CHAPTER

18

When Simulation Should and Should Not Be in the Curriculum

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KEY CONCEPTS

- Simulation, encompassing a broad range of modalities from written simulation to immersive simulation, can be used in training and in research, as an investigative methodology, or to assess the efficacy of simulation as a training methodology.
- A simulation-based curriculum includes content, processes, and needs by specifying the teaching methods to achieve predefined learning outcomes.
- To design their simulation training interventions, educators have to pay attention to some characteristics, such as the acuity and opportunity of the specific focus of training, and the instructional method (self-directed learning or instructor-based learning).
- Learning mainly depends on the level of reflection, and the quality of debriefing.

18.1 WHAT IS SIMULATION?

The use of simulation in health care, in its different aspects, is increasing worldwide. A broad range of medical disciplines uses simulation for teaching and training technical skills but also nontechnical skills defined as cognitive, social, and personal resource skills that complement technical skills, and contribute to safe and efficient task performance (see Chapter 25: Crisis Resource Management and Nontechnical Skills: From Individuals to Teams, From Danger to Safety).[1]

Clinical Simulation
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Simulation is a pedagogical strategy that recreates or replicates a clinical situation and/or a clinical context. One or more of these aspects resemble the reality of the workplace and allow participants to practice, learn, or assess their actions in a safe environment.[2–4] Simulation-based learning experiences include a multitude of structured activities that aim to develop and increase knowledge, skills, and attitudes (KSA). They allow participants to analyze and respond to realistic situations in an environment close to reality.[5]

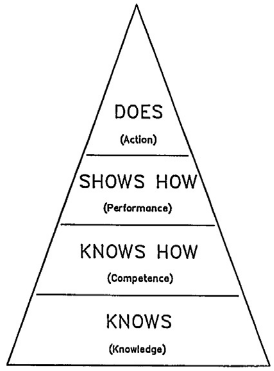

FIGURE 18.1 Miller's pyramid describing levels of competency. Source*: Miller GE. The assessment of clinical skills/competence/performance.* Acad Med *1990;**65**(9 Suppl.):S63.*

18.1.1 Simulation Modalities

Simulation-based training for healthcare professionals encompasses a broad range of modalities. Different typologies of these modalities exist in the literature. One way to describe simulation modalities is based on the technology used. According to this, it includes a human modality such as the standardized or simulated patient, a synthetic modality such as procedural simulators (e.g., intubation head trainers or venipuncture simulators) and patient simulators that are interactive tools representing different types of patients: adults, infants, and, more recently, premature newborns. A third modality is the virtual one that includes computer-based education, serious games, three-dimensional virtual worlds, and virtual patients (see Chapter 2: The Many Faces of Simulation and Chapter 4: Virtual Patients and Serious Games).[6]

A second commonly used typology is based on the fidelity (degree of similarity with the environment and the situation) and the interactivity between participant and simulator. Following this kind of typology, Alinier suggested a classification divided into six types of educationally focused medical simulation tools.[7] This classification could be put in parallel with Miller's pyramid describing a framework for assessing clinical competence in medical education and assisting teachers in matching learning outcomes (clinical competencies) with expectations of what the learner should be able to do at any stage (Fig. 18.1).[8]

According to Alinier,[7] the most basic level (level 0) is the written simulation. This corresponds to medical written cases such as problem-based learning. Learners receive a written case and have to reflect on the etiology, diagnosis, and interventions. This has two drawbacks: it is far from reality and feedback does not focus on skills or attitudes but only on knowledge. Nevertheless, written simulation constitutes a good way to acquire basic knowledge. This basic level corresponds to the base of Miller's pyramid, "KNOWS," referring to possessing knowledge, as shown in Fig. 18.1.

Level 1 involving procedural simulation allows training of specific psychomotor skills and their associated procedures or observing a demonstration. Knowledge development is weakly adapted to this. The next level is computer-based simulation (Level 2), in which the user interacts through a computer screen-based interface.[9] This modality includes several heterogeneous approaches,[10] such as case presentation and interactive scenarios where the learner has to choose, for example, between different treatment modalities, for which the term *virtual patient* has been used for many years. This type of simulation remains relatively unrealistic but can enhance knowledge and clinical reasoning.[9] More recently, the possibility to be immersed in a virtual environment with a headset and to dialog with a virtual patient has been introduced and could offer a higher fidelity, even exceeding other modalities in terms of realism. This kind of virtual patient could be used to train communication skills and even empathy.[11−13]

Levels 1 and 2 (in its basic version) could be compared to the "KNOWS-HOW" stage of Miller's pyramid, referring to the learner's capacity to apply knowledge, and to interpret and analyze data in a specific situation. For example, such modalities could be used to learn the management of a postoperative patient with a low blood pressure, and increased heart rate with an associated hemothorax—knowledge of the normal physiology and pathophysiology of the cardiovascular system will come into play.

Level 3 encompasses standardized or simulated patients: an actor, a patient, or a patient simulator plays the role of an actual patient (see Chapter 3: Simulated and Standardized patients). It is typically used for training in patient management, clinical diagnosis, and affective objectives. Levels 4 and 5 involve manikins and are closely related. Level 4 corresponds to intermediate patient simulators, not fully interactive, whereas high-technology patient simulators (Level 5) allow more possibilities. They may reproduce a lot of vital signs, auscultation sounds, and react to interventions done by the learners.

Each level involves limitations. For example, a manikin is less valuable for communication skills as nonverbal communication or eye contact is impossible. On the other hand, standardized patients are limited in their ability to change their heart sounds, breath sounds, or physiological reactions. In this case, it is better to use a manikin, but an additional modality has been developed: the blended simulation or hybrid simulation that combines two or more simulation modalities. For example, a manikin could be used as a patient with standardized actors playing the role of his family.

Levels 3−5 are related to the third level of Miller's pyramid, "SHOWS-HOW," implying that learners must perform the task, not merely explain how they would. Indeed, learners can know how to manage postoperative pain and understand why blood pressure is higher, but be unable to undertake appropriate management when required to. At this level, standardized patients, and intermediate- or high-technology manikins could be used in an immersive simulation with a realistic environment. Simulation can then be used to train learners in managing complex cases, such as managing a crisis situation in an interdisciplinary team.

In this way, simulation allows active learning and involvement. This engagement is an indispensable asset and enhances learner's critical thinking, problem-solving, and decision-making skills.[14] Despite disappointment, stress, and fear of the unknown, learners report that this active learning method is a useful one, enabling them to increase their self-confidence, learning, and knowledge.[15,16] Simulation also seems to be an appropriate solution for learners with diverse learning styles. For example, learners with a tactile style can touch the simulator, auscultate the heart, etc. Visual-style learners will be engaged by physiological monitoring, medical records, etc. Auditory learners will hear cough, manikin voice, etc. Finally, kinesthetic-style learners will benefit by simulation, because they can handle equipment.

The last stage of Miller's pyramid is "DOES," the action referring to the ability to act autonomously and professionally in real life. Simulation cannot really evaluate the top of the pyramid.

18.1.2 Research in Simulation

There is a growing interest in simulation-based research, including two main types: (1) studies where simulation is used as an investigative methodology and (2) studies that assess the efficacy of simulation as a training methodology.[17] The first type takes advantage of the standardization offered by simulation to answer research questions that may not be feasible, safe, or ethical in clinical settings. The simulation environment is used as an experimental model to study factors affecting the performance of people and systems in health care.[17] These factors to reduce errors may be related to individuals (e.g., fatigue), teams (e.g., communication), work environment (e.g., noise levels), technology (e.g., use of clinical decision support), organizations (e.g., work schedule), or patients (e.g., clinical presentation).[18] For example, emergency department triage scales have to be validated in a simulation context before being used in the clinical setting.[19] After this validation process, users of these scales are trained in simulation-based training. By using simulation as a research methodology, researchers can systematically identify potential security breaches, test new technologies and protocols, and improve the healthcare environment without the risk of harm to real patients.[17]

The second type assesses the effects of simulation on KSA. Many studies can be retrieved in the literature. For example, the National Council of State Boards of Nursing[20] conducted a 3-year longitudinal randomized controlled study encompassing the entire nursing curriculum in the United States. A total of 666 nursing students from 10 prelicensure programs were assessed on knowledge and competencies. Participants were randomized between students who had 50% of their clinical apprenticeship replaced by simulation, others who had 25% of their apprenticeship substituted by simulation, and a control group with no simulation. The results of this study showed evidence that substituting immersive simulation for clinical placement provides equal outcomes. In the United States, such research is interesting because of high insurance costs related to clinical internships. In Europe, the argument is not so much financial, but related to the limited number of places for training and the differences in practices between healthcare institutions. Simulation offers more standardized learning.

Research about simulation as a training methodology could also examine whether the specific features of simulation add to the overall educational effectiveness. A recent systematic review and meta-analysis noted that, compared with no intervention (e.g., a control group or preintervention assessment), simulation-based training was effective in improving the knowledge, skills, and behaviors of healthcare professionals.[21]

The research agenda has shifted from "if" simulation works to examining "who, what, when, where, why, and how" to integrate simulation into existing training curricula.[17]

18.2 WHAT IS A CURRICULUM?

A curriculum is "an attempt to communicate the essential principles and features of an educational proposal in such a form that it is open to critical scrutiny and capable of effective translation into practice."[22] A curriculum is not limited to a content statement, like a program, but focuses on processes and needs by specifying the teaching methods which allow learners to achieve learning outcomes and assessment procedures that demonstrate that the aims have been achieved.[22] As a cultural product, it depends on a frame of reference made up of the values of society, its laws, the need of the actors, the normative framework of the education system, and the social practices of reference.[23] Among its components are the specification of the educational approach (by content, learning objectives, or competences), the choice of related educational strategies (like lectures, video vignettes, interactive discussions, simulation, etc.) and didactic processes that concretize them, the definition of the contents, and the statement of the evaluation of learning.

In the traditional system, instruction was mostly teacher-centered. Today, the educational institutions of industrialized countries advocate a competency-based approach to implement active didactic situations, in a learner-centered way.[23] In this context, competence is defined as an ability to act effectively in a specific role in a specific situation. It relies on what John Ruskin described as education: "Education does not mean teaching people to know what they do not know. It means teaching them to behave as they do not behave."[24] This refers to what teachers or instructors want learners to be able to do at the end of a course. Competence involves three interdependent facets of learning outcomes. These facets represent various levels of learning complexity: cognitive, affective, and psychomotor. The cognitive level refers to the domain of knowledge and allows learners to achieve higher levels of learning. The affective level includes attitudes, emotions, feelings, and values,[4] and the psychomotor level refers to the skills used in the professional practice. Depending on these competences, educational strategies and didactic processes are chosen (see also Chapter 14: Educational Foundations of Instructional Design Applied to Simulation-Based Education).

Then, educators establish assessment procedures to objectivize the achievement of the learning objectives and the impact of learning methods.[25] The Kirkpatrick model[26] is a useful framework to categorize the learning outcomes into four levels: (1) *Reaction*—assessment of participants' satisfaction, (2) *learning*—assessment of changes in KSA, (3) *behavior*—assessment of changes in abilities in clinical practice, and (4) *outcomes*—assessment of the impact on quality and safety of care (see Fig. 14.2). A fifth level has been added, *return on investment*, demonstrated as mortality reduction, efficiency, etc.

The why, when, and how to integrate simulation into existing training curricula are discussed next.

18.3 WHY, WHEN, AND HOW TO INTEGRATE SIMULATION INTO EXISTING TRAINING CURRICULA?

Generally, simulation seems to be a convenient method of learning in a safe environment for learners and patients. Indeed, there is no risk of causing harm to patients or their families. By varying the simulation method, it is possible to expose learners to a broad range of situations that they could encounter in clinical practice. Simulation seems to be a response to the feeling of most learners not being sufficiently trained before working in clinical practice. In fact, clinical practice in the United States is progressively being replaced by simulation pedagogy. For example, in the nursing curriculum, 25% of clinical placement has been substituted by simulation training.

Before deciding to integrate simulation in a curriculum, it is first necessary to identify its learning objectives. An institutional assessment of needs could be done by means of a gap analysis, an end-training competencies analysis, learner surveys, etc.[27] Then, learning objectives should be written in terms of KSA that learners are expected to achieve, adhering to the hierarchical progression of the revised *Bloom's Taxonomy*,[28] from the lower levels (remembering and understanding) to higher levels (applying and creating). The acronym SMART for specific, measurable, assignable, realistic, and time related could also help in the development of measurable and meaningful objectives (see Chapter 14: Educational Foundations of Instructional Design Applied

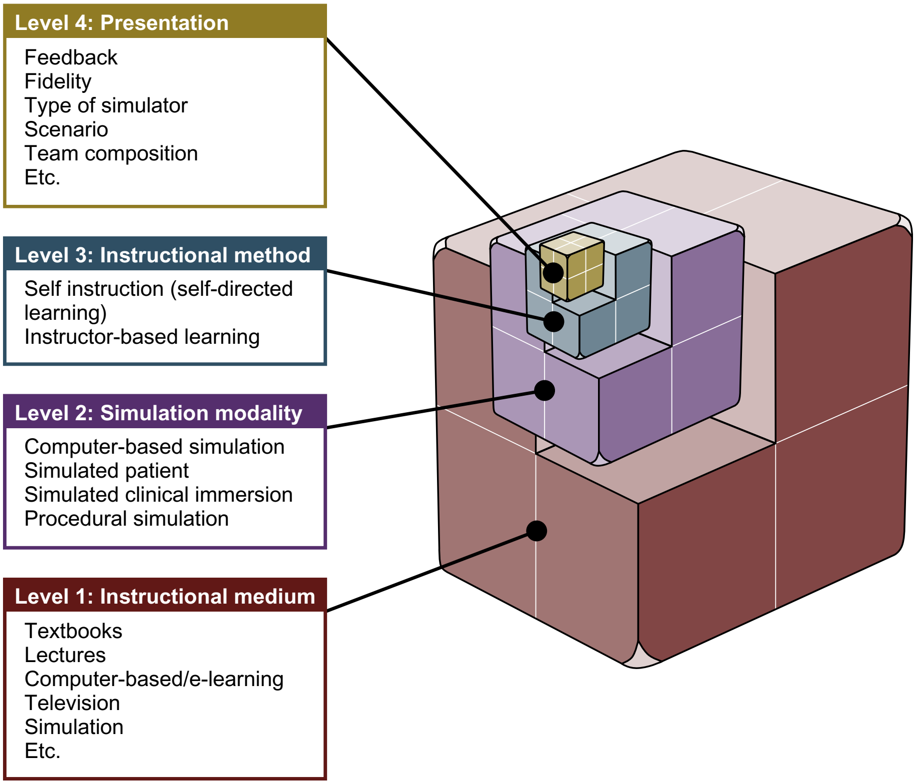

FIGURE 18.2 Instructional design model for simulation-based education with four levels that define the instructional medium, the simulation modality, the instructional method, and presentation. Source*: From: Chiniara G, Cole G, Brisbin K, Huffman D, Cragg B, Lamacchia M, et al. Simulation in healthcare: a taxonomy and a conceptual framework for instructional design and media selection.* Med Teach *2013;**35**(8):e1382.*

to Simulation-Based Education).[29] The definition of these learning objectives provides suggestions for simulation-based learning.[27]

Educators may analyze the relevance of simulation using the conceptual framework of Chiniara et al.[9] This framework for instructional design of educational activities using simulation in health care includes four levels defining different characteristics based on their specific impact: instructional medium, simulation modality, instructional method, and presentation (Fig. 18.2). This is linked to learning outcomes and could assist educators in selecting characteristics for the best design of simulation training interventions. The model describes an educational activity using four levels of instructional design. The choices for any characteristic at a given level usually depend on the choices made at the previous levels. At each level, the choices made are dependent on the actual learning needs and goals of the activity.

The model's first level is called "medium." This corresponds to the principal mode of delivery of instruction. Examples of media include textbook learning, lectures, etc., up to immersive simulation. Simulation constitutes one specific medium. Two of its core characteristics, the imitation of reality and its interactive nature, distinguish it from the other delivery

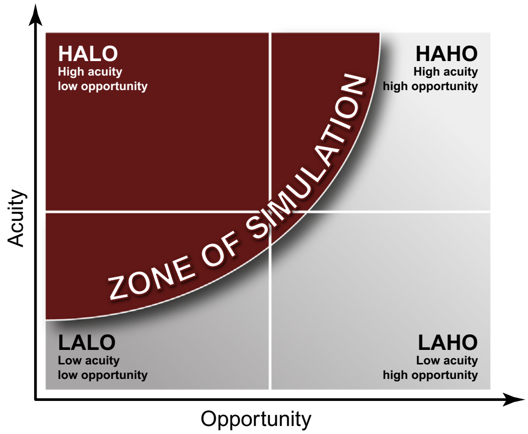

FIGURE 18.3 The zone of simulation matrix. Source: *From: Chiniara G, Cole G, Brisbin K, Huffman D, Cragg B, Lamacchia M, et al. Simulation in healthcare: a taxonomy and a conceptual framework for instructional design and media selection.* Med Teach *2013;***35***(8):e1382.*

media.[30] The decision to use simulation as an instructional medium should be based on the analysis of two characteristics of the specific events, series of events, or conditions that are the desired focus of training: acuity and opportunity.[9] Opportunity is the frequency of an event, whereas acuity is the potential severity of an event or a series of events and their impact on patients, family members, and/or healthcare professionals. These two characteristics define a matrix (Fig. 18.3), which can be divided into four quadrants: high-acuity low-opportunity (HALO), high-acuity high-opportunity (HAHO), low-acuity low-opportunity (LALO), and low-acuity high-opportunity (LAHO).

For example, out-of-hospital neonatal resuscitation is an uncommon event, opportunity to practice is weak, and emergency professionals have limited experience on this topic which requires specific KSA.[31] Considering acuity, a mismanaged resuscitation could have an important impact on children's cognitive abilities. Opportunity is thus low, and acuity high. It belongs to the first quadrant (HALO). Other events, such as the initial management of a polytrauma patient in a trauma center, have HAHO. The third quadrant, LALO, includes situations like managing a postpartum hemorrhage in a postpartum unit. The fourth quadrant, LAHO, involves a lot of tasks related to routine patient care in the clinical setting.

As simulation should be used when it is more advantageous than other media and more acceptable, for example, from an ethical point of view, the "zone of simulation" includes all HALO situations, and when feasible, some HAHO and LALO situations.

The second level of instructional design is the simulation modality. As described previously, simulation modality encompasses several simulation tools from Level 0 to Level 5 in Alinier's typology.[7] Each level allows the achievement of specific objectives and learning outcomes. The choice of modality determines a broad set of characteristics that alter the learning experience.

As Chiniara et al.[9] have underlined, simulation modalities and simulator types (e.g., Level 4) are distinct concepts that are unfortunately too often confounded.[32] The same simulator can serve very distinct purposes. For example, a patient simulator can be used to train technical skills or be used as a patient in a scenario of medication error. These are two different educational experiences, with different objectives. The "simulation modality" level aims to answer the question "How is simulation being used?" rather than "What simulator is being used?" (a question addressed by the model's last level).

The third level of instructional design is instructional method. Two instructional methods can be used with simulation: *self-directed learning* or *instructor-based learning*. In the *self-directed learning* method, learners define their objectives, and invest the necessary time to achieve them. This method is well adapted to procedural and computer-based simulations. For example, nursing schools developed skills labs to train procedural skills. Learners who want to train on inserting urinary catheters have just to register and self-train in the lab. A faculty member is present to answer questions. Considering computer-based simulations, Virtual I.V. Simulator (Laerdal Medical, Stavanger, Norway) can also be used by learners without teacher supervision. Feedback is provided by the computer. Learners can repeat an exercise as often as they want.

On the other hand, *instructor-based learning* is the method most used in clinical simulation. It requires instructor supervision and includes varying degrees of instructor involvement, from debriefing sessions to direct participation by the instructor in the training session. Instructor involvement varies depending on learners' level of experience and competence. During simulation, the instructor may deliver cues to allow learners to accomplish their expected objectives. Cues raise awareness regarding signs, symptoms, or other information, and could be planned or improvised. Planned cues are written into the simulation design, whereas unplanned cues are provided in reaction to unexpected actions. For example, in a simulation of an altered state of consciousness due to hypoglycemia, a family member phones to warn that the patient is diabetic (planned cue). As another example, during a dyspnea simulation, learners decide to defibrillate the patient, despite the cues. The instructor then decides to come into the simulation room as a senior physician and asks why they want to defibrillate. He goes on to analyze the electrocardiogram with the learners (unplanned cues). This shows that planned cues are not always sufficient and that other instructions or cues could be provided by the instructor.

There could be a third instructional method, observation. While observers are not active, participants are actively engaged in the simulation-based training. Since observer trainees have no hands-on experience and do not interact with the situation, Chiniara et al.[9] considered this method as irrelevant to simulation (but see Chapter 11: Motivational Dynamics in Simulation Training, on the active observer's role). Observation would rely on different learning mechanisms than simulation.

The fourth level of instructional design is called presentation and includes characteristics that define exactly how the simulation activity is shaped and designed. It involves simulation characteristics described elsewhere: fidelity, simulator type, scenario, team composition, etc.

An essential element that must be discussed here is the nature and quality of debriefing. In fact, learning mainly depends on the level of reflection, which is made possible at the time of debriefing. Debriefing enriches the effectiveness of simulation and enhances performance.[33] It often occurs at the end of the simulation scenario, but sometimes facilitators give feedback during simulation.[34] Debriefing is a moment where learners reflect on their actions, discover improvements, and consolidate learning to real clinical situations. It is led by a facilitator who encourages participants' discussion, but may also use unidirectional feedback by providing information to learners with the aim of improving understanding of ideas.[35] See Chapter 34, Debriefing Frameworks and Methods, and Chapter 35, Debriefing for the Transfer of Learning: A Cognitive Approach, for in-depth discussions of debriefing.

We provide below an example of the integration of simulation into a medical curriculum.

18.3.1 Example: Breaking Bad News in Emergency Medicine

Bad news can be defined as any significant news that negatively or seriously affects people's views of the present or future.[36,37] It is either a life-altering, life-limiting, or hopeless situation as well as death notification.[38,39] Over the past few decades, the process of breaking bad news (BBN) has drastically changed because the relationship between patients and health professionals has evolved into a partnership centered around information sharing. Patients prefer receiving individualized and clear information as well as warm and honest behavior.[40] In the context of an emergency department, BBN occurs practically every day. It is also considered one of the most important, difficult, and challenging responsibilities of a physician. Indeed, this is an extremely stressful task for medical students but also for experienced physicians. What's more, many health professionals do not feel sufficiently trained. This is likely due to a lack of formal training.[37] Moreover, medical students seem to lack opportunities to practice BBN, while supervisors are not always available to give feedback to young physicians.

Considering requests from the emergency department head and after a literature review, the Simulation Centre of the University of Liège conducted a needs' assessment in the department. This analysis demonstrated that medical students and junior residents did not receive courses or training on BBN, although the literature review had highlighted several guidelines specifically developed to help physicians in this domain. Among these guidelines, SPIKES is the most widespread protocol.[41] This acronym represents the six major steps of the BBN process: setting, perception, invitation, knowledge, empathy, and summary. Based on this analysis and the literature review, learning outcomes were identified in collaboration with emergency physicians and psychologists. They were written in terms of KSA, based on the revised *Bloom's Taxonomy*.[28] The knowledge learning outcome was formulated as follows "Students should be able to list and explain each step of the BBN process"; the skills learning outcome as follows "Students should be able to apply the BBN process during a BBN simulation and to use communication skills adequately"; and, lastly, the attitudes learning outcome was formulated as follows "Students should be able to adapt their nonverbal behaviors and develop an appropriate relationship with the family members." The acronym SMART was used to develop measurable and meaningful objectives.[29]

After this first step, the Simulation Centre of the University of Liège created a BBN simulation-based training for emergency medical students and junior residents. Referring to the conceptual framework of Chiniara et al.,[9] simulation seemed to be the most suitable instructional medium. Indeed, lectures or textbooks could enhance knowledge but do not allow training communication skills and attitudes in this domain. Computer-based training could improve knowledge and, perhaps, the application of BBN steps. Finally, medical students have few opportunities to announce bad news in the traditional clinical apprenticeship, so they were at risk of adopting inappropriate communication behaviors which could lead to high stress for them.[42] From the patients' or family members' points of view, these inappropriate behaviors could decrease comprehension and perception, but also their psychological adjustment as well as their long-term relationship with medical caregivers.[43] According to the analysis of acuity and opportunity, BBN in the emergency department is a HAHO situation (Fig. 18.3) and is therefore embedded into the zone of simulation.

Role-play between participants has been selected as a simulation modality, since simulation with manikins and computer-based learning did not represent an adequate solution for one major reason: eye contact and gestures cannot be adequately reproduced. While they allow the development of knowledge and clinical reasoning, they are ill-suited for nonverbal communication. Even if artificial intelligence is booming, a seamless communication is not yet possible. Finally, role-playing was chosen instead of standardized patients with actors, because of the higher cost associated with the latter.

Once this choice was made, a 4-hour simulation-based training in BBN was designed for medical trainees and junior residents in emergency medicine. The International Association for Clinical and Simulation Learning, Standards of Best Practice for Simulation,[27,44] and the NLN Jeffries Simulation Theory[45] provided the theoretical foundation for simulation. A blended learning training was composed of two parts. The first part included a brief theoretical course on BBN, SPIKES, and communication skills, a video vignette, and an interactive discussion about these themes (2 hours). The video vignette demonstrated how to announce bad news to a family member. It was accompanied by written information on facilitative attitudes and behaviors appropriate in these situations. All this information was then discussed in groups of six learners with two facilitators, a psychologist, and an emergency physician. This part targeted the KNOWS and KNOWS-HOW levels of Miller's pyramid (Fig. 18.1).

The second part included six role-play simulations experienced by the participants (2 hours). The content of the different scenarios was as follows: (1) disclosure of a stroke with hemiplegia to one family member; (2) delivering death notification to two family members after a patient's cardiac arrest; (3) delivering news of a new-onset paraplegia in a polytrauma patient to two family members; (4) delivering a diagnosis of respiratory distress syndrome in a child to the parents; (5) delivering the news of a life-threatening condition after a knife attack to two family members; and (6) delivering an oncological diagnosis to a patient. A medical student or resident participated in the simulation while the other five participants watched the situation in the debriefing room. Following each scenario, medical students and residents participated in a 20- to 30-minute learner-centered debriefing using the framework Promoting Excellence and Reflective Learning in Simulation (see Chapter 34: Debriefing Frameworks and Methods).[46] Role-play simulations were used to target the SHOWS-HOW level of Miller's pyramid.

The efficacy of this BBN simulation-based training was assessed by comparing a training group with a waiting-list control group. Referring to Kirkpatrick's four-level evaluation model,[26] training was assessed at the first two levels: satisfaction and learning (in attitudes and skills). Satisfaction, measured by the Simulation Design Scale,[27] was very high among participants. Participants agreed that the objectives were clear, they felt supported in the learning process, and they felt they could develop their problem-solving skills. The debriefing was also appreciated, and the scenario resembled a real-life situation. Concerning learning, the study demonstrated improvement in self-efficacy (attitudes), BBN processes, and effective communication skills in the training group, in contrast to the control group.

Based on these results, all medical students and residents in the emergency department are henceforth attending this course, with other medical specialties such as psychiatry, pediatrics, and neonatology interested in developing similar training for their residents.

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