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Antiviral Pharmacology: A Standardized Patient Case for Preclinical Medical Students

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Abstract

Introduction: Pharmacology is an important learning topic in preclinical medical education. Simulated patient encounters allow students to apply basic science knowledge in a clinical setting and have been useful in previous studies of pharmacology education. We developed a standardized patient (SP) encounter to reinforce antiviral pharmacology content for first-year medical students. **Methods:** Students were instructed to recommend a medication for shingles during an SP encounter and to answer questions from the SP on mechanism of action and adverse effects. Students then attended a large-group debrief session. Following the activity, students evaluated the exercise through a voluntary survey. For knowledge assessment, students were randomized into two groups to complete three multiple-choice questions either before or after the learning activity. **Results:** In 2020 and 2021, 144 and 145 students, respectively, participated. In 2020, there was no significant difference in the proportion of correct answers between the pre- and postsimulation groups ($p > .05$). In 2021, the postsimulation group significantly outperformed the presimulation group in knowledge of mechanism of action ($p < .01$) and adverse effects ($p < .01$), but no difference was seen between the groups regarding medication selection ($p = .27$). Most learners assessed the instructional design as effective for the tasks assigned. **Discussion:** This SP activity provided an opportunity for early medical students to practice integrating antiviral pharmacology knowledge into a patient encounter and was well received by learners. The instructional method offers a clinically relevant approach for reinforcing pharmacology knowledge for preclinical medical students.

Keywords
Communication Skills, Pharmacology, Infectious Disease, Standardized Patient

Educational Objectives

By the end of this activity, learners will be able to:

1. Identify the first-line antiviral medications for treating herpes simplex virus, varicella zoster virus, and cytomegalovirus infections.
2. Recall the mechanism of action of famciclovir/penciclovir, valacyclovir/acyclovir, and valganciclovir/ganciclovir.
3. Determine the adverse effects associated with acyclovir, valacyclovir, penciclovir, and famciclovir.
4. Identify the appropriate laboratory tests to evaluate for these adverse effects.
5. Practice discussing medication information with an inquisitive standardized patient.

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Introduction

Pharmacology is a critical learning topic during preclinical undergraduate medical education and represents between 16% and 23% of the material on USMLE Step 1.[1] In recent years, organizations such as the American College of Clinical Pharmacology (AACP) have called for the expansion and improvement of clinical pharmacology education in undergraduate medical education.[2,3] Specifically, the AACP called for increased instruction on pharmacokinetics and pharmacodynamics, dosage adjustments, drug interactions, and working with common problem drugs, among others.[3]

Simulation is an instructional approach that allows learners to apply pharmacology knowledge in a clinical context. Previous publications involving simulated patient encounters for pharmacology education have primarily used either high-fidelity mannequin simulations (HFMS) or standardized patients (SPs). Despite varying assessment methods, results are similar, with each technique generally shown to be effective and evaluated highly by learners. A curriculum using HFMS to teach ionotropic

pharmacology to medical students showed an increase in knowledge acquisition and long-term retention compared to a low-fidelity or sham simulation.[4] The University of Central Florida College of Medicine used HFMS to integrate pharmacology with physiology, pathology, and the clinical sciences across the curriculum.[5] Students who participated found the simulations to be helpful at highlighting the clinical relevance of their basic science material.[5]

While HFMS can be helpful, SP encounters provide a more realistic opportunity to apply pharmacology content to provider-patient discussions. A previous educational innovation used an SP encounter to supplement pharmacogenetics material for second-year pharmacy students and found significant improvement in application-style questions following the simulation.[6] Castleberry and colleagues created an SP activity for second-year pharmacy students, requiring them to counsel a patient about a new statin prescription. The simulation was rated highly by students, and the authors concluded that SP activities allow for the application of foundational knowledge during the preclinical years.[7] Within medical school curricula, SP encounters have been less widely adopted for pharmacology instruction. Karpa and colleagues published the results of four SP encounters that required third-year medical students to apply basic pharmacology principles to clinical encounters. Despite previous exposure to these topics, students were largely unable to apply these pharmacology concepts in a clinical setting.[8-11]

Patient-centered simulations can be especially useful for preclinical medical students, given their limited clinical experience, as such learning activities provide a clinical context for the content learned in their basic science courses.[12] Additionally, observations of experienced clinicians indicate that basic science knowledge is utilized in diagnostic reasoning only if related to clinical knowledge.[13] To our knowledge, no previous educational activities have evaluated the use of an SP encounter to teach antimicrobial pharmacology in preclinical medical education.

Two student authors (Karisma R. Gupta and Michael K. Jones) who had recently completed the preclinical curriculum at our institution, including the longitudinal clinical skills course and multiple simulated clinic events,[14-16] noted a lack of pharmacology content within these clinically focused learning activities. Therefore, we developed a formative SP encounter for first-year medical students to apply antiviral pharmacology knowledge during a simulated clinical encounter. This activity was intended to serve as an introduction to clinical pharmacology and reinforce both clinically and USMLE Step 1–relevant pharmacology knowledge. The SP methodology was chosen for ease of application in an existing simulated SP clinic and to provide an opportunity for students to practice counseling patients on medication information in a provider role in the context of a realistic patient encounter.[14] This case also highlighted foundational concepts such as pharmacokinetics (bioavailability), dosing, and adverse effect prevention with common antivirals in accordance with recommendations from the AACP.[3]

Methods

Curricular Context

The two student authors (Michael K. Jones and Karisma R. Gupta) collaborated with the virology course directors (Timothy R. Peters and Jennifer M. Jackson) and the pharmacology thread director (James R. Beardsley) to design this learning activity. It was implemented during the virology course for first-year medical students at the Wake Forest School of Medicine. The virology course occurred 6 months into the 18-month preclinical curriculum as part of a larger microbiology and immunology course that followed anatomy and biochemistry courses. Concurrently, these learners were participating in a longitudinal clinical skills course through which they had interacted regularly with SPs numerous times during formative class sessions and two clinical skills assessment events to practice foundational physician-patient communication skills, history-taking skills, and physical examination skills. Basic pharmacology principles, including pharmacokinetics and pharmacodynamics, were taught in previous lectures within the first-year basic science curriculum. Prior to this activity, students had not received formal instruction on how to counsel patients regarding medications nor had these students practiced this skill.

Learner prerequisites: Within the virology course, students received didactic instruction on herpes viruses and associated treatments 2 or 3 days prior to participating in the following SP encounter. Students were encouraged to review this didactic material prior to the SP activity, but no other assignments were required prior to participation in this event.

To meaningfully participate in this encounter, students were expected to have a basic understanding of the clinical presentation of herpes virus diseases, including shingles, congenital cytomegalovirus, and herpes simplex virus, and foundational pharmacology concepts such as bioavailability. Mastery of the virology and pharmacology principles used in the encounter was not required.

Event Overview and Logistics

Students participated in this SP encounter during a simulated virology clinic event, as this was one of eight SP cases among which all student small groups rotated; the decision to include this case in the simulated virology clinic event was made both out of logistical convenience and to align with the timing of the students' virology pharmacology classroom learning. The simulated virology clinic was described in detail by Jackson and colleagues[14]; of note, the learning objectives and learner tasks for the other seven SP encounters in the simulated virology clinic focused primarily on diagnostic reasoning, while the learning objectives and learner tasks for this SP encounter focused on pharmacology.

Location: The first implementation of this activity (January 2020) was conducted in person at our institution's simulation center, which contained multiple simulated outpatient exam rooms. Due to the COVID-19 pandemic, the second implementation of this activity (January 2021) was conducted virtually over videoconferencing software (Cisco WebEx).

Learners: First-year medical students participated in this activity in January of 2020 and 2021. Students in each class were randomized into two large groups, with half of the class participating in the activity at a given time. We assumed this randomization would theoretically result in approximately equal numbers of well-prepared and underprepared students in each group, although we did not formally evaluate each group's degree of student preparation. Within each of these large groups, students were further divided into smaller groups of four to five.

Learner orientation: Two days prior to participation, students were sent information about this SP encounter via email, including expectations regarding professional attire and event logistics (e.g., timing and location of the debrief session). In the 2021 implementation, students were also given instructions on how to connect to the SP encounter through videoconferencing software and information about the virtual debrief session.

Timing and materials: Students were given 15 minutes to complete the activity. At the beginning of the activity, 7-10 minutes were allotted for the student small groups to prepare for the patient conversation. Provided to each student group prior to the encounter was a handout with relevant patient information including name, age, chief complaint, and confirmed diagnosis of shingles (Appendix A). The handout also included student instructions for the encounter and a list of relevant resources. Prior to speaking to the SP, students were instructed to fill out a worksheet (Appendix B), which had specific prompts to prepare them for the patient encounter.

Upon entering the patient's room, one student took on the role of the provider while the other students observed the encounter. The student serving as provider had the remaining 5-8 minutes to discuss a recommended medication for the patient's shingles and answer the SP's questions on mechanism of action and adverse effects, as well as other questions from the SP script (Appendix C). Despite this activity occurring virtually during 2021, the structure, timing, learner tasks, SP script, and material covered were identical to the 2020 in-person event. The only other change that occurred between the 2 years involved the timing of the debrief, as discussed in detail below.

Event debrief: Following the encounter, an instructor (Michael K. Jones) led a 5-minute, PowerPoint-facilitated, interactive, large-group debrief discussion on the case highlighting each specific learning point for learners (Appendix D). This instructor had not had formal debrief training but had participated in multiple debrief sessions as a learner and was supervised by instructors with extensive debriefing experience (Jennifer M. Jackson and Timothy R. Peters).[14-16] In 2020, debrief attendance was optional and occurred within an hour-long debrief session for all eight encounters within the simulated virology clinic. This occurred after both large student groups had completed the whole simulated clinic activity (between 1 and 3 hours after the encounter, depending on the group to which students were assigned).[14]

The debrief was mandatory for students in 2021 and was timed to occur immediately after the SP encounter series concluded for each of the two large student groups (i.e., two total debrief sessions were conducted by instructors, one for each large student group), conducted independently from the debrief session for the other seven simulated virology clinic cases. This change in debrief timing (to occur prior to knowledge assessment for the intervention group) was made in recognition of the importance of the debrief to learning occurring in simulation-based activities and assisted our evaluation of the impact of this activity on students' performance on the associated multiple-choice questions (MCQs). The debrief session utilized several essential elements of effective debriefing to review and reinforce the pharmacology knowledge addressed in this activity, including the use of a shared mental model, asking open-ended questions, using silence, and addressing key learning objectives.[17,18]

Staff needs: The staff required for this event included (1) the SP program manager, who recruited SPs according to the

demographics for this case (middle age, any gender) and provided them with the script for the case (the number of SPs recruited was determined by the planned number of exam rooms used for this activity), and (2) one to two additional staff to prepare the event space or set up the videoconferencing sessions for student small groups, if held virtually.

SP training: Two experienced SPs were given a copy of the script and instructions, which included specific questions to pose to the student interviewer along with responses to student comments (Appendix C). A 15-minute training session for the SPs was led by the virology course directors (Jennifer M. Jackson and Timothy R. Peters), who reviewed the activity logistics and script and answered the SPs' questions. The SPs were made aware that this encounter was intended to focus on the learners' treatment recommendations for the patient's shingles and patient education about this treatment rather than history taking regarding the patient's symptoms. The SPs rehearsed the script individually on their own prior to the learning activity, though their performance was not directly observed or assessed by the instructors or SP educators prior to the implementation of the learning activity.

Evaluation and Learning Outcomes

Learner knowledge assessment: We assessed students' knowledge related to the relevant antiviral medications through three formative USMLE-style MCQs (Appendix E). As all students participated in the SP activity, we utilized a randomized crossover design to assess the effect of the activity on students' knowledge: Group 1 (presimulation group) completed the MCQs prior to the SP encounter, and group 2 (postsimulation group) completed the MCQs after the SP encounter (Figures 1 and 2). We compared the two groups' performance on the MCQs by performing a chi-square test, with a p value of .05 as the significance level. Students who did not complete the MCQs were omitted from our analysis.

The timing of the knowledge assessment changed slightly between the implementation years: The 2020 postsimulation group completed the MCQs after the SP encounter but before the debrief, whereas, in 2021, the postencounter group completed the MCQs following the encounter and the debrief (Figures 1 and 2). Since the debrief was considered a critical part of the simulation-based activities, we attempted to capture the full effect of the activity including the debrief during the second implementation.[19]

Learner evaluation surveys: Following the encounter and debrief session, learner evaluation surveys were sent via email to all participating students. Completion was anonymous and voluntary. The survey included a series of Likert-scale questions assessing the SP encounter's relevance, instructional design, and effectiveness for achieving the learning objectives, as well as two open-ended items for students' narrative comments about the activity's strengths and aspects needing improvement (Appendix F). In 2021, we added an additional question assessing the virtual format of the simulated encounter.

Results

Knowledge Assessment

First-year medical students in the classes of 2023 ($n = 144$) and 2024 ($n = 145$) participated in this activity in January of 2020 and 2021, respectively. Results from the USMLE-style MCQs are displayed in Table 1. One hundred thirty-three (92%) and 127 (88%) students who participated in the encounter completed the formative MCQs in 2020 and 2021, respectively. In 2020, there was no significant difference in the proportion of correct answers between the pre- and postsimulation groups for any of the three MCQs ($p > .05$). In 2021, the postsimulation group significantly outperformed the presimulation group in knowledge of mechanism of action (60% presimulation vs. 85% postsimulation, $p = .002$) and adverse effects (28% presimulation

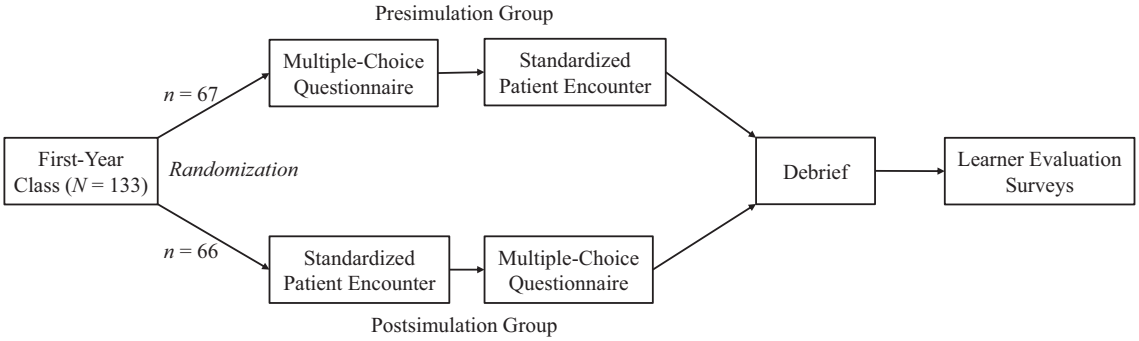

Figure 1. Experimental design for 2020 shingles simulated patient encounter implementation.

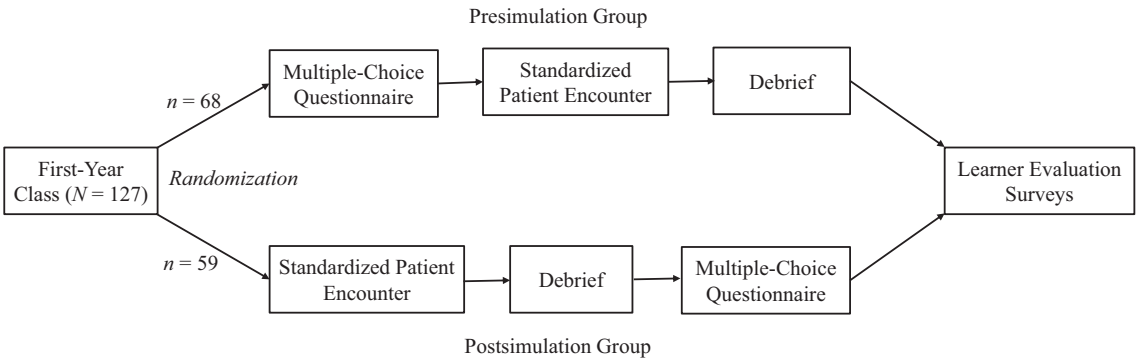

Figure 2. Experimental design for 2021 shingles simulated patient encounter implementation.

vs. 76% postsimulation, $p < .001$), but no statistically significant difference was seen between the groups regarding medication selection (75% presimulation vs. 83% postsimulation, $p = .27$).

Learner Evaluation

Forty-four (31%) and 26 (18%) students completed the learner evaluation survey in 2020 and 2021, respectively. Results are displayed in Table 2. Respondent feedback was positive overall. Nearly all learners believed that this exercise was relevant to their future as physicians (86% in 2020 and 92% in 2021), and many emphasized this in their narrative comments:

- "Skills used were extremely relevant in being a physician in the future because I anticipate having to talk to patients about medications [that] are prescribed and what their potential effects are."
- "We're going to need to be able to discuss medications with patients, especially when there are several medications that 'work' in order to determine what is the right one for each individual."
- "Good addition to the [simulated virology clinic] event. Not used to recommending treatments to patients, but I should have practice doing this."
- "Definitely important for us to know how to explain to our patients not only what their med options are but how the drug works in layman terms."
- "This gave us valuable experience explaining medication choice and dosing to a patient. We haven't really had this yet, so it was challenging in a good way."
- "Strengths [of simulation]: translating complex drug information into plain language, deploying knowledge of differences between drugs, managing both the clinical and human side of an encounter."

Respondents also called for integration of more pharmacology-based simulations into the curriculum:

- "This was a great addition to the [simulated] clinic. I highly recommend keeping it and maybe even adding a second."
- "This is an excellent idea to incorporate and probably should be used more often in our [simulations]."
- "I would love to have more events like this to incorporate pharmacology into our education."

Many students felt they did not have enough time between their didactic introduction to herpes viruses and associated antivirals and this simulation. Some also felt the encounter itself did not provide enough time to prepare for the patient conversation:

- "We felt a little rushed prior to entering the patient's room to fully investigate all of the learning objectives. I think we were still processing the material that was taught in lecture

Table 1. Medical Student Performance on Multiple-Choice Questions

	2020 Implementation			2021 Implementation		
	No. (%) With Correct Responses			No. (%) With Correct Responses		
Question Item	Presimulation Group ($n = 67$)	Postsimulation Group ($n = 66$)	p	Presimulation Group ($n = 68$)	Postsimulation Group ($n = 59$)	p
Medication election	50 (75)	46 (70)	.53	51 (75)	49 (83)	.27
Mechanism of action	53 (79)	53 (80)	.86	41 (60)	50 (85)	.002
Adverse effects	20 (30)	29 (44)	.09	19 (28)	45 (76)	<.001

Table 2. First-Year Medical Student Evaluations of the Standardized Patient Encounter

Question	Extremely or Quite Relevant	
	2020 (%)[a]	2021 (%)[b]
How relevant were the knowledge and skills used during the shingles pharmacology case to your role as a future physician?	86	92
	Yes	
Was the small-group format of this learning activity appropriate for the learning content provided?	100	100
Were the pace and duration of this learning activity appropriate for the learning content presented?	89	81
	Extremely or Quite Effective	
How effective was the shingles pharmacology case for practicing each of the following tasks?		
List the antivirals used for herpes simplex virus, varicella zoster virus, and congenital cytomegalovirus infections.	66	85
Select the most appropriate antiviral medication to treat a stable adult patient with shingles in the outpatient setting.	80	92
Describe to a patient the mechanism of action of the selected medication (famciclovir/penciclovir, valacyclovir/acyclovir, valganciclovir/ganciclovir).	75	85
Describe to a patient what an antiviral prodrug is.	66	69
List side effects associated with acyclovir, valacyclovir, penciclovir, and famciclovir.	75	81
Explain to a patient how to minimize or avoid these effects when taking these medications.	66	77
Identify a clinical test that can be used to assess kidney function for a patient starting one of these antiviral medications.	64	65
How effective was the debrief session of the shingles pharmacology case for helping you identify each of the above learning objectives?	70	85
How effective was virtual format for this patient encounter?[c]		65

[a]2020: $n = 44$ (31% response rate).
[b]2021: $n = 26$ (18% response rate).
[c]Asked only in 2021.

so we couldn't be super thorough in our explanations to the patient."

When asked about the postsimulation debrief, students indicated that it was an important part of the learning activity:

- "The breakdown afterwards ... was especially helpful."
- "The debrief after the event was really amazing, and I learned a lot from it."
- "Very helpful, excellent!"

Discussion

We introduced an innovative SP encounter that provided an opportunity for preclinical medical students to integrate antiviral pharmacology knowledge into a clinical encounter for a common condition (shingles). Tasking learners with applying their recently acquired knowledge to a realistic clinical encounter gave them an opportunity to reinforce relevant knowledge about antiviral medications as well as to practice communicating this information with a patient. In the second implementation year, participants demonstrated a significant improvement in knowledge related to the mechanism of action and adverse effects of the medications targeted in the activity. In both implementation years, learners' evaluation of the activity's effectiveness was high. These findings highlight the potential value of interactive SP learning experiences to enhance pharmacology instruction in the preclinical medical school curriculum.

Our innovation is part of a growing body of research using SPs to teach and reinforce clinical pharmacology knowledge. Nursing students performed better on postsimulation questions following a high-fidelity simulation (80% presimulation vs. 96% postsimulation), as did pharmacy students following an SP encounter (44% presimulation vs. 74% postsimulation).[6,20] It is worth noting that the results of our first implementation year did not show striking differences in knowledge performance between the pre- and postencounter groups, whereas we did detect significant differences between these two groups in the second implementation year. We attribute this change to the fact that the postencounter group in the first year's implementation completed the MCQs before participating in the event debrief, whereas, in the second implementation year, the postencounter group completed the MCQs following the debrief. This observation emphasizes the importance of the postsimulation debrief, reinforcing that the debrief is a crucial part of the learning process in simulation-based medical education.[17,19] We do not feel that conducting the debrief for this SP encounter within the larger simulated virology clinic debrief in 2020 versus conducting the debrief by itself in 2021 had any significant impact on the outcomes of this educational activity given that the debrief for all eight SP encounters occurred at some point during the day of the simulated clinic.

Lessons Learned and Limitations

The learners' evaluation of our SP encounter mirror those of previous activities in which learners often desired additional

clinically relevant pharmacology exercises.[5,7] In their evaluation of four pharmacology-focused SP encounters for third-year MD students, Karpa and colleagues noted that students were often unable to apply basic pharmacology principles in clinical settings and therefore called for the continued threading of similar encounters throughout the medical school curriculum.[8-11] These SP encounters were implemented later than ours in the medical school curriculum. By introducing a clinically relevant pharmacology exercise earlier, we hoped our learners would find the exercise helpful when approaching future pharmacologic material.

Some of our learners felt the time allotted was not sufficient to prepare for the SP encounter. This was likely due to these novice learners' lack of previous experience with or training for this type of patient encounter. Therefore, increasing the amount of time for students to prepare for speaking with the SP may be beneficial for students at this level of training.

A limitation of our activity was the small number of MCQs. Only three questions were included due to time constraints, but the activity could likely support additional questions if time allows. The case also addresses bioavailability, adverse effect prevention, and congenital cytomegalovirus treatment, which all could be assessed with added questions. Other limitations of our evaluation included a lack of historical comparison data, no long-term retention assessment, a single-institution event, and a low response rate to the learner evaluation surveys. Due to the specific learning goals of our encounter and a lack of pharmacology-based questions on the previous years' virology exam, we were unable to compare our learners to learners from previous class years. However, this encounter was designed as a supplement to the existing antiviral pharmacology material; therefore, a lack of comparable data is unsurprising. Additionally, we only conducted knowledge assessments immediately following the simulation, so we were unable to determine whether the simulation led to long-term retention of the pharmacology material covered. In previous evaluations of similar simulation-based activities, long-term retention has been variable.[4,21,22] The different implementation techniques between the 2020 and 2021 events (i.e., in person vs. virtual) may have also impacted the results of the knowledge assessment and evaluation surveys. The evaluation of this learning activity was conducted at a single institution with a relatively small sample size (<300 participants) and a low response rate on the postevent surveys, which may limit the generalizability of our results.

While this activity uses a simulated SP encounter, the event design and evaluation techniques could be modified to further maximize the benefits of simulation-based methodology, including allotting time for learner feedback from the SP, the other learners in their small group, and the instructors on students' performance discussing medication information with the patient. In addition, educators could consider including the SPs in the large-group debrief session. Each debrief session contained certain essential elements, including addressing the learning objectives and asking open-ended questions.[17,18] However, the facilitator did not specifically ask for learner self-reflection, which is beneficial in maximizing learning following a simulation (see speaker notes in Appendix D).[19] The timing of the debrief (within 3 hours of completion in 2020, immediately following completion in 2021) may have also contributed to the differences seen in knowledge assessment between the years. Lastly, the experience of the learners who acted in the provider role during the encounter was likely different from that of the learners who were observers, but the learner evaluation survey did not specifically evaluate this difference.

Future Directions

Despite this activity having occurred as a single case in a larger simulated virology clinic, other educators can use it as a single stand-alone event or with smaller groups of learners. However, the feasibility for educators to conduct this activity as a stand-alone event will be relative to their access to local simulation and SP resources. The learning activity might be improved if each student who participates has the opportunity to act as the provider, but then the event design would be more resource intensive. Since student feedback was similar between the in-person and virtual events, educators may select either method depending on local circumstances and access to learning spaces. We strongly recommend implementing this learning activity in person whenever possible, as in-person delivery significantly improves the authenticity of the activity for learners. However, if educators prefer to emphasize telehealth communication skills, the virtual format would be more useful.

Areas of future study are relevant to both the specific encounter and the technique in general. The encounter could be improved by increasing the time learners spend with the SP. This would allow the SP and observing students to give feedback to the learner who is in the provider role on their communication skills. Including time for learner reflection on the case during the large-group debrief session is another potential improvement. Having learners repeat the knowledge assessment (or similar MCQs) at a later date may also be beneficial for assessing long-term knowledge retention.

As for the use of SP encounters to teach pharmacology, we believe this instructional technique can be applied to other learning content in the preclinical curriculum and beyond, particularly with pharmacology content that is difficult to master. Additionally, educators may consider including this type of activity as part of the transition to the clinical medicine years of medical school, as a review for the USMLE Step 1 exam, as part of a capstone course in preparation for residency, or as practice for more advanced (resident) learners. Depending on the learner population, further evaluation of medication knowledge, adverse effect management, and patient communication skills could be included.[7]

Appendices

A. Student Instructions.docx

B. Preencounter Worksheet.docx

C. SP Script.docx

D. Debrief Presentation.pptx

E. Multiple-Choice Questions With Answers.docx

F. Learner Evaluation Survey.docx

All appendices are peer reviewed as integral parts of the Original Publication.

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The Wake Forest School of Medicine Institutional Review Board approved this project.

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