitation[20], safety in paediatric sedation[21] in measurement of situational awareness[22] and in development of numerous technical skills[23-25]. There is evidence that the team approach to critical care at the undergraduate level can be taught using hi-fidelity patient simulation[26].

Although we do not yet have robust evidence supporting effectiveness of simulation training in improving patient outcomes, there is no published evidence of negative effects, and the difficulties of studying impact on outcomes are legion. However, set-up costs for simulators are

significant and there are a number of inherent difficulties in delivering training sessions that need to be taken into consideration.

The main problems limiting the use of simulation technologies are lack of time to attend off-site sessions, and lack of human resources ie available trainers. It is recommended that simulation training should be delivered by clinically active teachers who are subject matter experts in their own fields[13] – such individuals clearly have numerous pressures on their time making an off-site teaching commitment difficult to integrate.

Weinstock et al set up an on-site comprehensive simulator adjacent to the paediatric critical care area and showed a major improvement in participation rates (>1100 encounters in 1 year) compared with off-site facilities 15 minutes away (5-8 fellows per year). On-site facilities may prove to be the way forward for effective multidisciplinary education by simulation. A similar project is underway in Bristol[27].

However, a simulator is only as good as the educational programme in which it is embedded – in order to avoid the problem of simulators purchased and then under-utilised, clear educational goals need to be defined.

Where next?

There is no doubt that our non-clinical skills are as important for our effective performance in critical situations as our knowledge and technical ability. However, they are much harder to define, quantify and assess. The use of simulation has allowed the development and validation of systems to achieve this, as in anaesthesia, and the ANTS model is now being adapted by other specialties for their own scores. In addition simulators give us the opportunity to test those skills in the complex situations where good performance is most critical, working in the same multidisciplinary teams as we do 'on the shop floor' and to reflect and receive feedback in order to improve.

The potential for development of simulator use in teaching and training for all healthcare professionals seems limitless. Simulators have a multitude of potential applications including education, training, assessment of performance of individuals, small teams and organisational practices (such as patient care protocols), and for research including investigation of human factors.

Some studies have already been undertaken exploring their use as an assessment tool[28-32] and have shown that simulation-based examination is reliable and valid, that it may be able to discriminate those who 'know how' from those who can 'show how', and provides a more realistic feedback system and a higher objectivity than other testing techniques currently employed.

Simulation in conjunction with telemedicine is being explored for continuing professional development of clinicians working in remote and rural environments in the US, Canada and UK. In a comparison of assessment of neonatal resuscitation skills face-to-face and remotely[28] Curran et al found that students were satisfied with the assessment, while examiners found some difficulties with technical aspects, and the level of multi-tasking involved. It was felt that orientation of users, among other factors, would be critical to the success of simulation for remote assessment. However, it remains a potentially very useful tool in this environment.

In Scotland, a project is underway to pilot a mobile skills unit incorporating simulators to travel to hospitals in the Highlands and Islands for ongoing staff training. This will include a Laerdal Simbaby for infant resuscitation training and retrieval training.

Simulation can be used to investigate the operation of medical equipment in high hazard clinical settings such as critical care areas[34,35] and simulator-based tests of the usability of clinical equipment and medical devices have been undertaken in devices already available.

As previously discussed, management of infant and paediatric resuscitation is a low-frequency, high-stress event with huge implications for the child involved, the family and clinicians. Our non-clinical skills as well as technical ability are central to a good outcome, and simulation is an ideal way for us to develop and practise these skills to ensure the best possible management of these complex and challenging events when they occur.

Simulators are expensive to set up, and require hard work, careful thought and ongoing commitment from trainers if they are to be used effectively. It remains to be seen whether the integration of simulators into medical training realises its full potential. However, it is an opportunity to improve training that I believe we would be foolish to lose.

"The future of simulation in health care depends on the commitment and ingenuity of the healthcare simulation community to see that improved patient safety using this tool becomes a reality". *Dr D M Gaba*

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