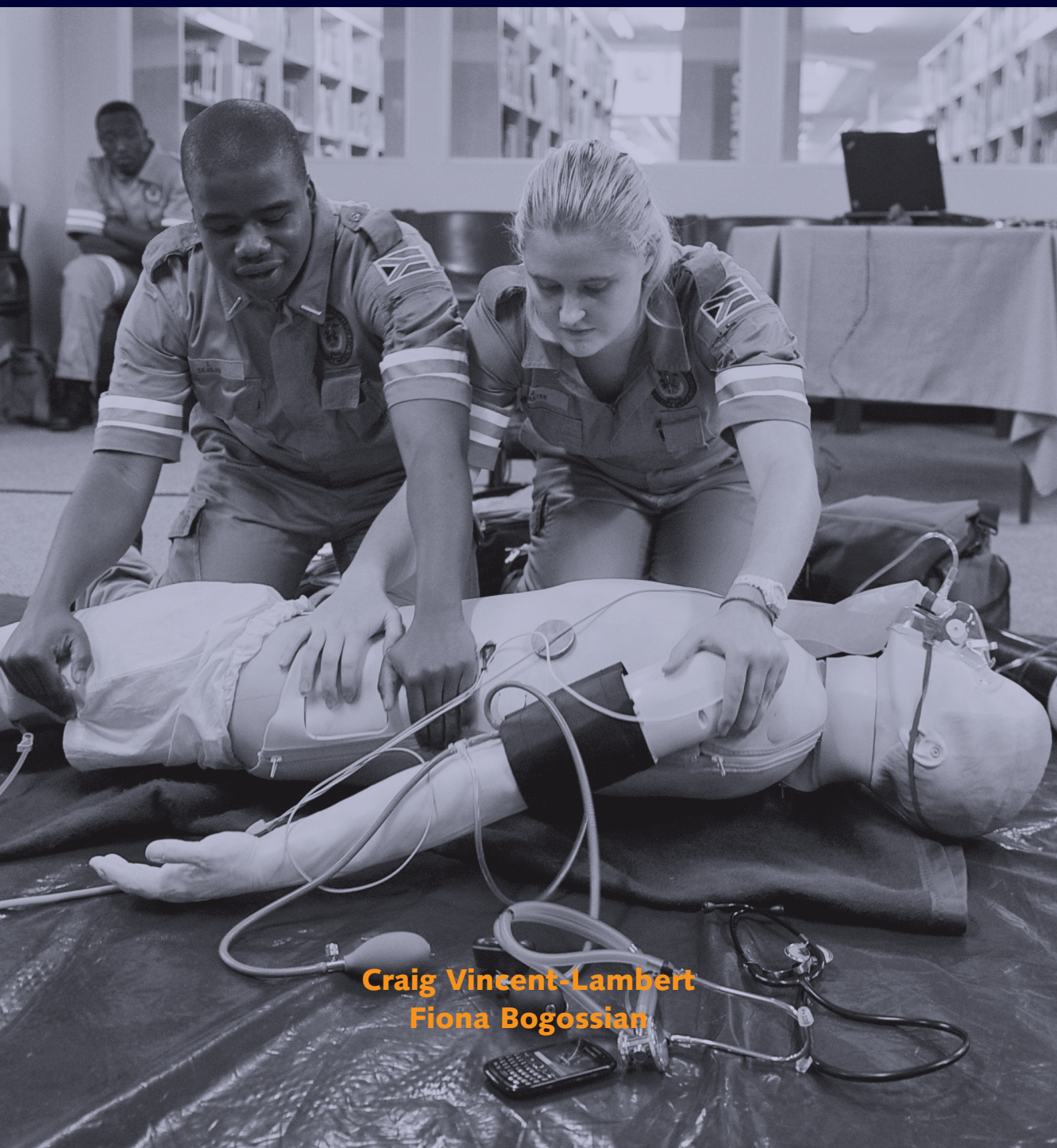
UNIVERSITAS 21 HEALTH SCIENCES GROUP

A guide for the assessment of clinical competence using simulation



Craig Vincent-Lambert
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Introduction

The awareness of simulation as a pedagogy in health sciences has developed rapidly over the course of the last two decades. And in response, we have seen the parallel emergence of simulation interest groups at local, national and international levels; an increase in scholarship in the field and; an increase in resources available to guide simulation in clinical health sciences education. So why did we develop this guide?

The idea behind the creation of this guide emanated from workshops and collegial discussions between health science educators within the Universitas 21 Health Sciences Group. Through our engagements it became evident that whilst clinical simulation practices are rapidly gaining traction in health professional education, not everyone is equally capacitated to make full use of this powerful and exciting teaching, learning and assessment methodology.

Changing the way in which we teach and learn and the implementation of any new pedagogical approach may be a potentially stressful and daunting task. For this reason, we specifically chose to focus and position this collaborative U21 contribution in the form of a guide, catering primarily for emerging and novice simulation practitioners, with a focus on assessment of clinical competence. We position this guide as a useful tool and resource document for health science educators who may be working in systems where the use of clinical simulation may not currently exist or, is in its infancy.

Given the intended audience and the focus of this guide, we did not set out to develop a comprehensive, authoritative text on clinical simulation and its role in the teaching, learning and assessment of health science students. Rather we have purposefully limited the length and the scope of contributions for the guide so as to focus on core principles, valuable information, and practical tips that may assist emerging and novice simulation practitioners to reflect on and possibly improve their current simulation practices. Consequently, citations have been limited to key references and resources. Should you be aware of any unintentional oversights we would welcome submission of these for inclusion.

U21 colleagues from all regions contributed to this guide. We invited them to participate because of their longstanding scholarship and/or pragmatic expertise in the field of simulation for health science clinical competence. Without exception our experts contributed enthusiastically and generously to the development of this guide. Our aim as Editors was to weave their submissions into a cohesive whole without diminishing the passion for simulation evident in their individual writing. We extend our gratitude to each of the contributors, and look forward to wider contributions from others to the U21 Simulation Community of Practice in future.

We also gratefully acknowledge the support of the U21 Health Sciences Scientific Committees 2015, 2016 & 2017 for allowing us to conduct workshops during the Annual General Meetings and to the U21 Health Sciences Group Executive Committee 2016 for the award of a project grant that funded part of this work

The guide begins with a clarification of selected terms and concepts applicable to clinical simulation before moving on to present options and advice on the design, construction and conduct of clinical simulations. The guide also provides suggestions regarding how one may make use of clinical simulation to gauge clinical competence and to conduct research in the simulated environment.

We hope you will find this guide enjoyable reading and that it may assist you in becoming more involved in the design and application of simulations within your individual learning contexts.

Craig Vincent-Lambert & Fiona Bogossian

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A GUIDE FOR THE ASSESSMENT OF CLINICAL COMPETENCE USING SIMULATION

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CONTENTS

SECTION 1

The Use of Simulation in Clinical Education

The use of simulated events and experiences for purposes of teaching and learning has been around for some time now. Simulations are often used in environments where people wish to teach, observe, assess and or record the responses of human subjects when they are confronted with specific real-world tasks or problems. The military and aeronautical industries are two areas where simulation has been extensively used for training of pilots and testing of systems. Simulation has many benefits including the ability to simulate events that do not occur with regularity. In such contexts, simulation often remains the only viable option for training, preparing and assessing human responses to real life problems. Simply put, one cannot wait for a natural disaster or a war, or a systems failure on an aircraft to test response systems and/or human reactions to such events. Rather, such events and contexts are simulated and the response of individuals to the simulated event is assessed.

The first use of simulation in health sciences education was in midwifery education in 17th century France. As technology has evolved, simulations have become more and more lifelike and there has been a surge in the financial investment and use of human patient simulation in health professions education over the past decade. Consequently there is a growing evidence base and acknowledgement of the value of simulation for clinical teaching, learning and assessment. The drivers for this uptake of simulation include the growing numbers of students vying for clinical placement experience in traditional settings, as well as an increasing workforce requiring on going clinical training. Time spent in simulation is recognised by some professional and accreditation bodies as a proxy for a proportion of the students' clinical placement time, for example, physiotherapy [1,2] and nursing [3] and in the accrual of some clinical skills. Therefore, simulation is now considered standard practice in the entry-level and post-graduate education for many healthcare professions.

Simulation in clinical education has been viewed as a means to improve clinical competence of health practitioners by providing experiences, enhancing knowledge and changing behaviours to improve the quality of care provided and, ultimately, patient safety outcomes. This goal is achieved by providing opportunities for students to refine skills away from real patients and in controlled environments. Exposure to typical as well as rare patient presentations and clinical situations can be engineered in simulation so that all students are guaranteed to encounter these situations. Further, the safety of the student may be enhanced through creation of a supportive learning environment that can improve student confidence and student satisfaction.

The simulation learning experience can be standardized to facilitate mastery of competencies such as the development of technical or procedural skills prior to clinical practice. It can also be used to allow students the opportunity to integrate performance of technical or procedural skills with those of non-technical skills such as situation awareness, decision-making, communication, professional behaviors and ethical practice. Additionally, simulation can provide opportunities for inter-professional education and the practice of effective inter-professional and team-based skills.

So if simulation offers such advantages why then don't health care educators make more use of simulation? The answer is multifactorial, however commonly cited reasons for limiting the use of simulation include:

- Simulations are costly, so why spend money when real patients are in abundance?
- Simulation cannot ever be a substitute for real patient contact.
- Educators lack skills and training to design and implement simulations and to operate simulation technologies.
- Designing and implementing simulation is time consuming and difficult.
- High fidelity simulations require a team of educators to set up and operate
- Students do not behave the same way in simulation as they do in the authentic clinical setting.

Whilst some of the above arguments may have merit, we contend that much of the anxiety and reluctance to engage with simulation comes from; a lack of understanding about what simulation pedagogy can and can't do, how simulations are designed and operated, and the potential benefits of using simulation in clinical teaching, learning and assessment environments. We hope that this field guide will put many of these "myths" about simulation to rest.

SECTION 2

The Language of Simulation

To make sense of this guide and the world of simulation there are certain core terms and concepts that need to be understood. In this next section we try to unpack some common terminology and concepts, and where appropriate we offer bullet points relevant to practical considerations in the context of simulation.

2.1 Actor

An actor is one who pretends to be that which they are not. In simulation, actors are individuals who have been briefed and trained to play a role in a clinical simulation. Depending on the nature and type of simulation, human actors can deliver performances that mimic the patient, family members, bystanders or other members of the health care team.

- The strength and quality of the actor's performance may have a direct relationship on the fidelity of the simulation. Some make use of drama students or professional actors. Whilst their acting performances are often good, the downside is that they may lack the clinical background necessary to properly mimic the desired signs, symptoms and responses. Conversely, whilst senior clinicians may have clinical insights their acting skills may negatively effect fidelity.
- All actors need to be well briefed and carefully prepared for their roles in clinical simulation. This would include a detailed pre-briefing and possibly a dry run with a formal script of responses to possible questions as well as how they will mimic reactions to clinical interventions. Where repeated performances are required in the case of assessment, this needs to be carefully managed so that fatigue does not impact on consistent quality of performances.

2.2 Assessment

Assessment refers to the systematic process of collecting and using data on student knowledge, skills, attitudes and beliefs to determine the extent to which learning outcomes have been achieved. In clinical simulation, assessment is often synonymous with clinical competence. Assessment of clinical competence remains arguably the most difficult and emotionally charged component of the clinical education continuum. Using a simulation rather than a real patient interaction to assess clinical competence has many benefits.

- The student can make "incorrect" clinical decisions and interventions (that in real life would be stopped and or corrected by the assessor in the interest of patient safety) and observe the consequences. Simply put, simulation allows for the making of errors and reflection on these without the ethical and clinical dilemmas created in an authentic environment.
- Using a standardized simulation for all students enhances the validity and reliability of the

assessment. In the authentic clinical setting it is not always feasible to have an entire class of students assess and manage the same patient.
- Simulation allows the educator to target the areas of practice they wish to assess and then set simulation activities to force student responses and behaviors.

2.3 Assessment Integrity

Assessment integrity is concerned with the honest, accurate, efficient and objective assessment of learning. As such, considerations around the integrity of a simulation assessment are fundamentally no different from those for other assessment methods. However, educators need to think about components of assessment integrity such as authenticity, fairness, validity and reliability in the context of simulation based assessment.

Authenticity

As is the case for other formal assessments such as examinations, the content of a simulation may need to be secured and kept secret in order to illicit authentic assessment performances. If students have prior knowledge of the simulation and the nature of the scenario or case it may allow for unrealistic prior preparation and thus their performance may not be as it would be in the clinical environment. This would be particularly applicable in disciplines where responses to an acute crisis and the interventions required, are the focus of the assessment. Having said this, if the real world context is such that a degree of forewarning, and or prior preparation exists then students should be allowed a similar opportunity to prepare prior to assessment.

Challenges with regard to maintaining secrecy include that simulation areas need to be prepared and equipment needs to be assembled. The number of persons involved with a simulation assessment and, the potential sharing of information between those students who have completed the simulation with those still to be assessed; all add to the risk of assessment integrity breaches. Ways to protect the authenticity of a simulation assessment include:
- Covering equipment and mannequins prepared prior to the assessment with drapes.
- Locking venues and preventing unauthorized access to the venue after the simulation has been prepared and set up.
- Limiting the number of persons who have prior knowledge of the full details of the simulation including the briefing assessors and actors only on the day of the assessment.
- Having a holding area for those who have completed the simulation where they will be invigilated under examination conditions until all candidates have been assessed.

Fairness

Fairness in assessment refers to students having equal opportunity to demonstrate the extent of their learning through an assessment task. In simulation assessment this means the student should be in a position from emotional, cognitive and psychomotor perspectives to competently manage the simulated case. Fairness also relates to the appropriate sampling and alignment of simulation assessment with the intended learning outcomes and reasonably expected standards of performance. For example, being sure we don't set an exit level simulation for a first year student or conversely where the simulation is so simplistic

and algorithmic in nature that with common sense and logic even the untrained layperson will demonstrate a passing performance.

Validity

Validity is concerned with the accuracy and credibility of the assessment. The central question being; does the simulation assessment and the assessment tool being used, faithfully represent the learning outcomes being assessed? Validity addresses whether the 'right' things are being assessed and measured and whether this is done in the 'right' way [4].

Validity can be applied to the simulation assessment experience and include:
- the realism (fidelity) of the simulated clinical interaction;
- the correctness of diagnostic cues provided and;
- the extent to which clinical interventions performed by students in their management of simulated cases resulted in the simulation of appropriate physiological responses.

Validity can also be applied to the assessment tool used, and how the results are interpreted to make a decision on the student's performance. Does the assessment tool properly assess all the expectations of good clinical practice or clinical competence, does it identify areas requiring improvement, does it distinguish between standards of performance such as competent from not competent or the expert from the intermediate and the novice?

Reliability

Reliability is concerned with the stability and consistency of the assessment. The central question being; are the simulation assessment and assessment tools able to be uniformly repeated and do they dependably pass and fail the 'right' students [4]. Stability refers to the degree to which the assessment and the assessment tools are able to be repeated on separate occasions. Consistency is the degree to which the assessment and assessment tools measure the constructs of interest. Equivalence relates to the consistency of scoring and when assessed among raters, is referred to as inter-rater reliability. In simulation, more than one assessor is often used to assess student performance, so strengthening inter-rater reliability is an important area for consideration.

2.4 Assessor

An assessor in the simulation context is normally an experienced practitioner, educator or clinician who is in a position to make accurate and consistent assessments of the competence and quality of performances and interventions delivered by students during a simulation assessment. Where multiple assessors are used moderation of performance expectations and the use of the assessment tools needs to be undertaken to ensure reliability of assessment.

2.5 Assistant

An assistant is any person who is assigned to help or assist the students during their management of the simulated case. The number of assistants and the degree to which they assist the student undertaking the simulation needs to be carefully considered and, as far as possible, matched to the authentic clinical setting and context. Having peers act as assistants is common practice

in many institutions. The use of peers as assistants in simulations or where assessment of competence is the central aim has both advantages and disadvantages.

The challenges associated with the use of assistants for students completing simulations for assessment include cases where we may encounter the assistant who:

- steps out of the assistant role and attempts to take charge of the situation or the patient or begins to direct the simulation.
- becomes flustered, is incompetent and does not assist very well or undoes the good work done by the student in the simulation.
- feels the need to try and help a little too much by giving hints, tips and non-verbal clues to try and guide their peers to do what they feel is right.
- deliberately sabotages the performance of their peers.

Much of the above may be avoided through careful briefing and coaching of the assistants, establishing expectations of their role and boundaries and highlighting the need for them to fulfill their role as assistant in as realistic a way as possible.

2.6 Briefing

Briefing is a term used in simulation to refer to orientation, provision of instructions or essential information to those involved in the simulation. Briefing implies that this process is conducted prior to conducting a simulation learning activity, however the terms pre-briefing and debriefing are also commonly used to distinguish briefings that occur before and after the simulation. Both briefings are normally conducted by those responsible for design and implementation of the simulation. Generally two separate pre-briefings are conducted prior to the simulation starting:

- The first pre-briefing includes the facilitators, assessors and moderators as well as any assistants and actors (if used). The purpose of this pre-briefing is to clarify the expected flow to the simulation as well as to deal with any queries regarding prompting, marking and or any other area that requires clarification prior to the first simulation starting.
- A second pre-briefing occurs with those individuals who will be completing the simulation. This allows for clarification of the "rules of engagement" and covers things such as access to equipment and use of assistants etc. It may also serve to provide background information about the simulation players e.g. through a patient handover.

Debriefing is a formal activity that follows the simulation. Debriefing can be multipurpose and include to understand the participant experiences and satisfaction with the simulation activity, to assist them to develop critical reflection and self-evaluation, to examine clinical decision making, and to identify areas for improvement. The same two phase model used in pre-briefing can be applied to debriefing to extend participation to include facilitators, actors, assistants, assessors and moderators who can all provide valuable feedback for improving future simulation learning activities.

2.7 Clinical Competence

Clinical competence is variously defined according to performance or attribution based approaches [5]. Assessment of clinical competence requires a clear definition of clinical

competence as this will guide assessment methods. The definition of the Nursing and Midwifery Board of Australia blends these approaches so that clinical competence is viewed as "a. combination of skills, knowledge, attitudes, values and abilities that underpin effective. and/or superior performance in a professional/occupational area" [6]. This suggests a global performance based approach to assessment of clinical competence, rather than assessment of individual elements of competencies. However, in simulation assessment either approach can be used providing the intention is clear and linked with objectives or learning outcomes.

2.8 Clinical Decision Making

Clinical decision making is a process that involves data being gathered, interpreted, and critically evaluated culminating in an evidence-based decision [7] about clinical interventions, treatment plans and or immediate courses of action.

2.9 Clinical Intervention

Clinical intervention refers to the performance of one or more clinical skills or procedures to achieve a predetermined management outcome. For example, securing the airway of a critically ill patient may be a clinical intervention that is associated with a number of individual clinical skills such as gaining IV access, administration of medications, direct laryngoscopy and others all for the purpose of securing the airway.

2.10 Clinical Lead

A clinical lead in the context of simulation is the individual who assumes overall responsibility and accountability for clinical decision making and patient care during a simulation experience. Those whose performance is being assessed via simulation would normally assume the role of clinical lead.

2.11 Clinical Procedure

A clinical procedure refers to a set of psychomotor skills and related interventions that are clustered around the performance of a routine predetermined intervention or task. Establishing an IV line or suturing a wound are examples of clinical procedures.

2.12 Clinical Reasoning

Clinical reasoning involves similar cognitive processes to those involved in clinical decision making. However, here the focus is more on development of a holistic and deeper understanding of a patient problem or situation. Clinical reasoning allows for the anticipation, evaluation and reflection on the physiological, psychological and social responses to treatment.

2.13 Clinical Skills

Skills have been defined as the ability, acquired through deliberate practice and sustained efforts to carry out activities [8]. Clinical skills encompass technical and non-technical skills, and may be developed through procedural simulation, defined as "the use of a simulation modality (e.g., task trainer, manikin, computer) to assist in the process of learning to complete

a technical skill(s), or a procedure, which is a series of steps taken to accomplish an end [9]. The acquisition of clinical skills includes three main components: procedural knowledge (learning how to perform certain movements), underlying basic science knowledge (why one should do so), and clinical reasoning (what the findings might mean) [10].

In the simulation context clinical skills are often categorized as technical (or procedural) and non-technical (or behavioral) skills.

- Technical skills includes those skills associated with patient assessment (patient interview, examination, palpation, auscultation, systems assessments, interpretation of investigations and diagnostic skills) and management and treatment skills (cardiopulmonary resuscitation, cannulation, IV fluid and drug administration, childbirth, surgical procedures, patient positioning and handling, airway management and clearance techniques and high-level functional tasks such as post-operative ambulation, exercise prescription and upper limb retraining).
- Technical skills are sometimes categorized as generic technical skills (such as assessment of vital signs, manual handling) and advanced technical skills (such as artificial airway maintenance, stoma care).
- Non-technical skills include task management, inter professional collaboration, situation awareness, decision-making, communication skills, professional behaviors and ethical practice, psychosocial skills.

2.14 Clinical Team

Simulation can be designed to allow students from one profession, or students from multiple professions, to practice interacting as members of a clinical team. The skills and behaviours required for effective teamwork that can be developed through simulation include “managing the team (e.g. coordination, monitoring and supporting others); managing the task (e.g. role allocation, planning, prioritizing, identifying and utilizing resources) and developing a shared team mental model (information sharing on task and role).” [11]

Scenarios can be designed to simulate a range of clinical settings, and thus focus on a range of clinical teams. For example, the interaction may focus on an inpatient clinical team (e.g. acute respiratory team, or post-surgical team) or an outpatient clinical team (e.g., a community-based allied health clinic).

Although a goal may be to use simulation to provide an inter professional education experience, “where students from two or more professions learn about, from and with each other to enable effective collaboration and improve health outcomes”[12], it may not always be feasible to have members from multiple professions in the same simulation session. As an alternative, the educator or peers may portray other member/s of the clinical team, to enhance diversity of the team roles and increase capacity for interactions with those members of the team. Simulation can therefore allow the student to practice interpersonal communication skills with members of the clinical team, and to develop an appreciation of their role within a range of clinical teams.

2.15 Core Outcome/s

A core outcome may be seen as a reflection of central learning outcomes or what we are intending to measure in a simulation. For example, if we want to know how competent a student is at managing a patient in cardiac arrest then one of the core outcomes would be the early recognition of cardiac arrest and another the performance of high quality CPR. In most instances there are between 3 to 5 core outcomes set for each simulation. Where assessment of clinical competence is the purpose of the simulation, students would need to achieve all of the core outcomes in order to be deemed competent.

2.16 Examiner

An examiner is an individual who has appropriate clinical insight and experience to deliver an unbiased accurate assessment and value judgment of the observed performance of the person/s completing the simulation examination.

2.17 Fidelity

In the simulation context, fidelity simply refers to the perception of how real or lifelike the particular simulation is for an individual. The level of realism is generally considered by those developing the simulation but ultimately determined by those undertaking this simulation. There are five dimensions of fidelity which are commonly addressed, physical (environment, equipment, tools), psychological (emotions, beliefs, self-awareness of participants), social (motivations, goals), culture of the group and degree of openness or trust.

2.18 Mannequin/Manikin

Traditionally “mannequin” is a term used for a model of human form used to display clothes in a store window. Mannequin-based simulators are an integral part of simulation based training in healthcare and they are used to train psychomotor and cognitive domains of learning for clinical skills. Mannequins have become increasingly sophisticated since the early mechanical models used for mouth-to-mouth ventilation like Resusci Anne to computer controlled entire patient simulators. A focus with technological advancement has been in improving the quality of mannequins in order to create more life-like experiences. More realistic responses from mannequins are possible however, more advanced technological features may translate into higher overall cost.

There are two main types of mannequins, operator driven and autonomous.

- Operator driven mannequins are generally controlled by the educator or technician conducting the simulation. There may be limited feedback from the mannequin making them less real. However, they are simpler to use and more cost effective.
- Autonomous mannequins are more sophisticated, using electronics and mathematical modelling algorithms that generally provide physiological outputs. For example, a simulation mannequin for administering intravenous fluid will respond with an increase in blood pressure and a reduction in heart rate. Such sophisticated mannequins are more complex and costly and in turn require time for staff to be trained in their use and to overcome any fear of the technology.

Mannequins have been developed and created to simulate certain training needs and have been developed to address the major disciplines in healthcare. The following are some common functions for mannequin uses.

- **Respiratory** – Measurement of oxygen concentration, simulation of end-tidal carbon dioxide, lung compliance and variable respiratory rates.
- **Cardiovascular** – Assessment of pulse volume and strength, auscultation of a range of heart sounds, jugular venous distension, full chest wall compression.
- **Airway management** – Bag-valve-mask intervention, endotracheal and nasotracheal intubation, cricothyrotomy, endotracheal tubes and masks and laryngeal mask airways
- **Neurologic** – State of consciousness by eye movements, pupil response to light, movement of head and assessment of anterior fontanelles for intracranial pressure.
- **Extremities** – Assessments of circumoral or peripheral cyanosis, amputation surgery.
- **Pharmacologic intervention** – For drug recognition and concentration and dosages administered using bar-coded syringes.
- **Procedural intervention** – Chest tube insertion, needle thoracotomy, diagnostic peritoneal lavage, urinary catheter placement and surgical cricothyroidotomy.
- **Birthing** – malpresentation, dystocia, caesarean sections, fundal massage, episiotomy repairs, suctioning, obtaining umbilical access, and intubation.
- **Pediatric and newborn care** – variable skin color, spontaneous movement, seizures, cyanosis, crying and anesthetic gas administration.

2.19 Moderation

Moderation in the context of simulation is concerned with the reliability of the simulation and assessment and consistency of application of criteria and standards resulting in judgments about performance. Moderation activities and processes are directed toward improving reliability and consistency.

Moderation of the simulation is undertaken prior to conducting the simulation and a moderator provides a second (and often external) opinion on the standard of the simulation looking at areas such as appropriateness, complexity, fidelity, time allocation and weighting of core outcomes.

Moderation of assessment assists in ensuring that assessors have a clear, shared understanding of the simulation core outcomes, the performance expectations, the criteria and standards to measure performance levels and the features that will characterize each level of performance.

Moderation of assessment can be conducted before, during and after the simulation:

- **Pre-moderation** – assessors discuss core outcomes, application of the criteria and performance standards, expectations of performance levels.
- **Intra-moderation** – assessors conduct a trial rating of the same sample of student performance (or cross rating student performance between groups), identify disparities in provisional ratings, justify ratings, reach consensus and calibrate ratings accordingly.
- **Post-moderation** – assessors discuss ratings of simulations by sampling and comparing low, median and high performance examples as well as performances that are borderline between pass or fail or between levels of performance.

2.20 Moulage

Moulage is a French word meaning casting or moulding. In simulation, this refers to the application of makeup or molds to humans or mannequins to imitate trauma or injury, disease, ageing, skin conditions, lesions, blood, vomitus, open fractures. It can also include the use of artifacts and odours [9].

2.21 Observation

Observation refers to the act of watching those completing the simulation. Observation may be direct i.e. the observers or assessors are present in the venue and may be seen by the student completing the simulation or indirect i.e. the observer is hidden behind a one-way mirror and cannot be seen by those completing the simulation. Alternately indirect observation may occur when simulations are videotaped and performances observed at a later time. Both methods (direct or indirect) have advantages and disadvantages.

Advantages of direct observation include:

- The observer generally gets a better, closer, first hand view of what is happening in the venue
- The observer may move position and change their angle of view
- The observer is able to engage in the simulation for purposes of gaining clarity, this practice is however more suited to simulations for learning and formative assessment and not for summative assessment.

Disadvantages of direct observation include:

- Being observed is inherently stressful and the more people watching the student the higher are their levels of anxiety [13] most especially if the simulation is for purposes of assessment.
- The presence of observers in a venue may impact negatively on the fidelity of the simulation.
- The potential for students to verbalise their actions and engage in dialog with the observers and assessors rather than actually engaging in the simulation.

2.22 OSCE (or OSCA)

Objective Structured Clinical Examination (or Objective Structured Clinical Assessment) is an approach to assessing clinical or professional competence in a structured way, with clear and objective criteria that allow for replicability and assessment of specific technical and non-technical skills. OSCEs may include stations or clinic rooms with individual standardized patients and allow for assessment of the individual's clinical competency. Assessment and or examination of performance may include direct observations, criteria checklists, and may be formative (offering feedback and opportunity to repeat) or summative (considered 'high-stakes' for educational decisions of pass/fail). Opportunities for debriefing, verbalization of clinical decision making and justification of actions, reflective exercises or remediation may be included in the OSCE design. Defining characteristics include: clear criteria for evaluation, individual student-patient interaction, and feedback interaction between instructor, patient, and student [9].

2.23 Part-task trainers

Part-task trainers simulate only a portion of a complete system or process. They focus on a particular skill set and specialist need with potential lower cost but they can also be high

fidelity. Part-task trainers are classified based on the type of procedures for which they are used and have been designed for: airway management, intravenous access, lumbar puncture and epidural trainers, orthopedic joint and anesthetic blocks, suturing and knot tying, thorax procedures, breast exams, nasogastric tube and tracheostomy care and surgical simulators.

2.24 Participation

Participation refers to all human subjects involved in any way with the simulation when it is in progress. Participation roles may include those of facilitator/conductor, clinical lead, member of the clinical team completing the simulation, assessor, examiner, moderator, debriefer and observer.

2.25 Performance Bias

The assessor's own experiences as a clinician are seen by some to influence their judgment of students' performances during simulation assessments. Simply put, the performance of students during simulation assessments is judged by assessors through the lens of their own clinical experiences and not necessarily against the core simulation outcomes and objectives, or established standards of clinical performance. This means that students may feel they need to appease the assessor by performing in a way that is similar to the way in which the assessor would if they themselves were managing the case.

2.26 Performance Rating

There are a variety of ways in which to rate and report on the performance of an individual in simulation. These range from simple competent or not yet competent to graduated Likert scale ratings from poor to excellent, and those employing stages of professional development from "novice" to "expert". However the Bondy Evaluation of Clinical Performance Scale seems to be one of the most widely used rating scales as it may be applied to any professional behaviour and provides the student with diagnostic feedback as well as a fair assessment of performance [14]. When deciding on a rating scale one needs to carefully consider the main purpose of the simulation, the type of individuals completing the simulation, institutional expectations regarding the submission of marks or grades, and the increasing requirement for performance rating to be defensible.

2.27 Prompter

A prompter plays a critical role in the success of most clinical simulations. Regardless of the technologies used or the fidelity of a simulation there may be certain actions that students will take in a simulation that are unexpected and diverge from the anticipated pathways and rubrics designed for the simulation. In these instances the prompter will have to rapidly reflect on what the student is doing or has done and then provide relevant feedback e.g. on the physiological responses to a particular action. Prompting also allows for setting the scene and context through the sharing of information relating to things that cannot be adequately simulated. Examples would include changes in appearance and or symptoms linked to the

simulated patient's improvement and or deterioration. The student may ask the prompter for responses such as "how do the patient's pupils look"? If we have a manikin where pupil size cannot be changed then the role of the promoter would be to provide the answer. Generally speaking high technology simulations should require less prompting and the less technology used the greater the need for prompting.

Prompters should be experienced clinicians and have experience with simulation practices. The prompter needs to have a deep understanding of the simulated case as well as the underlying pathophysiology and the physiological responses to expected treatment interventions if they are to provide realistic and logically conceivable responses in a timeous manner.

2.28 Prompting

The act of providing clues and information to those participating in a simulation, for purposes of guiding the flow of the simulation.

2.29 Real-time

Real-time means the accurate simulation of the flow of time in a simulation. An example of real time simulation would be where a student wishes to measure the patients' blood sugar level during a simulation. Real-time simulation would include having the student open the glucometer, switch it on wait for it to initialize, place a drop of simulated blood onto the test strip and then wait for the machine to give the reading. In real-time simulation interventions are allowed to occur in the same sequence and time period that they would in the real world. Real-time simulation may not be suitable for some simulations, where real-time might result in disengagement of student interest or not be feasible in the time allocated to the simulation environment such as simulation of labour and childbirth.

2.30 Reflection

Reflection in simulation refers to self-critique and reflective practice. This is a powerful tool that involves allowing the student to reflect on their own performance in the simulation and then to provide comment on this prior to or in addition to them receiving the assessors feedback. Reflection should be guided and purposeful and the process or outcomes of reflection may contribute to the overall result of a simulation assessment. In such cases the proportion of marks allocated to reflection should not be such that a student who failed to achieve the core clinical outcomes of a simulation ends up passing based on their ability to reflect on how poorly they performed.

2.31 Rubric

A simulation rubric is a detailed document that outlines the expected flow of a simulation, the expectations of quality and the levels of performance standards and criteria relevant to a simulation activity. Rubrics allow for recording and rating of the performance of the student. The completed rubric document may form a component of both pre and post moderation.

2.32 Simulated Case

Often based on a real-life clinical situation, a simulated case involves the development of a scenario and a detailed template that may include: story line, setting, learning objectives, participants roles (with scripts for role-playing if appropriate), facilitator role, scenario level, core outcomes, brief description of the situation, and rationales for different pathways depending on student performance.

Objectives may be developed for an unfolding case that increase in complexity or address different aspects. For example, the focus of the simulated case may change for each experience for example, simple assessment and patient education, focused assessment of an emerging change in patient status, communication with patient and family, or team management of a complex or urgent situation.

2.33 Simulation [Activity]

An educational method or pedagogy to create an occasion for experiential learning that represents a real clinical event and provides opportunities for teaching, learning, evaluation, testing and to amplify experiences for better understanding. This method can include a practitioner and patient or multiple levels of an event such as a disaster simulation. The simulation activity includes the event from initiation to termination, outlining actions for an individual event (equipment, environment, participants, pre-briefing, debriefing) and all the components of a simulation [9].

2.34 Simulator

A device, program or system that simulates a component or an individual with specific conditions programmed for a specific simulated case. In health care simulation, a full body device is often referred to as a human patient simulator. The simulator can be made from plastic, cloth, or household products in as realistic and standardized a way as possible. Highly sophisticated human patient simulators may display heart, lung, and bowel sounds, have palpable pulses, eyes that blink, tear, and change pupil sizes, or component body parts – such as arms for phlebotomy and intravenous administration. Simulators can reflect different points on the life continuum from infant (including premature) to older adult and have features which represent the global community.

2.35 Standardized Case

A scenario with standardized patient/s who portray an individual with specific conditions in a realistic, standardized, and repeatable way – the presentation varies based on the student's performance. This distinguishes standardized patients from simulated patients, because they can be used to teach and assess students with feedback on history/consultation, physical exam, and other skills in simulated environments and often participate in high stakes assessments. The standardized patient performs the whole sense of the patient – history, body language, physical and emotional findings [9].

2.36 Time Compression

Time compression is the opposite of real time simulation. Time compression involves compressing time to get the simulation to fast track or move to the next point where assessment of an outcome is possible. An example of time compression would be where the student wishes to find out a patient's blood sugar level. When they ask what the reading is the prompter simply gives them the answer without expecting them to go through the entire process of using the glucometer and test strip. Whilst there is a place for time compression in certain contexts its use needs to be carefully considered. Whilst time compression has its place in simulation, it invariably reduces fidelity and repeated switching between time compression and real time in a simulation can become confusing for the student completing the simulation as they are not sure what actions they are to simulate in real time and which will be fast tracked.

2.37 Virtual Simulation

Virtual Reality (VR) is a term coined in 1987 by Jaron Lanier, a pioneering computer scientist. VR deals with 3D, computer generated virtual environments and objects that individuals can explore and interact with. A person can see 3D life-sized images, interact with them, and get real time responses. This complex technology can interact with both human perception and cognition by using headsets and omni-directional treadmills to stimulate senses and create the illusion of reality. New advances in force feedback allow a more intuitive way of exploring virtual objects allowing use of glove based devices, minimally invasive surgery tools, micro-tactile sensors, and stylus based devices.

Medical and dental education have demonstrated use of a virtual cadaver for learning anatomy and virtual patients for practicing surgery. This offers a risk-free, practice-based learning process that can be performed in conventional and non-conventional learning environments, and allows potential customization of patients and scenarios. The advantages of VR by computer simulation are that the virtual procedures can be repeated and feedback can be received that is similar to what one may expect from a live patient. VR headsets can allow interaction with a virtual patient in different environments alone or in a team. Augmented reality can be used to combine with VR when used in simulation or authentic environments.

One of the drawbacks of VR is motion sickness (cybersickness) related to design issues or ergonomics, which may cause dizziness, nausea, and disorientation. In addition, development of VR is time consuming, complex, and costly all of which have challenged commercialization. In a field dominated by academic research and development, with some private industry collaboration; there are number of companies trying to translate the research into practical VR applications including biological tissue modeling for simulation of organs, Human-computer interfaces such as force-feedback and tactile interfaces, and display technologies that may utilize VR for effective visualization of human anatomy. It is expected that the future will see wider spread adoption, integration of VR with artificial intelligence, interactive learning, bio-feedback, and data analysis.

SECTION 3
Simulation Technologies

3.1 Introduction

In this section we clarify medical simulator technology so that health educators are empowered to select the most appropriate simulator or combination of simulators for use in a clinical simulation to achieve the desired learning outcomes. Learning through simulation involves active student engagement in an authentic situation, practice and feedback. Medical simulators include technology for authentic replication of patient anatomy and conditions, enable student engagement and provide feedback on performance. Although people can act in the role of a patient, termed a standardised or simulated patient, this form of simulation is not included in this section but will be addressed elsewhere. Software developed for scheduling and co-ordination of simulation sessions and simulation centre management are likewise not addressed in this section.

3.2 Types of technology for clinical simulation

Since clinical simulation involves replicating a clinical situation, or an aspect of this situation, medical simulators are physical or virtual devices and systems designed to mimic human patients, enable use of real or simulated medical equipment, replicate the clinical environment and / or reproduce social-professional interaction elements of clinical practice. Simulation can occur in a physical environment, virtual environment or a blend of both. Medical simulator technology refers to the combination of materials, hardware, software and systems that comprise and support simulator function, interaction in the simulation environment and enhance feedback on performance.

A key difference between a medical model and a medical simulator is that the simulator is purpose-designed as a device or system with interactive features that actively engage students in a real-world clinical process. A patient simulator, in particular, is designed to replicate either a part of human anatomy for clinical assessment, allow for the performance of one or more clinical procedures (task training) or represent a whole person (full-body patient simulator) which can support aspects of patient assessment, a range of clinical procedures and holistic integration of patient care for scenario-based learning. Augmenting or replacing physical patient simulators and simulation environments, audio-visual and digital technology provide various forms of augmented, virtual or mixed-reality for creating or enhancing patient interactions, replicating clinical settings and engaging social-professional interactions during a simulation event.

3.3 Features of patient simulator technology

The concept of fidelity is often used in conjunction with patient simulators to denote the degree to which the appearance and behaviour of the patient simulator reflects the appearance

and behaviour of a real patient. Since fidelity is a complex and multifaceted phenomenon that is more than the sum of patient simulator features, the term technology is more appropriate when referring to simulator features. Simulator technology also consists of more than the sum of patient features being replicated.

Simulators can consist of a simple construction or are composed of multiple components integrated into a complex simulator system. Patient simulators can also have differing levels of technology for different purposes. In order to better understand simulator technology, a deconstruction of simulator features is necessary (Figure 3.1).

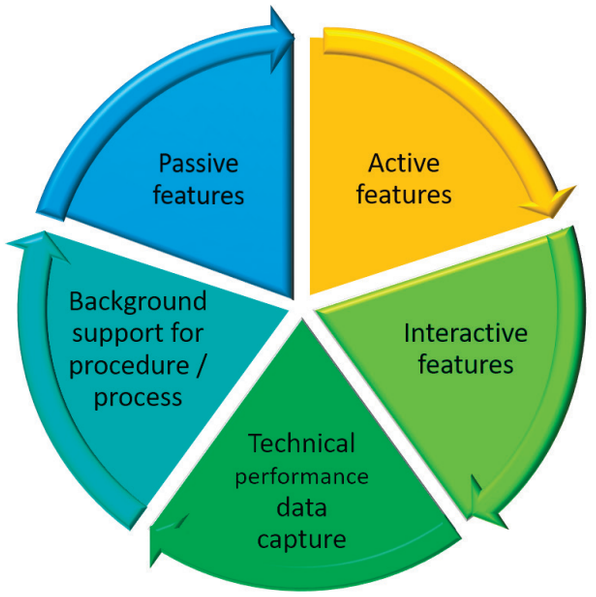
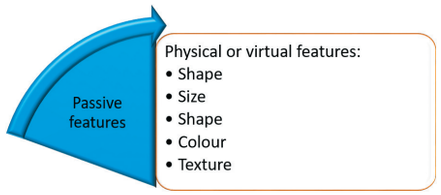
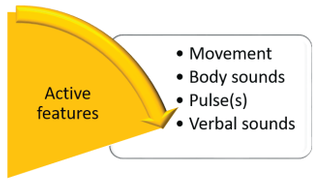


Figure 3.1 Schematic overview of patient simulator features

Patient simulators can be analysed according to the following features:

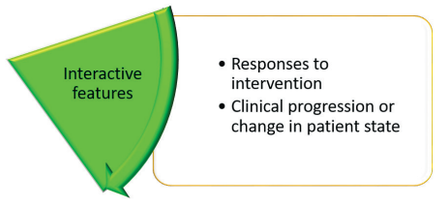




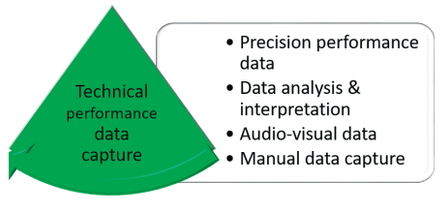
Passive simulator features: Involves the physical or virtual structure and appearance of a simulator and includes factors such as shape, size, colour, texture and weight of the simulator.

Active simulator features: Includes simulator behaviour that mimics real patient behaviour such as chest rise, body sounds (lung, heart and bowel sounds), eyelid and pupil response, palpable pulses and movement of body parts. These active features provide clinical cues to elicit participant responses to the patient and allow simulator behaviours to be changed during the simulation.

In the virtual reality (VR) context, interaction with the virtual patient simulator may include visual, motion and tactile effects of this interaction. An example of this is the sensation of tissue resistance when using instruments for laparoscopic surgery or resistance to inserting a needle in a virtual arm (Figure 3.4B). This tactile phenomenon in VR simulation is part of the concept of haptics. In a virtual environment, haptics also refers to the sense of weight, position and movement collectively referred to as kinaesthetics. A haptic patient simulator is one where the tactile response (or force-feedback) and motion elements in performing a procedure are critical to developing the correct technique in performing a procedure.

a 

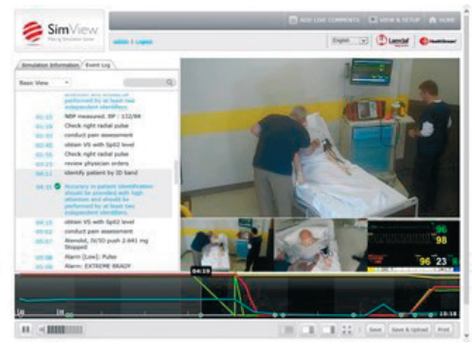
Interactive simulator features: These are changes that occur in response to participant actions or other events in the simulation. Examples include change in the patient condition such as the return of a palpable radial pulse with increase in blood pressure on administration of intravenous (IV) fluid, or the response to performing clinical procedures such as conversion of an arrhythmia after electrotherapy or drug administration, or backflow of simulated blood into the chamber of the catheter-over-needle when performing IV cannulation, or observing chest rise when using the bag-valve-mask-reservoir with corresponding improvement in the oxygen saturation reading on a virtual patient monitor (Fig. 3.6(C)). Active and interactive simulator features are analogous to functional attributes associated with engineered fidelity and important for promoting psychological fidelity.



Technical performance data capture: Technology for capturing audio-visual and technical performance data for precision feedback may be captured separately or integrated into the functions of the patient simulator. Technology-enhanced feedback allows for capturing data that is otherwise not possible through human senses; either through inattention in complex activity environments or not possible through observation. Such technology includes audio-visual systems and computer-based hardware and software systems that captures simulation activities, changes in the patient condition and technical performance data, such as depth of compression during CPR, the volume of a drug administered or volume of air given with manual ventilation. Some simulators have sensors that automatically detect and relay data to a logging system (Figure 3.2).

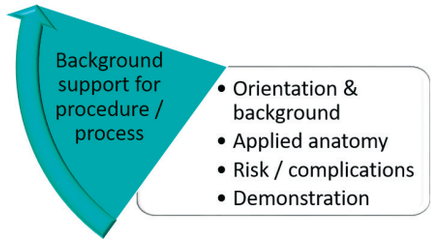
If a pulse is palpated or a jaw-thrust performed, for example, these actions may be automatically logged against a simulation time-line. Such data becomes available for technical feedback and debriefing and in some cases useful for course of action analysis, i.e. determining whether the participant has done the right thing at the right time [15]. Such logging systems may also provide the opportunity for manual entry of instructor comments. Some feedback systems may include an analytical component that provides quantitative and / or qualitative feedback to instructors and students.

(A) Laerdal® SimPad® PLUS with SkillReporter™ captures and analyses quality of CPR performance



(B) Laerdal® SimView™ system that integrates audio-visual and technical performance data together with an integrated virtual patient monitor (http://www.laerdal.com/images/L/ADQNSFAQ.jpg)

Figure 3.2 Examples of technical performance data capture technology: (A) Technical data capture and analysis system for CPR performance; and (B) Comprehensive integrated audio-visual, automated and manual entry data-capturing system supporting quantitative and qualitative feedback for debriefing.

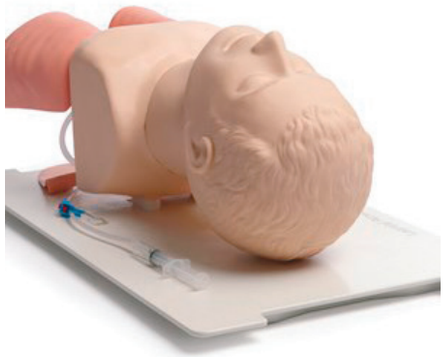
A 

Background support for procedures / processes: A patient simulator may come with a physical model, computer programme or combination that supports background understanding to the process, procedure or use of a diagnostic instrument supported by the simulator (Figure 3.3). Such support options may include applied anatomy and physiology relevant to the procedure, a demonstration of the procedure, indications, contra-indications and complications of the procedure or a stepwise explanation of the process involved. Such models or programmes may require the presence of an instructor or can be used independently of an instructor for self-directed learning.

In summary, the technological complexity of a patient simulator spans the simulator design features. The passive features may involve specialised materials with similar feel and behavioural properties to human tissue such as those used in advanced surgical simulators. Active and interactive features may require computer-based hardware and software technology that enable manipulation and programming of such features to represent a clinical condition, interact with participants and reflect dynamic clinical changes and responses to disease or injury progression and medical intervention.

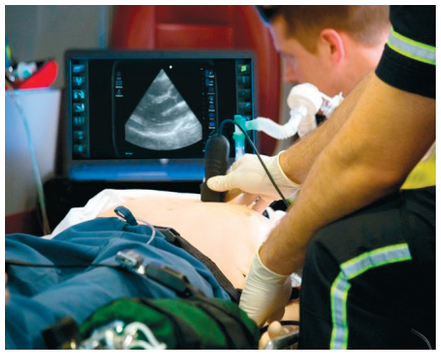
Simulator design and technology is a determinant of how realistically live medical equipment can be used in a simulation event. This includes patient monitors (e.g. ECG and pulse

(A) Laerdal airway demonstration model (http://www.laerdal.com/images/L/ABQLQLIZ.jpg)



(B) Laerdal® Airway Management Trainer(http://www.laerdal.com/images/L/AFSDCNWU.jpg)

(C) SonoSim® support for developing ultrasound skills (https://sonosim.com/our-solution/)



(D) Use of the SonoSim® ultrasound simulator with a full-body patient simulator (hybrid simulation). (http://www.laerdal.com/images/L/AFVABBEQ.jpg)

Figure 3.3 Examples of background support for skills supported by simulators: (A) physical model supporting (B) airway trainer and (C) anatomy and use of instrument supporting application in (D).

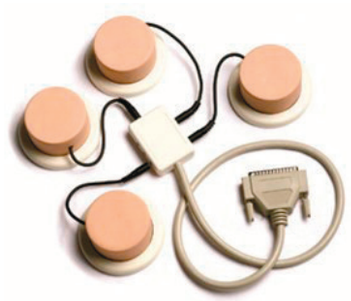
oximetry), diagnostic equipment such as ultrasound, and performance of procedures such as airway suctioning, drug administration, ventilation (manual and mechanical) and live defibrillation, pacing and synchronised cardioversion. Real-time physiological parameters such as End-Tidal CO_2 ($ETCO_2$), oxygen saturation, respiratory rate and non-invasive blood pressure (NIBP) may not support live use of patient monitors but can be replicated and represented in the same way by means of a virtual patient monitor. This simulated physiology monitoring can be used with other types of simulators such as task trainers and simulated or standardised patients to enhance the realism and challenge of the task.

3.4 Types of patient simulators

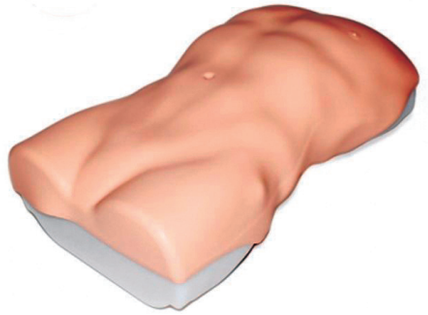
Simulators for developing diagnostic skills and experience of clinical signs and conditions

Preparing novice students to benefit from experience gained in clinical practice requires their exposure prior to clinical placement to clinical phenomena, conditions, and processes likely to be seen in practice. Advanced students require exposure to clinical conditions and features that may not be seen frequently in clinical practice. Providing exposure calibrated to student's needs facilitates learning and experience across the novice-to-expert spectrum. Skills in auscultation, palpation, percussion and use of diagnostic instruments such as ultrasound or blood pressure measurement can be developed, techniques mastered and experience gained in responding to normal and abnormal findings. A spectrum of low to high technology patient simulator options are available for focused body system, regional assessment and application of diagnostic tools.

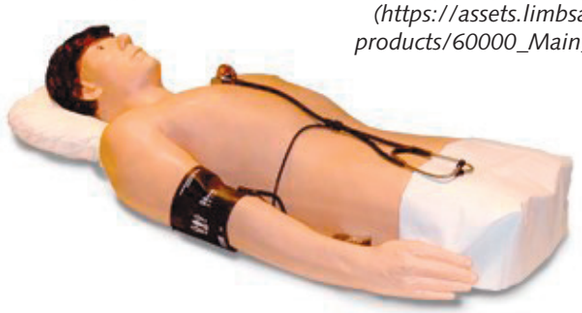
Sounds trainers: Figure 3.4A represents a low-technology simulator that generates a range of normal and abnormal heart, lung and bowel sounds. The passive simulator feature is the auscultation pads that allow the use of a stethoscope to auscultate sounds rather than anatomical placement of the stethoscope.



(A) Laerdal® SimPad Sounds Trainer (http://www.laerdal.com/images/L/ACLJVJIZ.jpg)



(B) Limbs & Things Abdominal Examination Trainer (normal and pathophysiological findings) (https://assets.limbsandthings.com/products/60000_Main_Abdo_WEB.jpg)



(C) Laerdal Harvey® (Cardiopulmonary Patient Simulator)

Figure 3.4 Examples of simulators for diagnostic training. (A) Low technology sounds trainer; (B) Low technology abdominal examination trainer; and (C) High technology cardiopulmonary diagnostic patient simulator.

The active simulator feature is the sound produced that can be auscultated using a stethoscope. The interactive feature is the ability for sounds to be changed in volume and by range of sounds. The same range of sounds are available in higher-technology, full-body patient simulators where a broader scope of patient assessment and clinical procedure options are available and the patient simulator may have active and interactive features appropriate for scenario-based learning.

Diagnostic assessment simulators are available in low to high technology options. Fig. 3.4B provides an example of a low-technology diagnostic simulator. The passive simulator features include the adult patient torso (appearance, shape, size and texture) and normal or abnormal structures that can be observed, palpated and percussed. Active features include abdominal sounds on auscultation and palpable normal and abnormal abdominal structures. There are no interactive features since no changes to abdominal structures or features can be made during the clinical assessment process. Figure 3.4C represents a high-technology diagnostic patient simulator. Passive features include the appearance, size, shape and feel of the simulator. Active features include the presence of pulses (carotid, radial and femoral), respiratory chest movement, lung and heart sounds. Interactive features include the ability to manipulate active features to represent a variety of cardiac conditions. This diagnostic simulator is driven using computer-based software.

Patient simulators for developing clinical procedure skills:

Clinical procedures vary from simple to complex procedures requiring various degrees of fine-motor movement, precision, dexterity and efficiency. The learning continuum from novice to expert requires progression of learning and mastery from a range of simple to complex procedures and their integration into holistic patient care. Some complex procedures and processes require deconstruction into sub-tasks which can be mastered and then integrated into a complex procedure or process. As an example, basic-life support (BLS) cardiopulmonary resuscitation (CPR) includes basic airway management, manual positive-pressure ventilation, external chest compressions and use of an automated external defibrillator (AED). For the novice, each of these skills needs to be learned and then integrated into a meaningful sequence in order to achieve quality BLS CPR. Ultimately, this skill-set can then be integrated into a complex cardiac arrest scenario.

Task trainers for focused skills training: referred to as part-task trainers, usually represent a part of human anatomy relevant to a skill or range of skills that can be learned. An airway trainer, for example, may support a range of basic and advanced airway procedures. Figure 3.5 illustrates two types of patient simulators with different levels of technology for learning intravenous (IV) access.

Figure 3.5A represents a low technology IV access trainer for the procedure and technique of IV cannulation. The passive feature includes the physical look and feel properties of the arm. There are no active features of this simulator i.e. no pulse or blood pressure. The interactive

(A) Laerdal IV trainer http://www.laerdal.com/images/L/ADDQWCHX.jpg

(B) Laerdal Virtual I.V.® (http://www.laerdal.com/images/L/ADBOCRBX.jpg)

Figure 3.5 Example comparing two levels of technology in the design of IV access trainers: (A) Low technology IV trainer, (B) High-technology IV trainer using virtual technology (hybrid simulator).

features include using a real catheter-over-needle for IV cannulation, getting a backflow of simulated blood when cannulating the vein, return of blood into the administration set when positioning the drip below heart level and getting free flow of fluid when opening the tap on the administration set. These interactive features also provide feedback on the success of IV cannulation. Since there is no integrated technical performance data capture, observation by a peer or instructor against performance criteria is the source of performance feedback.

Figure 3.5B represents a high technology IV access trainer. The passive features include the physical simulator for the psychomotor task of IV cannulation. A computer-based virtual arm augments the visual aspect of the passive simulator features. Active features include the ability to change the clinical condition for cannulation as well as change age, gender and skin colour. This allows gaining experience in IV cannulation across clinical conditions and patient profiles for progression beyond the novice stage. Interactive features include haptic feedback while cannulating the vein, virtual backflow of blood on accessing the vein and presentation of complications such as haematoma on over penetration of the vein. Technology-enhanced feedback is also provided through capturing performance data. Simulators such as this, which combine physical and virtual technology are referred to as hybrid simulators.

Patient simulators for multi-task training: patient simulators may support a broader range of procedures reflected in their design. Figure 3.6 represents examples of full-body patient simulators for training and performing a range of different clinical procedures.

Full-body patient simulators typically allow for a broader range of clinical procedures to be performed which, together with active and interactive features, support their use in scenario-based learning.

(A):Laerdal Newborn Anne: low-technology multi-task trainer: includes basic and advanced airway management, umbilical vein cannulation and intraosseous insertion (http://www.laerdal.com/images/L/AAPKASXG.jpg)

(B) Laerdal MegaCode Kelly™: a medium technology full-body adult patient simulator with some active and interactive features, supporting a range of skills such as patient assessment, airway procedures, electrotherapy, IV cannulation and needle decompression of the chest.

(C) Laerdal Resusci-Anne® QCPR manikin with PC Skillreporter™system: a low technology patient simulator supporting airway procedures, manual positive pressure ventilation and chest compressions with data-capturing technology for precision feedback on technical performance of quality CPR. Additional technology allows for integration of defibrillation (manual or automated). Illustrated: Laerdal® AED Trainer 3 (http://www.laerdal.com/us/products/skills-proficiency/defibrillation-cardiology/aed-trainer-3/) which is a simulated AED replicating the look and function of the Phillips Heartstart FR3 AED.

(D) Laerdal SimMan® 3G with the instructor PC and SimView™ system (http://www.laerdal.com/images/L/ADGBGNDD.jpg): a high-technology full-body patient simulator with comprehensive active and interactive features including advanced audio-visual and data capturing technology for precision feedback.

Figure 3.6 Examples of full-body patient simulators supporting multi-task training: (A) Low technology newborn simulator; (B) a medium-technology full-body adult simulator; (C) a low-technology simulator with precision feedback technology for technical performance; and (D) A high-technology simulator with comprehensive active simulator features, precision-feedback technology and integrated multi-data capturing system.

3.5 Digital technology: Green-screen technology, Virtual Reality (VR) and Augmented Reality (AR)

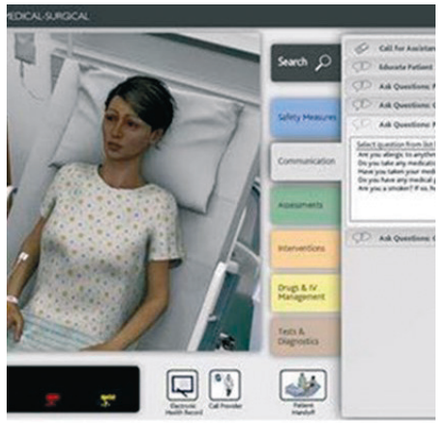
One of the challenges facing the use of simulation is sufficient replication of clinical environments and the interactions with and within these environments for immersive participation. Such interactions include medical equipment and social-professional interactions found in clinical practice. A number of digital and hardware technologies are developing with applications for healthcare simulation.

Green-screen technology: green screen technology uses chromakey technology to insert a static photo or dynamic video onto a backdrop that allows for creating background illusions. This could involve a video clip (with sound) of activity in a shopping centre while a patient simulator may be lying on the floor or sitting on a bench. This process does not include ability of participants to interact with this background. This is particularly useful where a multitude of patient care environments and contexts apply to a healthcare profession such as the emergency medical services where practical limitations exist in physically replicating the range of possible contexts or where it may be too risky to use real contexts for simulation. Similarly, hospital-based environments are varied and can be represented in similar manner.

Augmented and virtual reality: With the advent and rapid development of digital technology (hardware and software), clinical simulation is being developed across the spectrum of augmented (AR) and virtual reality (VR). AR provides a means of inserting digital information into a real environment in real time. Such digital information may include visual objects, sound and other sensory information that interacts with the real environment. The hardware includes any commonly-used smart device (phone / tablet) or specialised headgear. VR is a fully digital interactive environment presented via various forms of displays from flat-screen computer-based systems to immersive multi-sensory haptic technology systems. The three characteristics elements that define VR are (1) a digitally autonomous world (simulated) that (2) engages immersion or presence of the participant in that world (3) with ability to interact with(in) the virtual environment.

Figure 3.7 presents two examples of desktop or flat-screen VR simulation. Figure 3.7A represents a VR simulated patient in a VR clinical context for development of diagnostic and clinical reasoning skills for nursing. The participant is able to engage with the patient and use equipment within this virtual environment. Figure 3.7B represents a virtual standardised patient design to develop patient interview skills. The virtual patient is designed to reflect facial expression, body posture and voice tone reflective of their emotional state thus providing illusions of a realistic patient encounter. Figure 3.7C represents a virtual patient monitor that enables participants to activate monitor features and parameters as they would in clinical practice where such monitors are available. Such virtual monitors may integrate with active and interactive features of a patient simulator or be used independently to provide a physiological platform for other types of simulators such as task trainers and standardised patients.

“Serious games” is a term that captures the use of gaming platforms, traditionally used for entertainment, that are developed for educational purposes. Using digital technology, VR and



(A) Flat-screen VR simulation platform. vSim®(http://www.laerdal.com/us/products/courses-learning/virtual-simulation/vsim-for-nursing/vsim-for-nursing-medical-surgical/)

(B) Flat screen Virtual simulated / standardised patient (http://ict.usc.edu/wp-content/uploads/2012/03/virtual-patient-1.jpg)

(C) A virtual patient monitor with touch-screen technology. This Interactive that can be integrated with the active features of a patient simulator with interactive ability to change physiological parameters synchronised with patient changes. The tocuch-screen allows participants to select features on the virtual monitor as they would in a real patient monitor found in clinical practice (http://www.laerdal.com/images/L/ADYYFPWE.jpg)

(D) Microsoft Hololens. A head-mounted device (HMD) that contains a full holographic computer with audio and visual capability for augmented reality.

(E) Oculus Rift: a virtual reality HMD (supports visual and auditory sensory input)

Figure 3.7: Examples of screen-based virtual reality simulation. Illustrated: (A) vSim® for Nursing (Laerdal) and (B) Virtual Standardised Patient (SP) (University of Southern California Institute for Creative Technologies); (C) Virtual interactive patient monitor; (D) A head-mounted device (HMD) supporting augmented reality; and (E) A HMD supporting virtual reality.

AR games have been developed for health education. Such games are accompanied by learning goals, engage students with opportunity for developing knowledge, skills and attitudes relevant to healthcare practice, include a scoring system with feedback and have an element of fun. Serious games may also be developed for multi-user application which provides opportunities for team-based and interprofessional learning. Since such games can be web-based, individuals making up a team do not need to be in the same geographical location, thus improving access and frequency with which such activities can be conducted.

Given this development, patient simulators now range from physical to virtual simulators with combinations of both forms of technology (hybrid simulators). Virtual patients and clinical environments can now be replicated with increasing levels of realism for immersion.

3.6 The role of technology in promoting fidelity and authenticity in simulation

The objectives of healthcare simulation are to engage learning in a safe environment that is transferable to clinical practice and elicit authentic student responses relevant to clinical practice. To achieve learning in an authentic context, the necessary elements of clinical practice need to be accurately replicated. This includes clinical practice tasks or procedures, processes in practice, the setting and environment in which clinical practice occurs and the range of clinical cases complexity found in clinical practice. The relationship between preparation of students for realistic engagement in simulation, simulator technology, simulation setting and simulation design needs to be understood to achieve the appropriate realism and willingness of students to engage authentically.

The simulation setting includes a combination of the physical, spacial and social-professional contexts of the event. Audio-visual, AR and VR technology may be used to enhance the realism of the setting by including sound, background activity, interaction elements and environmental aspects appropriate to the event.

Technology used in simulation should be selected based on the learning outcomes, the level of the student and accurate replication of the task, process or clinical case to ensure authentic student engagement. The following are common categories of technologies currently available:

Diagnostic

- Simulation of physiological and pathophysiological processes that may be detected or observed. e.g. heart sounds, lung sounds, bowel sounds, airway noises, speech patterns, childbirth etc.
- Simulation of haptic and tactile feedback e.g. lumps, bumps, heat etc.
- Simulation of visual feedback e.g. color, skin condition, respiratory movements, wounds, bleeding and derangements of anatomical structures.

Procedural

- Simulation of clinical skills and diagnostic procedures such as IV fluid and drug administration, cannulation, CPR, airway and surgical procedures, vaginal birth etc.

Environmental

- Technologies applicable to simulation of the environment and context of the simulated case. e.g. green screen technologies, auditory and sensory stimulation.

Recording and documentation

- Technology and the use of audiovisual media, event and data logging systems that record the student activities associated with their management of the simulated case.

SECTION 4
Simulation Design and Construction

4.1 Considerations for Simulation Design

There are key components to be considered when designing a case for simulation. Best practice standards [8] outline specifics for each aspect of simulation design. The application of these standards is illustrated using an example and suggested template. Starting with an uncomplicated clinical example – assessment after vaginal delivery for post-partum hemorrhage (PPH) prevention.

Rationale: Post-partum hemorrhage (PPH) constitutes an obstetric emergency, it is the major cause of maternal morbidity and mortality globally and educating health professionals about PPH and teamwork should be a priority [12, 16, 17]. The most common reason for PPH is uterine atony, but proper assessment of the perineum for lacerations and hematoma that can result in PPH is also important [18].

Scene: Hospital delivery room, clinic site, or home.

Technology: Simple PPH cloth kit; VitalSim Anne with boggy/firm uterus; or Hi-fidelity mannequin with wig, breasts, and female genitalia.

Equipment: Patient identifier, gloves, BP cuff/stethoscope, thermometer, pad with blood, clean pads, peri-care bottle, gauze panties, medications, IV set-up.

Learning objectives: On completion of the simulation activity the student will demonstrate:
Assessment of woman at risk for PPH;
Examination of obstetric and labor and delivery history for risk-factors and;
Completion of a post-partum assessment.

Goal: Identify risk factors, evaluate for present status (vital signs, fundus, bladder, perineum), support to diminish risk-factors (early breastfeeding, assessment of placenta, careful monitoring of vital signs and fundus).

Roles: midwife, nurse, aide, physician, doula (depending on availability).

4.2 Considerations relating to Scenario Implementation

Initial Set-up: Setting the stage (equipment, technology). Wristband on patient, brief history of labor and delivery written or communicated by hand-over, medications available on hand, patient showing normal VS – BP: 100/70; P: 88; R: 16; T: 36.9ºC/98.5ºF; Pad with moderate blood stain; fundus firm centrally located 1 Finger breath below umbilicus.

Description of participants: (with scripts for role-playing if appropriate and detailed information).

Description of facilitator role: Person in control room/managing mannequin, change settings in response to student actions (e.g. decrease pulse/increase BP if student performs fundal massage, gives oxytocin, gives oxygen); speaks for patient in response to student's questions about obstetrical history and labor and delivery.

Scenario level: Novice/student, initial exposure to post-delivery patient.

Focus area: obstetric, maternal-infant assessment post-partum.

Brief description of the situation: Newly delivered 29 year old, G4 T3 P1 A1 L3, male 4000 gms, breastfeeding well, placenta intact delivered 10 minutes after infant.

Evaluation criteria: Wash hands; Introduce self; Check name; Ask how patient is doing/ pain/bleeding/urination; Assess VS- T/P/BP/RR; Put on gloves; Palpate fundus; Assess lochia; Assess perineum.

Rationale for different pathways depending on student performance: For simpler version, fundus can be firm, bleeding moderate, infant latching with mother c/o cramping – vital signs stay stable, all is good. For more complicated pathways – bleeding would increase, fundus would be boggy and displaced to the right (full bladder), VS change (P & RR increase, BP decrease) and interventions could include any of the following: empty bladder (catheterize if necessary); fundal massage; give oxytocin; re-check placenta for fragments missing; give oxygen; put baby to breast; continue to monitor VS closely; prepare for IV fluids, blood, or emergency care.

Debriefing guidelines: Allowing students to identify any challenges faced during the simulation; reviewing out loud the patient history, identified risk factors for PPH, signs and symptoms to monitor and what changes mean, describe appropriate actions. Important to discuss a plan of care, potential referrals, how team would be called, feelings about how quickly things can change in an otherwise healthy new mother.

SECTION 5

Conducting the Simulation

This section will deal with how to conduct the simulation.

5.1 Preparation of the equipment and environment

Preparation of the equipment and environment will be influenced by the simulation modality (e.g. task trainer, mannequin, standardised patient (actor) or hybrid). However, there are some common principles for effective preparation, summarised here.

The International Nursing Association for Clinical Simulation and Learning (INACSL) Standards of Best Practice: SimulationSM (2016) [18] provides recommendations about Simulation Design. Specifically, Criterion 5 states that best practice simulation should use "various types of fidelity to create the required perception of realism" (pS7):

- Physical (or environmental) fidelity – replicating the physical context including the patient(s), environment, equipment and related props.
- Conceptual fidelity – all elements of the scenario should relate to each other in a realistic way (eg, vital signs are consistent with the diagnosis).
- Psychological fidelity – the contextual elements should mimic those typically associated with the clinical setting (a range of factors including noise and lighting).
- Appropriate moulage should be used to replicate features of the patient (eg, wounds, attachments, smells).

Simulation equipment

Equipment that is typically relevant to hospital-based simulations includes:

- Hospital bed or plinth with details about required linen, pillows, towels.
- Bedside equipment such as over-bed table, chair, mobility aid
- Items on bedside table/trolley, e.g. (Figure 5.1A):
  - Stethoscope, pulse-oximeter, BP cuff.
  - Consumables: tissues, alcohol wipes and/ or alcohol gel, sputum cup and/or jar, suction catheters.
  - Patient-related props such as reading glasses, usual medications, book.
- Personal protective equipment,e.g. gloves, goggles, gowns.

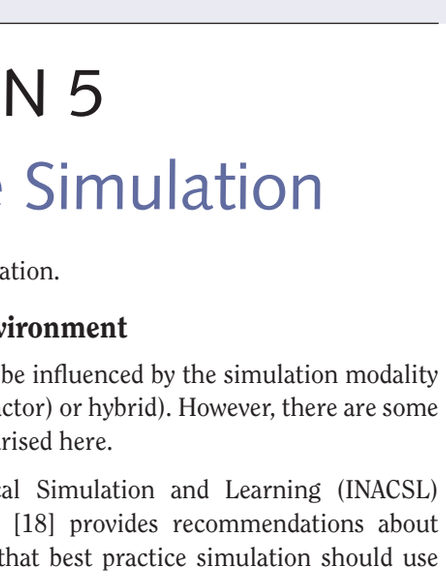


Figure 5.1A Bedside equipment

- Bins (e.g., standard or clinical waste).
- Handwashing facilities (simulated, or actual).

Set-up of equipment and environment

For efficient and replicable set-up of simulation equipment and the environment, it is helpful to use visual aids such as diagrams, checklists, and photos or videos, e.g.:

- An example of the room set-up for each simulation session (Figure 5.1B)
- Photo/s of the patient
- A checklist of required attachments and any moulage, e.g.:
  - Oxygen device (e.g. nasal prongs, mask).
  - Nasogastric tube.
  - IV line, Patient Controlled Analgesia, Patient Controlled Epidural Analgesia, Central Venous Pressure line.
  - ECG dots.
  - Wound, wound drain (with red food colouring), intercostal catheter.
  - Indwelling urinary catheter (with yellow food colouring).
  - Hospital gown, Anti-embolism stockings, Sequential Compression Devices (SCDs).
  - ± Sputum (prepare according to required quality, e.g. ultrasound gel, corn flour, apple puree; add food colouring as required).
  - Mannequin-specific items, e.g. monitor set-up.

Figure 5.1B Room set-up example

Standardised set-up

The number of 'patients' required for each simulation session should be considered, and equipment prepared accordingly. For example, does the simulation require a number of stations with task trainers (e.g. for practice of 'skills and drills' such as airway insertion and suction), or a single full human simulator mannequin, or a number of standardised patients (actors) (Figure 5.1C).

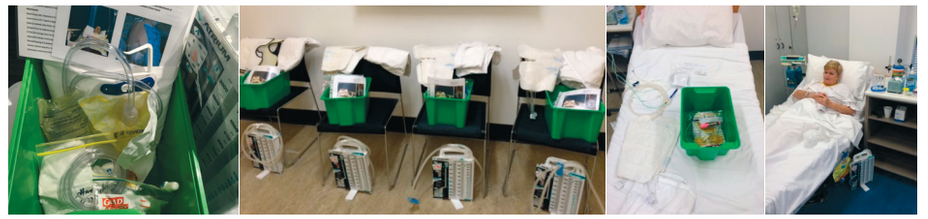


Figure 5.1C i) Crate with simulation equipment including set-up guide and photos; ii) Standardised crates for multiple actors; iii) Individual bed set-up; iv) Actor with attachments, ready to portray lobectomy case.

Equipment storage

It is essential that all equipment and props are stored for easy access to allow for efficient set-up of the simulation session. This can be enhanced by using sturdy boxes to store items, labelled clearly with contents or by the simulation case/s for which the items are to be used (Figure 5.1D).

Figure 5.1D Storage of simulation equipment

5.2 Pre briefing for prompters and assessors

It is important to provide very specific information for facilitators, assessors, and actors for the simulation. Whenever possible, creating a script with specific questions to ask or cues to give as the scenario unfolds is key. For example, in the PPH example given above – there could be a student nurse coming in for the morning shift, another student reporting off as the night nurse (an exact report should be written out), and one of the students could play the role of the family member, the patient's sister, who notices that the patient has become cold and clammy, whatever would be appropriate. In pre-briefing for the assessor/facilitator it will be important that they understand the level of learning expected, learning objectives for the scenario, core outcomes and expectations of competency of participants, and have had an opportunity to run through the simulation at least once. Their role is to provide cues (pre-determined or on-the-fly) that will assist participants in achieving the expected outcomes. If possible, a checklist will be provided for assessment of the learning objectives, and basic data collection and methods should be reviewed with the facilitator. Finally, a plan for debriefing and list of potential debriefing triggers to guide the facilitator once the simulation is completed should be provided and reviewed. The facilitator should have an opportunity to ask questions before, during, and after the simulation, and ideally, a debrief of the debrief and simulation experience will assure consistency among cohorts and improved rigor with each simulation based experience [8].

5.3 Pre briefing for students

Student pre-briefing is contextual. The simulation itself is often the guide to the pre-briefing. In the event of simulation for assessment, the pre-briefing would include information related to ensuring the integrity of the assessment and examination conditions. Students are reminded of conditions of the examination process and how they are to move between venues and secure their electronic devices. In the teaching and learning domain, the student may be pre-briefed on important simulation-specific information that they may require to adequately prepare their equipment. Peer-observers may be pre-briefed on the core outcomes and anticipated simulation progression. This may include information on what to expect and be cognizant of. The facilitator should be cautious of over-briefing students and should keep the briefing limited to critical information. Providing too much detail during the pre-briefing may negatively affect simulation integrity.

5.4 Dealing with actions that are unanticipated

It is impossible to predict all possible permutations for a simulation. Student interpretations and resultant actions may fall outside of those predicted for the simulation and not included in the rubric. This means that there will be no descriptors on how to score these deviations from the predetermined rubric. This has the potential to affect the reliability of assessor scoring. There are a number of methods to resolve this. The method involves an immediate intervention as soon as the simulation is complete. The assessors have a discussion on the possible benefits or adverse effects of the deviation. They then decide on the mark to be awarded. A description of this process and the result is documented and all parties sign to indicate their agreement.

Another way of doing this is to allow the assessors to score the simulation and the deviation as normal. The examiner and a moderator, who have not been involved in the initial scoring, review any video footage (or where video footage is not available they may listen to the assessors' objective accounts of the performance). Between them they decide on the appropriateness of the deviation and assign a score. The advantages and disadvantages of any retrospective scoring system should be carefully considered within the context of the specific simulation and its outcomes. It may be necessary to perform a review of the deviation by consulting literature that would make the first option obsolete. Regardless of the process followed, reliability and validity of the assessment and its result should always guide any decision where there may be a deviation requiring intervention.

5.5 Stop-Start method

Simulation is an important teaching tool. Various strategies exist to enhance the levels of learning taking place. The stop-start method involves pausing the simulation to focus on a particular aspect of the evolving clinical scenario. The facilitator pauses the simulation and a short discussion ensues after which the simulation resumes. Some reasons that may prompt the facilitator to pause a simulation include:

- Student actions that are causing a deterioration in the patient,
- Explanation of changes in patient condition due to management or interventions,

- Feedback related to best practice interventions and how these may have affected the course of the simulation.
- Requiring the student to clarify the reasoning behind certain intervention or management strategies.

The facilitator should ensure that the discussion remains short, structured, focused and positive. Where the student has deviated significantly from the anticipated progression of the simulation, the stop-start method can be used to guide the student and to resume the simulation with the relevant outcomes still intact. Where relevant, peer contributions should be considered. One of the perceived advantages is that students are corrected early and the possible consequences of an action explained contextually. The corresponding disadvantage is that the student's complete thought process and response cannot be fully evaluated.

5.6 End-to-end method

The end-to-end method involves allowing the simulation to run its course to completion without any interruptions related to feedback. This allows the student to perform interventions, whether appropriate or inappropriate and the simulation progresses accordingly. After conclusion of the simulation, the facilitator may use the feedback session to request clarification for interventions performed, may explain the simulation outcomes and how well these were met and may provide clarification on how the patient improved or deteriorated. One of the advantages is that the student can be observed in an environment where they are required to deal with the results of their interventions. The corresponding disadvantage is that the student may perform inappropriate actions that may not be adequately rectified within the context of the simulation. If these are not highlighted and corrected during the post simulation feedback session, these may become entrenched.

5.7 Timing

Timing may relate to a number of domains within the simulation. Total allocated time for the simulation should closely relate to timing of individual simulation components. Where fidelity is important within the simulation construct, adequate time must be included for the student to perform each procedure within realistic timeframes. Timing should be carefully considered to ensure that students are able to complete the required core outcomes within the allocated time. Verbalizing skills should not form a part of a simulation assessment. It is therefore important that timelines are physically possible for students. This can be ensured by performing a mock version of the simulation prior to the physical assessment.

There are a number of non-technical skills that do not involve physically performing a task. While these processes may be difficult to measure, there are an increasing number of measurement tools available which might be used e.g. Emergency Teamwork Assessment (The TEAM Tool) *http://medicalemergencyteam.com/* [19]. Apart from measurement the complexity of a simulation may means that additional time may need to be allocated for these processes. It is recommended that the examiner perform the simulation themselves prior to the assessment. This will ensure that timing and projected intervals have been measured and are realistic.

5.8 Recording

Recording involves making a temporary or permanent record of the simulation. There are a number of methods commonly used. These methods include audiovisual recording, hand-written notes and verbal recordings. Recordings are used for evidence of assessment, student feedback and formative facilitator feedback. Recording using hand-written notes may be challenging. Whilst the facilitator is writing, they are unable to observe student behavior. This may result in critical items being missed and not recorded. Where audiovisual recordings are used for assessment evidence and review these should have an appropriate viewpoint of the simulation environment and should include as much detail as possible. Recordings should be stored for an appropriate period as determined by the institution or relevant regulatory body.

5.9 Student movement and examination integrity in the case of simulation for assessment purposes.

The reliability of any assessment is heavily dependent on its integrity. The nature of simulation assessment means that not all students sit the same assessment simultaneously. This necessitates student movement to and from the assessment venue. It is important that venues be positioned to prevent any form of interaction between students who have completed the assessment and those who have yet to be assessed. The access to digital communication is important to consider. The variety of digital devices and the potential for inter-student communication is a threat that is difficult to control. The need for students to have access to electronic or other reference materials where appropriate further complicates this issue. It is important for the person controlling student movement to ensure sterility of the primary holding venue. This can be achieved by isolating all electronic devices outside the venue in a safe holding area. This area is accessible before the simulation to deposit and after the simulation to retrieve. This should include items such as smart phones, smart watches and any other electronic communication devices.

SECTION 6
Assessment, Debriefing and Feedback

In this section we deal with happens at the intersection between conducting and completing the simulation, and provide a case study of an innovative assessment technique developed to overcome some of the pitfalls of assessment. While assessors observe participant performances during the simulation, it is generally after the simulation that such assessments are summarised and feedback provided to the participants, during debriefing.

6.1 Debriefing and Feedback

In the context of simulation, feedback and discussion after a scenario most commonly take the form of debriefing. Originating from the military, the term debriefing describes a process in which a group of people who have experienced an event or series of events reflect on and analyse what happened in order to draw out learning to guide future conduct. Corresponding to the reflective observation phase of the experiential learning cycle described by Kolb (1984), debriefing is considered key to effective learning from simulation [20]. It differs from more traditional concepts of feedback in that, rather than being a one-way giving of information about performance, it involves an interactive discussion in which participants reflect on their experience and identify ways to improve their practice. Depending on the learning aims of the simulation activity, debriefing can focus primarily on technical clinical aspects, on non-technical skills or, in some cases, a combination of the two.

Although some groups of students are able to discuss and reflect on their learning independently, debriefing is most commonly undertaken with the guidance of a facilitator. Facilitators commonly find that conducting debriefing is the most challenging aspect of teaching with simulation. Fortunately, in recent years, much consideration has been given to how this phase of the learning cycle is best approached and several guidelines and models are now available to guide the debriefing process. These discuss the principles of effective debriefing, provide sequential breakdowns of the debriefing stages and, in many cases, suggest wordings for questions or prompts that the facilitator can use. Here we discuss factors that need to be considered when facilitating debriefing and suggest some models to consider for your own debriefing practice.

The first role of the facilitator is to establish a psychologically safe environment in which students are *'comfortable participating, speaking up, sharing thoughts, and asking for help as needed without concern for retribution or embarrassment'* [9]. Psychological safety can be fostered by the establishment of ground rules, particularly confidentiality, and by facilitators adopting an open and enquiring, rather than judgemental, approach to participant performance.

The concept of debriefing with good judgement [21] encourages facilitators to assume that simulation participants are intelligent and well-intentioned, and that they had valid reasons for acting as they did, even if their actions were in some respects inappropriate. Rather than making judgements based on their observations alone, facilitators who 'debrief with good judgement' are curious about and try to uncover the thinking (or mental frames) that underlie participants' actions. This gives participants positive regard that helps to foster open discussion and can help to identify attitudes or misconceptions for discussion and resolution.

A second important role of the facilitator is to guide the debriefing discussion so that it remains constructive and focussed. Structuring discussion into specific stages, each with a particular purpose can help in this regard. Debriefing models commonly divide the discussion into three main phases: reaction, description/analysis and summary [22]. In the reaction phase, sometimes described as defusing, participants can express their feelings and emotions about the scenario that has just taken place, clearing the way for a more objective discussion to follow. At this stage, participants may also wish to discuss any difficulty they may have experienced with the suspension of disbelief that simulation sometimes requires. Description and analysis, which may involve input from observers as well as participants, focuses on establishing a shared understanding or mental model of what happened during the scenario and why things occurred as they did. Finally, the summary stage brings the discussion back to the main learning objectives, drawing out the main learning points from the scenario to guide future action. Some models omit the reaction stage, instead separating out description and analysis into two distinct stages.

Appropriately worded, open questions can be invaluable for keeping debriefing discussion constructive and focussed, whilst maintaining a spirit of enquiry rather than judgement. Questions such as *'How did that feel?'* are appropriate for the defusing/reaction stages and *'What happened…'* and *'What happened then?'* type questions for the description stage. For analysis, the 'advocacy-enquiry' approach [21], in which the facilitator first makes an observation about something that happened (*'I noticed that…'*) and then follows this up with an enquiry that seeks to identify the thought processes the participant was using at the time (*'Can you explain what were you thinking when…?*) can be very helpful in drawing out issues for further discussion and encouraging participants to articulate their underlying thought processes. For the summary stage, questions such as *'What key points stand out in your mind about this scenario?'* and *'How will you change your practice as a result of this experience?'* can bring participants' attention back to the main learning points and how they will apply them in practice.

Examples of debriefing models include 'The Debriefing Diamond', which provides a visual prompt for where to focus most attention, suggests key questions and phrases to remember for each stage and provides an educational justification for each stage used [23] and the 3D model [24] which describes the stages of the debriefing as *'defusing, discovering and deepening'*. For inexperienced students who find the reflection associated with the advocacy-enquiry approach challenging, the 'Plus (+) Delta (Δ)' model in which participants are encouraged to consider what went well in a scenario and what could be improved [22] may be appropriate.

Debriefing with a co-facilitator can have several advantages. It can 'share the load' when facilitators each lead different stages of the debriefing process and can bring different viewpoints and expertise to the scenario analysis. Whilst video recordings may be used to revisit specific events in the scenario (sometimes referred to as photo ellicitation technique) and many simulation centres are equipped with sophisticated cameras and software that facilitate this, evidence for the advantages of using video review to support debriefing is limited [25].

6.2 Using Simulation for assessment: The SATLAB Case Study

Background

Development of clinical competence in health science students remains a complex and challenging task for health care educators worldwide. This is in part due to the multifaceted nature of clinical interactions. Achieving clinical competence requires application of theoretical understandings, clinical reasoning and psychomotor skill for the performance of clinical interventions and procedures. Simulation offers one method of developing clinical proficiency and assessment of clinical competence.

There are advantages associated with the use of simulation, including the ability to set standardized assessments allowing for the consistent replication of a clinical case. Using simulation allows the educator to focus on assessing pre-determined clinical decision-making and procedural competencies. Although the benefits of simulation within the teaching and learning domain are well described, less literature exists dealing with the use of simulation for assessment of clinical competence.

The Department of Emergency Medical Care (EMC) at the University of Johannesburg makes extensive use of simulation for teaching, learning and assessment of Emergency Medical Care students. Despite long standing use of simulation its reliability and validity as an assessment strategy continues to be questioned, particularly when poor pass rates and performances are demonstrated from simulation based assessments. Some of the criticisms and concerns raised around the use of simulation for assessment of clinical competence include:

Perceptions of assessor bias

There are a number of factors that may contribute to assessor bias. The assessor's own clinical experiences as a clinician are seen by some to influence their judgment of students' performances during simulation assessments. Despite well-articulated core simulation outcomes the assessor's expectations of performance will likely be subjectively influenced by the type, recency and extent of their own clinical experiences and their preferred management of the simulated case. The nature of clinical simulation is such that should an assessor have a particular clinical preference or bugbear or a personal dislike of a student; it is possible to become overly critical about a task component, or purposefully look for evidence to support findings of incompetence regardless of the actual overall performance.

Lack of detailed post assessment feedback

Many traditional methods of assessment (including our own practices) historically made use of a single rating score to generate an overall mark. Faculty and students were uncomfortable

with this, as it was not always clear exactly how this final mark was derived, or what it actually meant. This in turn made it difficult to defend differences in the overall mark awarded for a simulation. A final score alone was also seen to be limiting as it did not differentiate between specific areas of the simulation where the student may have excelled or alternatively performed poorly.

A disproportioned focus on negative feedback

Much of the narrative provided by assessors, in the comment sections of assessment rubrics, were seen to be more negative than positive. The focus on documenting mostly incorrect actions and examples of poor performance were seen as assessor's preemptive defensive strategies. These strategies were adopted in the event that the final outcome was a fail and the results were challenged by the student. The same was not true for students who excelled where feedback was more limited. This meant that assessors tended to spend a lot of time writing and correspondingly less time observing what the student was doing.

Low levels of inter rater reliability

There were occasions where two assessors would come up with vastly different scores for the same observed performance. This further reinforced student's perceptions of assessor bias. It was also difficult to isolate the contributing criteria for these differences. The limitation of the GRS is that it lacks measurable context and identification of assessor motivation for awarding a specific result.

In search of a more ideal assessment system

Characteristics of ideal assessments, assessment processes and those factors one needs to take into account when constructing a clinical simulation. These included issues such as validity (*face, construct and content*), reliability, repeatability and fairness. We felt due to the fact the student performances during simulation are often assessed by more than one assessor strengthening inter rater reliability became an important focus area for improvement. Other areas that we considered were repeatability, fairness and ease of use. Repeatability refers to the extent to which the assessment may be repeated and performances should deliver similar results. Fairness in our simulation context refers to whether or not the assessment provides a fair test of what the student should know and be able to do. Ease of use refers to how simple the tool is for assessors to understand, apply and use.

Analysis of the data together with our own experiences as clinicians and educators culminated in the design and refinement of the Simulation Assessment Tool Limiting Assessor Bias (SATLAB). The SATLAB has now been successfully piloted within the emergency medical care department at UJ since 2012 and continues to be the focus of further research scrutiny with regard to its validity and reliability. In this section we focus on introducing and describing the SATLAB with reference to its design and application.

Using the SATLAB system

The application of SATLAB involves a number of basic steps. Dependent on the assessment aims, objectives and type of simulation, certain of these steps may be unnecessary and omitted. The application and use of SATLAB is explained using an example of a simulated case of bronchial asthma. The structured explanation of how SATLAB works follows the six steps associated with the design and implementation of a simulation assessment using SATLAB.

Step one – Compiling a SATLAB simulation

The examiner compiles a simulation that considers the aims and outcomes of the assessment. The acuity of the patient can be adapted to the assessment. The example that we use is that of an asthmatic patient. The examiner compiles the initial patient presentation including relevant physiological variables and manikin settings. This would include the presentation of the asthmatic patient in question. A predicted simulation progression is envisaged and relevant interventions listed. Each intervention and its effects on the patient is considered. The relevant changes to the patient's condition are specified and incorporated into the simulation progression. Using the asthmatic example, the patient may present with tachypnea, wheezes and tachycardia. Administration of a bronchodilator during the simulation will result in a decreased ventilation rate, decreased wheezing and a reduction in heart rate. In this scenario, the aim would be to manage an asthmatic patient and the assessment outcomes would relate to specific tasks required of the student to achieve this aim. Available resources related to fidelity, or realism, may be need to be taken into account when compiling the simulation and the physiological variables of the patient.

Step two – Determining and specifying assessment outcomes

The examiner determines what outcomes will be assessed in the simulation. These assessment outcomes should link closely to the aim. Each of these assessment outcomes requires a descriptor. These assessment outcome descriptors serve to inform both assessor and students on the required competency required for each assessment outcome. Some assessment outcomes may be generic and will be applicable to virtually all simulated cases. One such generic assessment outcome would be scene safety. Other assessment outcomes will be specific to the context and case being simulated. An example of a specific assessment outcome would be the administration of a bronchodilator.

The assessment outcome descriptors are carefully formulated and linked to a rating scale. A six-point scale is used in SATLAB to provide marking options from Best Practice to Significant Harm having been done. Marks awarded are based on a simple percentage value that relates to the six-point scale having a maximum score of three. Values on the six-point scale are categorized on a sliding scale from 3 for Best Practice to -2 for Significant Harm having been done. The six-point scale carries percentages as depicted in Table 1. These percentages are calculated where Best Practice would be awarded a three out of three which translates into 100%. Table 1 provides a simplified example of rating scale descriptors for nebulization in our asthmatic example. Ideally best practice in the simulation environment should correspond with what is considered best practice in the clinical domain. It is important that the detail provided takes both assessment and feedback into account.

Table 1: Simplified example of a competency descriptor scale

	Best Practice	Competent	Not yet competent	Omitted	Some (minor) harm done	Significant (major) harm done
Descriptor	The student provides nebulization therapy rapidly. All appropriate diagnostic checks are carried out and tested/ retested as necessary.	There is some delay prior to applying nebulization therapy. Most diagnostic checks are carried out.	There is a significant delay before therapy is initiated. Few tests are carried out.	Omission of nebulized therapy is considered harmful to the patient and a negative mark applies.	Nebulised therapy is provided at an incorrect dose.	Nebulised therapy is omitted.
Mark awarded on six point rating scale	3	2	1	0	-1	-2
Equivalent percentage on six point rating scale	100%	67%	33%	0%	-33%	-67%

Step three – Setting standards and weightings for assessment outcomes

The simulation and assessment outcome descriptors are sent to a carefully selected panel of experts who serve to validate or set standard. The standard setters evaluate the simulation aims and assessment outcomes related to face validity. They are also tasked with determining the weightings of each core outcome within the context of the assessment. Selection of standard setters is based on a number of criteria, these include:

- recency of clinical practice,
- familiarity with assessment process,
- involvement in the educational setting.

The standard setters carefully consider each assessment outcome for its importance and effect on the patient within the context of the simulation as a whole. Based on its perceived importance, each assessment outcome is assigned a percentage weighting out of a total of 100%. This is done independently by each standard setter and without consultation. The aim is for the standard setter to give their own expert opinion of the importance of each assessment outcome. This is simulation-specific and should be done for each independent simulation assessed. The weightings of all standard setters are equally considered. The final weighting for each assessment outcome is calculated as the mean of all standard setters. Table 2 provides a simplified example of how the weightings for a total of three assessment outcomes in the asthmatic simulation would be calculated.

Table 2: Simplified example of a final weighting calculation

Descriptor	Standard setter 1	Standard setter 2	Standard setter 3	Final Weighting (SD)
History taking	20%	25%	20%	22% (2.3)
Patient assessment	30%	28%	35%	31% (2.9)
Administration of a bronchodilator	50%	47%	45%	47% (2.0)
Total	**100%**	**100%**	**100%**	**100%**

Step four – Conducting the simulation

The simulation is conducted in an appropriate environment using relevant fidelity enhancers. The simulation takes place and each student is likely to produce a unique interpretation of the patient and resultant management plan. As the student progresses through their simulation, the assessor compares their actions with the relevant assessment outcome descriptors. The assessor then links the assessment outcome descriptor that most closely corresponds to the student's performance and assigns the relevant result. It is important that the assessor is blinded to the weightings. This serves to further limit potential bias related to unconscious calculation of the final result based on the scores and weightings. The assessor is only required to assign a relevant mark for each specified component of the simulation. The assessor is not required to write extensive notes as the scores assigned should correspond to the assessment outcome descriptors. The assessor is also required to provide a perception mark at the conclusion of the simulation. This perception mark is similar to a GRS and is independent of the individual scoring. The perception mark summarises the assessor's overall impression of the simulation as a percentage.

Step five – Capturing assessor score and calculating final results

The results are entered into a spreadsheet or other appropriate calculation tool. Each assessment criterion's result is multiplied by the relevant weighting to calculate how much it counts to the final result. Table 3 provides a simplified example of how a mark would be calculated using the three assessment outcomes specified previously. The simplified asthma example is used and the weightings are as calculated above.

Each assessor generates a final mark based on the above calculation. The mean of these marks is the final mark awarded to the student. Where significant discrepancies exist a process of post assessment moderation can be used to resolve these. The final calculated mark is compared to the perception score as an additional check for consistency.

Step six – Providing feedback

Feedback is perhaps the most important component of any assessment. The student receives their final mark as a percentage. In addition, the student receives the result out of three for each component of the simulation. This is augmented by providing the student with

Table 3: Example of Results Calculation

Assessment outcome	Weighting (a)	Assessor mark on the six-point scale (b)	Percentage mark per outcome (b÷3=c)	Weighted contribution of each outcome (a x c = d)
History taking	22%	1.5	50%	10.8%
Patient assessment	31%	2	66%	20.7%
Administration of a bronchodilator	47%	2	66%	31.6%
	100%			
Final mark (Sum of weighted assessment outcome marks)				**63.1%**

the assessment outcome descriptors for all categories of competence for all simulation components. This in turn affords students the opportunity to read the descriptor for their result and more importantly to compare this with the descriptor for best practice. Students can then adapt their practice to better subscribe to the requirements for a future best practice result. The percentage result of each component classifies them into a simulation specific four-point competency scale. This is loosely based on the Developmental Rating Scale of the Albert Einstein College of Medicine.The scale ranks the competency of each outcome assessed as either beginner, developing, advancing or competent. This scale is customizable to the specific requirements of the examiner. Table 4 provides a simplified example of the different competency levels as they would be fed back to students.

Table 4: Competency descriptor feedback

Assessment outcome	Mark on six point rating scale	Calculated %	Competency stage	Comments
History taking	0.5	17%	Beginner: You have demonstrated that you are lacking in experience in this domain.	The manner in which you performed this history taking suggests that you require a significant amount of work in this domain.
Patient assessment	1.75	58%	Advancing: You have demonstrated that you are accumulating experience in assessing patients.	You adequately assessed this patient and would probably be able to assess a similar patient in common situations
Administration of a bronchodilator	2.5	83%	Competent: Well done!!!! You have demonstrated competence in administering a bronchodilator to an asthmatic patient.	Within the clinical environment you should be able to manage a similar patient very well.

Summary

There is no perfect tool for the assessment of clinical competence via simulation however SATLAB provides a practical solution to many of the issues that have traditionally plagued simulation assessment. Research is required in a number of domains to assess this new tool and to refine how best to implement it in the many potential domains where simulation assessment is used. It is important for the SATLAB to be evaluated not only by the assessors who use the tool, but also, perhaps more importantly, by the students who are subject to its systems. Reliability of the SATLAB needs to be quantitatively evaluated using a large data set. Further research will highlight areas of improvement and refinement.

SECTION 7
Research in the Simulated Environment

7.1 Introduction

Increasing investment of physical and human resources into simulation-based education has provided an impetus to use research in order to demonstrate the impact of simulation. Kirkpatrick's model of evaluation [27] provides a useful framework to examine the research in simulation as it delineates levels of evaluation: Level 1: Reaction (participants' degree of satisfaction); Level 2: Learning (changes in knowledge and skills); Level 3: Behavioural change (transfer of learning from the simulation to the clinical context/situation), and Level 4: Results (improvements in patient outcomes and/or organisational change).

There is good summary evidence for simulation education outcomes (Kirkpatrick Levels 1 & 2) across a range of areas. A critical review of simulation based on nursing education research from 2004-2011 indicated that when compared to lecture, simulation has positive outcomes on performance, competence, and satisfaction [28]. Key integrated literature reviews have been done in the following areas: care of the deteriorating patient [29] end-of-life care [30]; disaster preparedness [31]; simultaneous multiple patients [32], pre-briefing [33]; and critical thinking [34].

Systematic reviews of evidence of simulation effectiveness are available for paediatric intensive care [35]; with clinical decision making [36]; for improvement of medication administration/ decrease of errors [37, 38]; to enhance newly qualified nurses transition to practice [39]; and as an intervention to improve evidence-based nursing in clinical practice [40]. An important component of simulation research has included interdisciplinary simulation and team training. Systematic reviews of interdisciplinary practice include emergency situations [41,42]; multi-patient intensive care [43] and the use of standardized patients [44].

In the majority of the reviews, simulation has been demonstrated to have an effect on knowledge, confidence, and show promising results for improving safety and skill assessment related to evidence-based practice, but most of the reviews show the gaps where further investigation is necessary that more closely ties the acquisition of knowledge and confidence to a change in behavior, safety, and patient outcomes [42]. A systematic review and meta-analysis, examined the magnitude of effect of simulation concluding that when compared to no intervention, technology-enhanced simulation training has large effects for outcomes of knowledge, skills, and behaviors in health professional education, and a moderate effect for patient-related outcomes [45]. A finding confirmed in a recent scoping review [46] that shows there is little evidence of the impact of simulation based education in terms of higher level evaluation outcomes of clinical practice behaviors and patient outcomes.

Moving from education to clinical research outcomes, simulation offers the potential to replicate a real clinical environment in order to answer realistic clinical research questions. In other words, the research problems involved are actually clinical in nature (often to do with techniques or instruments) but simulated patient interactions, instead of real ones, are utilised for data collection.

7.2 Advantages and disadvantages of simulation research

Regardless of the outcomes, simulation research has a number of advantages and disadvantages that flow from the very nature of simulation itself. There are three main advantages to using simulation as a way of investigating clinical research problems. The first advantage is that a simulated clinical environment makes a high level of control possible, thus minimising the effects of extraneous variables that tend to be difficult to control in real clinical environments. The second advantage is that simulation allows research designs to be used that greatly enhance reliability. In other words, exactly the same clinical case with the same characteristics can be presented to research participants; this all but eliminates patient variability as a source of error.

Thirdly, the ethical considerations of clinical research using simulation are considerably less than in clinical research. Clearly, the use of simulation does not eliminate the need for ethical review and approval because there will still generally be human participants who must give voluntary informed consent and who must be protected from harm. However not having to consider the ethical pitfalls of patients, particularly those in vulnerable populations, and the associated complexities is a significant advantage.

Perhaps the single most significant disadvantage of clinically orientated research using simulation is the severe limitation of tissue realism. Although many advances have been made with the realism of modern simulators, the limitation still remains that tissue consistency often does not closely approximate that found in humans. Added to this is the fact that many clinical procedures involve dealing with complications such as bleeding or secretions; also generally are not simulated very authentically. Consequently, there is a degree of scepticism about the clinical external validity of a particular level of performance when demonstrated in a simulated environment.

It is also worth mentioning that reliability – one of the advantages of clinically orientated research – may also be viewed as a disadvantage. This is because, in reality, clinical procedural performance must take into account varied patient anatomy and physiological responses – something that is difficult if not impossible to simulate. Although this variation is a source of measurement error, its impact in real clinical patient care is considered to be so important that the absence of it in simulated environments may be a critical limitation.

Comparatively little simulation research deals with the testing of clinical techniques using simulation rather than a sample of real patients. However some disciplines, such as anaesthesia and emergency medicine, tend to be associated with proportionately more of these studies – particularly research on the efficacy of instruments or devices in isolation. As discussed, simulation research applied to clinical questions, often loosely referred to as "manikin studies",

may be limited by lack of external validity. It has been suggested in the anaesthesia literature that clinical research involving the safety and efficacy of new instruments (or methods) could follow a staged approach with simulator-based studies being a stage 1 "bench test". This would be followed by a human pilot study and then clinical trials. The problem with many simulation-based studies involving clinical questions, techniques or instruments is that the researchers tend to see their results as being directly transferable to patients – an assumption which cannot be made.

7.3 Challenges associated with research in the simulated environment

Regardless of the type of research outcomes being investigated, there are a range of challenges to simulation research in general. Fundamental principles of research are obviously critical in simulation investigations. Good research outcomes are based on: an initial question or problem, a thorough literature review, a refined research question and sound research methods. In particular researchers need to consider and establish the scale or test being performed. A sample of valid and reliable measures are available in a repository of instruments [47]. One measurement challenge in simulation research is that there is a need to measure theoretical constructs rather than physical quantities which makes research design all the more important. While there has traditionally been a predominance or reliance on quantitative data measurements on outcomes there is a move to include more qualitative or blended approaches so as to diversify analysis and understanding.

Although not unique to simulation research, issues of consent and conflict of interest need to be carefully considered and mitigated. For example, course organizers who have a position of influence, if directly involved with the research need to consider the coercive influence they may have on the participants. Also, they may inadvertently influence outcomes based on their subconscious bias in delivering the intervention. Likewise in situations in which an investigator may have an interest or obligation to a particular product or company and there may be benefit from the research outcomes, there may be actual, potential or perceived bias.

7.4 Improving the quality of research reporting

In order to maximize outcomes and impact of simulation research it is important to strengthen simulation research design and manuscript preparation. Simulation researchers should be aware of research and scholarship outside their individual healthcare or specialty practice areas. A wider knowledge of interdisciplinary research will raise the quality and application of insights from simulation research. Simulation researchers should demonstrate knowledge about educational research and behavioral science methods and give due attention to statistical power in research design demonstrate the significance of outcomes. Properties of educational interventions such as strength and integrity should be fully described. Similarly simulation researchers need to examine the measurement properties of educational and clinical research instruments, demonstrate validity and reliability and ensure that these are reported. Simple statistical reporting conventions need to be followed i.e. measures of central tendency, dispersion and effect size for dependent variables. Given the varied types of expertise required to conduct simulation research, consideration should be made at the start of a research project to gather a team with the appropriate complement of relevant research expertise.

The International Nursing Association for Clinical Simulation and Learning has created and regularly updates Standards of Best Practice [8] and these allow a common language for consistency in designing simulations, implementing and evaluating them.Another important component to enhance research rigor in the reporting of simulation based research (SBR) was created by extending the Consolidated Standards of Reporting Trials (CONSORT) and Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statements [48].

7.5 Future research directions

One of the key considerations when conducting research is that the need for new evidence is not exhaustible and it often appears that research is performed without evaluation of prior work or justification about what and how the new study will contribute to research knowledge. Consequently, and in light of the rapid increase in simulation research publications, it is imperative to conduct a thorough literature review to define the aims and contributions of any research. It may be argued that there is adequate evidence to show that simulation training is better than no training so repetition of such studies will likely contribute little to the science of education. However based on this established foundation the focus of future work should explore new and emerging research areas.

Participants in a joint simulation society organization conference in 2011 [49] discussed research topics around 3 main themes: instructional design, outcomes measurement and translational research to define future possible research. They recommended that there is a need for simulation research on conceptual and theoretical bases, the methods used and associated methodological foundations. In future, these should be more explicitly described to help explain phenomena and outcomes in the results. In addition, diverse research methods should be considered to support the objectives and components of the research question(s). The impact of the simulation needs to be assessed across different levels using different methodological approaches so that sense can be made of the elements of the simulation and the situational validity of the results needs to be taken into consideration. Also, the scope of simulation-related research needs to be widened from simulation as the focus of research i.e. research about simulation, to using simulation to investigate other phenomena i.e. research with simulation. Perhaps most importantly is the need to further investigate is the translational ability of simulation to demonstrate improved care practices and improved patient health (aligned with Kirkpatrick Levels 3 & 4), although challenges remain in the measurement of these outcomes.

There is also a need for more methodologically robust research capable of clearly identifying educational advantages of simulation as a teaching method. Such studies are difficult to design and execute, but more of them are needed to reinforce the evidence for simulation's educational application. Much published simulation research in the education domain seems to be focused on the use full body patient simulators or partial task trainers (within a range if fidelities) in learning and assessment. Relatively little research deals with simulated patients and almost none deals with computer screen-based simulation and its role in either learning or assessment.

In summary, further high quality research and reporting is needed for creating evidence-based clinical simulation scenarios using best practice standards; using theory-based research to study the effect of simulation education on outcomes in students and patients – specifically demonstrating the transfer of knowledge, subsequent behavior change, retention of evidence-based practice, and increased patient safety; using more reliable and valid tools; assessing the effectiveness of teaching with simulation in interprofessional situations; and enhancing collaboration for new skill development between academic and practice partners.

SECTION 8
Looking Forward

In addition to the future challenges posed in the previous section in relation to simulation research we highlight two further challenges for assessment of clinical competence in simulation namely; interdisciplinary learning and technological developments.

8.1 Interdisciplinary teaching and learning

There is a requirement of most contemporary health professional programs for the incorporation of interdisciplinary learning, and the opportunities for this within simulation are rich. The major challenges are coordinating the timing especially with availability of all the necessary professionals. Key components to successful interdisciplinary education with simulation include involving all disciplines in the planning (writing of the scenario with objectives identified that are discipline specific or team focused; equal provision of preparatory materials – readings, videos, case studies); implementation (have students/practitioners from each discipline available, not designating role-playing outside ones discipline, especially for novice/students); evaluation (co-decision-making on learning objectives, criteria for evaluation, and individuals assessing from specific discipline); and opportunities for shared de-briefing (representatives from each discipline available to de-brief).

Often the focus of interdisciplinary simulation focuses on trauma, disaster, and urgent care situations with deteriorating patients – so it is important if ones goals are to encourage learning about, with and from one another, that the focus on clinical skills in these crisis simulations does not negatively affect the overall team interaction and learning. For example, focusing on communication during a code, identification of the leader, clear expression of next steps, reporting out of what is accomplished, patient vital signs, medications given at what time, etc. will allow for assessment of team interaction and success. Incorporating communication with family members is just as critical. Six key areas for Interprofessional Education include: Interprofessional communication; Role-Clarification; Collaborative Leadership; Patient-Centered Care; Team Functioning; and Conflict Resolution [50]. Health professional educators want to believe they create a sense of psychological safety for learning to occur in a simulated environment, but the experience of interdisciplinary simulation can result in a threat to one's professional role identity if a shared sense of fallibility is not embraced. With psychological safety instructors can role model genuine curiosity in the learning and a positive regard for the value of each team members opinion and position encouraging expression of conflicting opinions and taking risks [51].

8.2 Technological Development

With technological development in materials, micro-technology and digital technology (hardware and software), the possibility for healthcare simulation is expansive. Developments

in micro-technology, have extended the age range of available life-size, high-technology full-body patient simulators to include preterm, newborn and infant patient simulators, which will improve fidelity for students in caring for these clinical groups. Likewise, developments in haptic technology, augmented and virtual realities promise very realistic and highly immersive simulation experiences. Precision feedback technology, such as eye-tracking, opens possibilities for obtaining more objective feedback and understanding of non-technical skills such as situational awareness [53]. Web-based serious games can eliminate geographical boundaries [54] and the need for specialised facilities for engaging individuals and teams in simulation activities.

A range of simulation experiences can now be engaged in a flexible and on-demand basis. Although technological developments in healthcare simulation continue to occur, their adoption into mainstream use by faculty will depend upon their affordability, added value to facilitation of learning, validity for authentic assessment and improved translation to clinical practice.

Despite technological developments in healthcare simulation, the role of the health educator remains central to the benefit of this educational methodology. The use of technology and having experiences in simulation may not, in and of themselves, lead to achievement of learning outcomes nor translate to effective clinical practice. The application of learning theories and the facilitation of learning and authentic assessment are central skills required by healthcare educators for converting simulation technology into educational, work-relevant experiences and evidence of learning and competence. Healthcare simulation will continue to require the creativity and innovation of healthcare educators in harnessing the potential of simulator technology while mitigating its limitations. Healthcare simulation as a system, a process and an educational methodology requires explicit adoption by faculty, embedding in the curriculum and intelligent application by educators as a significant part of developing mindful, responsive and competent healthcare providers. As such, this dictates that technology for simulation is a servant, rather than a master, to this process.

Planning and designing of simulation events with inclusion of programming computer-based, high-technology simulators is a complex and lengthy process and may require the inclusion of digital technology and communications technology specialists in the simulation team. Sharing and collaboration within and between faculties and institutions is increasingly necessary to maintain the viability and practicability of high-technology simulation. Skills to programme VR simulations tailored to unique local contexts and situations are necessary to improve relevance and authenticity of simulation experiences. Precision feedback technology enhances data collection of benefit to learning, assessment, system development and educational research. Increasing realism and authenticity will allow for better platforms for clinical research using simulation. Advances in simulation technology also allow for using simulation as a means of post-qualification continued professional development (interprofessional and professional licensing), rehearsal of complex cases and conditions for future patient care and testing healthcare policy and systems.

SECTION 9

Conclusion

Using simulation to teach, learn, and assess is a useful adjunct to conventional approaches to clinical education. Whilst simulation can never replace real patient contact, the clear and obvious benefits of this mode of instruction and assessment have seen simulation gaining widespread traction across virtually all of the health science disciplines. This, and the rapid development of simulation technologies have resulted in a situation where health professions educators find themselves in very different places in terms of their personal capacitation and ability to appreciate and implement simulation into their current teaching and assessment practices. We hope the readers of this guide found it to be an interesting and useful resource. If you are a novice simulation practitioner we hope the information provided in the guide has made you feel more comfortable to attempt simulation with your students. For the seasoned simulation practitioner we hope this guide may have stimulated ongoing action, much needed research and ongoing debate within the field. We end by reiterating our sincere thanks and appreciation to all of our colleagues who gave of their time and contributed to the content of this guide.

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