13 SIMULATION IN TEACHING-LEARNING OF HEALTHCARE PROFESSIONALS IN A VIRTUAL HOSPITAL SETTING

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13.1 Introduction

The past three decades have seen a rapidly growing interest in using simulation for purposes of improving patient safety and patient care through a variety of applications. Those working on the development and use of simulation in healthcare seek to produce a model in which the structures and systems of healthcare are optimised for safety, quality and efficiency. Current systems of healthcare throughout the world do not accomplish this: the reports of the United States (US) Institute of Medicine on medical error and on "crossing the quality chasm" are good examples. The revolution that has been envisioned concerns education, training and maintaining of skills by health care personnel to provide safe clinical care. Current healthcare system places a premium on basic science education, and leaves most clinical training to a relatively unsystematic apprenticeship process. The emphasis is on individual knowledge and skill rather than on honing the performance of clinical teams.

Medical education has, during the past decade, witnessed a significant increase in the use of simulation technology for teaching and assessment. Contributing factors for this trend include: changes in healthcare delivery and academic environments that limit patient availability as educational opportunities; worldwide attention focused on the problem of medical errors and the need to improve patient safety; and the paradigm shift to outcomes-based education with its requirements for assessment and demonstration of competence. The use of simulators addresses many of these issues: they can be readily available at anytime and can reproduce a wide variety of clinical conditions on demand. In lieu of the customary (and arguably unethical) system, whereby novices carry out the practice required to master various techniques – including invasive procedures – on real patients, simulation-based education allow trainees or clinical teams to hone their skills in a risk-free environment. Evaluators can also use simulators for reliable assessments of competence in multiple domains. (Scalese *et. al.* 2007)

Use of Information Technology has been the most important enabler: witness the widespread use of medical IT across the continuum of lifelong learning: medical students now view lectures online or via podcasts; residents consult resources stored in personal digital assistants (PDAs) to help make patient management decisions at the point of care; practitioners receive continuing education credits by attending teleconferences broadcast over the internet. (Scalese *et. al.* 2007)

13.2 Definition of Simulation

"Simulation" is a technique, not a technology, to replace or amplify real experiences with guided experiences, often immersive in nature, that evoke or replicate substantial aspects of the real world in a fully interactive fashion.

Gaba (2004) stresses that simulation should be interpreted as a strategy – not a technology – to mirror, anticipate, or amplify real situations with guided experiences in a fully interactive way.

Scalese *et al.* (2007) clarified aims of "medical simulations" as imitation of real patients, anatomic regions, or clinical tasks, and/or mirroring the real-life circumstances in which medical services are rendered. While "simulators" refers to particular simulation devices, which can take many forms and span the range from low to high fidelity, and from devices for individual users to simulations for groups of trainees. A convenient classification scheme groups these various simulators into 3 categories: part task trainers, computer-enhanced mannequins (CEM), and virtual reality simulators.

The interest in simulation for healthcare is derived in large measure from the long experience and heavy use of simulation for training and other purposes in non-medical industries. In particular, these include commercial aviation, nuclear power production, and the military industries that share with healthcare intrinsic hazards and complexity, but are considered high reliability organisations that have a very low failure rate considering their inherent risks. (Gaba DM, 2001).

Simulation-based training is a method or strategy of training that involves the use of several scientific, theory-based approaches to training, and includes information, demonstration, and practice-based methods. (Salas et. al., 2006) It is an approach to training that seeks to accelerate the development of expertise by systematically designing opportunities to practise that result in the desired learning (Salas and Rosen, 2008).

According to Salas *et al.* (2005) the key components of simulation-based training are as follows:

- performance history/skill inventory,
- tasks/competences,
- training objectives,
- events/exercises,
- measures/metrics,
- performance diagnosis, and
- feedback and debrief.

Simulation learning serves as a bridge between classroom learning and real-life clinical experience. Using simulation technologies in true-to-life medical settings, learners are free to build on their current knowledge base and develop important clinical skills before they work with real patients (Aukstakalnis *et. al.*, 2008).

In the current healthcare system, for most invasive procedures, novices at a task will typically first perform the task on a real patient, albeit under some degree of supervision. They climb the learning curve, working on patients with varying levels of guidance. Simulation offers the possibility of having novices practise extensively before they begin to work on real patients as supervised "apprentices". (Gaba, 2004)

13.3 Simulation–based Training

Simulation–based training provides opportunities for trainees to develop requisite competencies through practice in a simulated environment that is representative of actual operational conditions; trainees receive feedback related to specific events that occur during training (Oser et. al., 1999). The healthcare community can gain significantly from using simulation-based training to reduce errors and improve patient safety when it is designed and delivered appropriately (Salas *et. al.*, 2005)

Following The Berry/Cooper (2006) simulation-based training is dependent upon the fact-based scenarios that are played out by a cast of real participants and artificial patients. Together, they provide an experience that helps physicians, nurses, and students:

- acquire the procedural skills of medicine without "practising" on patients and then allow the practice of those skills to maintain them;
- rehearse the rare events, the equivalent of an engine failure event for a pilot in the flight simulator;
- behave and communicate more effectively as part of a team, particularly in a crisis;
- safely try out new and sometimes dangerous ideas and equipment;
- record their learning experience with the benefit of replay and reflection; and
- assess their performance more objectively than is now done in a purely clinical environment.

In healthcare, simulation will be employed for those activities for which it is best suited, particularly for activities that are hazardous, involve uncommon or rare situations, or for which experiential learning is of great value. Finding the right mix of traditional learning, simulation based learning, and actual patient care experience is an important challenge (Gaba, 2004).

13.4 Does Simulation-based Education Work?

More than 600 studies enrolling over 36,500 participants have attempted to answer whether simulation-based education worked by comparing simulation-based training against no intervention. In these comparisons, both virtual patients and technology-enhanced simulation are consistently associated with large, statistically significant benefits in the areas of knowledge, skills (instructor ratings, computer scores, or minor complications in a test setting), and behaviours (similar to skills, but in the context of actual patient care) (Cook *et. al.*, 2010 and Cook *et. al.*, 2011). For direct patient effects (e.g., major complications, mortality, or length of stay), the benefits are smaller but still significant (Zendejas *et. al.*, 2013). Clearly, simulation-based education works - at least when compared with no instruction.

There are studies comparing different simulation-based approaches to explain what works, for whom, and in what context. To this end, a review of 289 studies of technology-enhanced simulation (enrolling nearly 20,000 participants) confirmed theory-based predictions that feedback, repetition, range of difficulty, cognitive interactivity, clinical variation, distributed practice, individualised training, and longer training time significantly improve skill outcomes (Cook, 2013). Similar analyses for patient-related outcomes (behaviors and patient effects) revealed benefits of similar direction and magnitude that approached but did not reach statistical significance.

Comparing with other modalities is challenging because every study uses a slightly different simulation intervention and a slightly different "other" approach. However, evidence from more than 100 studies and 7000 participants indicates that simulation is non-inferior to other approaches (Cook, 2012 and Cook, 2013). Technology-enhanced simulation is associated with a small but statistically significant benefit for outcomes of knowledge and skills, while for patient-related outcomes (behaviors and direct patient effects) the benefits approached but did not reach statistical significance (Cook, 2013). In summary, simulation-based education is as good as, but perhaps not substantially better than other approaches.

Although effectiveness is now well established, value judgments require consideration of costs—not only the price of the simulator (many of which cost upwards of USD$75,000) but also faculty time, training expenses, facility fees, and opportunity costs (i.e. what else could trainees do with their time?). Very few studies have enumerated these costs, and none has offered a complete accounting (Zendejas *et. al.*, 2013) leaving us very much in the dark when it comes to judging the value of simulation-based education. However, one thing is clear - more expensive simulators are not necessarily better. Numerous examples illustrate that low-fidelity, low-cost training models can yield outcomes equal to much more expensive simulators (Norman *et. al.*, 2012).

13.5 Factors Influencing Use of Simulation-based Education

This shift to simulation-based training and assessment constitutes a significant departure from the traditional "see one, do one" approach and the customary reliance on real patients for education. In addition to developments in simulator technology per se, other factors have influenced this evolution. Changes in healthcare delivery (e.g.

outpatient management of many conditions for which inpatient treatment was previously indicated, higher acuity of illnesses and shorter hospital stays for patients who are admitted) have reduced patient availability as learning opportunities at academic medical centers; at the same time, resident work hour reforms and changes in staff compensation make it increasingly difficult for both trainees and clinical faculty to balance their service obligations with time for education and evaluation. Many simulators, by contrast, are ideally suited for independent learning and, thus, can save faculty time. Moreover, unlike real patients who are frequently "off the ward" when instructors and learners arrive to perform their assessments, simulators can be readily available at any time and can reproduce a wide variety of clinical conditions and situations on demand. This transforms curricular planning from an ad hoc process (dependent on finding real patients with specific conditions of interest) to a proactive scheme with great flexibility for educators. In addition, simulators do not become tired or embarrassed or behave unpredictably (as might real, especially ill, patients), and therefore they provide a standardised experience for all (Scalese *et al.* 2007).

Adopting these models in medical education, specialties such as anesthesiology, critical care, and emergency medicine have led the way in using simulation modalities, especially for teaching and testing the skills needed to manage rare and/or critical incidents. Examples of the effectiveness of such simulation-based training include the mastery of advanced cardiac life support skills by Internal Medicine residents, and a systematic literature review details other features and uses of high-fidelity medical simulations that lead to improved educational outcomes in multiple domains (Scalese *et. al.*, 2007).

Closely related to these safety issues are important ethical questions about the appropriateness of "using" real (even standardised) patients as training or assessment resources. Such debate often centers on instructional or evaluation settings that involve sensitive tasks (e.g., pelvic examination) or risk of harm to patients (e.g., endotracheal intubation). Use of patient substitutes, such as cadavers or animals, raises ethical concerns of its own and faces additional challenges (such as availability, cost, and maintaining an adequately realistic clinical environment). Use of simulators, conversely, circumvents most of these ethical obstacles: trainees can make mistakes and learn to recognise and correct them in the forgiving environment of the simulation, without fear of punishment or harm to real patients. At the same time, the educational experience becomes truly learner-centered, instead of focused on the patient, as is appropriate in actual clinical settings.

13.6 Simulation for Outcome-based Education

"While student learning is clearly the goal of education, there is a pressing need to provide evidence that learning or mastery actually occurs." (Kochevar, 2004) This statement reflects a recent worldwide shift in focus toward outcomes-based education throughout the healthcare professions. This paradigm change derives in part from attempts by academic institutions and professional organisations to self-regulate and set quality benchmarks, but chiefly it represents a response to public demand for assurance that doctors are competent. Accordingly, medical schools, postgraduate training programmes, hospital and health system credentialing committees, and licensing and specialty boards are all placing greater emphasis on using simulation modalities for the evaluation of competence across multiple domains. Thus, beyond its scope for teaching and learning, simulation technology offers potential advantages in the realm of clinical assessment. The new outcomes-based educational paradigm serves as a suitable framework for considering the best applications of simulation technology for testing purposes. The Accreditation Council for Graduate Medical Education

(ACGME) in the US describes 6 domains of clinical competence: 1) patient care, 2) medical knowledge, 3) practice-based learning and improvement, 4) interpersonal and communication skills, 5) professionalism, and 6) systems-based practice. Evaluators may use simulations to assess various knowledge, skills, and attitudes within these domains (Scalese *et al*, 2007).

Some examples: During a ward rotation for Internal Medicine residents, faculty can test aspects of trainees' patient care: using a cardiology patient simulator, demonstrate the ability to perform a focused cardiac examination and identify a fourth heart sound or a murmur. We can evaluate medical knowledge: using a full-body simulator during a simulated cardiac arrest, verbalise the correct steps in the algorithm for treatment of pulseless electrical activity. We can assess interpersonal and communication skills and professionalism: during a simulation integrating a simulated patient (SP) with a plastic mannequin arm, demonstrate how to draw blood cultures while explaining to the patient the indications for the procedure. This last example highlights the reality that actual clinical encounters often require practitioners to utilise their abilities in multiple domains simultaneously. Formal assessments have traditionally focused on isolated clinical skills, e.g. perform a procedure on a simulator at 1 station in an Objective Structured Clinical Examination (OSCE), obtain a history or deliver bad news with an SP at another station. More recently, very innovative work features evaluations more reflective of real clinical practice by combining simulation modalities—for instance, a trainee must interact (gather some history, obtain consent, explain the procedure) with a female SP, who is draped below the waist, while performing a bimanual exam on a pelvic simulator placed beneath the drape—for simultaneous assessment of both technical and communication skills (Scalese et al. 2007).

13.7 Simulation for Competency Assessment

Additionally, within any of the domains of competence, we can assess learners at 4 different levels, according to the pyramid model conceptualised by Miller. These levels are:

A. knows (knowledge) – recall of basic facts, principles, and theories;

B. knows how (applied knowledge) – ability to solve problems, make decisions, and describe procedures;

C. shows how (performance) – demonstration of skills in a controlled setting; and

D. does (action) – behaviour in real practice.

Various assessment methods are more or less well suited to evaluation at these different levels of competence; for example, written instruments, such as exams consisting of multiple choice questions, are efficient tools for assessing what a student "knows". Conversely, it makes little sense (despite longstanding custom) to test the ability to perform a procedure by writing about it. Rather, for evaluation of those outcomes that require trainees to demonstrate or "show how" they are competent to perform various skills, the ACGME Toolbox of Assessment Methods 27 suggests that simulations are the most appropriate instruments. In the patient care domain, for example, the toolbox ranks simulations among "the most desirable" methods for assessing ability to perform medical procedures and "the next best method" for demonstrating how to develop and carry out patient management plans. Within the medical knowledge competency, examiners can devise simulations to judge trainees' investigatory/analytic thinking or knowledge/application of basic sciences. Simulations are "a potentially applicable method" to evaluate how practitioners analyse their own practice for needed improvements (practice-based learning and improvement) and, in the realm of professionalism, simulations are among the methods listed for assessing ethically sound practice. One of the strengths of simulators for testing purposes is their generally high degree of reliability - because of their programming, simulators consistently present evaluation problems in the same manner for every examinee and minimise the variability inherent in actual clinical encounters. This reproducibility becomes especially important when high stakes decisions (e.g., certification and licensure) hinge on these assessments.

Use of simulators for such examinations is already occurring in several disciplines: for instance, the Royal College of Physicians and Surgeons of Canada is utilising computer-based and mannequin simulations in addition to SPs for their national Internal Medicine certification (oral) exams, and the American Board of Internal Medicine employs similar simulations in the Clinical Skills Module that is part of their Maintenance of Certification Programme. Numerous published studies offer evidence of validity (usually "face", "construct", or "content validity") for various medical simulators, but whereas determination of these psychometric properties is important, research often has not addressed the perhaps more important question of "predictive validity" i.e. will performance on a given assessment predict future performance in actual practice? Only recently have there been reports of newer simulation devices for testing (e.g. virtual reality systems for minimally invasive surgery 29,30) related to these considerations that are fundamental to the competency based education model.

13.8 The Technology Applicable or Required for Simulations

To accomplish these goals a variety of technologies (including no technology) will be relevant for simulation. Verbal simulations ("what if" discussions) and standardised patient actors require no technology but can effectively evoke or recreate challenging clinical situations. Similarly very low technology – even pieces of fruit or simple dolls – can stand in for skin and muscle for the initial training of some manual tasks. Certain aspects of even complex tasks and experiences can be recreated even with low tech means. For example, some education and training on teamwork can be accomplished with role playing, analysis of videos, or drills with simple mannequins. Ultimately though, learning and practising complex manual skills (for example, surgery, cardiac catheterisation), or practising the dynamic management of life threatening clinical situations that include risky or noxious interventions (such as intubation or defibrillation), can only be fully accomplished using either animals, which for reasons of both cost and issues of animal rights is becoming very difficult, or a technological means to recreate the patient and the clinical environment. Simulation technologies vary from relatively simple multimedia to different sorts of part-task trainers to simulators. A part-task trainer is a device that replicates limited aspects of a task, but does not present an integrated experience. A "patient simulator" is a system that presents a fully interactive patient and an appropriate clinical work environment in one of the following ways:

- In actual physical reality, using a patient mannequin ("a mannequin based simulator").
- On a computer screen only (a "screen based simulator").
- Using virtual reality (VR; a "virtual reality simulator") by which parts or all of the patient and environment are presented to the user through two or three dimensional visual and audio representations, with or without touch (haptics) to create a more "immersive" experience. A screen based simulator can be viewed as a very limited VR simulator. In addition, VR devices that replicate particular procedures (for example, laparoscopic surgery) in a fully interactive fashion, and that use replicas of actual tools, are also referred to as simulators, even though they do not present the full patient.

13.9 Site of Simulation Participation

Some types of simulation—those that use videos, computer programmes, or the Web – can be conducted in the privacy of the learner's home or office using their own personal computer. More advanced screen based simulators might need more powerful computer facilities available in the medical library. Part-task trainers and virtual reality simulators are best fielded in a dedicated skills laboratory. Mannequin based simulation can also be used in a skills laboratory, although the more complex recreations of actual clinical tasks require either a dedicated patient simulation centre with fully equipped replicas of clinical spaces, or the ability to bring the simulator into an actual work setting (in situ simulation). There are advantages and disadvantages to doing clinical simulations in situ versus in a dedicated centre. For example, using the actual site allows training of the entire unit with all its personnel, procedures, and equipment. On the other hand, there will at best be limited availability of actual clinical sites and the simulation activity may distract from real patient care work. The dedicated simulation centre is a more controlled and available environment, allowing more comprehensive recording of sessions, and imposing no distraction on real activities. For large scale simulations (such future vision of simulation as disaster drills) the entire organisation becomes the site of training.

Video conferencing and advanced networking may allow even advanced types of simulation to be conducted remotely (see dimension 10 below). For example, the collaborative use of virtual reality surgical simulators in real time has already been demonstrated, even with locations that are separated by thousands of miles.

13.10 The Extent of Direct Participation in Simulation

Most simulations, even screen based simulators or part-task trainers, were initially envisioned as highly interactive activities with significant direct "on site" hands-on participation. However, not all learning requires direct participation. For example, some learning can take place merely by viewing a simulation involving others, as one can readily imagine being in the shoes of the participants. A further step is to involve the remote viewers either in the simulation itself or in debriefings about what transpired. Several centres have been using video conferencing to conduct simulation based exercises, including morbidity and mortality conferences. Because the simulator can be paused, restarted, or otherwise controlled, the remote audience can readily obtain more information from the onsite participants, debate the proper course of action, and discuss with those in the simulator how best to proceed.

13.11 The Feedback Method Accompanying Simulation

Much as in real life, one can learn a great deal just from the experience itself, without any additional feedback. For most complex simulations, specific feedback is provided to maximise learning. For onscreen based simulators or virtual reality systems, the simulator itself can provide feedback about the participant's actions or decisions, particularly for manual tasks where clear metrics of performance are readily delineated. More commonly, human instructors provide feedback for simulations. This can be as simple as having the instructor review records of previous sessions that the learner has completed alone. For many target populations and applications an instructor provides real time guidance and feedback to participants while the simulation is going on. Here too, the ability to start, pause, and restart the simulation can be valuable. For the most complex uses of simulation, especially when training relatively experienced personnel, the typical form of feedback is a detailed post-simulation debriefing session, often using audio-video recordings of the scenario. Waiting until after the scenario is finished allows experienced personnel to apply their collective skills without interruption but then allows them to see and discuss the advantages and disadvantages of their behaviours, decisions, and actions.

Of the features and best practices in stimulation-based education, McGaghie (2010) highlighted the importance of debriefing in giving medical trainees feedback in the context of simulated-based education. According to the author, the following evidence-based practices described by Salas *et. al.* (2008) for team debriefing for use after critical incidents or recurring clinical events can be adopted for simulation-based education:

1. Debriefs must be diagnostic.
2. Ensure that the organisation creates a supportive learning environment for debriefs.
3. Encourage team leaders and team members to be attentive of teamwork processes during performance episodes.
4. Educate team leaders on the art and science of leading team debriefs.
5. Ensure that team members feel comfortable during debriefs.
6. Focus on a few critical performance issues during the debriefing process.
7. Describe specific teamwork interactions and processes that were involved in the team's performance.
8. Support feedback with objective indicators of performance.
9. Provide outcome feedback later and less frequently than process feedback.
10. Provide both individual and team-oriented feedback, but know when each is most appropriate.
11. Shorten the delay between task performance and feedback as much as possible.
12. Record conclusions made and goals set during the debrief to facilitate feedback during future debriefs.

13.12 Cost

The cost of implementing various applications of simulation varies widely. Cost depends greatly on the mix of target population, purpose of simulation and technology used. Some forms of simulation are inexpensive and distributed (e.g. screen-based or web-based simulations and part-task trainers). Low cost is particularly important for early learners of tasks and skills, where routine availability and the possibility of repeated practice are most valuable. Where simulation training replaces existing training (e.g. as a substitute for animal laboratories) its relative cost will also be relatively low. At the highest end – providing new training curricula to experienced clinical teams or work units, using high fidelity scenarios – the costs are likely to be substantial. Yet it is exactly for these applications that the greatest potential is seen for improving patient safety.

13.13 Benefits

The benefits derived from the various applications of simulation will be much harder to measure than the costs. Safety gains are intrinsically difficult to assess, whereas the magnitude of the investments made are starkly apparent (Gabam, 2001). Some benefits may be direct, stemming from immediately discernable improved performance of individuals and teams. This might result in efficiencies in care and reduced errors that more than offset the costs of simulation based training. Many benefits probably depend on long term cumulative synergies.

13.14 Types of Simulation

There are 4 types of simulation:

- Simple
- Mechanical
- Standardised Patient
- Virtual Scenario

Simple simulation allows practice of basic skills with minimal supervision; it is relatively inexpensive, and it is available 24 hours. The learner is able to practise to the point of automaticity for simple skill. However, there is no direct feedback to the learner. There is also lack of patient interactivity.

Mechanical simulation can be further divided into simple mechanical and complex mechanical. Mechanical simulation allows practice of more complex skills and teamwork and also allows for varied levels of risk. Having learnt from mechanical simulation, students will have the basic skills when they enter an operating room or clinic. Mechanical simulation, however, involves high cost, need of supervision and lack of patient interactivity. It is also time consuming and requires dedicated space and personnel.

Available Technologies

Part-Task Trainers

Part-task trainers consist of representations of body parts/regions with functional anatomy for teaching and evaluating particular skills, such as plastic arms for venipuncture or suturing, or head/neck/torso mannequins for central line placement or endotracheal intubation. In most cases, the interface with the user is passive - the user performs some procedure with no response from the model.

These trainers generally have lower engineering fidelity and do not require sophisticated technological components, making them less expensive, yet they can reproduce the tasks to be assessed with moderate to high degrees of psychological fidelity.

There are numerous simulators for teaching of general examination skills. For example, ocular examination simulators consist of a mannequin head whose eyes have variable pupil sizes for teaching funduscopic technique, allowing examinees to use a real ophthalmoscope for diagnosis of normal eyegrounds, as well as many pathologic retinal findings of common diseases. Breast exam trainers simulate realistic anatomy for teaching technique and ability to diagnose pathologic findings (cyst, lipoma, fibroadenoma, carcinoma); some even allow training of procedural skills, such as cyst aspiration.

For emergency skills, Laerdal Medical created Resusci Anne, one of the earliest mannequin simulators, for teaching and practising critical lifesaving techniques (Laerdal Manikins, 2007). Although it mimics a full-sized adult, rather than just one body part or region, it is still essentially a task trainer, with functional anatomy for performing ventilation and chest compressions, but no (patho)physiologic functions or interactive features. Child- and infant-sized mannequins are available for analogous pediatric skills training and assessment.

Computer-Enhanced Mannequin (CEM) Simulators

Computer-enhanced mannequins consist of life-sized (often full-body) mannequins connected to computers, which reproduce not only the anatomy but also normal and pathophysiological functions. The interface with the user can be active or even interactive. In the former case, the simulator responds in a preprogrammed way to user actions (for example, if in ventricular fibrillation, the heart rhythm will change to sinus rhythm whenever the user shocks the mannequin); with interactive programming, the simulator response will vary according to user actions (for the previous example, the heart rhythm will only return to sinus rhythm when a certain energy level is used for defibrillation). Such high fidelity simulators often contain high-tech components, making them more costly. Training with CEMs can focus on individual technical skills (such as ability of a paramedic to intubate) or team communication skills (an emergency department resuscitation scenario). CEMs are adaptable to a host of simulation scenarios, and thus are more generally applicable to multiple disciplines.

Those specialties with high-risk performance environments (particularly anesthesiology and emergency medicine) have led the expansion in medical simulation by incorporating these technologies into their training and evaluation programmes; following the example of flight simulators in commercial aviation, the focus has been on emergency or crisis management skills, both of individuals and teams. Sim One was the earliest such CEM: introduced in 1967, it was a full sized mannequin with computer controls that interfaced with an anesthesia machine and simulated hemodynamic, cardiac, and airway problems (Abrahamson, Denson, and Wolf 1969). This prototypal simulator no longer exists, but – despite computer and other technological advancements that have allowed significant improvements in later systems—the general concept and design of Sim One still serve as a template for current human patient simulators. A present-day descendant of the high-fidelity anesthesia simulators, and perhaps the most sophisticated CEM, is the Human Patient Simulator (HPS) from Medical Education Technologies, Inc. (Human Patient Simulator 2006). This adult-sized mannequin simulates not only blood pressure, multiple peripheral arterial pulses, and breath and heart sounds, but also muscle twitch from nerve stimulation, pupillary reflexes, salivation, lacrimation, and bleeding from several anatomic sites. A system included with the simulator (or conventional external monitors) can display vital signs, electrocardiogram, oxygen saturation, and other physiological parameters in real time; these recordings are particularly useful when the HPS is used for assessment. In addition, the simulator responds appropriately to the administration of multiple medications and to a host of procedures, including intubation and ventilation, chest compressions and defibrillation/cardioversion, needle or tube thoracostomy, and arterial and venous cannulation. The HPS contains multiple preprogrammed patient profiles and can simulate numerous scenarios involving these patients; educators and evaluators have developed many more customised programmes for use in particular settings, and these are often freely available online or from simulation users groups.

Virtual-Reality (VR) Simulators

Virtual-reality simulations are even newer innovations in which a computer display simulates the physical world, and user interactions are with the computer within that simulated (virtual) world. Existing technologies now allow for very high-fidelity simulations, ranging from desktop computer-generated environments (much like those in 3-D computer games) to highly immersive VR (such as CAVE simulations where the user wears goggles and sensor-containing gloves and/or sits within a specially designed display). Sound and visual feedback are often highly realistic in these simulations, with recent progress in haptic (touch feedback) technology improving the feel of the experience as well.

Commercially available VR systems (and more are under development) simulate a wide variety of procedures, ranging from relatively simple non-operative techniques such as intravenous cannulation to more complex surgeries such as laparoscopic cholecystectomy, and from percutaneous catheter-based approaches such as carotid artery stenting to endoscopic methods such as flexible sigmoidoscopy.

Beyond these applications for training of procedural skills, however, VR simulators can facilitate learning of other patient management and communication skills; VR simulations can be used to teach both individual and collaborative skills.

One potential advantage of training in the virtual environment is that learners need not be co-located with other team members. Just as with educational programmes delivered via the Internet or teleconferencing, distance learning in virtual but realistic clinical contexts is now possible. For example, in a virtual emergency department for trauma resuscitation scenarios or a virtual delivery room for neonatal exams, we can remotely and simultaneously train multiple participants, as they take part in the management of virtual patients in a computer-generated environment. Institutions like the University of Otago have set up the Otago Virtual Hospital (OVH) (http://hedc.otago.ac.nz/magnolia/ovh.html), a virtual hospital in which medical students, playing the role of junior doctors/housemen, solve open-ended clinical cases. These cases are written by practitioners and drawn from real-life events. Reflecting the actual practices in a New Zealand emergency department (ED), students can use their avatars to move around the hospital; communicate with patients and peers via text chat (e.g. to take patient's history); examine the patient (e.g. requiring interpretation of chest sounds); order laboratory and radiology tests from an extensive list; check the results of these tests (e.g. X-ray images); share documents with peers (e.g. ECG results); prescribe from a range of medicines readily available in New Zealand Emergency Departments and write patient admission / discharge / handover notes.

Using "Virtual-reality simulations" in which a computer display simulates the physical world, and user interactions are with the computer within that simulated (virtual) environment, students in healthcare profession will be taken through various sites:

1. At Home: using scenario, students learn first-hand how to manage patients in their homes.
2. Clinic: using scenario, students learn work flow in clinic, consulting skills, team working, communication, professionalism etc.
3. Hospital (example scenario below, also to include CPR and other emergencies): multiple learning opportunities, multi-disciplinary team training.
4. Long term care (including rehabilitation): self-care and monitoring, access to clinic/hospital, access to information, access to medication (e.g. by courier to be delivered to patient's home)

- Using technology to help patients in managing their health / chronic diseases: appointment, access for patient to check medication & other aspect of management, getting reminder on medication, online consultation etc. Commercially available eKlinik (cloud group clinic) for home care, primary care and tertiary care.
- EMR in place for sharing of patient's information, and to support integrated, boundary-less care of patients: in particular those with chronic diseases.

- Call centre: to provide quick access to manage acute episodes, to provide access to relevant and accurate information, to provide online appointment and other functions.

Skills that can be enhanced via virtual settings include critical thinking and problem solving skills whilst there may be limited benefit where communication skills are concerned. Resources that will need to be developed include thinking, planning and writing scenarios with healthcare professional and patient interactions. This would be a complicated challenging task in itself. New softwares, programmes and equipment will necessitate the need for training of all involved before successful outcomes can be achieved.

13.15 Instructional Design

Chiniara *et al.* described a comprehensive instructional design for simulation in healthcare (Chiniara *et. al.*, 2012). For simulation to integrate and be successful as a learning tool, the delivery of the instruction design must involve four levels of learning experience. Level 1 would be the instructional medium which forms the basis of learning. It consists of textbooks, lectures, computer-based learning, videos and others. This medium is considered the core of learning whereby it should be the principal mode of delivery of instruction (Cook, 2005).

The decision of using stimulation as a learning tool is dependent on certain factors that can be illustrated by using a zone of stimulation matrix. The zone of stimulation matrix is broadly divided into four levels based on two characteristics: acuity and opportunity. Acuity is defined as the potential severity of an event or a series of events and their subsequent impact on patient. Opportunity is defined as the frequency in which a particular department or individual is actively involved in the management of the event. In other words, acuity denotes how severe a medical condition is and opportunity denotes how frequent this condition occurs. The zone of stimulation matrix thus is divided into high-acuity low-opportunity, high-acuity high-opportunity, low-acuity low-opportunity and low-acuity high-opportunity. Simulation is most beneficial if used for conditions with high-acuity low-opportunity. Simulation sometimes is useful for conditions with high-acuity high-opportunity or low-acuity low-opportunity. Simulation is not useful in conditions with low-acuity high-opportunity.

Simulation modality forms level 2 of this instructional design (Chiniara *et. al.*, 2012). The choice of simulation modality will be dependent on the type of learning experience needed. Simulation modality can be computer-based, procedural-based, simulated clinical immersion, a simulated patient or hybrid-simulations. Computer-based simulation involves users interacting with the simulation through a screen based interface. Procedural-based simulation involves training the users' psychomotor skills through the use of a manikin. Simulated clinical immersion involves a simulated environment of a clinical situation by using actors or patient simulators. A stimulated patient uses an actor to interact with the user for a particular clinical scenario. A hybrid simulation involves the use of two or more of the above simulation modalities.

Level 3 of this design is the instruction method. Instruction method or mode represents the specific technique used for learning (Gagne´ & Medsker, 1996). Any methods can be used depending on the outcome intended. These methods can be self-directed learning, instructor-based learning or instructor-observed learning. Self-directed learning allows learners to set their time and pace of learning. Instructor-based learning requires instructor's supervision, learning with certain involvement of the instructor. Instructor-observed learning allows learners to learn independently without interference of the instructor but allows feedback from the instructor.

The final level (Level 4) of the instructional design is presentation. It involves how the simulation is shaped, designed and carried-out. Presentation consist of the types of simulator, scenario, feedback, simulation team members etc. Types of simulator can be actors, computer or web application, a part-task trainer (a synthetic simulator that replaces a component of a patient or system), patient simulator (life size patient manikin), real patient, virtual patient, virtual reality or virtual world.

13.16 Challenges of Simulation-Based Healthcare Education

Costs are often among the most significant challenges to implementing a simulation programme, especially those utilising sophisticated technologies. High fidelity patient simulators can range in price anywhere from ~$30,000 up to ~$250,000. Beyond the initial purchase price, there are ongoing costs to operate, store, maintain, and update the devices. In addition to these obvious direct financial expenditures, educators should not underestimate the human resources required in any training programme, including those employing simulation-based methods. Even relatively low-tech simulations entail costs associated with recruiting and training personnel. Development of scenarios for use in simulator-based training can also be time- and resource-intensive. Ideally, pilot testing of these schemes should occur, and this has associated costs that accrue even before programmes are implemented.

Another drawback of some simulators for education is lack of portability: they may be bulky, and their computer or other hardware components may be delicate, limiting training to dedicated centres and controlled environments. This imposes significant disadvantages if we are trying to train pre-hospital providers or military personnel in a realistic field setting. Moreover, many devices simulate only specific conditions or procedures; although such models may have very high fidelity within their domains, the lack of flexibility for a wide range of clinical contexts or skills is a limitation of these tools. Rational allocation of resources for training programmes—whether at the level of medical schools, residency training programmes, credentialing bodies, or certification boards—demands evidence that the investment will yield valuable results.

13.17 Features and Uses of High-Fidelity Medical Simulations that Lead to Most Effective Learning

A recent systematic review from the Best Evidence Medical Education (BEME) Collaboration addressed this issue in the question: "What are the features and uses of high-fidelity medical simulations that lead to most effective learning?" We identified 10 features that healthcare educators should know and adopt when using high-fidelity simulations (Issenberg *et. al.*, 2005):

1. **Feedback**. Feedback provided during the learning experience is the most important feature of simulation-based education to promote effective learning.
2. **Repetitive practice**. Learners should engage in focused, repetitive practice where the intent is skill improvement, not just idle repetition.
3. **Range of difficulty level**. Learners should engage in skills practice across a range of difficulty levels, beginning with basics and advancing to progressively higher difficulty levels based on objective measurements.
4. **Multiple learning strategies**. Depending on the learning objectives being addressed, simulation-based training strategies should be flexible, including instructor-centered formats, small group tutorials, and independent study.
5. **Clinical variation**. Simulations should represent a wide variety of patient problems to provide more sampling than simulations that only cover a narrow patient range.

6. **Controlled environment**. Simulations work best when embedded in controlled educational settings where (unlike real clinical environments) learners can make, detect, and correct patient care errors without negative consequences.
7. **Individualised learning**. Simulation-based educational experiences, individualised according to particular learner (or team) needs, should engage trainees as active participants, not passive bystanders.
8. **Defined outcomes/benchmarks**. Educational goals should have tangible, objective measures that document learner progress in terms of training benchmarks.
9. **Simulator validity/realism**. The simulation and the behaviour it provokes should approximate the clinical challenges that occur in genuine patient care contexts.
10. **Curricular integration**. Simulation-based educational experiences should be routine or required features of the normal educational schedule, not optional activities ("just for fun").

13.18 IMU SWOT Analysis

Medicine (includes Medical Sciences, Clinical School), Pharmacy, Dentistry, Nursing, Nutrition & Dietetics (N&D) and Chiropractic did a SWOT analysis of their respective programmes in terms of teaching-learning using simulation. A summary of the strengths, weaknesses, opportunities and threats are presented below:

Strengths

- Availability of space in Clinical Skills Simulation Centre, Bukit Jalil (CSSC, BJ).
- State of the art equipment: CCTV recordings, large TV display units.
- 28 bedded open ward concept.
- Availability of models and manikins (of low fidelity).
- Availability of a technician for the above.
- Strong management support in terms of budget.
- Input from PMS into clinical skills training.
- Availability of simulation lab and adequate number of manikins in CS Seremban.
- Availability of case scenarios.
- Clinical students have adapted and are comfortable using the simulation lab and manikins.
- Hybrid simulation has been used, combining manikins with actors for simulated case scenarios.
- Availability of e-learning platform as springboard to simulated pharmacy practice experiences (aligned to the course outcomes); medication therapy management and e-prescription activities.
- Availability of e-learning platform to provide e-simulated activities for early semesters: role of pharmacist, inter-professional activities in hospital setting, scenarios focussed on ethical and professional issues.
- 64 state-of-the-art simulators in SimLab, instruction on usage given in Semester 2 at commencement of lab sessions. All simulators equipped for mechanical work in ergonomically realistic environment.
- Each simulator is with a workstation and equipped with monitor for video or static instruction with hi-fidelity sound broadcast system.
- Students complete each required competency before being allowed to practice in the clinics.
- Students work in pairs and learn the art of treating as well as assisting, teamwork and communication.

- Compatible with training done in Partner Dental Schools (PDS).
- One intake of students for dentistry annually results in adequate supervision.
- Technicians on site for trouble shooting and maintenance.
- All simulators and clinics in BJ premises, so students can go back to simulators any time to refresh their skills.
- Skills centre has space identified for each programme.
- Core of enthusiasts exists.
- Curriculum teaching can be integrated.
- Clinical skills models available to complement simulator.
- Learning and practising of diagnostic and manual skills.
- State of the art A/V equipment with internet and recording capabilities.
- Onsite radiographic facilities and mock facilities for hands on educational experience using chiropractic student simulated patients.
- Sets of anatomical models for reference and visualisation exercises. Such models can be used in exercises to develop surface and deep anatomical landmark palpation as well as palpation of anatomical spatial relationships.
- Availability of Speeder Boards for the development of manual manipulative techniques.
- Experienced educators with broad and deep practical experience in education and practice.
- Willingness of faculty to engage students outside of scheduled laboratories.
- Semesters 7 & 8 interdisciplinary learning unit with Dentistry.
- Systemic use of fellow classmates and lower year chiropractic students as simulated patients provides exceptional feedback opportunities as well as developing empathy for future patients.
- Availability of IMU patient simulators.
- Opportunities to provide public outreaches increase communication skills and professionalism.
- Interaction with other health disciplines at IMU develops understanding, professional relationships and the opportunity for team building within the healthcare system.
- Availability of adequate facilities and space in CSSC for use by N&D students.
- Availability of case examples to write and simulate scenarios.
- Availability of experienced faculty to facilitate simulated sessions.

Weaknesses

- Constraints of staffing, training of staff, and dealing with 2 intakes of medical students a year.
- Lack of simulation lab space in Clinical School, not much more can be done with current facilities.
- Absence of trained operator to run and manage SimLab and manikins.
- Only used by a few departments, while others have not adopted virtual learning via simulation or manikins.
- Manikins generally used for single skill training. Lack of simulated case scenario based learning on the manikins.

- Lack of IT support/softwares/staff to develop more interactive case scenarios and other e-simulated activities.
- Not contributing to overall patient experience: lack of interaction and communication in the available activities. Virtual patient softwares, high fidelity simulators and disease-specific manikins may improve overall patient experience in the simulated environment.
- Simulators are passive and do not contribute to an overall patient experience.
- Students must have each step evaluated before moving to the next one leading to time wastage.
- The supervisor can evaluate and give feedback on the final outcome but not the process.
- There is a potential for possible bias between student evaluations.
- High-fidelity simulator not available yet in BJ, may need more than 1 unit.
- Storage place not sufficient.
- Space identified but layout may not be appropriate for simulation lab.
- No simulator technician to support handling of high-fidelity simulator system – ACLS, PALS.
- NRP training requires all this support.
- Faculty not familiar with simulation teaching.
- Need a large pool of trainers from all faculty.
- Physical lab facilities almost at full capacity with currently no prospects for expansion.
- Division understaffed with difficulty in attracting experienced educators.
- Single available appropriate lab space creates scheduling dilemmas and limits number of stations for OSCE exams utilising simulated patients.
- Lack of radiographic case files for which simulated case studies may be generated.
- Lack of mechanism to practise real life radiography (legal issues).
- No significant training of classmate simulators decreases effectiveness of interactions and particularly development of communication and professional skills.
- Current use of classmates or IMU simulated patients provides narrow case mix for physical training of mechanical dysfunction diagnosis and actual manipulative skills.
- Current silo structure of professional programmes at IMU limits integration and interdisciplinary teaching/learning – Reference Royal University Hospital, Saskatoon, Canada.
- Pressure to increase class sizes puts further strain on faculty and other resources within division.
- No current presence of chiropractic postgraduate training for future chiropractic researchers and educators.
- Inadequate training of SP for dietetic scenarios.
- Lack of skilled instructors to train N&D faculty for simulated learning.
- Increased workload and time on faculty (preparation of scripts, training & assessment).
- Cost in remuneration of SP.
- Simulated learning in food service and community dietetics not implemented in curriculum.

- Development of softwares beyond manpower and resources of eLearning and will have to be outsourced.

Opportunities

- Availability of many PMS, and many IHH hospitals.
- Availability of expatriate community to serve as SPs.
- Availability of a pool of trained SPs (>60 persons).
- Deployment of 2 nurses as nurse educators: for simulation and CSSC.
- Streamlining competencies in Medical Sciences and Clinical School.
- sing simulation across all departments in BJ and in inter-professional learning (IPL).
- CSSC Clinical School (CSSC CS) has conducted courses within IMU for students and faculty as well as for private and public hospitals: available clientele.
- Training opportunities for students to be familiar with acute clinical situations.
- Training opportunities for students to be familiar with common clinical procedures.
- Extending training to practising doctors & paramedics in IHH hospitals.
- Extending training to postgraduate doctors.
- Achieving learning experience which is difficult to achieve in clinical posting or in actual practice: e.g. Medication Therapy Management.
- Scope for virtual online pharmacy to support health promotion, self-care, patient safety and to develop experiential learning environment in community pharmacy set-up.
- Enhancement of learning through feedback and reflection through the use of video facilities.
- Students achieving competence in common standardised technical skills, as well as in high risk, low occurrence medical situations (e.g. medication errors).
- With increase in student numbers, simulation helps to overcome constraints in placement or classrooms.
- Shared simulated activities provide opportunities to interdisciplinary and multidisciplinary learning.
- Enhancement of knowledge integration among different departments in Pharmacy School.
- Greater readiness for more complex procedures when students reach the clinics.
- An increasing number of Partner Schools for students.
- Simulators are for internal and external CPD.
- All programmes can benefit from this project.
- Opening market niche to train others to help meet demand of specialised healthcare professionals and healthcare providers.
- Able to open courses to the public as well.
- Current climate and upper level support within IMU for integrated teaching/learning and interdisciplinary cooperation.
- IMU's medical faculty and school have resources that may overcome several weaknesses, particularly related to availability of radiographic teaching files and closer cooperation for simulation teaching/learning.
- IMU's healthcare side and the existence of the medical clinical school in Seremban provides the opportunity to explore clinical opportunities for chiropractic housemen,

our chiropractic interns and interdisciplinary cooperation including the development of cases to be used in simulation teaching/learning.

- The chiropractic division sees opportunities to partner with chiropractic programmes in Canada and the United States and benefit from computer simulations in use.
- There are opportunities for chiropractic students to become simulated patients for medicine and dentistry and further add to interdisciplinary education.
- There are opportunities for medical and dental students to become simulated patients for chiropractic and further add to interdisciplinary education.
- There are opportunities to develop postgraduate programmes at IMU to develop our future educators and scientists who are experienced in developing simulation models. With the involvement of ICE, IMU could develop a chiropractic educational product specifically for other chiropractic programmes around the world.
- Students are better prepared for real-world placements, ready to work on higher level of clinical care for both students and preceptors during external placements or postings.
- Students with experience in simulated learning will have increased self-sufficiency: hence placement may accommodate more students.
- Inter-professional learning opportunities between N&D and other programmes.
- Opportunities for simulated learning in food service, community dietetics and in research.

Threats

- CSSC training focus may be inappropriate for junior medical students if there is greater emphasis on high fidelity.
- Rapid change in technology and equipment: existing hardware and software becoming outdated.
- More space needed for CSSC for programmes like Chiropractic.
- Lack of faculty enthusiasm.
- Costly equipment maintenance.
- Need support from School and staff, time constraints to develop simulation learning.
- Heavy burden for departments involved in simulation learning.
- An increased number of dental schools that offer cheaper education.
- The number of staff required for supervision inadequate for increasing student numbers.

- Funding may not be secure.
- Maintenance of simulator and equipment high – frequent usage.
- Workload of faculty: full time teaching, online teaching, ongoing research work – trainings may take place outside working hours.
- Insufficient staffing.
- Space expansion in CSSC.
- Few faculty familiar with simulation teaching/learning methods.
- Chiropractic specific computer simulation products undeveloped or costly to attain.

13.19 Integration Across Disciplines

Strengths

- Cross teaching occurs in about 20% of the teaching – learning hours in most disciplines.
- Interprofessional learning occurs amongst most disciplines: e.g. Dentistry and Medicine, Nursing and Medicine, N&D and Pharmacy etc.
- Availability of an e-learning site that is accessible to all disciplines.

Weaknesses

- Distributed learning among senior students in many disciplines causes dispersion of students from simulation learning site.
- Accessibility to e-learning system is compromised due to the inability of the server to maintain access demand.
- Lack of training of the trainers to produce appropriate materials for integrated learning across disciplines.

Opportunities

- Clinical Scenarios can be developed to closely simulate real life clinical situations which usually require interdisciplinary approach.
- Content experts from various disciplines are available under one roof to contribute to Simulation Teaching-Learning for all health professionals.
- Patient-centred care system can be introduced as all disciplines will be managing the same case scenarios.

Threats

- Lack of cooperation from any discipline in contributing towards development of simulation training.
- Needs a committed and dedicated lead teacher who can take charge of learning and teaching for all disciplines.
- Cost of planning the learning activities increases as schedules need to be revised.

13.20 Integration Across Disciplines on Core Values, Ethics and Professionalism, Patient's Safety

Strengths

- The basic principles of ethics and professionalism can be integrated easily into the contents of simulated teaching-learning.
- Core values can be explicit in each activity outline.
- Patient's safety goals can be made available in all activity outlines.
- The theory and knowledge base of these initiatives can be provided online and serve as constant reminders.

Weaknesses

- The value of such integration may not be truly reflected in actual practice.
- The evaluation of its internalisation could be difficult to perform.
- The ideal values and goals learnt at simulation practice may be different in real practice where other factors may affect the way some values and goals are interpreted.

Opportunities

- Allows students to practise under controlled environment where mistakes could be rectified.
- Increases confidence level thus improves competencies in clinical areas.
- Sharing of experience in simple and complex scenarios by content experts.

Threats

None.

13.21 Recommendations: Using Simulation to Improve Teaching-Learning, Patient Safety and Inter-Professional Learning

1. Provide a safe environment for teaching-learning in a common-user "Simulated Learning Unit'.
   - In clinical training, using simulated clinical scenarios and manikins would allow the content experts from various disciplines to contribute in creating learning activities to suit the level of competencies of students from different schools.
   - Simulated teaching activities can incorporate different practical and procedural skills that are relevant to specific disciplines conducted at the same time.
   - Mistakes can be rectified instantly, coupled with feedback, will help students to learn in their own time and without stress and anxiety.

2. Create a 'virtual platform' for broader learning process as patients can be engaged in simulated scenarios or activities.
   - With the advanced technology in multimedia system, direct communication with patients through live systems can be organised during actual learning and teaching activities. Students from various areas can come together virtually to learn about the same scenario through such system.

3. Use 'care bundle approach' in acute simulated clinical scenarios or intensive care.
   - The steps that need to be followed to complete each task will determine success of patient care?
   - It could be carried out as virtual learning or face to face simulated teaching in a controlled environment.

13.22 Simulation in Teaching-Learning in IMU

In order to adopt simulation-based teaching, establishment of the infrastructure, acquisition of learning resources, and training of the educators are necessary. In addition, there should be budget allocation for maintenance of the equipment and other resources. Thus, heavy investment is required for the setting up and maintenance of a simulation-based teaching centre. For instance, in Australia a capital funding of $46 million and recurrent funding for 2010–11 of $48 million was invested to further develop stimulation-based education capacity (Weller *et. al.*, 2012).

The Clinical Skills & Simulation Centre needs to be further upgraded with the proper resources and effective IT support to ensure smooth running of simulation teaching-learning activities. The education resources required include plastic models for partial task training, mannequin-type simulators, screen-based virtual-reality simulators, and simulated or standardised patients (Akaike *et. al.*, 2012). In addition, recruitment of the appropriate teaching and support staff is needed to ensure effectiveness of simulation-based teaching. It is strongly recommended that nurses play a bigger role in simulation of teaching-learning activities. It should be realised that clinical experience alone is not a proxy for simulation instructor effectiveness, and simulation instructors and learners need not be from the same healthcare profession (McGaghie *et. al.*, 2010). Visits to our PMS (e.g. St George's University) and medical schools in the region (National University Singapore) where simulation teaching has been successfully implemented would be beneficial to our faculty. Experts from PMS may be invited to come for short attachment with IMU to train our faculty.

Besides the mannequins and other equipment, the use of simulated patients should be continued as a teaching modality in simulation-based education. Simulated patients are still relevant in the teaching and assessing of skills such as communication skills (e.g. history taking). Proper training of the simulated patients is crucial to ensure the session is effective. The pool of simulated patients may include part-time actors, as practised in UK partner schools. In addition, teaching resources such as case scenarios, real experiences and course content (e.g. video and journal articles), and assessment tools such as test scores and exam blueprints need to be developed.
The pedagogy of simulation-based education and their benefits should be disseminated to faculty to get their buy-in. Interdisciplinary team-based learning is important for the success of simulation-based education, and this will also further promote inter-professional learning, which is emphasised in IMU educational philosophy. An interdisciplinary team training programme that incorporates proven methods of team management needs to be established.

The effectiveness of simulation teaching should be regularly assessed and may form part of Medical Education research projects. The IMU Centre of Education (ICE) should conduct relevant training to enhance the research capacity of our faculty in designing the appropriate research questions regarding simulation teaching-learning. Some of the gaps in understanding of stimulation-based medical education research that warrant further research include aspects on feedback, curriculum integration, outcome measurement, skill acquisition and maintenance, mastery learning and instructor training (Table 13.1). Thematic research programmes based on the questions raised should be formulated (McGaghie *et. al.*, 2010).

Table 13.1 Gaps of understanding in simulation-based education that warrant further research (adopted from McGaghie et. al., 2010).

Stimulation features	Gaps in understanding / Research questions
1. Feedback	• What model of feedback? • What dose of feedback? • How to gauge quality of feedback? • Feedback adaptation to educational goal?
2. Curriculum integration	• What is the best mix of learning modalities? • How and when to best integrate with other modalities?
3. Skill acquisition and maintenance	• What are the mechanisms of skill maintenance? • What determines the conditions of skill decay: person, context and tasks?
4. Mastery training	• What are the sources of variation in time to mastery standard: cognitive aptitude, motor skill, professional experience? • What is the level of resources needed?
5. Team training	• What approaches should be used to determine the appropriate clinical team composition and assembly? • Are team members interchangeable? • What are the factors that affect team skill maintenance?
6. Instructor training	• Should simulation instructors be certified for various devices? • What are appropriate mastery learning models for simulation instructors? • Should the training be specific to simulation or general teaching skills?

13.23 Specific Recommendations

13.23.1 Medicine

1. Upgrading of CSSC CS: convert second floor completely to CSSC, with bigger rooms for teaching practical skills, clinical skills using simulated patients and simulated teaching using manikins. There is a lot of potential for the utilisation of CSSC if the inadequacies are addressed.

2. More undergraduate communication skills training using the standardised patients available in our "patient bank", encompassing ethics and professionalism and any other areas.

3. Acute medical or obstetric emergencies: Students practise these skills at their own time using the simulation lab where the scenarios are already available in the system.

4. The sessions can be recorded and replayed with or without the teachers: to improve learning.

5. Training of professionals especially procedural and practical skills using simulation. Surgeons can come and train the surgical skills they need to sharpen on their own. We provide the facilities.

6. Offer skills training to private and public hospitals for nurses, house-officers, medical officers and even specialists.

7. We can provide the facilities, help coordinate courses that other institutions want to conduct.

13.23.2 Dentistry

1. The curriculum should be modified to include simulation in all areas that it are deemed necessary.

2. Simulators like DentSim and Simodont have great potential for an improved student learning experience, as do virtual world software like Second Life. While newer technologies are emerging even now, older ones are in a continual upgrading process and it is envisaged that there will be a definitive improvement in simulations within 5 years. However, given the evidence of the effectiveness of these current simulators, it should be recommended that IMU invest in students' learning experience and supplement the existing simulations with the current technology available at hand. This will also go a long way in enhancing skills of our students as well as ensuring patient safety at every level.

3. Virtual worlds like Second Life be incorporated in teaching – learning activities where they could provide most benefit.

4. Collaborations be created with other schools in Malaysia as well as worldwide (including Partner Schools) to enhance opportunities for inter-professional learning.

13.23.3 Nutrition & Dietetics

1. Need for more research to validate simulation as a teaching-learning strategy.

2. Need for more research to validate simulation in assessment/evaluation method in the field of dietetics. This is because many dietetics programmes have not fully utilised this method for clinical skills assessment compared to real life patient assessment.

13.24 Conclusion

Virtual hospitals based on simulation-based training have the potential to initiate entirely new educational applications in healthcare. Evidence-based practices can now be activated with protocols and algorithms, which can be practiced safely with the help of simulation scenarios. However, a vital component towards this will be to ensure integration within the curriculum of each programme. Resources have to be identified and acquired early on, whilst faculty will have to be engaged and trained. Teamwork within the pedagogy in a simulated environment will enhance and supplement the didactic instruction, and ensure better outcomes for a safe patient experience. Interprofessional education within differing healthcare specialties will benefit from the virtual environment and with the adoption of simulation as a standard of training and certification, healthcare systems may be seen as becoming more responsible and ethical by the community. Case scenarios in various virtual settings train doctors and healthcare professionals of the future to support care of patients by harnessing technology, promoting patient-centred care, patient safety, integrated, boundary-less care, and in overcoming many of the shortfalls in the present system of healthcare.

Example Gilbert Program in Medical Simulation: Simulation Casebook: Harvard Medical School Draft of the 1st edition (2011), updated 3/2/1. See Appendix 1 below.

13.25 References

Agency for Healthcare Research and Quality, Web M&M: Perspective, July 2013. (http://webmm.ahrq.gov/perspective.aspx?perspectiveID=138 Accessed 29/3/2015.

Akaike M, Fukutomi M, Nagamune M, Fujimoto A, Tsuji A, Ishida K, Iwata T. Simulation-based medical education in clinical skills laboratory. The Journal of Medical Investigation. 2012; 59(1-2): 28-35.

Aukstakalnis N, Baniulis K, Pauliute J, Slotkiene A. Graphical Model: The Means for Simulation-based Learning. J Comp Inf Tech. 2008; 16: 4.

Bambini D, Washburn J, Perkins R. Outcomes of clinical simulation for novice nursing students: Communication, confidence, clinical judgment. Nurs Educ Perspect. 2009 Mar-Apr; 30(2): 79-82.

Berry W, Cooper J. Beyond watch One/Do One/Teach One, In: Simulation - based team training for patient safety. Ed. LaValley, D., Forum. 2006; 26(4).

Chiniara, G., Cole, G., Brisbin, K., Huffman, D., Cragg, B., Lamacchia, M. and Norman, D. Simulation in healthcare: A taxonomy and a conceptual framework for instructional design and media selection. Medical Teacher. 2013, e1380–e1395.

Chiniara, G., Cole, G., Brisbin, K., Huffman, D., Cragg, B., Lamacchia, M., & Norman, D. (2012). Simulation in healthcare: A taxonomy and a conceptual framework for instructional design and media selection. Medical Teacher, (0), e1-e16.

Cook DA, Erwin PJ, Triola MM. Computerized virtual patients in health professions education: A systematic review and meta-analysis. Acad Med. 2005;85: 1589–1602.

Cook DA, Hatala R, Brydges R, Zendejas B, Szostek JH, Wang AT, Erwin PJ, Hamstra SJ. 2011. Technology-enhanced simulation for health professions education: A systematic review and meta-analysis. JAMA 306: 978–988.

Cook DA, Hatala R, Brydges R, Zendejas B, Szostek JH, Wang AT, Erwin PJ, Hamstra SJ. Technology-enhanced simulation for health professions education: a systematic review and meta-analysis.JAMA 2011:306(9):978-88norm

Cook DA, The Literature on Health Care Simulation Education: What Does It Show?

Cook DA, Triola MM. Virtual patients: A critical literature review and proposed next steps. Med Educ. 2009 Apr; 43(4): 303-1.

Gaba DM. The future vision of simulation in healthcare. Qual Saf Health Care. 2004;13 (Suppl 1):i2–i10.

Hansen MM. Versatile. Immersive, creative and dynamic virtual 3-D healthcare learning environments: a review of the literature. J Med Internet Res 2008; 10(3):e26.

Hovancsek M, Jeffries PR Escudero E, Foulds BJ, Huseb SE, Iwamoto Y. Creating simulation communities of practice: An international perspective. Nursing Education Perspectives, 2009; 30(2): 121-125.

Howard Z, Siegelman J, Guterman E. Hayden EM, Gordon JA. Harvard Medical School Simulation Casebook, 2012. http://mycourses.med.harvard.edu/ResUps/GILBERT/pdfs/HMS_7607.pdf Accessed 29 March 29, 2015.

Issenberg SB, McGaghie WC, Petrusa ER, Gordon DL, Scalese RJ. Features and uses of high-fidelity medical simulations that lead to effective learning: a BEME systematic review. Med Teach 2005; 27(1): 10–28.

Issenberg, S. Barry, Scalese, Ross J. Simulation in Health Care Education. Perspectives in Biology and Medicine, Volume 51, Number 1, 2008, pp. 31-46.

Kohn LT, Corrigan JM, Donaldson MS, Institute of Medicine. To Err is Human: Building a Safer Health System. Washington, DC: National Academy Press; 2000.

Lane JL, Slavin S, Ziv A. Simulation in Medical Education: A Review. Simulation Gaming 2001; 32; 297-314.

LaVelle, BA, McLaughlin JJ. (2008). Simulation-based education improves patient safety in ambulatory care. In Henriksen K, JB. Battles (Eds.), Advances in patient safety: New directions and alternative approaches (Vol. 3: Performance and Tools). Rockville (MD): Agency for Healthcare Research and Quality 2008.

McGaghie WC, Issenberg SB, Petrusa ER, Scalese RJ. A critical review of simulation-based medical education research: 2003–2009. Medical Education 2010; 44: 50–63.

Morton PG. Creating a laboratory that simulates the critical care environment. Critical Care Nurse, 1995; 16(6); 76-81.

Nehring WM, Wexler T, Hughes F, Greenwell A. Faculty Development for the Use of High-Fidelity Patient Simulation: A Systematic Review. Int J Health Sci Educ. 2013; 1(1): 4.

Nehring, WM, Lashley FR. High-fidelity patient simulation in nursing education. Jones and Bartlett Publishers, Boston; 2010; 199-200.

Norman G, Dore K, Grierson L. The minimal relationship between simulation fidelity and transfer of learning. Med Educ. 2012;46: 636-647.

Passiment M, Sacks, H, Huang G. Medical Simulation in Medical Education: Results of an AAMC Survey, September 2011.

Salas E, Klein C, King H, Salisbury M, Augenstein JS, Birnbach DJ, Robinson DW, Upshaw C. 2008. Debriefing medical teams: 12 Evidence-based best practices and tips. Jt Comm J Qual Patient Saf 34: 518–527.

Salas E, Wilson KA, Burke CS, Priest HA. Using simulation-based training to improve patient safety: What does it take? Jt Comm J Qual Patient Saf. 2005;31: 363–371.

Scalese RJ, Issenberg SB. Effective use of simulations for the teaching and acquisition of veterinary professional and clinical skills. J Vet Med Educ 2005; 32(4):461–7.

Scalese RJ, Obeso VT, Issenberg SB. Simulation technology for skills training and competency assessment in medical education. J Gen Intern Med 2008;23 (Suppl 1): 46–49.

Tanner CA. The next transformation: Clinical education. J Nurs Educ. 2006; 45(4): 99-100.

Walker KL. Use of Simulated Learning Environments in Dentistry and Oral Health Curricula. Health Workforce Australia, 2010.

Wayne DB, Butter J, Siddall VJ, Fudala MJ, Wade LD, Feinglass J, McGahie WC. Mastery learning of advanced cardiac life support skills by internal medicine residents using simulation technology and deliberate practice. J Gen Intern Med 2006; 21(3):251–256.

Weller JM, Nestel D, Marshall SD, Brooks PM, Conn JJ. Simulation in clinical teaching and learning: practising clinical skills and teamwork in a safe environment. Med J Aust. 2012;1 96(9):594.

Zendejas B1, Brydges R, Wang AT, Cook DA. Patient outcomes in simulation-based medical education: a systematic review. J Gen Intern Med. 2013 Aug; 28(8): 1078-89.

13.26 Appendix

Example Gilbert Programme in Medical Simulation: Simulation Casebook

Harvard Medical School Draft of the 1st edition (2011), updated 3/2/12

Anterior Myocardial Infarction

I. Target Audience: Medical Students, Residents

II. Learning and Assessment Objectives
Participants are expected to understand the scientific and humanistic issues underlying the disease assessment and treatment plan, and to critically consider and deploy the therapeutic options described.

Participants should provide a concise presentation of the patient to each physician consultant who participates in the exercise. Debriefing sessions by on-site clinical faculty is essential to discuss critical thinking and knowledge pathways, and to provide a forum for individual and team reflection on learning and practice goals. While the case descriptions are written with medical terminology, it is important that the provider and patient (i.e. the simulator) engage in authentic dialogue with lay terminology to reflect an actual patient encounter.

Critical Actions Checklist:
DONE CRITICAL ACTION

_ Telemetry monitoring

_ Patient history

_ Physical examination

_ Supplemental O2

_ IV Access

_ Immediate ECG and portable CXR (within 10 minutes of start of case)

_ Obtain appropriate laboratory studies: cardiac biomarkers

_ Administer immediate aspirin

_ Administer pressor agent

_ Administer anticoagulation medication

_ Consult cardiology for further treatment

III. Environment

A. Simulation room set up: Emergency Department
B. Manikin set up:
   1. High fidelity patient simulator
   2. No moulage needed
   3. Lines needed
C. Props:
   1. Code blue cart
   2. Lab values (see Appendix A)
   3. Images (see Appendix B)
D. Distracters: none

IV. Actors

A. Nurse: facilitate scenario
B. Consultants (optional for higher level residents who can provide interpretation on their own)
   1. Radiologist: reads chest x-ray
   2. Cardiologist: reads ECG, recommends treatment plan

Case Narrative

PATIENT: 60 year old

CC: Chest pain, "There is an elephant sitting on my chest."

HPI: Use lay terminology as the voice of the patient
Patient complains of crushing substernal chest pain radiating to his neck and jaw on the left side.

Symptoms started one hour ago during a business meeting. Patient had to excuse himself from the meeting as he became obviously diaphoretic and pale.

Patient reports nausea and lightheadedness after the onset of the "crushing" chest pain. Patient denies fevers, chills, vomiting, and palpitations. Patient reports mild shortness of breath and one previous episode of chest pain that lasted about 15 minutes one week ago that resolved spontaneously while he was in Japan.

PMHx:
Hypertension

MEDICATIONS ALLERGIES
Lisinopril Codeine
Shellfish

PSHx:
Hernia repair, age 22

SOCIAL Hx:
EtOH: Occasional
Tobacco: Denies
Illicits: Denies
Occupation: Ambassador to the U.S.
Additional: Married

FAMILY Hx:
Father: Gastric cancer, expired age 80

ROS:
(+) Chest pain with radiation to neck/jaw, mild shortness of breath, diaphoresis, nausea, lightheadedness
(-) Denies palpitations, vomiting, headache, blurred vision, numbness/motor weakness, abdominal pain, urinary symptoms, or fever/chills

PHYSICAL EXAM: Those signs not demonstrable by the mannequin should be verbalised when students perform / verbalise the examination manoeuver

HR BP Temperature (°C) O2 Sats (RA) RR
110 88/60 37.5 92% 24
GENERAL: A&OX3, moderate distress
HEENT: PERRL/EOMI
NECK: Supple, no JVD
CV: 2/6 systolic apical murmur, tachycardia
PULM: Diffuse rales all lung fields
ABD: Soft, NT/ND, + BS
EXT: No C/C/E, palpable pulses all extremities
NEURO: WNL, MAE X 4, grossly intact

LABS: See Appendix A
Amylase/Lipase Level Comprehensive Metabolic Panel
Arterial Blood Gas Hepatic Panel
Basic Metabolic Panel X Lactate/Cortisol Level
Cardiac Markers X Thyroid Panel
Coagulation Profile X Toxicology Screen
Complete Blood Count (CBC) Urinalysis
CBC with differential X Urine HCG
Additional Labs: none

IMAGES: See Appendix B
Angiogram ECG X
CT Scan, with contrast MRI
CT Scan, without contrast X-Ray X
Echocardiogram Ultrasound
Additional Images: none

CONSULTS:
Cardiology – Dr Jones: ECG will be read as STEMI in leads V1-V6 and leads I and AVL. Cardiology will recommend preparing the patient for cardiac catheterisation: aspirin, Plavix, heparin, and "… if it's safe in light of the patient's vital signs," B-blocker and nitroglycerin. Indicate that the catheterisation team will need about 20 minutes to get in and that the patient must be stabilised prior to catheterisation.

Cardiologist asks the students to tell the patient that they will need to have a cardiac catheterization.

If vitals have not been stabilised, tell participants to call back after blood pressure and other vitals improve. If participants ask about increasing the pressure safely, recommend pressors (dopamine).
Radiology – Dr Smith: CXR shows diffuse pulmonary edema consistent with congestive heart failure.

CLINCAL PROGRESSION:
History and physical, IV/O2/monitor, and immediate aspirin. Pressors should be started after physical exam and stat portable CXR indicative of cardiogenic pulmonary edema with hypotension. ECG will indicate AMI either after participants' own interpretation or after consultation.
*** If over 500 CC's IV fluids given or supplemental O2 not initiated within the first 10-15 minutes of case, patient will continue providing history in short one word (monosyllabic) answers and indicate that shortness of breath is getting worse. O2 saturation will drop:

HR BP Temperature (°C) O2 Sats (RA) RR
116 88/60 37.5 88% 26
***If Morphine or Nitroglycerin given (sublingual or IV) blood pressure will drop, heart rate will increase but rhythm stays regular, patient will become less responsive:

HR BP Temperature (°C) O2 Sats (RA) RR
122 68/50 37.5 92% 24
***If B-blockers given, heart rate and blood pressure will decrease, pt will become unresponsive:

HR BP Temperature (°C) O2 Sats (RA) RR
100 68/50 37.5o 92% 24

V. Instructor Notes

A. Tips to keep scenario flowing
   1. If students are unsure of pathology, instructor can prompt the students to create differential diagnosis and lead them towards imaging and laboratory studies necessary to confirm diagnosis. Prompting can come in form of a primary care physician calling to check in on their patient.

   2. If supplemental O2 is not provided, nurse can verbalise concern as patient becomes increasingly dyspneic.

B. Scenario programming
   1. Optimal management path:
      - O2/IV/monitor
      - History and physical examination
      - Immediate aspirin
      - Appropriate lab workup: CBC, BMP, cardiac markers, coagulation profile
      - Appropriate imaging: stat portable CXR,

ECG within 10 minutes

- Administer pressor agent
- Administer anticoagulation medication (e.g. Heparin, Plavix, +/- IIb/IIIa)
- Consider administering morphine, B-blocker, and nitrates
- Consult cardiology for further treatment

2. Potential complications/errors path(s):
    - Failure to administer O2
    - Administering over 500 CC's IV fluid
    - Administering large dose of Nitroglycerin, B-blocker, Morphine

VI. Debriefing Plan

A. Method of debriefing: Group with multimedia teaching materials

B. Debriefing materials: See Appendix C

C. Potential debriefing topics

1. Team dynamics
    a. Leadership
    b. Collaboration
    c. Communication
    d. Professionalism

2. Didactic material
    a. Presentation
        i. Appropriate differential diagnosis
        ii. Varying presentation of MI in different location Contrast fluid overload requiring + inotropy from anterior MI with preload dependence and need for IV fluids in inferior MI
    b. Pathophysiology
        i. Atherosclerotic vs. nonatherosclerotic causes
        ii. Laboratory results: troponin, CKMB levels
    c. Treatment
        i. Need for immediate diagnosis and reperfusion for the acute M "Time is muscle"
        ii. Role of aspirin therapy: decrease mortality / reinfarction rates
        iii. Role of other antiplatelet therapy
            - Clopidogrel (Plavix) at 600mg dose if emergent CABG not anticipated
        iv. Role of pressors vs. fluids in the anterior MI patient
        v. Role of anticoagulants
            - Heparin: indicated in recurrent / persistent chest pain, AMI, positive biomarkers, dynamic EKG changes. Dose is 60U / kg bolus followed by 12U / kg infusion, titrating to apt1.5-2.5 times control
            - LMWH at 1mg/kg BID, adjusted for renal insufficiency
            - *GP IIb/IIIa inhibitor*
        vi. Role of acute beta-blockade and nitrates
            - B-blocker: heart rate control and resultant decrease of myocardial O2 demand to reduce rates of reinfarction, recurrent ischemia and potentially mortality
            - Nitrates: preload reduction and symptomatic relief

- Contraindications in the hypotensive MI patient

  a. Hold NTG for SBP < 90

  b. Hold BB if signs of cardiogenic shock

vii. Treatment options: thrombolytic therapy vs. heart catheterisation (PCI) vs. coronary bypass graft

VII. Development and Deployment

This case, along with it precursors (reference Gordon, below) and variants have been used over several years for a wide range of students, including high school, college, masters/PhD candidates, medical students (preclinical and clinical) and resident trainees. The presentation and progression is tailored to the level of the learner; often the Anterior MI case is paired with the Inferior MI case to allow students to compare and contrast diagnosis, anatomy, physiology, and management. It is commonly used as part of a “train the trainer” curriculum for faculty development in the use of simulation.

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