Human patient simulators in nursing education: An overview

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Professional competency will be a critical performance outcome in the years ahead. Current investigations have found an alarming increase in the morbidity and morality rates of individuals in hospitals across the United States. With such findings, the competency levels of health care professionals, including nurses, are under scrutiny. The use of human patient simulators (adult and pediatric) in baccalaureate and graduate nursing education provides an excellent, objective tool by which to measure competency in the application of knowledge and technical skills. Emphasis is placed on educational, research, and evaluative applications of the simulators for nursing education. Critical Incident Nursing Management is further described as an instructional framework for the use of this technology. Last, administrative considerations will be addressed.

KEYWORDS: critical incident nursing management (CINM); human patient simulator (HPS); nursing education.

The consumers of our changing health care delivery system have mandated that schools of nursing provide their students with current education and technical learning to achieve competency in the nursing role (Pew Health Professions Commission, 1998). In response to this mandate, the present methods of nursing education are no longer satisfactory and must be altered to adequately prepare the undergraduate and graduate nursing student for today’s practice. The Human Patient Simulator (HPS) (Medical Educational Technologies, Inc.) provides objective, state-of-the-art technology by which current, comprehensive, and interactive instruction and evaluation can be given. The purpose of this article is to describe the HPS and discuss the value of this technology for undergraduate and graduate nursing education, research, and evaluation. The simulator program at a school of nursing in the Midwestern United States will be used as an example. Critical Incident Nursing Management (CINM) is introduced as a framework for instruction using the HPS, and a brief discussion of administrative considerations completes this article.
Key Points

- HPSs provide a comprehensive, objective measure of the nursing student’s knowledge, skill level, and critical thinking.
- CINM is an instructional framework for this technology in nursing education.
- HPSs have educational, research, and evaluative value in the undergraduate and graduate nursing programs.

The HPS

The HPS was developed through the cooperation of medical and health care professionals and computer technology. The first use of the HPS was with the specialization of anesthesia. The HPS is a computerized full-body mannequin that is able to provide real-time physiological and pharmacological parameters of persons of both genders, varying ages, and with different health conditions. For example, normal and abnormal heart and lung sounds are present, all pulses can be felt, the eyes blink, the pupils constrict and dilate, and the tongue can swell. The monitors attached to the system are able to provide waveforms for EKG, cardiac output, heart rate, respiratory rate, wedge pressure, and real-time readouts for blood pressure, blood gases, vital signs, and other physiological parameters as needed for a particular patient scenario. Both adult and pediatric models are available. The adult model is based on the physiology of a healthy male in his late 20s and the pediatric model is based on the physiology of a 6-year-old. Although the size and form of the mannequins may limit the outward appearance of the “patient” and for some, be an impediment to participation in the scenario, the adult HPS can be programmed to range in age from 12 to approximately 100 years of age and the pediatric HPS from 2 to 11 years of age, and become either gender. The HPS is operational in a lying, sitting, and standing position.

The complete HPS system includes the mannequin, computer and software, monitors, and gases (i.e., oxygen, carbon dioxide, and nitrogen) to operate the system. The software includes a repertoire of patients and preprogrammed scenarios. A cordless microphone is also useful to simulate the “patient’s voice.” Adequate space must also be present for the placement and safe housing of the equipment and for students and faculty to function.

CINM

CINM is an interactive, competency-based method of nursing instruction in which nursing care is taught in the context of a critical health incident (e.g., inability to breathe well during an asthma attack). The outcome of such instruction is the satisfactory performance of nursing care using appropriate knowledge, technical skills, and critical thinking within the nursing process model. The HPS allows the undergraduate or graduate nursing student to
• assess the critical health incident with the “patient” through observation, measurement of
  the physiological parameters, and verbal communication (if applicable);
• plan the next appropriate steps in care based on current and changing information;
• intervene in a manner to correct or stabilize the situation; and
• evaluate the situation to take additional steps or alter the plan of care.

The positive and/or negative outcome(s) of the student’s interventions are revealed by
the HPS in real-time. Learning goals, objectives, preparation by the student and fac-
ulty for such instruction (including baseline information on the scenario), and evalua-
tion of the experience by students and faculty are all necessary components of this
form of instruction. Faculty must also prepare the environment for the critical health
incident to be learned by using props, such as clothing, equipment, supplies, and other
faculty to serve as members of the family or health care team. Cognitive, psychomotor,
and affective domains of learning are present in this learner-centric framework for
nursing instruction. Debriefing is an essential conclusion to this form of instruction
and will be discussed in more detail later. CINM is a derivation of the anesthesia crisis
resource management approach for anesthesia instruction with the HPS designed by
Gaba and DeAnda (1988).

Educational, research, and evaluative
uses for the HPS in nursing education

The HPS provides nursing faculty with many educational, research, and evaluative
applications. Currently, physicians and anesthesiologists administrate and operate the
majority of simulator programs across the world (Watterson, Flanagan, Donovan, &
Robinson, 2000). Within the next few years, it is expected that increasing numbers of
undergraduate and graduate nursing programs will develop such programs as the value
and efficacy of such technology is known.

Educational implications for the HPS

The educational implications for the use of an HPS in a nursing program are great.
The software is programmed to run either preset or faculty-designed patient scenarios
in which (a) the students observe the progression of a critical health incident (e.g.,
heart attack) to learn how the human body is affected, and/or (b) the student is
instructed to make initial and ongoing assessments of the patient and intervene as nec-
essary, with the administration of medications for example, to prevent untoward health
events, such as death. The first option places the student in a less active role, while the
latter option is completely learner-centric and uses CINM.

Both of these instructional options are useful in the nursing curriculum. Faculty can
use the HPS in beginning level courses to illustrate pathophysiological and
pharmacokinetic principles, normal and abnormal parameters, and changes based on
critical health incidents or interventions, such as drug or intravenous fluid administra-
tion. The HPS will respond in “real-time” to the interventions just as a real person
Principles of physical assessment can also be demonstrated on the HPS to the beginning nursing students.

Once clinical courses begin, the faculty can develop patient scenarios from actual clinical patients, preserving the confidentiality of the patient and providing students with a clinical experience that only a few students may have experienced in the past. The ability to save the data on the patient provides for repetitive teaching events to review and even test skill development or run the scenario with different interventions, asking the question “what if?” to assess different outcomes in a safe environment. In this way, many students over several semesters may be able to experience the same learning experience thereby maintaining the consistency of the “patient care experience” from year to year. The software is capable of both the development of new scenarios that incorporate clinical situations and to change running scenarios as the need or the teaching requires.

Often faculty will develop a module on a topic, such as asthma, and then develop two-to-four patient scenarios to illustrate this condition with different patients. For example, asthma could be illustrated with a 2-year old child, a 6-year old child, and a 10-year old child. Students would need to recognize normal and abnormal physiological differences in children of these ages. Severity of the condition could also vary between the scenarios so that students would need to know appropriate nursing interventions for the varying presenting symptoms. When using a module during class time, these sessions should be videotaped for a fuller discussion of what happened during the running of each patient scenario. Students may also be encouraged to videotape their work with the HPS and a particular scenario when on their own time so that faculty can provide feedback at a later time. Overall, the system is only limited by the imagination and skills of the faculty to respond to changing clinical settings and patient mixes.

Debriefing. Equally important to the actual performance of the scenario is the debriefing that occurs at the end of the scenario. The student or students who performed the scenario must discuss what they learned, how they felt, and what they would do differently if presented with a similar patient situation or critical health incident. Faculty should also provide constructive evaluation to the students involved in the role-playing of the scenario. If additional students are present during the scenario enactment, their input should also be given. The faculty may decide to run another scenario with other students participating so that every student has an opportunity to participate in the running of a scenario or they may choose to concentrate on only one scenario per class period.

Another debriefing opportunity exists when other outlets are available for student viewing of the scenario being run. For example, computers could be placed around the psychomotor lab, as is the case in our nursing program, where groups of students can gather to watch what is being done with the HPS. Faculty can be present with each group to facilitate discussion and debriefing of the scenario.

Finally, at the end of the class, faculty can gather to debrief on the HPS instruction for that day. They may discuss how the scenario ran, what problems were encountered, things they would change in the scenario, patient situations they would save for later
instruction, and future plans. These sessions should be ongoing throughout the semester.

Advantages and disadvantages of the HPS. In discussing the educational implications of this technology, advantages and disadvantages must be weighed. The major advantage of the HPS is that it offers the nursing student interactive experiences with various health conditions and critical incidents in a “safe” simulated real-world environment. Other advantages include the ability to

- visualize physiological effects on the human body that are hard to conceptualize when learned through lecturing and/or reading;
- observe the physiological effects of medications;
- practice interventions in a safe environment to see the consequences when a wrong decision is made;
- enhance prior learning on the topic(s);
- improve student confidence, decision making, and critical thinking;
- provide opportunities for self-study;
- use structured laboratory experiences instead of trying to find appropriate and/or rare patient care opportunities in a health care setting;
- involve students from both the undergraduate and graduate nursing programs in completing a scenario; and

Disadvantages are present and may include the

- student’s feeling inadequate in handling a critical incident,
- student’s concentrating on one aspect of the situation instead of seeing the total health picture,
- student’s sensing the artificiality of the environment at times during the scenarios,
- cost of the technology ($200,000-$300,000) and annual maintenance and upgrading costs,
- small number of students who can work at the bedside at one time with the HPS, and
- faculty time for training and development of modules (Henrichs, 1999; Monti et al., 1998).

Use of the HPS in our Undergraduate Nursing Program. In the first year of our simulator program, it is our goal in the undergraduate nursing program to develop and write a portion of the baccalaureate nursing simulator curriculum using CINM. Both faculty and student versions will be completed. The first portion of the curriculum will involve the development and testing of patient scenarios in the areas of Maternal-Child Nursing, Pediatric Nursing, and Advanced Adult Medical-Surgical Nursing. Each patient scenario will be part of a module. Each module will consist of the goal and rationale for the module, learner objectives, readings and assignments needed to be completed prior to the module, a description of the patient scenario in order to provide the student with enough baseline information to begin their assessment, evaluation
criteria, and an evaluation form. The faculty version of the module will also include additional props and equipment needed to conduct the module, discussion questions, and an evaluation form to record their experiences in leading this module. The elements of the modules are based on previous literature (Murray & Schneider, 1999; O’Donnell et al., 1998) and teaching experience of the faculty. Each module will be pilot tested and refined before the final form of the module is completed.

Maternal-newborn nursing presents a special challenge for nursing students as the theoretical and technical knowledge differs greatly from the medical-surgical knowledge and skills they have previously learned. The actual observation of childbirth is often “scary” and newborn care presents additional anxiety and inadequacy. An Empathy Belly will be the major prop for these modules in order to make the mannequin appear pregnant. The four modules for the Maternal-Newborn Nursing course held in the junior year will consist of assessment, pregnancy-induced hypertension, abruptio placenta and placenta previa, and preterm labor.

Care for children often presents unique challenges such as listening for breath sounds when the child is crying or finding answers to questions about how the child feels when they are not yet talking. The pediatric HPS will be used for this course. The model allows for the simulation of a child from 2 to 11 years. Additional props and the addition of another faculty member acting as a parent will be needed for these modules. The four modules for the Pediatric Nursing course held in the junior year will be assessment, asthma, increased intracranial pressure, and diabetes mellitus.

The final course to which HPS modules will be developed in the initial phase is the Advanced Adult Medical-Surgical Nursing course held in the last semester of the senior year. In this course, the student will experience critical care settings. Eight modules will be developed for this course and they include advanced heart and lung assessment, advanced neurological assessment, pulmonary conditions, cardiac conditions, metabolic conditions, types of shock, neurological and trauma conditions, and mock codes.

To date, there is only one article published by nurses in which two elective undergraduate nursing courses are described in which a HPS is used. These elective courses are a perioperative and a critical care nursing course (Monti et al., 1998). As we complete our initial phase of module development across these three nursing clinical courses, we will submit manuscripts on our work in order to add to this new category of nursing literature.

In the future, we plan to add modules representing the other nursing clinical specialties. We also plan to develop modules for remedial instruction of particular didactic and technical content for continuing education purposes. More complex critical incidents may be developed for nursing honors students. These students may also be given the opportunity to develop their own scenarios.

Use of the HPS in our Graduate Nursing Program. Like the undergraduate nursing student, the graduate nursing student is learning new skills while refining previously learned techniques. The HPS provides educational opportunities for all advanced
nursing specialties, but the nurse anesthetist and the nurse practitioner will be highlighted in this article.

The nurse anesthesia student is expected to have an in-depth knowledge of physiology, pathophysiology, pharmacology, clinical applications, and specific interventions for many pathophysiologic conditions. Moving from simple to complex patient situations and critical health incidents, the faculty has developed scenarios for the graduate nurse anesthesia students for each nurse anesthetist course that they take in their program. Plans are underway to develop a HPS manual for each course. In an unpublished work by Henrichs (1999), nurse anesthetist students were able to feel comfortable in a difficult clinical situation following exposure to clinical scenarios using the HPS. Students were able to demonstrate increased learning and less stress with repeated practice with the simulator.

Opportunities to use the simulators are also present in the nurse practitioner program. The advantage of the HPS is that scenarios can be specifically developed and adapted to the many different possible clinical opportunities in the primary care setting. Currently, an advanced pediatric assessment module using the pediatric HPS is being developed for use in the graduate physical assessment course.

Research and evaluation using the HPS

The majority of health-related HPS research done to date has been on the testing of the effectiveness of this technology in medical and anesthesiology education. Researchers have determined that medical (Devitt, Kurrek, & Cohen, 1997; Morgan & Cleave-Hogg, 2000; Tome, Fletcher, & Lydell, 1997), anesthesiology (Devitt, Kurrek, Cohen, & Lam-McCulloch, 1999; Gordon, 2000; Holzman et al., 1995; Steadman, Oyesola, Levin, Miller, & Larson, 1999), and nursing (Henrichs, 1999; O’Donnell et al., 1998) students rate the simulator experience as positive. They have also found little correlation between scores on a checklist of desired behaviors used with a simulator experience and clinical evaluations or written examinations (Devitt et al., 1997; Morgan & Cleave-Hogg, 2000; Morgan, Cleave-Hogg, & Guest, 1999). But performance on simulator scenarios is significantly better for faculty, practicing anesthesiologists, and more advanced than beginning students in several studies (Byrne & Jones, 1997; Devitt et al., 1998; Devitt et al., 1999; Mayer, Freid, & Boysen, 1999) indicating some degree of discriminant validity. Finally, Steadman et al. (1999) found that clinical performance was improved in those students educated with a HPS.

Overall, although more research is needed to continue to refine a tool for the evaluation of the student’s HPS performance, it appears that there is evidence to support the use of the HPS in the education of health professionals. Kapur and Steadman (1998) did caution faculty to spend the time to determine what aspects of clinical competence can be measured with the use of a HPS, and how closely correlated is competence using the HPS and actual clinical competence in the practice arena. Specifically, very little nursing research is found in the literature regarding the use of HPS in nursing education (Henrichs, 1999) providing fertile ground for future projects.
Research and evaluation using the HPS in our School of Nursing. Research is a vital component of the simulator program at our School of Nursing. Early research plans are to complete pretest and posttests on the information presented in the earlier described modules for both the undergraduate and graduate nursing students and to test for knowledge retention. Evaluation of CINM as an instructional framework is an integral part of this research.

A convenience sample of 42 senior nursing students in the Spring 2000 semester was obtained to test the first completed Advanced Medical-Surgical modules covering the topics of airway obstruction, congestive heart failure, pulseless electrical activity, and hypovolemic shock. After obtaining informed consent, eight groups of five to six students received a lecture on these topics for one hour by two faculty. A pretest was then completed. Next the students were presented with three case scenarios in which the HPS or “patient” experienced these various critical health incidents and the students had to work together to assess, plan, intervene, and evaluate their actions to prevent a potentially fatal outcome. After the scenarios were completed the first posttest was completed. Then, 5 to 7 days later, a second posttest was taken. Using the Wilcoxon signed ranks test for two related samples, a significant difference existed between the pretest and first posttest scores ($Z = -5.84, p < .05$). No difference was found between the two posttests ($Z = -0.577, p > .05$) indicating retention of the learning regarding the four topics.

Two nursing graduate students have completed data collection on modules related to advanced pulmonary and cardiac assessment and a refinement of the congestive heart failure module. They are currently in the data analysis phase. These graduate students tested their modules with participation from senior undergraduate nursing students. This provided a wonderful opportunity for the undergraduate students to interact with graduate nursing students around a specific practice activity.

As we develop and test the modules for use in the undergraduate nursing curriculum, additional refinement must take place. Checklists must be developed and tested for student performance. We also hope to explore the comfort levels of the undergraduate nursing students after their exposure to the HPS. It will further be interesting to note if area hospitals, who hire a majority of our graduates, will notice a difference in our students’ performance in the hospital setting after the HPS is implemented throughout the undergraduate nursing curriculum. No research has yet been published on baccalaureate nursing students and the use of HPSs for instruction and learning and is an untapped area.

Plans are underway to conduct research in our graduate nurse anesthesia program involving clinical learning, decision making, and comfort with the HPSs in the operative setting. The outcome of scenario testing by the students will be compared with past students who received minimal HPS education and experience. Results on the national certifying examination will also be used as a variable in this comparison. Additional research underway in the nurse anesthetist program will compare comfort and performance using the HPS between first and second year students.

In regards to evaluation, we feel that both process and summative evaluation is important. Therefore, we are developing modules for use throughout the under-
graduate or graduate nursing curriculums as described earlier. Specific scenarios will be developed for use in summative evaluation of the student in specific clinical courses. The purpose of these summative scenarios is for objective evaluation of the student’s critical thinking, knowledge, and technical skills at the end of the course. In the clinical setting, the faculty cannot spend the same amount of time with every student and therefore, cannot evaluate each student in the same manner. The summative HPS experience will allow for an additional objective measure of the student’s achievement of the course objectives. This data will be compared to the current literature on comparing simulator instruction with final written examinations and clinical evaluations when completed.

Administrative considerations in the use of this technology

As mentioned earlier, the present cost of a HPS is great and there are many avenues that administrators of nursing programs can take to recoup this investment. The HPS can be made available to other nursing or health professional groups, individuals, and/or the public. A fee could be charged for the use of the HPS, as well as for the faculty needed to provide the desired instruction. Individuals or groups could come to the laboratory for instruction or they could participate in the instruction through distance learning. Another way of recouping income is to charge a clinical laboratory fee to students who are using the HPS. The opportunity for faculty to design and write original scenarios for use with the HPS provides an additional benefit for stimulating faculty creativity. In turn, this may also bring in income from grants for the writing of these scenarios or for research projects that compare learning outcomes using various modalities as discussed earlier.

Summary

The psychomotor skill laboratories in nursing education have grown from the infamous Mrs. Chase and other crude mannequin-driven laboratory projects of the early part of the last century to the advanced simulation environment of today. This has been accomplished through the integration of medical and nursing education with the emerging and expanding computer technology, such as the HPS, available throughout the world. This has been done to insert the learner into a more realistic simulation environment where the development and application of knowledge, skills, and the practice of protocols can be enhanced. Opportunities for education, research, and evaluation using the HPS at all levels of nursing education are limitless. We have also specifically described how one school of nursing has and plans to incorporate HPS technology into the undergraduate and graduate nursing programs. CINM was discussed as a framework for instruction using this technology.
References


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interest and area of expertise, but she is fascinated with the potential of the human patient simulators in the education of undergraduate nursing students.

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