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INSTRUCTIONAL DESIGN AND ASSESSMENT

High-Fidelity Patient Simulation Series to Supplement Introductory Pharmacy Practice Experiences

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Objective. To introduce a high-fidelity simulation series into a 5-year doctor of pharmacy (PharmD) curriculum to demonstrate a hybrid model for introductory pharmacy practice experience (IPPE) delivery.
Design. Fourth-year pharmacy students at a satellite campus participated in a 6-week high-fidelity patient simulation series in which small groups of students worked with members of a patient care team to care for patients in the following scenarios: asthma exacerbation, acute decompensated heart failure, and infective endocarditis with a subsequent anaphylactic reaction to the antibiotic. Fourth-year pharmacy students at the main campus who did not participate in the simulation served as a comparator group.
Assessment. Students' scores on a knowledge-based post-simulation quiz were significantly higher than scores on the presimulation quiz ($p < 0.05$). Knowledge retention was significantly higher among the simulation participants than students in the comparator group ($p = 0.004$). The majority (76%) of students felt more confident "making clinical recommendations to a healthcare provider" after completing the simulation series ($p = 0.01$).
Conclusion. High-fidelity patient simulation is an effective active-learning strategy to augment IPPEs that allows students to apply clinical skills in a realistic but low-risk patient care setting.

Keywords: simulation, patient simulation, pharmacotherapy, experiential education, introductory pharmacy practice experience

INTRODUCTION

The shortage of pharmacists in the United States has prompted increases in class sizes and the number of satellite and distance programs at colleges and schools of pharmacy, as well as the creation of new colleges and schools of pharmacy.[1-3] This rapid expansion has created a burden on existing clinical experiential sites.[4-6] The Accreditation Council on Pharmacy Education (ACPE) requires at least 1440 hours of advanced pharmacy practice experience (APPE).[7] Skrabal and colleagues described that, on average, colleges and schools of pharmacy require approximately 1,000 APPE sites per year for a class size of 100 PharmD students.[8] Experiential coordinators often experience difficulty placing students in non-community-based clinical sites.[9] Compounding the problem is the ACPE requirement to provide a minimum of 300 hours of introductory pharmacy practice experience interspersed throughout the first through third years of the pharmacy curriculum.[7]

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Colleges and schools of pharmacy must explore other acceptable models for experiential education to reduce the burden on experiential sites.[10] Simulation training may be one such model to provide students with the opportunity to apply didactic knowledge and reduce the burden on experiential sites. High-fidelity simulation has been used as a successful active-learning tool to teach pharmacotherapy concepts, advanced cardiac life support skills, and other clinical skills.[11-16] High fidelity simulation closely mimics a real life patient scenario directly integrating learners and computerized manikins programmed to display predetermined clinical and verbal responses in a patient care setting as opposed to low-fidelity simulation that uses verbal or written descriptions of a patient case. High-fidelity simulation has been widely studied in the medical and nursing literature as a means to teach technical, clinical, and teamwork skills.[17-27]

The inclusion of simulation in IPPEs has gained acceptance and is encouraged by ACPE as described in the Policies and Procedures for ACPE Accreditation of Professional Degree Programs – January 2010.[7] Addendum 1.3, Simulations for Introductory Pharmacy Practice Experiences – Approved June 2010, states:

> Simulation may not be utilized to supplant or replace the minimum expectation for time spent in actual

pharmacy practice settings as set forth in the previously established policy. Beyond the majority of time in actual pharmacy practice settings, colleges and schools may utilize simulation to account for no greater than 20% (e.g., 60 hours of a 300 hour IPPE program) of total IPPE time.

In this paper, we will describe and assess a hybrid model of an IPPE in which both direct patient care and high-fidelity simulation are used to expose students to acute clinical situations.[11-16]

DESIGN

The University of Missouri-Kansas City School of Pharmacy has a satellite campus approximately 120 miles away from the main campus. The satellite campus enrolls about 28 PharmD students in each academic year; about 140 students distributed within the 5-year professional program. The students are required to complete all 4 years of didactic coursework and IPPEs at the satellite campus. Students primarily enroll in APPEs in Missouri but are able to select APPEs in various locations throughout the nation and internationally.

Fourth-year students at the satellite campus were enrolled in a longitudinal clinical IPPE that provided 160 hours of patient care experiences over 2 semesters. The IPPE ran simultaneously with the capstone therapeutics course, Pharmacotherapy, to provide students with the opportunity to apply didactic principles in the fourth year of a 5-year curriculum. Both the satellite and main campus students received identical lectures via video conferencing technology. During the 2009-2010 academic year, IPPE sites for students at the satellite campus were available at a university hospital and a veterans' affairs hospital. IPPE practice areas included inpatient adult medicine, family medicine, and medical intensive care.

In addition to their direct patient care responsibilities, students were enrolled in a high-fidelity simulation series that began in October 2009. The simulation series provided 9 contact hours; however, in compliance with the 2007 ACPE standards and guidelines, these were not counted towards the contact hour requirements for the IPPE. The simulation series was held at the university's clinical simulation center, a 10,000-square foot facility consisting of simulation, observation, and instruction rooms. The simulation scenarios were scheduled to occur every 3 weeks.

IPPEs are designed to provide students with the opportunity to design, implement, monitor, evaluate, and adjust pharmacy care plans that are patient-specific and evidence-based. These care plans should also address health literacy, cultural diversity, and psychosocial issues. The objectives specific to the simulation series were to better equip students to serve effectively as a member of a multidisciplinary team and expose them to acute clinical situations that otherwise may not be presented during their IPPEs. Detailed objectives and competencies are outlined in Table 1.

In order to achieve the stated objectives, 3 distinct simulation scenarios were developed: asthma exacerbation, acute decompensated heart failure, and infective endocarditis with a subsequent anaphylactic reaction to the antibiotic. These specific diseases were chosen due to the emergent nature of their presentation and the capability of the high-fidelity manikin to illustrate various signs and symptoms, physiologic changes, and responses to medications administered. Each simulation was scheduled during the timeslot allotted for the IPPE and within 1 week of the corresponding pharmacotherapy lecture. Simulation scenarios were written by individual faculty members and then revised as a group to establish uniformity. The

Table 1. Expected Outcomes and Learning Objectives for a High-Fidelity Patient Simulation Series for Doctor of Pharmacy Students

Knowledge	**To improve the student's ability to**. . .
	Identify medication errors
	Recall appropriate medication dosages
	Identify drug-drug interactions
	Describe physiologic effects of drugs on the human body
Skills	**To improve the student's ability to**. . .
	Create a care-plan for a patient with asthma
	Create a care-plan for a patient with heart failure
	Create a care-plan for a patient with infective endocarditis
	Create a care-plan for a patient with anaphylaxis from an antibiotic
	Utilize drug information resources to find appropriate answers
	Communicate with physicians, nurses, and other healthcare providers
	Calculate correct drip rates for intravenous medications
	Write medication orders in a patient chart
	Analyze clinical cases in a limited time frame
	Identify lab abnormalities
	Apply evidence based treatment guidelines to clinical situations
	Educate patients and caregivers about pharmacologic and non-pharmacologic issues
Attitudes	**To increase the student's**. . .
	Awareness of medication errors
	Understanding of the physiologic effects of the medications
	Self perceived assessment of his/her clinical skills

scenarios incorporated drug-drug and drug-disease interactions, intravenous drip concentration and rate calculations, medication recommendation requests, physiologic changes, responses to medications, and patient education. Scenarios included roles for a physician, nurse, patient (simulation manikin), and family member, as well as for PharmD students. The role of the physician was played by pharmacy faculty members, the role of the nurse was played by licensed nurses, and the role of the family members was played by standardized patients who were trained and provided with specific cues to follow during the simulation. Standardized patients also were trained to display emotional responses and concern regarding the patient's well-being, home medications, and dietary needs during the scenario to add an extra layer of complexity and realism to the experience.

A number of vague and specific cues were incorporated into each case to prompt interventions by the students. The approach followed Benner's theory of teaching novice learners.[28,29] The vague cue provided students with subtle guidance regarding the care of the patient and was followed by a specific cue if the vague cue was not detected. Select vague and specific cues from each simulation case are provided in Table 2.

High-Fidelity Patient Simulators

The S3000 HAL Mobile Team Trainer (Gaumard Scientific, Miami, FL) was programmed to simulate the clinical scenarios. The manikin simulated various signs and symptoms including wheezing, cyanosis, angioedema, palpable pulse, heart sounds, apnea, cheyne-stokes, and stridor. Through the use of moulage, the manikin also simulated splinter hemorrhages, Osler's nodes, peripheral edema, and jugular venous distention. The manikin had the capability of providing limited verbal responses. For responses that were not preprogrammed into the manikin, the standardized family member provided additional information as needed. Simulation center staff members remotely operated the manikin, initiating preprogrammed changes in vital signs and physiologic findings.

Simulation Sequence

Students were divided into 10 teams of 2 to 4 students each. The 3 simulation scenarios consisted of a case preparation period, the clinical encounter, and a debriefing period, each 30 minutes in length. Two student teams proceeded simultaneously through the entire 90-minute simulation experience, first sharing the case preparation room, then separating into 2 identical simulation rooms, and finally reconvening in the debriefing room (Figure 1). During the case preparation period, students completed a presimulation quiz individually and then were given the patient's history and physical findings and instructed to develop an assessment and care plan as a group based on SOAP (subjective, objective, assessment, plan) note principles. Students were allowed to use their class notes and also received disease-specific guidelines to assist in the development of the treatment plan. Students also had access to Lexi-Comp Online (Lexi-Comp, Inc., Hudson, OH) during the simulation as a drug information resource. During the debriefing, either a pharmacy faculty member or resident provided feedback based on their observations, shared clinical pearls from the scenario, and answered questions posed by the students regarding the

Table 2. Example Vague and Specific Cues Used In Each Simulation Case

Opportunity for Intervention	Vague Cue	Specific Cue
Asthma case: Recommendation regarding first line medication during an acute exacerbation	Nurse says to the student "The intern physician was paged urgently. I think he wrote for theophylline for this acute attack. What do you think?"	Physician says, "No, I just looked it up in the guidelines, theophylline is not recommended for an attack." Then asks "What do you recommend to treat this exacerbation?"
Decompensated heart failure case: Physician continues the patient's home medications including metformin (which is contraindicated) and holds the patient's carvedilol (the patient has tachycardia and is hypertensive)	Physician says to the student "Can you review the rest of these admit orders before they are sent to the pharmacy please? I am open to suggestions."	Physician says "Any changes you suggest for his home medications?"
Infective endocarditis case: Physician writes order for nafcillin and continues the patient's home warfarin. The patient's INR is 2.0	Physician says to the student "Go ahead and write the order in the chart and I will sign it. (chart contains home medications)	Physician says "Just got a page from pharmacy about a drug interaction. Any thoughts?"

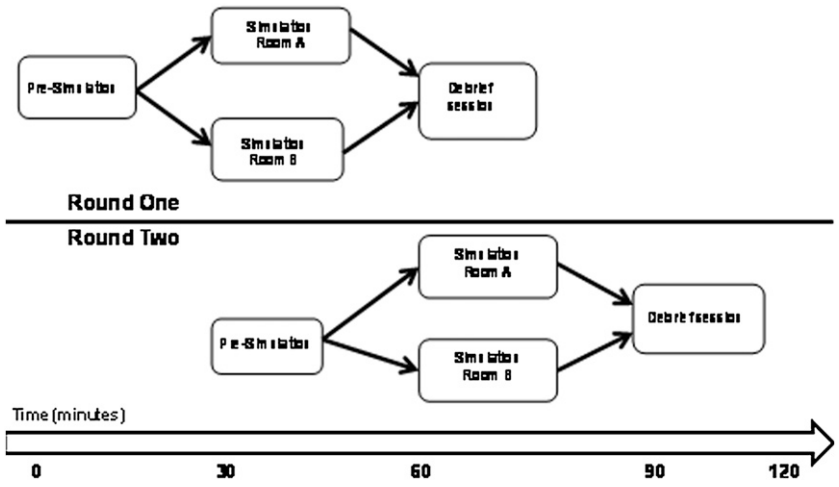

Figure 1. Pharmacy students' progression through a simulation experience. Two rounds of 2 student teams (4-6 students total) were able to complete the entire experience in 120 minutes. Student groups continued to begin the experience in this manner until five rounds had been completed. By having two simulations occurring simultaneously 28 students were able to complete the simulation in 4.5 hours.

scenarios. Students also reflected on the simulation and discussed their role on the patient care team. This investigation was reviewed and approved by the university social sciences investigational review board.

EVALUATION AND ASSESSMENT

Following each simulation exercise, students completed a postsimulation quiz. The 5-15 question presimulation and postsimulation quizzes were specific to each simulation scenario and used to gauge whether students' knowledge was enhanced through participation in the simulation. To evaluate long-term retention of disease-specific knowledge, an identical quiz was administered 3 months later. Students enrolled on the main campus also completed the follow-up quiz and served as a comparator group. These students received identical didactic lectures but did not participate in the simulation series.

Student team performance was assessed using a checklist which consisted of vague and specific cues, corresponding expected answers, a "yes/no" checkbox, and a comment section. A pharmacy faculty member and resident who were assigned to each team as observers completed the checklist during the simulation. The checklists were used to provide summative feedback to the teams during the debriefing session. The checklists also were provided to the individual IPPE instructors to determine any areas of weakness that could be addressed through direct patient care activities.

A confidence survey instrument was used to assess changes in 10 domains as students progressed through the simulation series (Table 3 and 4). An evaluation tool also was administered to determine student agreement with various statements and satisfaction with components of the simulation series (Table 5 and 6). The survey tool utilized a 4-point Likert-scale and freeform comments.

Predictive Analytics SoftWare (PASW) Statistics, version 17.0.2 (Chicago, IL), was used for statistical analysis. A paired *t* test alpha set to 0.05 was used to analyze changes in pre- and post- quizzes. The Wilcoxon sign-rank test was used to analyze the confidence survey responses.

Twenty-eight students were enrolled in the simulation experience with 27 students completing all assessment materials. All scores on knowledge-based quiz items at the completion of the series demonstrated significant improvement compared to the presimulation quiz ($p < 0.001$) (Figure 2). Knowledge retention measured by the 3-month follow-up quiz scores was significantly higher among simulation participants compared to students in the control group (50.8% vs. 48.7%, $p = 0.004$). Of note, 76% of students felt more confident in "making clinical recommendations to a healthcare provider" at the end of the simulation series ($p = 0.01$). Additionally, 70% of students also felt more confident "identifying the physiologic effects of medications on the human body" postsimulation ($p = 0.01$). Student confidence regarding their self-perceived skills is summarized in Table 3 and 4. Table 4 demonstrates a significant positive change in the confidence levels as matched by unique student identifiers. For example, 22% of students indicated they were "somewhat confident" using drug resources before the simulation and shifted to "confident" after the simulation series. Ninety-six percent of participants were in strong agreement that simulations should be offered each year during the IPPE and 93% felt simulation

Table 3. Change in Pharmacy Students Confidence Level After Completing a High-Fidelity Patient Simulation Series

Question	Percentage of Students With a Net Increase in Confidence	*P*[a]
Using drug information resources to find appropriate answers	48	0.01
Identifying medication errors	70	< 0.01
Communicating with physicians, nurses and other healthcare providers	78	< 0.01
Making clinical recommendations to a healthcare provider regarding medication regimen adjustments	78	< 0.01
Working up clinical cases in a limited time frame	67	< 0.01
Writing drug orders in a patient chart	62	0.03
Looking up patient information in an electronic medical record	52	0.023
Calculating drip rates for intravenous medications	56	0.003
Identifying drug-drug interactions	78	< 0.01
Identifying physiologic effects of drugs on the human body	70	0.011

[a] P values demonstrate a change in the positive direction with matched student identifiers. An example demonstrating the change in each student's confidence level is displayed in Table 4

training enhanced clinical learning in comparison to standard lectures alone (Table 5). Additionally, 93% of students were either satisfied or very satisfied with the simulation series. However, 14% were dissatisfied by the number of simulations offered during IPPE. Freeform comments revealed that these students would have preferred more simulations during IPPE (Table 6).

DISCUSSION

The positive responses on student evaluations, improvements in students' self- perceived skills, and improvements in pre- and postsimulation quiz scores indicate that high-fidelity simulation is a useful active-learning tool that allows novice learners to apply therapeutic concepts and improve self-confidence in clinical skills. This is consistent with the findings of other published studies which showed promising results in using high-fidelity simulation to teach students clinical skills, such as interpretation of electrocardiograms, evaluation of blood pressures, and the development of pharmacy care plans.[11-16]

One limitation of this study was that it did not compare the effects of direct patient care versus simulation training on student confidence and improvement in clinical skills. This would have provided valuable information regarding the utility of simulation during IPPEs. However, the small number of students on the satellite campus did not allow for such a comparative study. Another limitation was that there was no way to determine whether students' participation in direct patient care activities in their IPPEs and knowledge and skills learned in subsequent pharmacotherapy courses may have contributed to the significant increase in their confidence in self-perceived skills seen after completion of the simulation series. However, pre- and postsimulation confidence surveys were completed within a 6-week period, minimizing the potential effect that the semester-long pharmacotherapy course may have had. Additionally, the study was unable to show whether simulation-based teaching enhances long-term knowledge retention. While this study did find significantly higher scores on the follow-up quiz

Table 4. Statistical Analysis of Confidence Survey (Example Question 1: How confident do you feel "using drug information resources to find appropriate answers?")

Pre Course Rating	Post Course Ratings, No. (%)			
	Not Confident	Somewhat Confident	Confident	Very Confident
Not Confident	0	0	0	0
Somewhat Confident	0	2 (7%)	6 (22%)	2 (7%)
Confident	0	2 (7%)	7 (26%)	5 (19%)
Very Confident	0	0	1 (4%)	2 (7%)

Net Increase in Pre-/Post Confidence Rating: 48%
Unchanged Pre-/Post Confidence Rating: 41%
Decrease in Pre-/Post Confidence Rating: 11%

Table 5. Pharmacy Students' Evaluation of Intoductory Pharmacy Practice Experience Augmented With a High-Fidelity Patient Simulation Series (N=27)

Statement	Median Response	Percentage Who Agreed or Strongly Agreed[a]
Time off given during IPPE to study for the cases was adequate.	3.0	89
The simulation exercises helped reinforce didactic course materials.	3.0	96
I better understand the physiologic effects of the medications.	4.0	96
I am now more aware of medication errors due to the simulation exercises.	4.0	96
Simulation is a helpful tool for training for PharmD students.	4.0	96
I would prefer more courses with a simulation component.	4.0	93
The simulations were a positive experience.	4.0	96
Compared to standard lectures, I learn clinical patient care better using simulated patient scenarios.	4.0	93
Simulation learning should be offered each year to IPPE students.	4.0	96

[a] Responses based on a 4-point Likert scale on which 1 = strong disagree and 4 = strongly agree

completed by the participating students vs. the comparator group, it is difficult to determine whether this was truly related to participation in the simulation series. A crossover study design would have provided better insight into this question.

Based on the findings of improved knowledge, confidence, and self- perceived skills, we demonstrated a hybrid model of IPPE that used simulation to provide patient experiences that would otherwise not be guaranteed during IPPEs. Experiences that could be provided using high-fidelity simulation include providing care for special patient populations, patients with seasonal conditions, and patients suffering adverse effects from medications, as well as providing care in emergent situations and disaster-related scenarios. These simulated experiences would allow students to develop confidence in an environment that does not compromise patient care prior to starting APPEs.

CONCLUSION

Simulation training allows the educator to bridge the gap between didactic coursework and "real-life" experiences by putting students in a realistic, controlled environment without compromising patient safety. Additionally, simulation training coupled with direct patient care experiences can provide a suitable model for IPPEs and may alleviate some of the burden on experiential sites.

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Table 6. Pharmacy Students Satisfaction With a High-Fidelity Patient Simulation Series (N=27)

Statement	Median Response[a]	Percentage of Students Satisfied or Very Satisfied
The pre-simulation orientation	3	93
The simulation exercise overall	4	93
The asthma simulation	4	93
The congestive heart failure simulation	3	93
The endocarditis simulation	4	93
The debrief session after each simulation	3	93
The length of each simulation exercise	4	93
The number of simulations	3	86
Resources available during simulation	3	93

[a]Responses based on a 4-point Likert scale on which 1 = very dissatisfied and 4 = very satisfied.

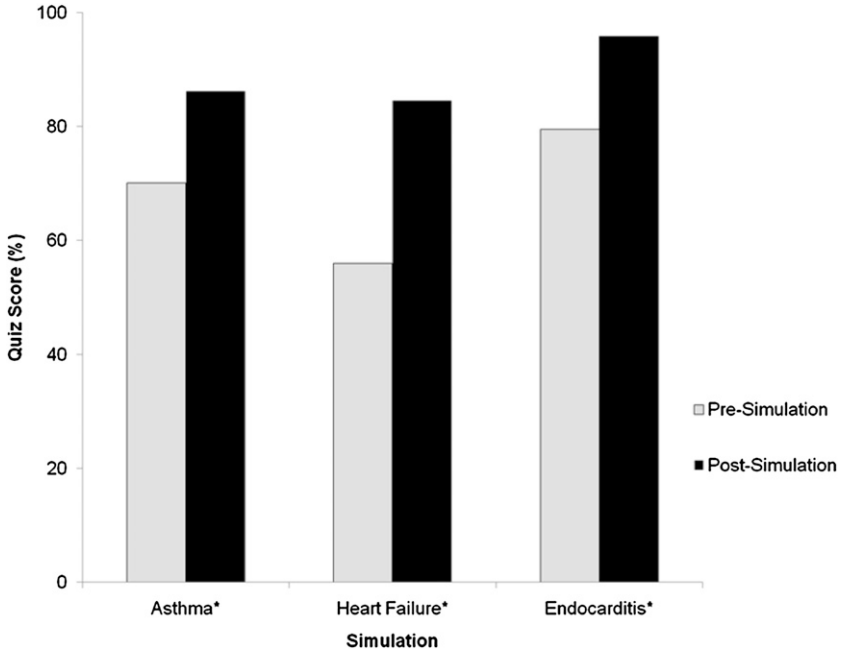

Figure 2. Pharmacy students' quiz scores pre- and postsimulation (*$p < 0.01$).

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