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Improving Student Pharmacists' Learning Through the Use of Pediatric Simulation

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OBJECTIVE The purpose of this study was to assess the effect of low-fidelity simulation on students' confidence, knowledge, and skills in pediatric physical assessments, and to compare students' interest ratings of topics and effectiveness of learning activities between students' who experienced simulation and those who did not.

METHODS Within a pediatric elective, a vital signs and physical assessment activity was re-designed to incorporate a low-fidelity heart and breath sounds simulator. Students rated their confidence in completing 9 different physical assessment skills before and after the activity and assessment. Students' perspectives of the activity were also assessed. Course evaluation surveys were compared with prior course offerings (without simulation) to determine a change in students' interest ratings of the topic and effectiveness of learning activities. The Wilcoxon signed rank test, thematic analysis, and descriptive statistics were used to analyze outcomes.

RESULTS All 106 second professional year students in the elective completed the pre- and post-simulation surveys and course evaluations for 3 offerings. Students' post-simulation average confidence scores increased statistically on all 9 skills compared with pre-simulation scores. All students agreed or strongly agreed "the lecture and simulation activity done in class helped me overcome challenges I had with learning the skill." Students (98%) successfully demonstrated competency on the formal assessment. Compared with previous course offerings, students reported higher interest ratings in the topics and instruction effectiveness when simulation was incorporated into the activity.

CONCLUSIONS Low-fidelity simulation is an effective teaching and learning approach to increase students' confidence, knowledge, and interest in pediatric vital signs and physical assessment.

ABBREVIATIONS P2, second professional year; SBLE, simulation-based learning experience

KEYWORDS education; pediatric; pharmacy; physical assessment; simulation

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Introduction

Simulation is an educational tool to enhance student learning. Simulation-based learning experiences (SBLE) are defined as "an array of structured activities that represent actual or potential situations in education and practice. These activities allow participants to develop or enhance their knowledge, skills, and attitudes, or to analyze and respond to realistic situations in a simulated environment."[1] These simulations serve as an alternative to a real patient and allow students to learn in a realistic, clinical environment. They are also beneficial for consistency and the ability to provide the exact same scenario to a plethora of students and assessing their abilities in a standardized manner. Lastly, simulations can provide a safe environment where students may make incorrect decisions without negative patient care consequences. SBLEs align with constructivist theories of learning, such as Lave and Wenger's[2] situated learning. They posit that authentic learning experiences are useful for helping learners transition from novices to mastery and members of the community of practice.

Pediatric patients are difficult to represent in classroom teaching. Simulation-based models are an alternative to having actual patient representatives. Integrating simulation provides an experiential level of teaching and assessment within classroom courses and allows students to learn and practice physical assessment skills, such as listening to real-life heart rates and breathing sounds. Simulations may include a simulator, defined as a setting, device, computer program, or system that performs simulation.[1]

Simulators can be described as low- or high-fidelity. Low-fidelity simulators may be computer- or paper-based and may not need external control or programming such as case studies or task trainers (e.g., model arm to practice intravenous line insertion), whereas high-fidelity simulators are highly realistic and interactive, such as mannequins that mimic human body functions and respond clinically to interventions in a simulated environ-

ment.[1] A simulator of any level of fidelity can be incorporated into activities to increase students' confidence and competence in technical skills.[3] Simulation has been described as offering a "contemporary approach to teaching and learning in pharmacy education"[4] and as a "valuable addition to traditional teaching approaches."[5]

The Accreditation Council for Pharmacy Education states in the 2016 Standards for the doctor of pharmacy degree that students should have access to educational simulation capabilities.[6] The American Association of Colleges of Pharmacy states assessing a patient's signs and symptoms is a core entrustable professional activity for a new pharmacy graduate.[7] Furthermore, incorporation of simulation-based learning exercises prior to advanced pharmacy practice experiences in the terminal portion of the curriculum is recommended in the Joint Statement on Pediatric Education at School of Pharmacy by the American Association of Colleges of Pharmacy Pediatric Pharmacy Special Interest Group, American College of Clinical Pharmacy Pediatric Practice and Research Network, and Pediatric Pharmacy Association.[8] In evaluating pediatric pharmacy education, only 2 pharmacy programs have published outcomes from simulation activities; both described a high-fidelity simulation laboratory exercise in a pediatric elective course.[9,10]

Although SBLEs have increased over the years, our school of pharmacy has only provided a required adult blood pressure simulation activity within the curriculum for all students. Additionally, not all pharmacy programs have access to or funds for a high-fidelity simulator. Beginning in 2019 within a pediatric elective, a vital signs and physical assessment activity was re-designed to incorporate low-fidelity simulation. Our hypothesis was that exposing student pharmacists to real pediatric patient heart and lung sounds through an affordable simulator and developing an engaging learning activity would increase their confidence in completing a physical assessment skill and interest in this and other pediatric topics. The primary objective of this study was to assess the effect of low-fidelity simulation on students' confidence, knowledge, and skills in pediatric physical assessments. Secondary outcomes were to compare students' interest ratings of topics and effectiveness of learning activities between students' who experienced simulation and those who did not in the pediatric elective course.

Materials and Methods

Three course offerings of an "Introduction to Pediatrics" elective was taught in Spring and Fall 2019 and Fall 2020 to second professional year (P2) student pharmacists who participated synchronously between a main and satellite campus. These course offerings included a new, re-designed vital signs lecture that included a simulation activity for pediatric physical assessment using a heart and breath sounds simulator. The Heart and Breath Sounds Simulator (TUTOR-MS Data Selector, Pinnacle Technology Group, Inc, Ottawa Lake, MI) is a hand-held simulator that plays different sounds by plugging cards into the unit.[11] The Infant and Pediatric breath and heart sounds cards were used for this activity. Each card provides 16 heart and lung sounds for newborns, infants, and children of various ages and includes abnormalities or symptoms such as ventricular septal defect, wheezing, and stridor. Sounds are heard through external sounders, of which up to 15 sounders can be attached to the simulator unit. Each student listens to a sounder through their stethoscope, and all students hear the same sound. The unit can also be plugged into external speakers for audience listening.

For the activity, first, a pre-brief was conducted by the instructor. The instructor then played a recording of the simulator sounds through speakers and explained the sounds to the class. Next, students listened via stethoscope to adult heart rates and breath sounds on each other or themselves for an adult comparison. Students then individually listened to various pediatric heart and lung sounds with their stethoscopes using the simulator as the instructor facilitated the activity. During the activity, the instructor would explain each sound again and then alternate between sounds allowing the students to compare them for the different ages. Next, the instructor played a few selected sounds via the simulator and asked the students to identify the sound or state if the breathing or heart rate was for a younger or older patient. Lastly, the instructor provided a debrief for the students.

The 2 faculty members who teach the elective are pediatric residency or fellowship trained pharmacists with Pediatric Pharmacy board certification credentials. The primary instructor conducted the activity in-person on the main campus with synchronous videoconferencing to the satellite campus for all sessions. The second instructor conducted the identical portion of the activity where students listened with their stethoscope to the simulator sounders in-person on the satellite campus.

Pre- and post-simulation confidence surveys on Qualtrics (Qualtrics Survey Software, Provo, UT) were distributed electronically via the course learning management system to all students in the 3 iterations of the course. Students voluntarily completed the survey and rated their confidence (1 = not confident, 2 = somewhat confident, 3 = very confident) in completing 9 different physical assessment skills, which involved distinguishing a heart rate and breathing rate in various ages of pediatric and adult patients and identifying abnormal lung sounds (e.g., wheezing). The survey was distributed before and 2 weeks after the activity and assessment.

Knowledge assessment occurred as part of a quiz and asked the students to distinguish a heart rate and breathing rate of various ages of pediatric patients and identify an abnormal lung sound (e.g., stridor). In this assessment, students individually listened to a recorded audio clip through the online examination software and

Table. Pre- and Post-Simulation Student Confidence Ratings (N = 106)

Question and Skill	Level of Confidence		p value
	Pre-Simulation (n=106)	Post-Simulation (n=106)	
Q1. Distinguishing an adult heart rate versus a pediatric heart rate			
Simulation Rating, mean ± SD*	1.64 ± 0.62*	2.90 ± 0.30	<0.001
Not Confident, n (%)	46 (43)	0 (0)	—
Somewhat confident, n (%)	52 (49)	11 (10)	—
Very confident, n (%)	8 (8)	95 (90)	—
Q2. Distinguishing a newborn, 7-month, 1-year, and 6-year-old's heart rate			
Simulation Rating, mean ± SD*	1.18 ± 0.41	2.58 ± 0.51	<0.001
Not Confident, n (%)	88 (83)	1 (1)	—
Somewhat confident, n (%)	17 (16)	42 (40)	—
Very confident, n (%)	1 (1)	63 (59)	—
Q3. Identifying an abnormal heart sound in a pediatric or adult patient			
Simulation Rating, mean ± SD*	1.44 ± 0.58	2.60 ± 0.53	<0.001
Not Confident, n (%)	64 (60)	2 (2)	—
Somewhat confident, n (%)	37 (35)	38 (36)	—
Very confident, n (%)	5 (5)	66 (62)	—
Q4. Distinguishing an adult rate of breathing versus a pediatric rate of breathing			
Simulation Rating, mean ± SD*	1.77 ± 0.63	2.91 ± 0.29	<0.001
Not Confident, n (%)	36 (34)	0 (0)	—
Somewhat confident, n (%)	58 (55)	10 (9)	—
Very confident, n (%)	12 (11)	96 (91)	—
Q5. Distinguishing a newborn, 9-month and 6-year-old's rate of breathing			
Simulation Rating, mean ± SD*	1.23 ± 0.46	2.60 ± 0.49	<0.001
Not Confident, n (%)	84 (79)	(0)	—
Somewhat confident, n (%)	20 (19)	42 (40)	—
Very confident, n (%)	2 (2)	64 (60)	—
Q6. Identifying an abnormal lung sound in a pediatric or adult patient			
Simulation Rating, mean ± SD*	1.40 ± 0.56	2.74 ± 0.47	<0.001
Not Confident, n (%)	68 (64)	1 (1)	—
Somewhat confident, n (%)	34 (32)	28 (26)	—
Very confident, n (%)	4 (4)	77 (73)	—
Q7. Identifying rhonchi			
Simulation Rating, mean ± SD*	1.17 ± 0.47	2.44 ± 0.57	<0.001
Not Confident, n (%)	92 (87)	4 (4)	—
Somewhat confident, n (%)	10 (9)	51 (48)	—
Very confident, n (%)	4 (4)	51 (48)	—
Q8. Identifying wheezing			
Simulation Rating, mean ± SD*	1.75 ± 0.66	2.54 ± 0.57	<0.001
Not Confident, n (%)	39 (37)	4 (4)	—
Somewhat confident, n (%)	54 (51)	41 (38)	—
Very confident, n (%)	13 (12)	61 (58)	—
Q9. Identifying stridor			
Simulation Rating, mean ± SD*	1.26 ± 0.55	2.58 ± 0.57	<0.001
Not Confident, n (%)	84 (79)	4 (4)	—
Somewhat confident, n (%)	16 (15)	37 (35)	—
Very confident, n (%)	6 (6)	65 (61)	—

* 1 = not confident, 2 = somewhat confident, and 3 = very confident.

selected an answer in a multiple-choice format question. The post-simulation survey also included open-ended questions assessing students' perspectives of the activity. The Wilcoxon signed rank test was used to compare the students' confidence pre- and post-simulation ratings, with a $p < 0.05$ considered significant. The Cronbach α test was 0.78 (pre-test) and 0.85 (post-test), demonstrating good internal consistency for the survey. Thematic analysis was used for qualitative data, and descriptive statistics were used to analyze quantitative survey data.[12]

Course evaluation surveys for 2019 and 2020 were also compared with the prior course offerings (2 iterations during 2017 and 2018 without simulation) to determine a change in students' interest ratings of the topic and effectiveness of learning activities. Students ranked both their interest in each topic and learning effectiveness of each activity on a scale from 1 to 5 (least to most). Analyses were conducted using Microsoft Excel for Microsoft 365 (Microsoft Corporation, Redmond, WA).

Results

One hundred six P2 student pharmacists completed the 3 elective course offerings in 2019/2020 and participated in the simulation activity (Spring 2019, n = 40; Fall 2019, n = 31; Fall 2020, n = 35). The students were predominantly female (76%). Seventeen students were on the satellite campus (Spring 2019, n = 7; Fall 2019, n = 5; Fall 2020, n = 5).

All students (100%) completed the pre- and post-simulation surveys rating their confidence in completing 9 different skills (Table). After the simulation activity and assessment, students' post-simulation average confidence scores statistically increased on each of the 9 skills ($p < 0.001$). The percent of students who had changes in their self-reported confidence pre- and post-simulation are depicted in the Table.

In the pre-simulation survey, the most common challenge students (35%, n = 37) stated in learning these skills was the ability to distinguish heart and lung sounds between the different pediatric ages. The lack of experience in listening to these sounds in the pediatric population was the second most common challenge noted in learning these skills by students (20%, n = 21). In the post-simulation survey, students agreed (26%, n = 27) or strongly agreed (74%, n = 78) with the statement, "the lecture and simulation activity done in class helped me overcome challenges I had with learning the skill." Students rated the simulation activity as "very helpful" in learning an adult versus pediatric heart and breathing rate (97%, n = 103 heart; 98%, n = 104 breath), with all other students rating them as "somewhat helpful." When using simulation to differentiate the heart and breathing rates of various pediatric ages, most students rated the activity as "very helpful" (92%, n = 98 heart; 93%, n = 99 breath). All other students noted it to be "somewhat helpful." No student rated the simulation activity as "not helpful" for learning any skill. Most students (91%, n = 96) stated the lecture on normal heart and breathing rates and abnormal sounds was "very helpful" in learning the skills, with all others rating the lecture as "somewhat helpful."

From the open-ended responses, several themes emerged. Numerous students stated hearing the sounds in the simulation was helpful and listening through their stethoscope reinforced differentiating and identifying the heart and lung sounds compared with listening via a recording. The use of listening through a stethoscope helped them make an association of the sound with the "numbers" (normal values) provided in the vital signs chart in the lecture. Hearing the faculty member's descriptions and explanations during the activity as well as switching back and forth between 1 sound for different ages helped students distinguish the sounds. Students also stated the lecture on vital signs and "seeing the numbers" in the charts helped prepare them for the simulation activity. Most students did not have recommended changes to the simulation activity, except a few students asked for more time to listen to the sounds during class.

Recordings of the simulation sounds were available on the course's webpage in the learning management system for the students to listen to at any time after the simulation activity. Eighty-two percent of students (n = 87) stated they listened again prior to the formal assessment, where they were tested on distinguishing and identifying sounds. On the knowledge assessment, 99% (n = 105) of the students correctly distinguished the breathing rate of a 9-month-old compared with a newborn, 98% (n = 104) of students correctly distinguished a newborn's heart rate compared with a 6-year-old, and 98% (n = 104) of students appropriately identified stridor when compared with wheezing and rhonchi. Several students noted having the sounds posted and being able to play them as many times as needed was beneficial for learning the skills.

On the course evaluations, students' interest ratings of the topic and effectiveness of learning activities were higher when simulation was incorporated into the activity compared with previous students' perspectives of similar topics and activities without simulation in the prior course offerings. Data are presented as the average rating (SD) out of 5. Vital signs, 4.60 ± 0.68 was ranked as the highest topics of interest in the elective course for the 2019/2020 offerings. Physical assessment, 4.37 ± 0.86, was ranked as the third-highest topics of interest in the course for the 2019/2020 offerings. Both topics were ranked higher than any topic taught in the prior course offering. For the 2019/2020 course offerings, stimulation used for teaching physical assessment, 4.59 ± 0.85, was ranked highest for effectiveness at learning the material. Vital signs taught using a lecture, 4.53 ± 0.81, was ranked second highest for

learning effectiveness. Both topics were ranked higher compared with the previous course offering, where physical assessment had an average effectiveness rating of 3.1 ± 1.3 using a video assignment and vital signs as a lecture, 3.92 ± 1.11.

Discussion

This study demonstrates that student pharmacist can increase their confidence and learn a skill using low-fidelity simulation in a classroom setting. Simulation is primarily thought of within a skills laboratory course or experiential course; however, incorporating simulation into a classroom session increases students' interest and the effectiveness of the learning activity. The students also found having access to the sounds through the learning management system after the simulation activity assisted with their learning. Formal assessment, which occurred weeks after the activity, showed students' retention of skills to differentiate pediatric heart and lung sounds. In addition, students' interest in the topics of vital signs and physical assessment and rating of the effectiveness of the learning activity was higher when simulation was incorporated with a lecture into the class session as compared with prior course offerings that included a video assignment with a lecture on the same topics. Students commented positively on how the hands-on activity put in context and reinforced the lecture content and strengthened how they learned to differentiate the sounds. Students commented they were able to differentiate learning between hearing sounds over a computer speaker versus listening with their stethoscope, which is the practical skill.

This study evaluated student outcomes of low-fidelity simulation in a pediatric elective course taught synchronously to 2 campuses. A 2018 survey of pharmacy schools in the United States (n = 27 responses) reported only 1 pediatric pharmacy elective course that used simulation in which the activity involved students participating in an interprofessional simulation lab for 1 day.[13] In this pediatric elective, Tofil et al[9] demonstrated student knowledge and application skills improved after 1 experience with high-fidelity interprofessional simulation. Since the survey, Cho et al[10] presented data demonstrating an increase in student confidence from a first to a second high-fidelity simulation laboratory exercise in 30 third-year student pharmacists who were enrolled in a pediatric elective course. Specifically, students were able to assess, obtain pertinent information, and develop a treatment plan for pediatric patient cases. Collectively, these studies demonstrate improved student learning can occur with the use of low- and high-fidelity simulation in a pediatric elective course.

Lessons learned when implementing simulation activities in the classroom can benefit others seeking to add these activities to their curricula. The primary instructor developed step-wise instructions for the pre-brief, simulation activity, and debrief. This strategy was essential for consistency of the activity between course iterations and the 2 campuses. Additional time (~30 minutes) was needed before and after each course session for setting up, taking down, and cleaning the equipment. Students were provided alcohol swabs to clean their stethoscopes and sounders, and the instructor also cleaned the equipment before and after the activity. There was also the initial time investment of recording the sounds from the equipment and converting them to audio files for the learning management system. Lastly, students were reminded several times before the activity to bring their stethoscopes to class. The instructor had a neonatal, pediatric, and teaching stethoscope to show students and allow them to use if needed. Teaching the third course iteration during the COVID-19 pandemic required additional sessions of the activity in class as the sounders were 3 feet apart. To accommodate social distancing guidance, only every other sounder could be used for the activity.

Not all pharmacy programs can afford or access high-fidelity simulation equipment for teaching. This study demonstrated throughout 3 course iterations that students' confidence and skills increased using a less-expensive, low-fidelity simulation device. In addition, lab space and time were not needed for this educational activity as it was conducted in the assigned classroom for the elective. This study also provides an example of how to incorporate simulation into the classroom setting as compared with a skills laboratory setting or introductory or advanced pharmacy practice experiences. Future studies could consider exploring low-fidelity simulations in courses that are not skills-based.

Limitations of this study include the inability of the students to practice with their stethoscope and simulator after the activity and prior to the assessment. This is due to the primary instructor being an off-campus faculty member and no safe location to store the equipment or have the students use the equipment on campus during the time frame. However, students had access to the sound recordings on the learning management system after the activity to assist with learning. Despite having a teaching outline, minor differences in teaching by the 2 instructors for the stethoscope and simulator activity may have occurred. Also, the second instructor solely taught these 2 topics in the previous course without simulation. Although the topics and content were the same, differences in the instructor may have confounded students' interest ratings. It is also unknown if the confidence and competence demonstrated from the simulated learning activity in the classroom will transfer to clinical practice. Lastly, we did not assess long-term retention of the skill or knowledge.

Because of the success of the simulation activity in the elective, the same activity was piloted in a core course when the students learned about pediatric respiratory infections. Students voluntarily attended, and due to their positive feedback, the activity is planned to be

permanently incorporated as a skills laboratory starting spring 2022 for all 150 P2 students. The instructional methods and simulation activities developed for this Introduction to Pediatrics elective can be applied to a variety of courses, such as a skills laboratory, advanced pediatric electives, and/or specific cardiac and pulmonary disease state courses in other schools of pharmacy or interdisciplinary pediatric courses.

Conclusion

Students' confidence in completing skills related to pediatric heart and lung vital signs and physical assessment increased when simulation was incorporated into a teaching and learning activity. Students demonstrated competency in the skills formally assessed. Topics and activities that incorporated simulation were rated of higher interest and learning effectiveness when compared with the same prior topics and teaching strategies without simulation. Low-fidelity simulation is an effective teaching and learning approach to increase students' confidence, knowledge, and interest in vital signs and physical assessment of the pediatric population.

Article Information

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