Simulation in paediatrics: An educational revolution

Adam Cheng MD FRCPC[1], Jonathan Duff MD FRCPC[2], Estee Grant MD FRCPC[3],
Niranjan Kissoon MD FRCPC[4], Vincent J Grant MD FRCPC[5]

A Cheng, J Duff, E Grant, N Kissoon, VJ Grant. Simulation in paediatrics: An educational revolution. Paediatr Child Health 2007;12(6):465-468.

Recent changes in the culture of medical education have highlighted deficiencies in the traditional apprenticeship model of education, and emphasized the need for more experiential modalities of learning. Simulations, which are scenarios or environments designed to closely approximate real-world situations, have recently found their way into the medical training of health care providers. High-fidelity simulators are life-like mannequins connected to computer systems that control the physiological and physical responses of the mannequin. These simulators are able to provide direct feedback to learners in safe, risk-free environments. This technology has been used to teach all aspects of medical care, including medical knowledge, technical skills, and behavioural training or communication skills. The present article provides a general overview of simulation that will hopefully help to generate interest in paediatric simulation across Canada. Several tertiary care paediatric hospitals in Canada are already using simulation to teach health care providers; continued growth and interest is expected in this exciting area of medical education.

Key Words: *Education; Fidelity; High; Medical; Paediatrics; Simulation*

La simulation en pédiatrie : Une révolution en éducation

Les récentes modifications apportées à la culture de l'éducation en médecine ont mis en lumière les lacunes du modèle classique d'éducation par stages et souligné la nécessité de modalités plus expérientielles d'apprentissage. Les simulations, caractérisées par des scénarios ou des milieux conçus pour approximer étroitement les situations réelles, ont récemment été intégrées à la formation médicale des dispensateurs de soins. Les simulateurs haute fidélité sont des mannequins d'aspect naturel reliés à des systèmes informatiques qui commandent les réactions physiologiques et physiques du mannequin. Ces simulateurs renvoient des réactions immédiates aux stagiaires dans un milieu sécuritaire, sans risque. Cette technologie permet d'enseigner tous les aspects des soins médicaux, y compris les connaissances médicales, les aptitudes techniques et la formation comportementale ou les aptitudes de communication. Le présent article donne un aperçu général de la simulation qui, espère-t-on, contribuera à susciter l'intérêt envers cette technologie en pédiatrie au Canada. Plusieurs hôpitaux de soins tertiaires du Canada font déjà appel à la simulation pour l'enseignement aux dispensateurs de soins. On prévoit une croissance et un intérêt continu envers ce domaine passionnant de la formation médicale.

Medical education has traditionally relied on an apprenticeship model to educate learners. However, as trainee numbers continue to increase in Canadian medical schools and postgraduate programs, there are fewer opportunities for learners to be exposed to less common medical conditions. As a result, deficits have been found in the knowledge base and clinical skills of resident housestaff, especially in the area of acute care medicine (1). With the release of the Institute of Medicine's report, *To Err is Human: Building a Safer Health System* (2), patient safety has become a burning issue because educators are emphasizing the need for more hands-on learning before medical trainees are exposed to real patients. Moreover, the concept of 'see one, do one, teach one' is impractical and may no longer be appropriate, when modern technology can afford us the luxury of practising on realistic models before working with real patients (3). Therefore, new approaches to medical education are required to improve opportunities for experiential learning. Simulation using realistic models and scenarios may provide these opportunities.

WHAT IS SIMULATION?

Simulations are scenarios or environments designed to closely approximate real-world situations, usually for the purposes of training or evaluation. In various forms, simulation has been used for centuries, from medieval knight training for jousts using quintains as mock opponents to the early flight simulators used to train fighter pilots in World War II (4). Simulation continues to play a large role in the education of personnel in industries in which there are inherent risks of catastrophic error, and where training in the real world would be too costly or dangerous. These

[1]*Division of Emergency Medicine, BC Children's Hospital, University of British Columbia, Vancouver, British Columbia;* [2]*Division of Intensive Care, Stollery Children's Hospital, University of Alberta, Edmonton;* [3]*Division of Critical Care, Alberta Children's Hospital, University of Calgary, Calgary, Alberta;* [4]*Acute and Critical Care Services, BC Children's Hospital, University of British Columbia, Vancouver, British Columbia;* [5]*Division of Emergency Medicine, Alberta Children's Hospital, University of Calgary, Calgary, Alberta*
Correspondence: Dr Adam Cheng, Division of Emergency Medicine, BC Children's Hospital, Room K4–226, Ambulatory Care Building, 4480 Oak Street, Vancouver, British Columbia V6H 3V4. Fax 604-875-2414, e-mail acheng@cw.bc.ca
Accepted for publication June 6, 2007

TABLE 1
Ways to achieve realism in simulation

Variable	Things to consider
Students	Must be fully engaged in their learning
	Must be oriented to the capabilities of the simulator
Instructors	Should stay hands-off as much as possible
	Should minimize verbal feedback during simulation
	Should remain out of sight from learners during simulation
Environment	Room design should match resuscitation area in hospital
	Equipment should be familiar to team (crash cart, airway equipment, intravenous equipment, monitors, etc)
	Documentation should be realistic (patient chart and nursing flow sheets)
	Appropriate resources should be made available, eg, telephone, gown and gloves, and blankets
	Multimedia display for test results and clinical findings: x-rays, ECGs, laboratory results, photos (rashes, deformities, etc), or actual patient video (seizures and respiratory distress)
Personnel	Use of multidisciplinary team training
	Team members should assume their normal roles
	Team members may enter in stages
	Consultants may be incorporated into scenarios
	Actors may be added to play roles as necessary

ECGs Electrocardiograms

industries include commercial aviation, nuclear power, the military and NASA (5). Medicine can now be added to the list of industries, because it is from these industries that the field of medical simulation was born. The era of modern medical simulation has its roots in the mid-20th century with the development of the 'Resusci Annie' mannequin by Åsmund Lærdal, a Norwegian toy-maker (6), and the first high-fidelity simulator designed by Denson and Abrahamson, appropriately named 'Sim One' (7). Although the 'Sim One' project was short lived, the medical simulation industry has grown substantially since then, now with commercially available high-fidelity mannequins offering a variety of realistic functions and capabilities.

Various types of simulators exist, ranging from simple models to highly advanced, computer-driven systems. Fidelity is the extent to which the appearance and behaviour of the simulator or simulation match the appearance and behaviour of the simulated system (8). Simulator fidelity ranges from low-fidelity models including static mannequins and partial task-trainers (designed to teach one specific skill such as intubation), to high-fidelity simulators with life-like mannequins connected to computer systems designed to control the mannequin's physical and physiological responses (9). These high-fidelity simulators facilitate student interaction by providing direct feedback in the form of physical findings such as heart sounds, breath sounds, palpable pulses, blinking eyes and even speech. Physiological responses, generated by the operator through a computer-driven model, allow for vital signs to change in preprogrammed stages or in response to administered medications or interventions. Due to their extensive capabilities, these types of simulators can be quite expensive. However, with the growth of simulation over the past decade, manufacturers have managed to produce more reasonably priced simulators which can be purchased for approximately $40,000 to $50,000. For many centres, the investment in such simulators is justified by developing simulation programs aimed at teaching all types of health care providers the cognitive, technical and behavioural aspects of managing a wide array of medical conditions in simulated acute care settings.

HOW IS REALISM ACHIEVED IN SIMULATION?

Although simulation experiences are designed to be as real as possible to facilitate experiential learning, there are many challenges inherent in achieving this realism. This underscores the tremendous advantage of using high-fidelity simulation in which the simulator itself is able to mimic real physical findings and real physiological responses. However, the cost and limited availability of high-fidelity simulators means that they cannot be used in all areas of medical training as yet. To maximize their value and potential, medical educators should aim to match the amount of realism to the desired educational objectives of the simulation session.

For simulations in which a high degree of realism is desired, the primary goal of the simulation-based educator should be to 'suspend disbelief', allowing students to immerse themselves in a learning experience that most closely matches that encountered in real life. To achieve suspension of disbelief, students must commit to becoming fully engaged in their learning, and instructors should stay as hands-off as possible during the simulated scenario. Other variables to consider involve recreating a physical and psychological environment, including utilization of other personnel to achieve learning objectives. Table 1 outlines the specific ways to achieve realism in simulation.

BENEFITS OF SIMULATION

Critical events in paediatrics are infrequent, yet patients can have good outcomes if successfully managed (10-12). Although many practicing health care providers will at some point be required to manage acutely ill or injured children, very few opportunities to learn and practise the necessary skills are encountered during medical training or practice. Many of these skills are taught didactically, with few opportunities for hands-on practice. Lack of opportunities to practice skills erodes health care provider confidence, adversely affects their performance, and increases the possibility of medical errors or an adverse outcome (13-16). Until now, opportunities for hands-on practice have either been left to chance or have been created using static mannequins with indirect patient feedback from an instructor. Because these experiences lacked the realism of actually assessing and treating an acutely ill or injured child, there are significant limitations in terms of the knowledge, clinical skills and confidence these sessions have imparted to learners. By comparison, the immersive nature of simulation training allows participants to practise in an environment that closely mimics the assessment and treatment of real patients (17,18). The suspension of disbelief achieved by a well-designed simulation allows learners to speak and act as if in an actual patient encounter, while receiving direct feedback from the simulation equipment.

Increasing exposure to acutely ill or injured children in this type of immersive environment is a major benefit of simulation education. According to adult learning theory, learning is enhanced when 'real-world' application is appreciated by the learner, when direct feedback is incorporated and when small groups with varied experiences are able to reflect together to direct their learning and generalize their experience (19). Using David Kolb's Experiential Learning Model (20), simulation can provide a learning experience that incorporates these important elements to meet the adult learner's needs. This model involves using a highly realistic experience (the simulation) with immediate 'real-world' relevance, followed by reflection on this experience in small groups to generalize learned concepts to new experiences. This reflective component is usually accomplished using video-assisted debriefing to stimulate a discussion with expert feedback regarding what occurred during the simulation experience. This is then followed by a discussion of how concepts can be generalized more broadly, ultimately allowing for the opportunity to try out new or different approaches the next time that same experience is encountered (20). Given these enhanced abilities for reflection, generalization and application, the ability to provide additional and ongoing opportunities for experience and practice in the assessment and management of acutely ill or injured children is likely the greatest benefit of simulation. Experiences can be provided on an on-demand basis versus by chance alone, and scenarios with unexpected or unfortunate outcomes can be repeated and mastered (5,9).

Other significant benefits of the simulation experience include practice in a risk-free environment, allowing errors to occur and reaching a conclusion; presentation of uncommon disease presentations or atypical presentations of common diseases; practice of complex clinical situations; and the ability to evaluate new equipment, interventions, treatment protocols and procedures (21-28). Even with all of these potential benefits of simulation learning, there is an emerging body of evidence that indicates that the potentially greatest benefit of simulation may be the ability to train in a team setting with the incorporation of training in human factors that contribute to medical error. The quality of team behaviour has been shown to improve following training as a team using simulation, and this may lead to a subsequent reduction in the number of medical errors (29-33). Ongoing assessment of the value and benefits of simulation is essential for integration into formal medical education. Table 2 summarizes the benefits of simulation-based education.

TABLE 2
Benefits of simulation

Benefits
• Immersive, experiential learning
• Reflective learning
• Multifaceted learning: Knowledge, skills and attitude
• On-demand learning: Increased exposure to various common and uncommon diseases
• Safe, risk-free learning environment
• Skills can be practised repeatedly
• Ability to evaluate new equipment, interventions, treatment protocols and procedures
• Multidisciplinary team training
• Allows for assessment of learners with standardized clinical scenarios

PAEDIATRIC SIMULATION IN CANADA

High-fidelity simulation has been evolving rapidly over the past few years within Canadian tertiary care paediatric centres. Simulation programs have been developed on- or off-site in several cities across Canada. The advent and growth of the paediatric simulation community in Canada will eventually help to address many pertinent and pressing issues in paediatric acute care. These include questions pertaining to acute care protocols, multidisciplinary team functioning and dynamics, patient safety, risk management, as well as mass casualty preparedness and disaster management. From an educational point of view, clinical modules and scenarios already developed for simulation should ideally be shared among centres to help move simulation forward in our country. The next step for simulation-based educators will be the development, implementation and evaluation of simulation curricula with specific learning objectives and target audiences in mind. These advances will help to train the next generation of physicians, nurses and allied health professionals, providing them with the skills and knowledge necessary to treat our paediatric population.

SUMMARY

Paediatric simulation has experienced rapid growth in Canada over the past two years. To ensure continued development of simulation in paediatrics, collaboration among existing and new paediatric centres is crucial. New programs can look to existing centres for support with design plans, technical assistance, budget issues and scenario development. Dissemination and sharing of pre-existing scenarios among centres will help to build simulation programs and facilitate the formal incorporation of simulation into all levels of medical training. Formal instructor training programs in Canada are still lacking and should be developed to help ensure a consistently high quality of simulation-based learning. Research opportunities in simulation are endless, which include the need for studies on various aspects of medical education, patient safety and risk reduction, team training and communication, as well as the implementation of new treatment protocols and procedures. The future for paediatric simulation in Canada is bright, and the development of paediatric simulation centres across our country signifies what may be the true beginning of an educational revolution.

REFERENCES

1. Nadel FM, Lavelle JM, Fein JA, Giardino AP, Decker JM, Durbin DR. Assessing pediatric senior residents' training in resuscitation: Fund of knowledge, technical skills, and perception of confidence. Pediatr Emerg Care 2000;16:73-6.
2. Kohn LT, Corrigan JM, Donaldson MS. To Err is Human: Building a Safer Health System. Washington DC: National Academy Press, 1999.
3. Ziv A, Wolpe PR, Small SD, Glick S. Simulation-based medical education: An ethical imperative. Acad Med 2003;78:783-8.
4. Grenvik A, Schaerfer JJ, Medical simulation training coming of age. Crit Care Med 2004;32:2549-50.
5. Bradley P. The history of simulation in medical education and possible future directions. Med Educ 2006;40:254-62.
6. Tjomsland N, Baskett P. Asmund S Laerdal. Resuscitation 2002;53:115-9.
7. Denson JS, Abrahamson S. A computer-controlled patient simulator. JAMA 1969;208:504-8.
8. Farmer E, van Rooij J, Riemersma J, Joma P, Morall J. Handbook of Simulator Based Training. Aldershot: Ashgate Publishing, 1999.
9. Maran NJ, Glavin RJ. Low to high-fidelity simulation – a continuum of medical education? Med Educ 2003;37(Suppl 1):22-8.
10. Slonim AD, Patel KM, Ruttimann UE, Pollack MM. Cardiopulmonary resuscitation in pediatric intensive care units. Crit Care Med 1997;25:1951-5.
11. Zaritsky A. Outcome of pediatric cardiopulmonary resuscitation. Crit Care Med 1993;21:S325-7.
12. Innes PA, Summers CA, Boyd IM, Molyneux EM. Audit of pediatric cardiopulmonary resuscitation. Arch Dis Child 1993;68:487-91.
13. Buss PW, McCabe M, Evans RJ, Davies A, Jenkins H. A survey of basic resuscitation knowledge among resident paediatricians. Arch Dis Child 1993;68:75-8.
14. Cappelle C, Paul RI. Educating residents: The effects of a mock code program. Resuscitation 1996;31:107-11.
15. Scweich PJ, DeAngelis C, Duggan AK. Preparedness of practicing pediatricians to manage emergencies. Pediatrics 1991;88:223-9.
16. Thwaites BC, Shanker S, Niblett D, Saunders J. Can consultants resuscitate? J R Coll Physicians Lond 1992;26:265-7.
17. Gaba DM. The future vision of simulation in health care. Qual Saf Health Care 2004;13(Suppl 1):i2-10.
18. Halamek LP, Kaegi DM, Gaba DM, et al. Time for a new paradigm in pediatric medical education: Teaching neonatal resuscitation in a simulated delivery room environment. Pediatrics 2000;106:E45.
19. Knowles M. The Adult Learner: A Neglected Species, 3rd edn. Houston: Gulf Publishing, 1984.
20. Kolb D. Experiential Learning: Experience as a Source of Learning and Development. Englewood Cliffs: Prentice Hall, 1984.
21. Gordon JA, Wilkerson WM, Shaffer DW, Armstrong EG. 'Practising' medicine without risk: Students' and educators' responses to high-fidelity simulation. Acad Med 2001;76:469-72.
22. Gaba DM, Howard SK, Flanagan B, Smith BE, Fish KJ, Botney R. Assessment of clinical performance during simulated crises using both technical and behavioral ratings. Anesth 1998;89:8-18.
23. Yee B, Naik VN, Joo HS, et al. Nontechnical skills in anesthesia crisis management with repeated exposure to simulation-based education. Anesthesiology 2005;103:241-8.
24. Issenberg SB, McGaghie WC, Hart IR, et al. Simulation technology for health care professional skills training and assessment. JAMA 1999;282:861-6.
25. Curran VR, Aziz K, O'Young S, Bessell C. Evaluation of the effect of a computerized training simulator (ANAKIN) on the retention of neonatal resuscitation skills. Teach Learn Med 2004;16:157-64.
26. Hall RE, Plant JR, Bands CJ, Wall AR, Kang J, Hall CA. Human patient simulation is effective for teaching paramedic students endotracheal intubation. Acad Emerg Med 2005;12:850-5.
27. Marshall RL, Smith JS, Gorman PJ, Krummel TM, Haluck RS, Cooney RN. Use of a human patient simulator in the development of resident trauma management skills. J Trauma 2001;51:17-21.
28. Gilbart MK, Hutchisin CR, Cusimano MD, Regehr G. A computer-based trauma simulator for teaching trauma management skills. Am J Surg 2000;179:223-8.
29. Shapiro MJ, Morey JC, Small SD, et al. Simulation based teamwork training for emergency department staff: Does it improve clinical team performance when added to an existing didactic teamwork curriculum? Qual Saf Health Care 2004;13:417-21.
30. Wallin C-J, Meurling L, Hedman L, Hedegård J, Felländer-Tsai L. Target-focused medical emergency team training using a human patient simulator: Effects on behaviour and attitude. Med Educ 2007;41:173-80.
31. Østergaard HT, Østergaard D, Lippert A. Implementation of team training in medical education in Denmark. Qual Saf Health Care 2004;13(Suppl 1):i91-5.
32. Holcomb JB, Dumire RD, Crommett JW, et al. Evaluation of trauma team performance using an advanced human patient simulator for resuscitation training. J Trauma 2002;52:1078-86.
33. Morey JC, Simon R, Jay GD, et al. Error reduction and performance improvement in the emergency department through formal teamwork training: Evaluation results of the MedTeams project. Health Serv Res 2002;37:1553-81.