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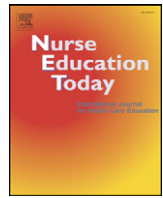
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The effect of human patient simulation on critical thinking and its predictors in prelicensure nursing students

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SUMMARY

Human patient simulation (HPS) is becoming a popular teaching method in nursing education globally and is believed to enhance both knowledge and critical thinking.

Objective: While there is evidence that HPS improves knowledge, there is no objective nursing data to support HPS impact on critical thinking. Therefore, we studied knowledge and critical thinking before and after HPS in prelicensure nursing students and attempted to identify the predictors of higher critical thinking scores.

Methods: Using a one-group, quasi-experimental, pre-test post-test design, 154 prelicensure nursing students (age 25.7 ± 6.7; gender $= 87.7\%$ female) from 3 schools were studied at the same point in their curriculum using a high-fidelity simulation. Pre- and post-HPS assessments of knowledge, critical thinking, and self-efficacy were done as well as assessments for demographics and learning style.

Results: There was a mean improvement in knowledge scores of 6.5 points ($P<0.001$), showing evidence of learning. However, there was no statistically significant change in the critical thinking scores. A logistic regression with 10 covariates revealed three variables to be predictors of higher critical thinking scores: greater "age" ($P=0.01$), baseline "knowledge" ($P=0.04$) and a low self-efficacy score ("not at all confident") in "baseline self-efficacy in managing a patient's fluid levels" ($P=.05$).

Conclusion: This study reveals that gains in knowledge with HPS do not equate to changes in critical thinking. It does expose the variables of older age, higher baseline knowledge and low self-efficacy in "managing a patient's fluid levels" as being predictive of higher critical thinking ability. Further study is warranted to determine the effect of repeated or sequential simulations (dosing) and timing after the HPS experience on critical thinking gains.

Introduction

Using the Delphi technique, critical thinking (CT) was defined by a multidisciplinary, expert consensus panel sponsored by the American Philosophical Association (APA) in 1990 as being the "process of purposeful, self-regulatory judgment" (Facione, 1990). In an attempt to achieve a consensus on CT in nursing, an international nursing consensus group also analyzed CT using the Delphi process. Their findings confirmed the affective domains found by the APA ("habits of mind") and added two more specific to nursing (creativity and intuition) (Scheffer and Rubenfeld, 2000).

Attributes of CT as well as knowledge are desired of nurses regardless of where they practice (American Association of Colleges of Nursing (AACN), 2008; National League for Nursing (NLN), 2003). Many educators in the training of prelicensure nursing students emphasize these

characteristics because of the clinical challenges inherent to nursing (American Association of Colleges of Nursing (AACN), 2008; Benner et al., 2010; Daly, 1998; del Bueno, 2005; National League for Nursing (NLN), 2003). To accomplish these goals, nursing schools frequently use human patient simulation (HPS), a form of manikin based experiential learning. It has been embraced largely due to the belief that students learn better by experience when compared to other types of learning, such as by a lecture format (Cioffi et al., 2005; Jeffries, 1998).

Background

The supportive literature for this teaching method is scarce. While many initial HPS nursing studies were subjective and with small sample sizes, HPS has since been linked to gains in knowledge (Brannan et al., 2008; Hoffmann et al., 2007; Howard, 2007; Jeffries and Rizzolo, 2006; Shinnick et al., 2011), gains in self-efficacy (Brown and Chronister, 2009; Sinclair and Ferguson, 2009) and skill attainment (Alinier et al., 2006). Comparisons of HPS with other teaching methods have shown it to be superior to both problem based learning (Steadman, et al., 2006) and interactive case study (Howard, 2007). While HPS has

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been suggested as a means of improving CT skills (Ravert, 2008; Sullivan-Mann et al., 2009), this remains unsubstantiated as findings among studies are not congruent and many relied on student or faculty perceptions of CT (Cant and Cooper, 2009).

The ability of a nurse to critically think is a common theme in nursing programs (Forsberg et al., 2011). Due to its importance to safe patient care, eliminating gaps in this area of research is important. Establishing the impact of HPS on CT as well as identifying factors which could predict higher CT skills would clarify outcome expectations for educators using HPS. Therefore, two specific aims and hypotheses were chosen for this study and were based on commonly assessed attributes in the nursing literature (knowledge, self-efficacy or confidence and learning style) as well as author suspected influences on CT. Aim 1 was to determine if CT improves in prelicensure nursing students after a HPS experience using the Health Science Reasoning Test (Insight Assessment, 2011). The hypothesis was that the prelicensure nursing students who participated in HPS would have improved CT skills. Aim 2 was to determine the predictors of higher CT scores using 10 covariates suspected of influencing knowledge or critical thinking (age, gender, prior simulation exposure, previous employment as a nurse helper, time employed as a nurse helper, learning style, baseline knowledge score, baseline self-efficacy in the management of HF, prioritizing physician orders and managing a patient's fluid levels) on a multivariate logistic regression in prelicensure nursing students participating in an HPS experience. The hypothesis for this aim was the prelicensure nursing students who were older, had prior employment or prior simulation exposure would have increased CT scores after HPS.

Method

Study Design and Sample

This study used a one-group, quasi-experimental, pre-test, post-test design. A convenience sample (n = 154) of four cohorts of prelicensure nursing students was recruited from three Schools of Nursing at the same point in their prelicensure nursing curriculum. All Schools used the same simulation equipment (Sim Man® Laerdal Medical Corp., Wappinger Fall's, NY) and Institutional Review Board approval was obtained from all three schools prior to the study. Power analyses indicated that a sample size of 128 subjects would allow detection of moderate (0.25) effect sizes on a *t*-test with a power of 0.80 (Faul et al., 2007).

Inclusion criteria were students in the same course at each School that had successfully completed instruction in the care of the decompensated heart failure (HF) patient, as that was the topic of the HPS scenario. This point in the prelicensure curriculum is the standard equivalent of a Medical Surgical Course, Level III, traditionally taken in the third year of a four-year nursing program. Exclusion criteria were students who either had HF or had family members with HF.

HPS Scenario Development

Simulation of patients with HF is important, as it is the most common hospital discharge diagnosis in the United States in patients aged 65 years and older (Schocken, et al., 2008). Three simulation scenarios of clinical cases of acute decompensated HF were created for this study. They were identical to each other in design with the exception of the patient history and gender. They were parallel in nature in order to decrease cross-talk between participants and reduce scenario predictability. Three experts in HF management (two doctorally prepared nurses with HF expertise and one physician from a world renowned HF clinic) provided content validity for the scenarios with 100% agreement.

The HF scenarios were designed to elicit problem solving behaviors such as repositioning a dyspneic patient, applying appropriate

oxygen, choosing the priority medication from physician's orders (i.e., intravenous Lasix® instead of oral Lasix®) and monitoring appropriate electrolytes in a patient receiving a diuretic. The scenario events required the student to use CT in order to provide and prioritize care. Since most gains in knowledge during simulation occur during the debriefing component (Shinnick, et al., 2011), a structured debriefing using a "debriefing with good judgment" technique was used. This approach includes the disclosure of instructors' judgments, an eliciting of trainees' assumptions about the situation and their reasons for acting as they did (Rudolph et al., 2006). It was done by the same, blinded faculty member for all simulation groups in the study. While each student participated in an HPS one on one, five students were debriefed at a time within 1 hour of their event.

Data Collection Instruments

Demographic Questionnaire

A demographic questionnaire including the participant's age, gender, history of personal or family experience with HF, prior simulation exposure, and previous employment as a nurse helper (i.e., nurse's aide, care partner, etc.) was collected at the time of the pre-test.

Critical Thinking

A well known, validated and reliable tool was chosen for this study. The Health Sciences Reasoning Test (HSRT), administered on line by Insight Assessment (2011) was chosen to measure the student's CT ability at baseline (pre-test) and after a single HPS (post-test). This assessment has been used in health care settings and professional programs in order to assess an individual's reasoning skills (Botden et al., 2008, 2010; Fero, et al., 2010; Ingram, 2008; Ravert, 2008; Rogal and Young, 2008). Others have used it to determine CT skill in cases of employment or admissions to a health related program (Facione and Facione, 2008; Fero, et al., 2010). This computerized test consists of 33 items in a multiple-choice format and is designed to measure CT skills and "habits of mind" (i.e., perseverance, open-mindedness, etc.). HSRT test items are set in health related clinical and professional practice contexts and supply the necessary content for applying one's thinking skills without assuming specific knowledge (Facione and Facione, 2008). While the assessment provides a Total Score as well as five subscale scores, only the Total Score is addressed here as the aim was to determine any change in CT, not one's attributes toward CT.

The HSRT Total Score reflects the strength or weakness of one's skill in making reflective, reasoned judgments about what to believe or what to do. Scores ≥ 25 indicate a subject with very strong CT skills while scores in the 15–24 range indicate CT skills "suitable for learning and development" (N. Facione and Facione, 2008).

Other Covariates

Learning Style

The Kolb Learning Style Inventory (LSI) has been tested extensively in the nursing and medical fields (Cleave-Hogg and Morgan, 2002; Laschinger, 1986, 1990; Stiernborg and Zaldival, 1996) and was used in this study to identify a student's learning preference. It is a well known, 12-item questionnaire taken on-line used to determine the learner's style preference which is based on 4 primary scale attributes. Reliability on these scales as sub scores is > 90% for each (Kolb and Kolb, 2005). One example of a sub scale is "Active Experimentation" (AE). Students with this learning style preference have learning skills important for success in technology careers such as nursing and medicine. It also identifies the participant as having the ability to learn from primarily hands-on experience such as laboratory assignments, simulations and practical applications (Kolb and Kolb, 2005).

Knowledge

The 12-item HF Clinical Knowledge Pre-Test and Post-Test were developed by the investigator and focused on the symptom management of a patient with HF. Each version of the HF Clinical Knowledge Test was different but considered parallel to the others (Table 1). The questions did not mention HF by name so the participant was blinded to the topic of the simulation. However, the questions focused on desired nursing interventions for common issues associated with HF and the maximum score was 12 points. Content validation of the HF Clinical Knowledge Tests was done by three experts in the nursing care of patients with HF and by one cardiologist who practices at a large HF specialty clinic. Each version of the HF Clinical Knowledge Test had 100% agreement on the content by the panel of judges for this study.

Scoring of the HF Clinical Knowledge Tests was via Scantron. Item analysis and test scores were computerized and entered into an Excel file then uploaded into SPSS version 16.0 (SPSS Inc., Chicago, Illinois).

Self-efficacy

Self-efficacy, or confidence, was evaluated by a 12-item Likert-scale (1 = "not at all confident" to 5 = "extremely confident") which measured responses to confidence in performing skills associated with those needed in acute heart failure. This assessment included such items as self-efficacy in the "management of HF", "prioritizing physician orders" and "managing a patient's fluid levels". Reported reliability by its original author (Ravert, 2004) is 0.87 by coefficient alpha though it was edited slightly, with the author's permission, to fit the clinical scenario of HF. Chronbach's Alpha for the current study was .95 or greater on all items.

Data Collection Procedures

A two-day data collection interval for this study was scheduled at each site within 3 weeks of the HF lecture. Following informed consent, participants in groups of five rotated together through pre-tests, post-tests and debriefing but the simulations were done one-on-one using a random numbers table to determine scenario selection. Each student participated in one HF simulation.

Study participants were asked to take the baseline (pre-test) HSRT and the LSI online prior to arrival but the Demographic Questionnaire and the Clinical Knowledge Questionnaire on the study day. Following the simulation experience, the participants were given two weeks to take the post-test HSRT. The researchers felt this delay was necessary to prevent test fatigue and errant responses as the HSRT can take up to 45 min to complete. Additionally, it was believed unlikely that other CT opportunities in the short time frame would influence the test result. While many completed it on the study day, most of the students completed it within one week of the HPS. Only students who completed both HSRT tests were included in the sample. The study protocol is depicted in Fig. 1.

Table 1
Examples of a HF clinical knowledge question on parallel tests.

Knowledge pre-test	Knowledge post-test
The reason Harold has crackles in his lungs is:	Harold's chest X-ray reveals pneumonia. How can the nurse determine the cause of his crackles in the lungs?
a) Fluid volume overload	a) Use percussion to assess the lungs
b) Increased pressure in the pulmonary vasculature	b) Check for jugular venous distension
c) An upper respiratory infection	c) Base assessment on his history of heart failure
d) Pre-existing pulmonary edema	d) Check for weight gain

Statistical Analyses

Statistical analysis was done using paired t-tests for the pre- and post-test Knowledge and HSRT scores. Pearson's Correlation and Chi Square analysis were done to determine variables of significance to enter into the multivariate regression. In an effort to determine the predictors of higher CT scores, a multivariate regression was done (StatSoft, 2011). Those variables and those commonly believed to influence CT ability were entered into a forward, stepwise multivariate logistic regression (age, gender, prior simulation exposure, previous employment as a nurse helper, time employed as a nurse helper, learning style, baseline knowledge score, baseline self-efficacy in the management of HF, prioritizing physician orders and managing a patient's fluid levels) for all subjects using a bivariate HSRT score as the dependent variable.

Results

Prior to analysis, the variables were examined for accuracy, fit between their distributions and assumptions examining histograms, normal probability plots of residuals and scatter diagrams of residuals versus predicted residuals. Data distribution was normal and no violations of normality, linearity or homoscedasticity of residuals were detected. In addition, box plots revealed no evidence of outliers. Tolerance values for all variables was >.2775 so there were no concerns for violation of assumptions.

One hundred and fifty four (154) students completed all components of the study. Subjects were predominately female (87.7%) with a mean age of 25.7 (Table 2).

Even though there were statistically significant gains in knowledge following HPS (mean knowledge score increased 6.5 points [P<0.001], [Fig. 2]), there were no statistically significant gains in CT. Paired t-tests revealed that total HSRT scores between the pre-test and post-test
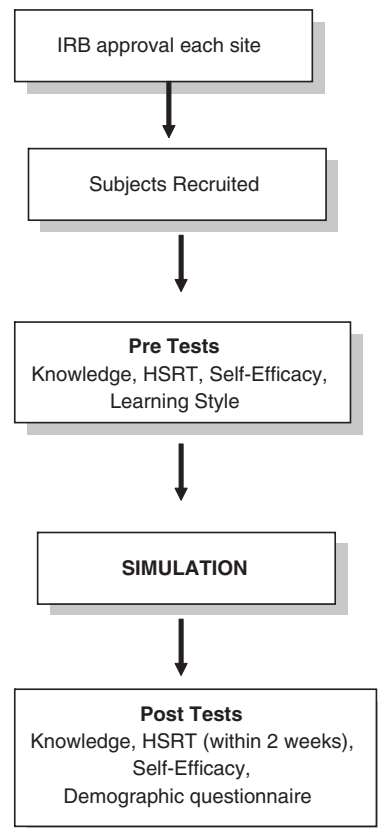

Fig. 1. Study protocol.

actually decreased slightly between testing points, though this was not statistically significant (21.79 ± 4.72 and 21.34 ± 5.08 respectively; $P = 0.76$) (Fig. 3). In this sample, the mean HSRT scores do not indicate subjects with very strong CT skills (HSRT scores ≥ 25) but rather skills "suitable for learning and development" (15–24 range) (Insight Assessment, 2011). Therefore, specific aim 1 and hypothesis 1 were not supported.

In order to determine the predictors of CT in the students who achieved the higher CT scores (≥ 25), a bivariate transformation of the HSRT pre- and post test scores was done for all subjects. "High scores" were those ≥ 25 and "low scores" were considered those 1–24. Of the original multiple variables collected in the study, the covariates included in this regression model were those with a P value < 0.05 on a Pearson's Correlation or Chi Square analysis (see Table 2) or those commonly believed to influence CT ability. This resulted in ten covariates entered into the multivariate analysis (age, gender, prior simulation exposure, previous employment as a nurse helper, time employed as a nurse helper, AE learning preference (identified learning style of 28% of sample), baseline knowledge for HF score and the self-efficacy scores of "management of HF", "prioritizing physician orders" and "managing a patient's fluid levels").

Of the sample, 71% (n = 109) of the participants scored < 25 so were in the "low" CT category while 29% (n = 45) scored ≥ 25 so were in the "high" CT category on the HSRT. Based on the logistic regression, the only statistically significant predictors for "high" CT were the variables "age" (older students [P = 0.01]), "baseline knowledge for HF" (higher pre-test knowledge scores [P = 0.04]) and the self-efficacy score of 1 ("not at all confident") in "baseline self-efficacy in managing a patient's fluid levels" (P = .02). Therefore, the hypotheses for this aim were only partially supported. Prelicensure nursing students who were older had increased CT scores after HPS but those with prior employment or simulation exposure did not. Table 3 represents the most significant of the variables entered into the analysis.

Discussion

Knowledge and CT skills are expected of prelicensure nursing students regardless of where they practice (American Association of Colleges of Nursing, 2008; Jones and Brown, 1991; National League for Nursing (NLN), 2003). Today they are more important than ever due to global changes in healthcare, nursing practice with the addition of more advanced technology and an increase in patient acuity (Daly, 1998).

Though not a new topic, (del Bueno, 1994; Laschinger, 1986; Stiernborg and Zaldival, 1996), a recent publication has highlighted a disconnect between nursing education and CT at the bedside (Benner, et al., 2010). In this report of the Carnegie Foundation study, the authors recommended that clearer links be made between nursing theory and clinical practice. Prelicensure nursing education has begun to use HPS as a means of reducing this disconnect (Lasater, 2007; Sinclair and Ferguson, 2009) despite the uncertain value.

The current literature assessing HPS impact on CT is unclear. A systematic review of eleven nursing studies assessing CT by Cant and Cooper (2009), reported nine studies using student or faculty perceptions of confidence in the ability to make the clinical judgments in lieu of actual CT measurement. Subject perceptions of improvement were interpreted as increased CT. It is not known how subject

Table 2
Demographic data on study sample (n = 154).

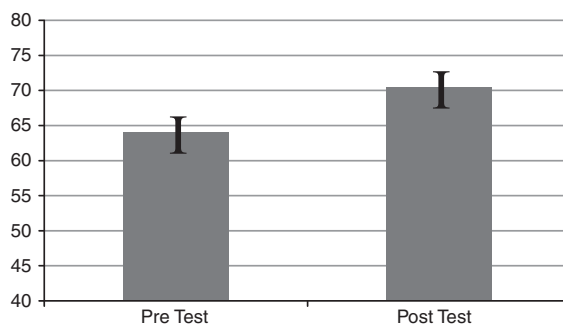| Mean age	25.7
Gender	Female (88%)
	Males (12%)

Fig. 2. Comparison of test scores: Analysis of Knowledge scores post-simulation compared to pre-simulation revealed a mean *improvement* of 6.5 points (P < 0.001).

perceptions correlate to CT improvement. The other two studies used the HSRT (Ravert, 2008; Sullivan-Mann, et al., 2009) but sample sizes were small (n = 40 and 53, respectively) and only one found any gains in CT (Sullivan-Mann, et al., 2009).

Many faculty purport HPS as a means of gaining both knowledge and CT skills, despite the lack of supportive data (Bearnson and Wiker, 2005; Jeffries and Rizzolo, 2006). While gains in knowledge after HPS are much easier to quantify either in debriefing or by written exam, gains in CT are not. In this study, despite gains in knowledge, there were no statistically significant gains in CT which is consistent with the literature (Brown and Chronister, 2009; Howard, 2007; Ravert, 2008). The pre-test mean HSRT score in this study population was greater than 21 which, while not in the highest category of CT ability, indicates a study population with strong baseline CT skills (Insight Assessment, 2011). This is likely due to the caliber of students in this study sample. Not only is entry into a nursing program highly competitive in California, the sample consisted of baccalaureate students all being in their third year of nursing education. Similar findings were seen in a large study of college students in which only slight improvements in CT were found between first and fourth years of college (Giancarlo and Facione, 2001). Thus, it is not surprising that a single HPS had no effect on CT, as such skills may take years to accomplish and are likely to be due to a multitude of variables.

Despite the lack of improvement in CT, faculty may also be interested in knowing the predictors of higher CT scores in order to maximize CT opportunities. The logistic regression in this study found "age" (older students), "baseline HF knowledge" (higher pre-test knowledge scores) and "low self-efficacy in managing a patient's fluid levels" (low confidence) to be predictive of higher CT. Interestingly, HSRT criterion validity studies done with college nursing students did not find age or scholastic ability to be predictive of greater CT (Facione and Facione, 1997, 2008). The difference in this sample may be due to the fact that there was one cohort of students who
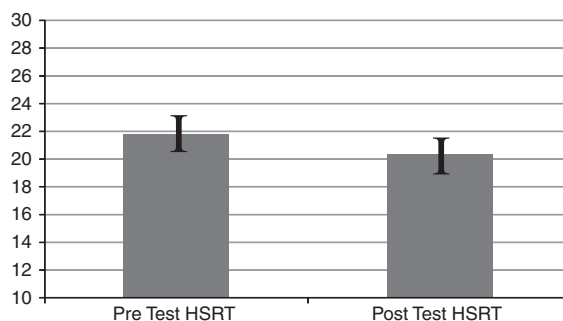
Fig. 3. Comparison of HSRT scores: Analysis of HSRT total score post-simulation compared to pre-simulation revealed a mean *decrease* of 0.45 points (P = −.76).

Table 3
Study descriptives, univariate and multivariate values.

Covariate	Descriptives	Univariate P-value	Multivariate P-value	B	Exp (B)
Age (years)	25.66 ± 6.75	0.008	0.011*	0.065	1.067
Gender:					
Females	(135) 88%	0.825	0.668	–	–
Males	(19)12%				
Baseline knowledge score	64.87 ± 12.19	0.121	0.039*	0.035	1.036
Baseline SE: prioritizing physician orders	2.55 ± 0.85	0.497	0.670	–	–
(1) Not at all confident	(16) 10.4%	0.183	0.383	–	–
(2) Slightly confident	(15) 35.7%	0.948	0.791	–	–
(3) Moderately confident	(69) 44.8%	0.475	0.690	–	–
(4) Very confident	(11) 7.1%	0.599	0.924	–	–
(5) Extremely confident	(3) 1.9%	–	–		
Baseline SE manage patient's fluid levels	2.62 ± 0.98	0.026*	0.022*	–	–
(1) Not at all confident	(11.7) 11.7%	0.010*	0.061	2.49	12.13
(2) Slightly confident	(54) 35.1%	0.203	0.153	1.84	6.30
(3) Moderately confident	(55) 35.7%	0.022*	0.529	0.089	2.25
(4) Very confident	(22) 4.3%	0.457	0.485	0.929	2.53
(5) Extremely confident	(5) 3.2%	–	–	–	–
Baseline SE: management of HF	1.98 ± 0.88	0.041*	0.116	–	–
(1) Not at all confident	(55) 35.7%	0.074	0.106	–	–
(2) Slightly confident	(53) 34.4%	0.912	0.767	–	–
(3) Moderately confident	(40) 26.0%	0.264	0.201	–	–
(4) Very confident	(6) 3.9%	–	–		
(5) Extremely confident	0				

SE: self-efficacy
* Statistically significant at P<.05.

were working toward their second baccalaureate degree whose mean age is higher than the average undergraduate college student. However, scholastic ability in this study is only reflected by the pre-test for HF knowledge and was not based on a student's grade point average (GPA) as in the criterion study. Therefore, for the purpose of this study, it follows that those who had higher scores on this assessment would be better critical thinkers. Finally, low "self-efficacy in managing a patient's fluid levels" being predictive for higher CT may reflect a student's ability to more accurately appraise their skill level. While self-efficacy is important for self motivation, high self-efficacy or overconfidence, can be detrimental to the safety of patients. A student or new nurse who is overconfident may believe that they know the answers and may not be prepared to think through clinical dilemmas or ask for assistance. Thus, based on the lack of experience of a prelicensure nursing student, faculty should expect lower self-efficacy in some areas and be alert to unrealistic high self-efficacy as it does not correlate to knowledge and may impact patient care. Unfortunately, there is no data which identifies the ideal level of self-efficacy in prelicensure nursing students. Further study is clearly warranted.

Lack of measured change in CT may also be due to the instrument (Insight Assessment, 2011). Though commonly used in studies of nursing students, it may not be the best instrument to measure CT change after a HPS experience. Conversely, a single HPS experience may have minimal impact on a prelicensure nursing student's CT skills. Further study should evaluate the "dosing" of HPS needed to make an impact on CT as the current literature is inconclusive in this area (Ravert, 2008; Sullivan-Mann, et al., 2009). Moreover, changes in CT may not be the outcome faculty should be striving for. HPS is inherent with problem solving opportunities for students such that CT skills are applied. Since the ability of a nurse to critically think is vitally important to safe patient care, the integration of problem solving into the HPS scenarios and the evaluation of the student's CT *during* the HPS may be more valuable to the faculty.

In conclusion, despite knowledge gains after a single HPS experience, gains in CT ability did not occur. Predictors of higher CT scores included greater age, higher baseline knowledge and low self-efficacy in the "management of a patient's fluid status". The effects of increasing the "dose" of simulation or repeating the same simulation are areas for further research. Until evidence evolves on the effect of HPS on changes in CT, faculty should not assume gains in knowledge equate to improvements in CT. However, they can be reassured a student's age, knowledge and more realistic self-efficacy appraisal are predictors for higher CT ability.

Study Limitations

Efforts were made to minimize study limitations though some were unavoidable. For the lecture component of the course at each research site, different resident faculty gave their usual cardiac lecture which included HF. To eliminate study bias, faculty not involved with the study did the lecture at the home site of the principal researcher. In addition, the emphasis on HF may have varied from school to school as it was part of a larger, cardiac topic lecture. However, school membership was not a significant predictor of HF knowledge or CT in this study.

The timing of the second HSRT test for CT was offered for up to two weeks post intervention in order to prevent test fatigue. While it is possible a student encountered a HF situation in their clinical rotation during this time, none were reported and most took this assessment within one week. Additionally, study subjects did not participate in any other HPS events during this time frame.

Students may have had different and unequal clinical experiences in HF. Attempts were made to control this by scheduling the study within three weeks of the lecture at each site. Contamination of the study content may have occurred with students discussing content of the simulation amongst themselves (cross talk) despite confidentiality agreements. This was only apparent at the end of the last study day at one site.

Previous simulation experiences differed slightly between the groups as one of the four study cohort had experienced up to 3 HPS experiences in other courses. This "dosing" effect was included in the analysis for CT without evidence of effect. All students were

oriented to the HPS manikin and the environment prior to the simulation to decrease the effect of this limitation.

Conclusion

This study has demonstrated simulation to be an effective learning modality for a clinical situation in HF in prelicensure nursing students. It also clearly identifies value to students who may not be exceptionally strong critical thinkers. This is great news for educators as many have already invested in expensive simulation devices and programs as well as for others who were waiting for evidence of HPS value. However, further study is necessary in order to determine optimal preparation and simulation dosing for improved knowledge scores and any further improvements in CT.

Acknowledgments

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