Clinics in Surgery

Research Article
Published: 20 May, 2022

# Evaluating the Impact of Peri-Simulation Education on Medical Student Performance: A Randomized Controlled Trial

*Logan D Glosser[1]*, Wade Hopper[2], Conner V Lombardi[1], Yixing Chen[3], Sprio Veria[1], Elliott Oberneder[3], Benjamin Talbot[1], Alexander N Young[1] and Coral D Matus[4]*

[1]University of Toledo College of Medicine and Life Sciences, USA

[2]Edward via College of Osteopathic Medicine, USA

[3]Lloyd A. Jacobs Interprofessional Immersive Simulation Center, USA

[4]Department of Family Medicine, University of Toledo College of Medicine and Life Sciences, USA

## Abstract

**Introduction:** Limited research exists evaluating pre-clinical medical student performance in Simulation Patient Encounters (SPEs), nor the effectiveness of teaching interventions as part of the learning. We sought to determine if a teaching intervention prior to simulation training improves medical student clinical decision-making skills compared to baseline performance.

**Methods:** A prospective randomized single-center crossover study comparing performance of second-year medical students in two SPEs. The groups were then randomized to receive an educational intervention either the day before the SPEs or at the conclusion of the two SPEs. The educational intervention was a 10-min video. Analysis was designed to evaluate if a difference existed between performance outcomes using a standardized checklist.

**Results:** The video prior cohort scored higher than the no video prior group in both case scenarios. In the anemia case scenario, video prior cohort scored 41.6% (23.69) *vs*. 38.9% (22.19) in the no video cohort. In the diverticular bleed case scenario, the video prior cohort scored 37.6% (19.94) *vs*. 37.1% (19.69) in the no video prior cohort. Additionally, for the diverticular bleed scenario there was a statistically significant higher number of prompting in the video prior cohort than the no video prior, with an average of 2.44 prompts *vs*. 1.56 respectively (p=0.04).

**Conclusion:** Our results did not find an impact of the educational video on the performance scores in the SPEs. This study had several limitations and calls for future studies with a more controlled environment to determine timing, efficacy, and impact of educational interventions in simulation training.

**Keywords: SPE; Clinical reasoning; Diagnostic error; Medical education; Educational intervention**

OPEN ACCESS

***Correspondence:***
*Logan D Glosser, University of Toledo College of Medicine and Life Sciences, 3565 Brookside Road, Toledo OH, 43606, USA, Tel: 419-705-6757; E-mail: Logan.Glosser@rockets.utoledo.edu*

**Received Date**: *04 Apr 2022*
**Accepted Date:** *05 May 2022*
**Published Date:** *20 May 2022*

***Citation:***
*Glosser LD, Hopper W, Lombardi CV, Chen Y, Veria S, Oberneder E, et al. Evaluating the Impact of Peri-Simulation Education on Medical Student Performance: A Randomized Controlled Trial. Clin Surg. 2022; 7: 3510.*



## Abbreviations

SPE: Simulated Patient Encounter; HPI: History of Presenting Illness; PE: Physical Exam; MCQ: Multiple Choice Questionnaire; VI: Vertical Integration; GI: Gastrointestinal

## Introduction

Mannequin-based simulation trainings (SIMs) are a cornerstone of modern medical education. It is increasingly used as it has developed into a highly effective teaching modality for a broad range of settings [1,2]. SIMs have shown to be an efficient, and cost-effective to develop such clinical skills, especially when compared to traditional teaching methods of slideshows and lectures [3-8]. Additionally, this they allow students to learn in a safe and controlled environment without the risk of harm to real patients [9]. The advent of COVID-19 prohibited medical students from entering the clinical environments which further highlighted the importance of clinical development without patient contact [10,11]. In addition to the cost-effectiveness and risk avoidance, there are benefits to pre-clinical medical student learning; SIMs can be directed to a target a broad range of specific knowledge and skills targeting the development of clinical interviewing, physical

examination, and diagnostic skills [12,13]. When designed well, this training allows for detailed data collection; assessment of score performance; and provide real-time feedback to learners [1,12,14,15]. Despite the increased utilization and employment of SIMs in medical school education, significant challenges remain. Although medical simulation has great potential, SIMs have significant variation in methodology, design, and outcomes. Research on SIMs within medical education has demonstrated insufficient technical quality to produce reliable results. This variation may be attributed to the lack of standardized guidelines for conducting SIMs for medical student training [1,3,16]. Incorporating teaching methods that is specific to the simulation learning objectives is a key component of optimizing simulation training. However, there is limited such research on such peri-SIM evaluating the impact of educational interventions on performance outcomes. Barriers to effective simulation from the institutional standpoint include the need for skilled simulation operators, financial support for the resources, and educators trained in simulation [17,18]. Several qualitative and quantitative evaluations measuring performance outcomes from SPEs have been identified. Quantitative outcomes are preferred due to a higher resolution of data [3,13,19,20]. Validated quantitative outcome measures of learner performance in simulations include time-to-action, pre-test assessments, and performance scoring using checklists of definable actions [3,19-22]. Although several studies have attempted to validate methods of simulation for medical student clinical skills acquisition, systematic reviews of the SIMs have proven limited by variations in methodology [19,20,23]. Medical schools should aim to approach simulation training in parallel to the rigorous method of evidence-based practice in modern medicine. Proper practice confers application of proper technique, and conversely improper practice can beget poor habits. Further research is needed to assess the impact of simulations on pre-clinical medical student skills competence and whether specific educational interventions can improve learning. Thus, our study aimed to add to the literature our experience with the use of simulation training as a learning modality for medical student education. We sought to determine how the timing of an educational intervention impacted the performance of second year medical students in a SPE setting as measured by a standardized skills checklist.

## Materials and Methods

### Study participants

All second-year medical students attending the University of Toledo College of Medicine and Life Sciences were eligible for the study. The trial was explained in detail to the group, and students were assured of the anonymity and confidentiality of personal information for all responses throughout the study period. Students that did not consent for the study did not have their coursework grades accessed and they were not asked to complete the voluntary feedback survey. A total of 174 medical students were eligible for and participated in this single center, IRB approved double blinded randomized trial.

### Study design

A mixed methods study was implemented that included a randomized-controlled trial with two intervention arms designated as "gold" and "blue". To ensure that all students had a similar overall learning experience, all students received an educational video. The blue group received instructions to view the video the day prior to the SPEs. The gold group received instructions to view the video at the conclusion of the SPEs. The SPE's were a formative, non-graded, activity designed as an opportunity for medical student learning. A two-stage randomization strategy was implemented. First, students were randomized into 32 groups of approximately equal size (4 to 6 students each). The 32 groups were then randomized into either the gold group or the blue group. The blue group was randomized to receive the video prior to the SPEs, and gold group was randomized as the control with no video prior. The randomization process was carried out by a faculty of UTCOMLS blinded from the study. The groups had a pre-randomization to the location of the simulation room and the SPE scenario. The blue and gold intervention arms each had half of the students participate in the upper GI bleed scenario first followed by the diverticular bleed second and the other half participated in the diverticular bleed scenario first followed by the upper GI bleed scenario second (Figure 1). Assignment of students and the randomization process was concealed from the students and independent from the research team. After randomization, the students received the intervention in a double blinded setting (both the subject and the investigator were blinded, such that the subjects ID and the intervention group were not linked together until after the end of the study when all results were unblinded for analyzation. The groups were assessed for completing key aspects of the history of presenting illness, physical exam, assessment/plan/intervention, and number of times the facilitator had to prompt students to keep the sim moving forward. Prompting statements were standardized to include: "are there any tests/labs/imaging or other-diagnoses that you may want to consider for this patient." The reporting guidelines for health care simulation research extensions to the CONSORT and STROBE statements were utilized to guide study design and write-up with attached checklists [24].

### Simulated patient scenarios

Each simulation scenario was 15 min long followed by a 5-min debriefing session. There were four simulations running simultaneously with 8 SPE's per group session, for a total 64 SPE's. Both scenarios mirrored a total of two simulation groups running at the same time. There was a total of 4 operators running the simulated patient scenarios. The operators ran the same case, in the same room and manakin for the duration of the study. The operators were given a standardized training session for their respective cases in attempt to keep the language and overall atmosphere the same for each of the groups. The two SPE scenarios were developed by faculty, medical physicians, at UTCOMLS independent of the research investigators. The study team did not have an impact on the patient scenarios or presentation of the scenarios in any manner. The scenarios included were one adult patient with an acute lower GI bleed from diverticulitis and one adult patient with a chronic occult upper GI bleed. The information the students were expected to obtain were developed by the faculty independent of the study team as well, which were used for the performance evaluation as explained in the measurement of outcomes section below. The students were given the following information verbally from the simulation operators, "You will have 15 min to conduct a focused history and physical exam. As you develop your differential diagnosis you may order labs, tests, and imaging that you believe is necessary for the work-up of the patient. Perform any necessary interventions as you see fit."

### Educational intervention

The educational intervention was designed by collaboration between UTCOMLS faculty and the study team. The intervention encompassed a 10-min recorded power-point presentation. The learning objectives were to teach, and review the evaluation,

management, diagnosis and treatment of intestinal ischemia and bleeding.

### Data collection

Two blinded independent evaluators viewed video recordings of the groups during their SPEs. Both reviewers were 4th year medical students who were observed independently by a faculty for 3 videos to ensure accuracy of the assessment. The evaluators recorded whether the students performed the checklist of activities for the respective chronic upper GI bleed and acute diverticular bleed SPE's (Supplemental Table 1). These checklists were modified versions of the checklists used at UTCOMLS for their in-person patient interviews as part of the medical student educational curriculum. The modification was performed by two physicians on faculty at the medical school.

### Statistical analysis

The primary objective is to compare the performance effect as measured by adapted analysis of student performance in a group setting of simulated patient encounters. The hypothesis that the Intervention = 0 was tested utilizing independent t-tests to compare mean group performance scores in the separate intervention arms. A p-value less than, or equal to 0.05 was regarded as statistically significant. This analysis approach makes two main assumptions (in addition to the normality assumption for the students paired t-test): No period effect and no intervention-period interaction. Secondary objectives will be to compare the sub-categorization of the scoring checklist. The change in accuracy of group performance in patient encounters was compared between the two intervention arms, video prior *vs.* no video. Comparisons of proportions were conducted via chi squared test. All statistical tests were performed using excel.

## Results

170 students participated in the two SPEs. The total scores in the video prior cohort were higher than the no video prior group in both case scenarios (Table 1). In the Anemia case scenario, video prior cohort scored 41.6% (23.69) *vs.* 38.9% (22.19) in the no video cohort (p=0.26). In the diverticular bleed case scenario, the video prior cohort scored 37.6% (19.94) *vs.* 37.1% (19.69) in the no video prior cohort (p=0.85). In the diverticular bleed scenario, there was a statistically significant higher number of prompting in the video prior cohort with an average of 2.44 prompts *vs.* 1.56 in the no video cohort (p=0.04). The average scores of the anemia case were higher in room 2 compared to room 1, with 42.2% *vs.* 38.3% respectively. The average scores of the diverticular case were higher in room 3 *vs.* room 4, with 39.1% *vs.* 35.6% respectively. However, there was not a statistically significant difference in scores by the room in which the case was presented (Table 2).

## Discussion

### Importance of medical student clinical skills training

SPEs were previously a feature of the United States Medical Licensing Exam (USMLE) Step 2 Clinical Skills (CS), however recently the CS portion of Step 2 was discontinued [25]. The CS portion of Step 2 was used by residency programs to screen applicants, and prior to its discontinuation, many programs indicated a desire for higher resolution data from the score report of Step 2 CS [26,27]. In response, co-sponsors of the USMLE program have stated an intention to develop novel assessments of clinical competency [28]. Although USMLE Step 2 CS was discontinued, most residency program directors previously endorsed Step 2 CS as factoring heavily into their admissions decision-making [27]. The removal of Step 2 CS has created a vacuum in the standardized assessment of medical students' clinical and communicative prowess [25]. A high granularity of data is desirable when considering the viability of potential clinical assessment methods [25,27]. Clinical skills and communication abilities are seen by many RPDs as lagging behind the book knowledge of incoming residents. The evaluation of soft skills including communication and professionalism is undoubtedly more complex than the accurate assessment of content knowledge. The present study typifies the need for continued research into the process-based evaluation of medical students' clinical competency.

### Medical student learning through simulation

Cook et al. reported a moderate effect of simulation in health professionals compared to other instruction methods in a systematic review and meta-analysis [29]. Previous studies on laparoscopy and Advanced Cardiac Life Support (ACLS) have demonstrated simulation training improves clinical outcomes [1]. However it is unclear whether simulation training improves patient outcomes across other skill domains, and further studies comparing the efficacy

**Table 1:** Two-tailed Independent T Test analysis of performance score totals and sub-categorical scores comparing the intervention to no intervention expressed as the mean (SD), percent correct, and 95% CI. Sub-categories included the History of Presenting Illness (HPI), Physical Exam (PE), Assessment/Plan/Intervention (A/P/I). Categories are expressed with the (total number) of eligible points. The normality assumption was checked based on the Shapiro-Wilk Test (alpha =0.05).

| Anemia | | | | | |
|---|---|---|---|---|---|
| Category (points) | **SPE-1 (no video)** | **95% CI** | **SPE-2 (video prior)** | **95% CI** | **P-Value** |
| **Total** (57) | 22.19 (3.78) 38.9% | 20.33-24.04 | 23.69 (3.63). 41.6% | 21.91-25.47 | 0.26 |
| **HPI** (20) | 9.00 (2.66) 45.0% | 7.69-10.30 | 8.69 (2.55). 43.4% | 7.44-9.94 | 0.74 |
| **Vitals & PE** (12) | 3.94 (2.02) 39.4% | 2.95-4.93 | 5.13 (1.82). 51.3% | 4.24-6.02 | 0.09 |
| **A/P/I** (25) | 9.25 (1.77) 37.0% | 8.38-10.12 | 9.88 (2.19). 39.5% | 8.80-10.95 | 0.38 |
| **Prompting** (*) | 2.44 (1.26) | 1.82-3.06 | 2.50 (1.59) | 1.72-3.28 | 0.9 |
| **Diverticular Bleed** | | | | | |
| Category (points) | **SPE-1 (Video Prior)** | **95% CI** | **SPE-2 (No video)** | **95% CI** | **P-Value** |
| **Total** (53) | 19.94 (3.66) 37.6% | 18.14-21.73 | 19.69 (4.00) 37.1% | 17.73-21.65 | 0.85 |
| **HPI** (20) | 6.94 (1.65) 34.7% | 6.13-7.75 | 6.31 (2.24). 31.6% | 5.21-7.41 | 0.38 |
| **Vitals & PE** (10) | 3.94 (1.61) 32.8% | 3.15-4.73 | 4.31 (1.54). 35.9% | 3.56-5.07 | 0.51 |
| **A/P/I** (23) | 6.56 (1.75) 28.5% | 5.71-7.42 | 6.63 (2.16). 28.8% | 5.57-7.68 | 0.93 |
| **Prompting** (*) | 2.44 (1.21) | 1.85-3.03 | 1.56 (1.09) | 1.03-2.10 | **0.04** |

**Supplemental Table 1**: Checklist for performance scoring in Sim 1 and Sim 2 respectively. Red text indicates categories; black text indicates 1 point available for completion.

| **Chronic Upper GI bleed** | **Acute Diverticular Bleed** |
|---|---|
| **HPI** | **HPI** |
| Patient Name | Patient Name |
| Chief complaint | Chief complaint |
| location/radiation | location/radiation |
| quantity/severity | quantity/severity |
| timing (Onset/frequency/duration) | timing (Onset/frequency/duration) |
| setting in which it occurs/has it happened before | setting in which it occurs/has it happened before |
| exacerbating factors | exacerbating factors |
| remitting factors | remitting factors |
| associated symptoms | associated symptoms |
| patient perspective | patient perspective |
| medications | medications |
| allergies | allergies |
| tobacco use | tobacco use |
| alcohol use | alcohol use |
| illicit drug | illicit drug |
| ROS (8 categories for a point) | ROS (8 categories for a point) |
| Family History | Family History |
| Vaccinations | Vaccinations |
| Past Medical Hx | Past Medical Hx |
| Past surgical hx | Past surgical hx |
| **Physical Exam & vitals** | **Physical Exam & vitals** |
| Auscultate abdomen x 4 quadrants | Auscultate abdomen x 4 quadrants |
| palpate/percuss | palpate/percuss |
| Look to assess symmetry/contour | Look to assess symmetry/contour |
| Assess for Peritoneal signs (rebound tenderness/guarding) | Assess for Peritoneal signs (rebound tenderness/guarding) |
| Rectal exam | Rectal exam |
| Auscultated Heart areas | Heart rate |
| Auscultated Lung Fields | RR |
| Heart rate | Temperature |
| RR | BP |
| Temperature | o2 sat |
| BP | **Assessment/Plan/Interventions** |
| o2 sat | Ask for CXR |
| **Assessment/Plan/Interventions** | Identified Normal lung fields |
| Ask for CXR | Ask for VBG or ABG |
| Identified Normal lung fields | Ask for CBC |
| Ask for VBG or ABG | Identified Anemia aka low hemoglobin |
| Identified acidosis aka Low PH | Ask for CMP |
| Ask for CBC | Identified acidosis |
| Identified Anemia aka low hemoglobin | Identified prolonged PTT/INR |
| Identified normocytic anemia | Ask for Fecal Occult Blood test (FOBT) |
| Ask for CMP | Ask for EKG |
| Identified elevated BUN | Identified sinus tachycardia |
| Ask for coagulation panel | Performed blood Type and cross |
| Identified prolonged PTT/INR | started 2 large bore IV access |

| | |
|---|---|
| Ask for Fecal Occult Blood test (FOBT) | Administer Fluids |
| Ask for EKG | Administered PRBC |
| Identified sinus rhythm | oxygen (nasal cannula) |
| Performed blood Type and cross | Vasopressor administered |
| Ordered Troponin | Warfarin Reversal agent PCC/FFP administered |
| Started 2 large bore IV access | Ordered EGD |
| Administer Fluids | Ordered Colonoscopy |
| Administer Oxygen (nasal cannula) | Ordered CT abdomen & pelvis |
| Ordered EGD | NG Tube |
| Ordered Colonoscopy | **prompting** |
| Ordered CT Abdomen | |
| Ordered CT angiogram | |
| Ordered NG tube | |
| Administered PRBC | |
| **prompting** | |

**Table 2:** Two-tailed Independent T test of combined total score of SPE-1 & SPE-2 comparing intervention to no intervention, and simulation room of the cases.

| | Combined SPE-1 & -2 Score | 95% CI | P-Value |
|---|---|---|---|
| Video Prior | 43.63 (4.88) 39.7% | 41.23-46.02 | 0.339 |
| No Video | 41.88 (5.32) 38.1% | 39.27-44.48 | |
| Room 1 (anemia) | 21.81 (3.67) 38.3% | 20.01-23.61 | 0.09 |
| Room 2 (anemia) | 24.06 (3.53) 42.2% | 22.33-25.79 | |
| Room 3 (diverticular) | 20.75 (3.51) 39.1% | 19.03-22.47 | 0.16 |
| Room 4 (diverticular) | 18.88 (3.90) 35.6% | 16.97-20.78 | |

of the multitude of simulation modalities, especially on pre-clinical medical students, are needed [1,23]. Issenberg et al. [16] identified 10 features of simulation that contribute to effective learning in 2005. These features listed in descending order from most effective to least effective include providing feedback, repetitive practice, curriculum integration, range of difficulty, multiple learning strategies, capture clinical variation, controlled environment, individualized learning, defined outcomes, and simulator validity. The metanalysis by cook in 2012 confirmed these factors, but also found that group instruction was associated with improved outcomes [20]. Our study incorporated most of these factors, apart from having a controlled simulation environment and individualized learning.

## Simulation methodology

Our study assessed the impact of a 10-min video intervention on performance scores of second-year medical students in two gastrointestinal SPEs. Students either received the intervention the day prior to the SPE experience or after the conclusion of the second SPE. In this population of second-year medical students, we found no significant difference in performance scores when comparing the group that received the video-intervention the day prior to the simulations versus those that did not receive the intervention prior. Although statistical significance was not reached, the video-prior group scored higher in both simulation exercises. On further analysis there were differences in the total average score of the SPEs depending on the room, and operator, in which the activity was performed. Although these differences did not reach statistical significance, it highlights the importance of standardizing the instructions for operators and having highly trained competent operators for simulation training. A metanalysis comparing simulation interventions found the time of the simulation to be a significant factor affecting performance [20]. In our study, the sims were limited to 10-min sessions which may not have been enough time for them to have fully assessed the patient.

## Simulation performance assessments

No significant inter-rater reliability was observed, owing to the skills checklist composed of largely objective measures. There was room for rater subjectivity on some of the physical examination items (e.g., "Look to assess symmetry/contour") and diagnostic testing items ("Identified normal lung fields on chest X-ray"). A planned multiple-choice questionnaire pre and post-test as part of the study protocol was not administered due to time constraints. Thus, the student's baseline knowledge was unable to be assessed and may have been a confounder of the results observed. Additionally, without the MCQ testing we were unable to define if the simulation had an impact on objective knowledge testing. A post-SPE feedback survey could have elucidated if learners felt the simulation improved their application of knowledge in the clinical setting. Lower scores were observed in the acute diverticular bleed SPEs compared to the chronic GI bleed SPEs. This could have been due to slight differences in between the two grading rubrics; however, the acute nature of the former presentation could have contributed to learner stress levels and thus cognitive load. The acute scenario showed less difference in overall performance between the intervention group and the treatment group compared to the chronic scenario. Additionally, learners in the acute scenario performed lower on nearly all subsections of the checklist compared to learners in the chronic scenario, potentially reflecting a relationship between cognitive load and acuity of care. In the acute care setting, perceived case difficulty has shown to be a strong predictor of cognitive load [30]. Prompting was the only subsection in which learners in the acute setting outperformed those in the chronic setting-in the acute SPE, the intervention group required on average nearly one more cue prompt per SPE. This could simply be because acute care affords practitioners less time to pause, deliberate, and possibly get stuck during decision-making.

## Educational interventions for simulation

Carter et al. [31] performed a cross over study involving third year medical students to determine if a 60-min lecture prior to a 20-min SPE involving peripheral vascular disease affected third year medical

student performance scores as measured by a standardized checklist. The students who received the pre-SPE training scored higher than did those who did not receive the lecture. Our study observed similar results with increased performance in the physical exam and vitals subcategory among learners receiving a pre-SPE educational intervention; however, the results observed in our study failed to reach statistical significance. Other studies have observed SPEs to be especially effective at improving medical student history-taking and physical examination skills [4,32]. Further research is needed to assess the impact of SPEs on pre-clinical learners who have a limited to no clinical experience and potentially a lower degree of confidence in their clinical skills compared to third-year students participating in clinical rotations.

### Future considerations

For the performance scores as the day progressed, there may have been a knowledge gap. These sims were held as part of a full day of GI activities which may have influenced students' abilities to perform during the sims. All groups participated in a 'GI Olympics' education day, in which they had a team-based learning activity in the anatomy lab followed by an introduction to suturing session before participating in the SPE scenarios evaluated in this study. Additionally, the students later in the day may have had cognitive fatigue, whereas the students earlier in the day had less exposure to the GI activities which may have weakened their performance. Due to the students having interactive activities throughout the day there was ample opportunity that the students may have shared information about the simulation cases which may have impacted their performance. Cognitive load theory suggests that certain types of education are unconducive to learning new knowledge and skills due to the cognitive fatigue they impose [33]. Managing cognitive load plays an important role in the setting of medical education, in which problems are complex and students are expected to learn a high volume of material [34,35]. The design of the present study relates to cognitive load theory because the use of a pre-SPE intervention video was intended to help students schematize the complex process of reaching a diagnosis by starting with a chief complaint. We observed higher skill checklist completion percentages in the pre-SPE video intervention group compared to learners who finished the SPE before receiving intervention, albeit without statistical significance.

## Conclusion

This article has presented an overview of the difficulty in conducting research relevant to medical student simulations training using a failed experimental design. It discusses technical considerations when approaching the design, assessment of, and implementation of simulation. This article provides meaningful recommendations for future simulation execution and research study considerations. The key findings from this study relate the importance of developing standardized protocols for assessing medical student performance in simulation training.

## Acknowledgement

We would like to give a special thanks to Karla Dixon, the Lloyd A. Jacobs Interprofessional Immersive Simulation Center staff, and the University of Toledo College of Medicine and Life Sciences and for their support of this study.

## References

1. Okuda Y, Bryson EO, DeMaria S, Jr., Jacobson L, Quinones J, Shen B, et al. The utility of simulation in medical education: What is the evidence? Mt Sinai J Med. 2009;76(4):330-43.
2. Chakravarthy B, Ter Haar E, Bhat SS, McCoy CE, Denmark TK, Lotfipour S. Simulation in medical school education: Review for emergency medicine. West J Emerg Med. 2011;12(4):461-6.
3. Beal MD, Kinnear J, Anderson CR, Martin TD, Wamboldt R, Hooper L. The effectiveness of medical simulation in teaching medical students critical care medicine: A systematic review and meta-analysis. Simul Healthc. 2017;12(2):104-16.
4. Fletcher KE, Stern DT, White C, Gruppen LD, Oh MS, Cimmino VM. The physical examination of patients with abdominal pain: The long-term effect of adding standardized patients and small-group feedback to a lecture presentation. Teach Learn Med. 2004;16(2):171-4.
5. Sachdeva AK, Wolfson PJ, Blair PG, Gillum DR, Gracely EJ, Friedman M. Impact of a standardized patient intervention to teach breast and abdominal examination skills to third-year medical students at two institutions. Am J Surg. 1997;173(4):320-5.
6. Papadakis MA, Croughan-Minihane M, Fromm LJ, Wilkie HA, Ernster VL. A comparison of two methods to teach smoking-cessation techniques to medical students. Acad Med. 1997;72(8):725-7.
7. Lane C, Rollnick S. The use of simulated patients and role-play in communication skills training: A review of the literature to August 2005. Patient Educ Couns. 2007;67(1-2):13-20.
8. Angarita FA, Price B, Castelo M, Tawil M, Ayala JC, Torregrossa L. Improving the competency of medical students in clinical breast examination through a standardized simulation and multimedia-based curriculum. Breast Cancer Res Treat. 2019;173(2):439-45.
9. Bradley P. The history of simulation in medical education and possible future directions. Med Educ. 2006;40(3):254-62.
10. Rose S. Medical student education in the time of COVID-19. JAMA. 2020;323(21):2131-2.
11. Ren R, Parekh K, Franzen D, Estes M, Camejo M, Olaf M, et al. Emergency medicine clerkship director experience adapting emergency remote learning during the onset of COVID-19 pandemic. AEM Educ Train. 2021:e10594.
12. Ainsworth MA, Rogers LP, Markus JF, Dorsey NK, Blackwell TA, Petrusa ER. Standardized patient encounters. A method for teaching and evaluation. JAMA. 1991;266(10):1390-6.
13. May W, Park JH, Lee JP. A ten-year review of the literature on the use of standardized patients in teaching and learning: 1996-2005. Med Teach. 2009;31(6):487-92.
14. Kunkler K. The role of medical simulation: An overview. Int J Med Robot. 2006;2(3):203-10.
15. Sakakushev BE, Marinov BI, Stefanova PP, Kostianev SS, Georgiou EK. Striving for better medical education: The simulation approach. Folia Med (Plovdiv). 2017;59(2):123-31.
16. Issenberg SB, McGaghie WC, Petrusa ER, Lee Gordon D, Scalese RJ. Features and uses of high-fidelity medical simulations that lead to effective learning: A BEME systematic review. Med Teach. 2005;27(1):10-28.
17. Hamstra SJ, Brydges R, Hatala R, Zendejas B, Cook DA. Reconsidering fidelity in simulation-based training. Acad Med. 2014;89(3):387-92.
18. Boet S, Bould MD, Layat Burn C, Reeves S. Twelve tips for a successful interprofessional team-based high-fidelity simulation education session. Med Teach. 2014;36(10):853-7.
19. Howley L, Szauter K, Perkowski L, Clifton M, McNaughton N; Association of Standardized Patient E. Quality of standardised patient research reports in the medical education literature: Review and recommendations. Med Educ. 2008;42(4):350-8.

20. Cook DA, Hamstra SJ, Brydges R, Zendejas B, Szostek JH, Wang AT, et al. Comparative effectiveness of instructional design features in simulation-based education: systematic review and meta-analysis. Med Teach. 2013;35(1):e867-98.

21. Findley JC, Schatte D, Power J. A difficult patient encounter: Using a standardized patient scenario to teach medical students to treat medication-seeking patients. MedEdPORTAL. 2017;13:10612. Epub 20170804.

22. Nassif J, Sleiman AK, Nassar AH, Naamani S, Sharara-Chami R. Hybrid simulation in teaching clinical breast examination to medical students. J Cancer Educ. 2019;34(1):194-200.

23. Kaplonyi J, Bowles KA, Nestel D, Kiegaldie D, Maloney S, Haines T, et al. Understanding the impact of simulated patients on health care learners' communication skills: A systematic review. Med Educ. 2017;51(12):1209-19.

24. Cheng A, Kessler D, Mackinnon R, Chang TP, Nadkarni VM, Hunt EA, et al. Reporting guidelines for health care simulation research: Extensions to the CONSORT and STROBE statements. Simul Healthc. 2016;11(4):238-48.

25. Howley LD, Engle DL. Discontinuation of the USMLE step 2 clinical skills examination: Studying the past to define the future. Acad Med. 2021;96(9):1247-9.

26. Cuddy MM, Winward ML, Johnston MM, Lipner RS, Clauser BE. Evaluating validity evidence for USMLE step 2 clinical skills data gathering and data interpretation scores: Does performance predict history-taking and physical examination ratings for first-year internal medicine residents? Acad Med. 2016;91(1):133-9.

27. Paniagua M, Salt J, Swygert K, Barone MA. Perceived utility of the USMLE step 2 clinical skills examination from a GME perspective. J Med Regul. 2018;104(2):51-7.

28. Work to relaunch USMLE Step 2 CS discontinued 2021 03/10/2022.

29. Cook DA, Brydges R, Hamstra SJ, Zendejas B, Szostek JH, Wang AT, et al. Comparative effectiveness of technology-enhanced simulation versus other instructional methods: A systematic review and meta-analysis. Simul Healthc. 2012;7(5):308-20.

30. Vella KM, Hall AK, van Merrienboer JJG, Hopman WM, Szulewski A. An exploratory investigation of the measurement of cognitive load on shift: Application of cognitive load theory in emergency medicine. AEM Educ Train. 2021;5(4):e10634.

31. Carter MB, Wesley G, Larson GM. Lecture versus standardized patient interaction in the surgical clerkship: A randomized prospective cross-over study. Am J Surg. 2006;191(2):262-7.

32. Gilliland WR, Pangaro LN, Downing S, Hawkins RE, Omori DM, Marks ES, et al. Applied research: Standardized versus real hospitalized patients to teach history-taking and physical examination skills. Teach Learn Med. 2006;18(3):188-95.

33. Sweller J. Cognitive load during problem solving: Effects on learning. Cogn Sci. 1988;12(2):257-85.

34. van Merrienboer JJ, Sweller J. Cognitive load theory in health professional education: Design principles and strategies. Med Educ. 2010;44(1):85-93.

35. Leppink J, van den Heuvel A. The evolution of cognitive load theory and its application to medical education. Perspect Med Educ. 2015;4(3):119-27.