INSTRUCTIONAL DESIGN AND ASSESSMENT

Comparison of Low- and Higher-Fidelity Simulation to Train and Assess Pharmacy Students' Injection Technique

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Objective. To evaluate 2 forms of simulation used to train and assess third-year pharmacy students' subcutaneous and intramuscular injection techniques.

Design. A cross-over comparison was used to evaluate an injection pad vs a patient simulator injection arm to train students in injection administration.

Assessment. Students completed a survey instrument rating their proficiency, confidence, and anxiety before and after each form of simulated practice. All students demonstrated competence to administer an injection to a peer after using both forms of simulation. Students' self-ratings of proficiency and confidence improved and anxiety decreased after practicing injections with both forms of simulation. The only significant difference in performance seen between students who used the 2 types of simulations was in students who first practiced with the injection pad followed by the injection arm.

Conclusion. Student ability to administer an injection and their self-perceived levels of confidence, proficiency, and anxiety were not dependent on the type of simulation training used.

Keywords: simulation, simulator, vaccination, immunization, injection

INTRODUCTION

All 50 states, the District of Columbia, and Puerto Rico authorize pharmacists to administer vaccinations.[1] As health professionals qualified to administer vaccines, pharmacists must support public health initiatives by promoting vaccinations and providing immunization services.[2] Pharmacist-provided patient education and immunization services align with the Healthy People 2020 goal to "increase immunization rates and reduce preventable infectious disease."[3]

Immunization rates remain low in the United States. One answer to this problem is to educate future pharmacists through the promotion of immunization-related public health initiatives within the pharmacy curriculum. The American Association of Colleges of Pharmacy Center for the Advancement of Pharmaceutical Education (CAPE) Advisory Panel on Educational Outcomes has defined criteria for promoting public health. The CAPE outcomes state that doctor of pharmacy (PharmD) graduates must possess the ability to promote public health initiatives including the ability to promote patient wellness and health improvement, and prevention of disease.[4]

As the need for immunizing pharmacists expands, pharmacy colleges and schools are called upon to make immunization training part of their required curriculum.[2] Training can be enhanced through the use of simulation, which allows students to develop patient care skills in a controlled environment.[5,6] The use of patient simulators in education increases student confidence, enhances knowledge, and ensures accuracy of patient care activities.[5,7] Simulation can also be used to meet introductory pharmacy practice experience requirements.[8]

Patient simulators are available in low, medium, and high fidelity and vary widely in cost.[9] Thus, one must consider which simulation technology will result in the best student learning outcomes for the expenditure. Faculty members at North Dakota State University currently use 2 types of simulation to teach students injection technique. The objective of this study was to determine if one type of simulation is superior to another for injection administration training, and if either had an effect on students' learning outcomes or self-ratings of proficiency, confidence, and anxiety.

DESIGN

The PharmD program at North Dakota State University is a 4-year program. During the second semester of

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the third year, students are required to complete an immunization certificate training program. Prior to this training, students do not receive any formal training or clinical experience related to immunization or injection administration. This certificate training course is completed in 2 parts. Students are enrolled in a 1-credit classroom course which focuses on immunization schedules, state laws, rules and regulations, emergency procedures, vaccination storage and handling, and immunization service implementation. Students are simultaneously enrolled in a 1-credit pharmaceutical care laboratory where they are taught proper subcutaneous and intramuscular injection techniques. The primary learning objective for the laboratory portion is to ensure students' ability to properly administer a subcutaneous and intramuscular injection to a peer. Upon successful completion of the classroom and laboratory courses, students receive an immunization administration certificate, which authorizes them to administer immunizations to patients. This immunization certificate training program was developed by North Dakota State University College of Pharmacy, Nursing, and Allied Sciences and is accredited by the Accreditation Council for Pharmacy Education.

Injection technique was taught and evaluated in Pharmaceutical Care Laboratory IV, which is part of a 4-semester laboratory series. Eight 2-hour laboratory sections taught by 4 pharmacist faculty members were offered each week, with 12 third-year students enrolled in each section. Laboratory activities focused on medication therapy management, disease state management, injection administration, and patient consultation. Students received a 1-hour lecture on proper injection administration technique, followed by a faculty demonstration of an immunization consultation, which included performing a subcutaneous and intramuscular injection.

Following the live demonstration, students were asked to practice their injection technique prior to administering an intramuscular and subcutaneous injection to a peer. Use of simulators has been shown to offer students a realistic experience, increase student confidence, and ensure accuracy.[6,10,11] Two types of simulators were used by students to practice their injection technique: injection pads and a patient simulator injection arm.

Each simulator varies in its degree of physical fidelity. Greater physical fidelity and realism (more features including simulated environment) typically equate to higher cost.[12] The injection pad offers a low-fidelity simulation and is relatively low in cost (approximately $5.00 each).[13] A patient simulator injection arm (3B Scientific: Hamburg, Germany) costs approximately $1,000, but provides a higher-fidelity simulation and feedback on proper injection technique using lights and sound.[14] Both types of simulation can be used to assist students in locating appropriate anatomical landmarks and allow practice of injection administration technique.

To determine if one form of simulation was superior to the other, the investigators designed a crossover study (Figure 1). Students were randomly assigned to either group 1 or group 2. Group 1 practiced with the injection pad first. Group 2 practiced with the patient simulator injection arm first. After administering 1 practice injection using the first simulator, students were asked to switch to the other type of simulator and practice administering a second injection. Faculty members observed each practice injection and provided formative feedback using a 5-item faculty-developed evaluation rubric.

After practicing with both types of simulators, students administered a subcutaneous and intramuscular injection to a peer under faculty observation. Students were evaluated based on their ability to administer the injection at the appropriate anatomic landmark, insert the needle at the appropriate angle, and inject the vaccine using steady pressure.

Each group also completed an anonymous 3-item survey instrument at 4 points during the study: prior to practicing injection administration, after using the first simulator (injection pad or arm, depending on group assignment), after using the second simulator, and after administering an injection to a peer (Table 1). The 3-item survey instrument was adapted from a self-assessment used

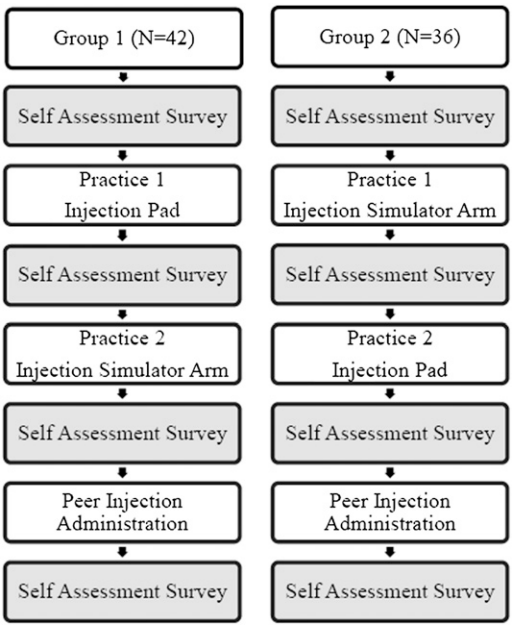

Figure 1. Testing Sequence Used in a Study Comparing the Effectiveness of Two Types of Injection Simulation in Training Pharmacy Students

Table 1. Pharmacy Students' Responses Regarding Use of an Injection Pad vs a Simulator Injection Arm to Learn Injection Technique (N=78)

Question	Survey Administered: Pre-training	Post- simulator Practice 1[a]	Post- simulator Practice 2[a]	Peer Injection
Rate your current proficiency in administering an injection to a peer[b]	1.9	2.9	3.1	3.4
Rate your confidence about being able to independently administer an injection to a peer[c]	2.6	3.1	3.2	3.5
Rate your anxiety when you think about administering an injection to a peer[d]	2.5	2.9	2.9	3.3

[a] Group 1 used the injection pad in practice 1, while group 2 used the simulator arm. The simulators used were reversed in practice 2.
[b] 1 = no proficiency; 2 = low proficiency; 3 = somewhat proficient ; 4 = very proficient.
[c] 1 = no confidence; 2 = low confidence; 3 = somewhat confident; 4 = very confident.
[d] 1 = high anxiety; 2 = some anxiety; 3 = low anxiety; 4 = no anxiety.

in medical education for students to rate their proficiency, confidence, and anxiety in performing procedural skills.[15] The literature has shown anxiety, perceived proficiency, and self-confidence can be used as indicators of performance and competence.[16-18]

Faculty members hypothesized that students' self-ratings of anxiety, proficiency, confidence, and ability to perform injections based on faculty observations would be better after using the higher-fidelity injection arm than after using the low-fidelity injection pad. The North Dakota State University Institutional Review Board approved the informed consent document and instruments used in this study.

EVALUATION AND ASSESSMENT

Eighty-three students were enrolled in Pharmaceutical Care Laboratory IV and 78 agreed to participate in the study. Groups 1 and 2 contained 42 and 36 students, respectively. Results of the survey were recorded as: pre-training, post-simulator practice 1, post-simulator practice 2, and post-simulation peer injection. This allowed faculty members to determine if gains in confidence and proficiency and a decrease in anxiety were seen after practice with the injection pad vs practice with the injection arm. When analyzing the self-assessment responses of all 78 participants, regardless of group assignment, the mean responses increased as students progressed from the pre-training to post-simulation peer injection (Table 1). This mean increase correlates with the students' progression through the simulated practice and peer injection ($p<0.05$).

Because the use of simulation was effective in increasing self-assessed proficiency and confidence and decreasing anxiety, groups 1 and 2 were looked at independently. If the injection arm was superior to the injection pad as an educational tool, a greater difference would be seen for group 2 between pre-training and post-simulator practice 1, as this group used the injection arm first. Similarly, a greater difference in group 1 would be seen between post-simulator practice 1 and post-simulator practice 2 because group 1 used the injection arm during post-simulator practice 2. A greater difference would correlate with a gain in proficiency and confidence, and decreased anxiety.

First, the self-assessment survey responses for groups 1 and 2 were compared between pre-training and simulated practice 1. The mean responses and mean differences are reported in Table 2. If the patient simulator injection arm was superior to the injection pad, a greater difference in the mean scores would be expected for the 3 survey questions between pre-training and post-simulator practice 1 for group 2. Group 2 showed a greater difference in self-assessed confidence and decreased anxiety, but not in self-assessed proficiency.

The self-assessment survey responses were then used to compare the mean differences between the first and second round of practice (Table 2). If the injection arm was superior to the injection pad, a greater difference would be seen in the mean scores between post-simulator practice 1 and post-simulator practice 2 for group 1. When groups 1 and 2 were compared, variance in all 3 survey questions was evident; however, whether the difference was significant remained to be determined.

An analysis of variance test (ANOVA) was used to compare mean differences between groups 1 and 2 (Table 3). Non-parametric tests were also run and supported the findings in the ANOVA test (Mann-Whitney and Median Sign). All tests used a 5% significance level and were run under the null hypothesis that there was no difference between groups 1 and 2. In all but 1

Table 2. Comparison of Pharmacy Students' Responses Before and After Using an Injection Pad and a Simulator Injection Arm to Learn Injection Technique (N=78)

Question	Survey Administered: Pre-training	Survey Administered: Post-simulator Practice 1	Difference	Survey Administered: Post-simulator Practice 1	Survey Administered: Post-simulator Practice 2	Difference
Rate your current proficiency in administering an injection to a peer[a]						
Group 1 (used injection pad in practice 1)	1.8	2.8	1.1	2.8	3.1	0.3
Group 2 (used simulator arm in practice 1)	2.1	3.1	1.0	3.1	2.8	0.3
Rate your confidence about being able to independently administer an injection to a peer[b]						
Group 1	2.6	3.1	0.5	3.1	3.3	0.2
Group 2	2.5	3.1	0.6	3.1	3.1	0.1
Rate your anxiety when you think about administering an injection to a peer[c]						
Group 1	2.4	2.8	0.4	2.8	2.9	0.1
Group 2	2.6	3.0	0.4	3.0	2.9	0.1

[a] 1 = no proficiency; 2 = low proficiency; 3 = somewhat proficient ; 4 = very proficient.
[b] 1 = no confidence; 2 = low confidence; 3 = somewhat confident; 4 = very confident.
[c] 1 = high anxiety; 2 = some anxiety; 3 = low anxiety; 4 = no anxiety.

instance, the statistics failed to reject the null hypothesis. Group 1 showed a significant difference between pre-training and post-simulator practice 2 for self-assessment of proficiency.

Both groups met the learning objective by demonstrating competence in their ability to administer subcutaneous and intramuscular injections to a peer. During administration of peer injections, 100% of students administered the injections at the appropriate anatomic landmarks, and inserted the needle at the appropriate angle. Ninety-seven percent of students inserted the needle quickly and injected the vaccine using steady pressure. Based on these findings, we concluded that student ability to administer an injection was not dependent on the type of simulation used.

DISCUSSION

Faculty members hypothesized that the higher-fidelity injection arm would be superior to the low-fidelity injection pads for learning injection technique based on students self-ratings of anxiety, proficiency, confidence, and faculty observations. However, student self-ratings of proficiency, confidence, and anxiety improved after using either injection simulator. While students in group 1, who practiced with the injection pad followed by the patient simulator injection arm, showed a greater improvement in perceived proficiency, confidence, and anxiety than those in group 2, the only significant difference was the improvement in self-assessed proficiency. This could be attributed to the low-fidelity simulation providing a better means for initial practice than the higher-fidelity

Table 3. Analysis of Variance Between Group 1 and Group 2 Self-Assessment Survey (N=78)

Variable	Group 1, Mean (SD)	Group 2, Mean (SD)	Probability
Post-simulator practice 1 score minus pre-training score			
Rate your current proficiency in administering an injection to a peer	1.1 (0.7)	1.0 (1.0)	0.71
Rate your confidence about being able to independently administer an injection to a peer	0.5 (0.6)	0.6 (0.8)	0.51
Rate your anxiety when you think about administering an injection to a peer	0.4 (0.6)	0.4 (0.7)	0.94
Post-simulator practice 2 score minus pre-training score			
Rate your current proficiency in administering an injection to a peer	1.4 (0.7)	0.9 (1.0)	0.03
Rate your confidence about being able to independently administer an injection to a peer	0.6 (0.6)	0.5 (0.8)	0.46
Rate your anxiety when you think about administering an injection to a peer	0.5 (0.6)	0.4 (0.6)	0.25

simulation. This would also support literature stating that more "complex training aids are not appropriate where novices are learning the basic skills involved in a task."[12]

Because there was not a significant difference in students' anxiety, proficiency, confidence, or ability to administer injections that was attributable to using an injection pad or an injection simulator arm first for training, the act of practicing injection technique appears to be what made the difference. This finding that the amount of practice that students received was the most important factor in learning a new skill has been reported in the medical literature for other procedural performances.[19]

Simulation prepares learners for patient contact, increase self-confidence, and deepens their understanding of a subject.[7,10,11] Although simulation is valuable to student learning, the cost of the simulator vs the added benefit for students should be calculated when choosing which type of simulation to use.

Although the survey results did not prove the injection simulator arm was superior to the injection pad, the authors recognize its value in teaching students proper injection technique. The simulator provides feedback if an injection is being administered in the correct anatomical landmark and determines if the appropriate angle was used. When observing an injection being administered to a human subject or an injection pad, it is almost impossible for the instructor to verify if it was administered in the correct tissue. However, through the use of colored indicator lights and sounds, the injection simulator arm verified correct tissue placement. Also, students' responses regarding the injection simulator arm was positive and they appreciated the electronic feedback it provided. Students also stated that both kinds of simulation were valuable.

This study had some limitations. First, there are other means of injection simulation that were not compared in this study. For example, injection simulation using an orange is a commonly used simulation method during injection training. Second, while injection administration is a skill that is easily practiced in a simulated environment, learning more complex pharmacy skills such as treating a patient experiencing an anaphylactic reaction or cardiac arrest may require higher fidelity simulators. Also, this study did not attempt to determine whether there would be a clinically significant difference in students' injection skills based on which type of simulator was used in teaching. In the future, this same research could be conducted in injection training courses with other members of the healthcare team to expand the findings.

SUMMARY

Injection simulation improved students' self-ratings of proficiency and confidence and decreased their anxiety. Having students practice with a low-fidelity simulator and progress to a higher-fidelity simulator may be beneficial when teaching students injection skills.

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