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Original Research

The Efficacy of Table Top Simulation as a Didactic Adjunct for an Undergraduate Emergency Medicine Clerkship Curriculum: A Prospective Cross-Over Study

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ABSTRACT

Introduction: Simulation is used by many medical specialties, throughout the world, as an effective educational adjunct to clinical learning experiences. There is limited prospective research to support the use of table-top, low fidelity, simulation experiences as a suitable replacement for traditional lecture-based modalities in the context of undergraduate emergency medical education. We designed, implemented and evaluated sections of a table-top simulation-based curriculum for fourth year medical students participating in the department's advanced emergency medicine clerkship.

Methods: A prospective, randomized, cross over study comparing lecture-based learning activities to an experimental table-top simulation exercises based on a primary outcome objective, considering the quantitative acquisition of clinical knowledge, and a secondary outcome looking at the results of survey data, considering student perspectives on learning experience. Four student cohorts participated in the study, each spending one month in the department's advanced emergency medicine medical student elective.

Results: Medical knowledge learning outcomes did not show a significant improvement in the experimental modality when compared to the traditional format. Likert scale survey data showed, with statistical significance ($P<.05$), that students preferred the simulation modality over the traditional lectures finding it to be more interactive, and a more effective format for teaching medical knowledge and applicable clinical information.

Conclusion: Findings showed, with statistical significance, that students preferred this learning modality but that more research would be needed to further evaluate our findings of improved learning outcomes. Further research should be pursued to characterize this modality's benefit, as compared to traditional small group lecture and high-fidelity simulation modalities, in order to evaluate its possible effectiveness for furthering the development of undergraduate emergency medicine education in the future.

Keywords: emergency medicine clerkship, emergency medicine, medical education, simulation

INTRODUCTION

Over the past two decades, simulation has assumed an increasingly important role in both graduate and undergraduate emergency medicine (EM) education in the United States and throughout the world. Simulation encompasses a broad spectrum of educational experiences, ranging from static two dimensional models to interactive task training to high-fidelity simulations of case-based clinical management, leading to highly variable learning experiences at the undergraduate emergency medicine (medical-student clerkship education) level.[2-4] While high-fidelity simulations have demonstrated their effectiveness in medical education they continue to present significant logistical challenges, particularly at the medical school level of training, due to their considerable financial expense and complexity of their advanced technologies.[5-7]

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As a result of these barriers, simulation experiences are used selectively and still do not represent the primary educational adjunct for most existing educational curricula in EM. Even at advanced levels of undergraduate clinical training, there remains a heavy emphasis on classroom-based or non-clinical small group activities.[8] Consequently, questions as to the utility of low fidelity simulation (modalities focusing less on general clinical realism), as compared to its high fidelity counterparts (designed to recreate a scenario where learners fully interact with complete patient models in highly realistic clinical environment), remains an area of academic interest.[9-11] This study aims to show that low fidelity table-top simulation experiences (a commonly used educational modality where small groups participate in interactive scenarios with or without the use of rudimentary props that are not specifically designed to physically replicate clinical realism) can offer objective educational benefit as well as an improved learner experience.[12] Please note, throughout the article, the experimental learning modality will be referred to primarily as either the 'low fidelity' simulation curriculum or the 'table-top' simulation curriculum. However, during the study's implementation (including the official survey) it was commonly referred to as Teddy Bear simulation. These terms are used interchangeably and all refer to the experimental curriculum utilized and studied in the course. By demonstrating the effectiveness of this modality, we hope to show that clinical simulation, even with low fidelity experiences, offers an improvement over traditional lecture based small-group activities.

MATERIALS & METHODS

Course Design and Setting

The academic program, and research study, were conducted in an academic emergency department holding full departmental status in a large urban medical university. In addition to its undergraduate programing, the department also includes one of the country's largest emergency medicine residency programs consisting of a Level 1 urban trauma center as well as both tertiary and quaternary referral teaching hospitals. During the 2018 academic year we sought to expand the use of simulation as our clerkship's primary didactic adjunct. To accomplish this goal, we designed a low fidelity, table-top, simulation curriculum using teddy bears as clinical models. In line with national standards, the clerkship lasted four weeks and was intended to give fourth-year medical students a clinical and academic introduction to emergency medicine.

The course's content addressed four nationally recognized core topics in undergraduate emergency medicine education: chest pain, shortness of breath, abdominal pain and cardiovascular shock, and included modules pertaining to each of these topics.[13] Each module was divided into four clinical cases (sixteen cases across the entire curriculum) each containing standard learning points. Over the course of the four-week clerkship experience, each student participated in a learning activity dealing with each of the four topics.

The experimental modality of the curriculum was

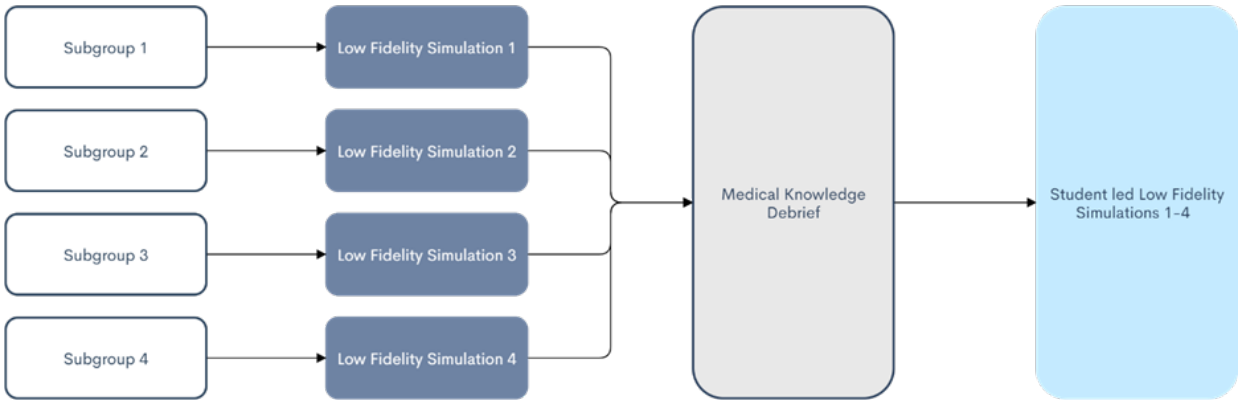

Figure 1 Simulation workflow

taught via table-top simulation sessions (utilizing teddy bears as clinical models) and was comprised of three distinct learning activities: an oral board style case simulation, a clinical knowledge discussion and a summative simulation exercise. For the introductory sessions, students were divided into four subgroups of two to four students. Each of these smaller groups was randomly assigned to one of the four subgroups (Figure 1). Utilizing the teddy bears, students, under the guidance of the clerkship faculty, went through the clinical cases, developed differential diagnoses and took critical clinical actions in line with expected management. During this activity no clinical actions were taken directly on the teddy bear simulator. However, efforts were made to shift the abstract role of the patient from the session moderator, typical of most oral board style activities, to the teddy bear to help focus the educational activity on a tangible simulated entity.

After the simulation sessions, the four subgroups were again brought together for a short presentation highlighting the topic's clinical and medical knowledge teaching points. After this medical knowledge debriefing, members of each subgroup were tasked with preparing the case they had just experienced for presentation to the entire cohort of students.

The summative simulation exercise enabled all four of the session's cases to be reviewed by the entire cohort of students, with the students themselves serving as the primary educator for their peers. This was again done through table-top simulations utilizing teddy bears as the models. During the summative experience, focus shifted from primary evaluation and diagnosis to management of these pathologic processes in their most clinically unstable and hemodynamically compromised presentations. As with the initial simulation sessions, medical students were expected to identify and implement emergent diagnostic, therapeutic and resuscitative interventions on the teddy bear models. During this activity students interacted directly with the teddy bear simulator either by verbally expressing or, when technically feasible such as in performing cardio pulmonary resuscitation (CPR), physically performing critical actions. Equipment for the obtaining of 'vascular access,' non-invasive forms of ventilation and simulated 'patient monitoring' were made available to augment the student's interactions with the teddy bear simulators. Unique to the summative simulation was the opportunity for participating students to serve as educators and simulation leaders.

Research Study Design, Interventions and Methods

In order to evaluate our curriculum, a prospective, randomized, cross over study was designed to compare acquisition of clinical knowledge and student perceptions of the educational experiences between the table top simulation sessions and traditional lecture based small-group activities (Figure 2). This design had been used in past studies to evaluate the efficacy of high-fidelity simulation in the undergraduate emergency medicine education setting.[14] Primary outcomes were assessed by comparing pretest and posttest analysis of medical knowledge. Survey data, pertaining to learner experience, was also considered. The study was approved by the university's institutional review board. Consent forms were signed by all participants.

To control for the different educational topics and the different student cohorts we evaluated the program within and between clerkship sessions. As a result, each clerkship cohort was randomly assigned to have two of the learning topics taught by our experimental modality and the other two topics taught via the control modality. All students of a given elective class experienced each learning topic via the same educational modality. Randomization of the topics, taught via the control or experimental methods, was done via a coin toss of the initial cohort's configuration and continued on a rotational basis throughout the program. Over the course of the academic year, each topic was taught by each modality an equal number of times.

For the medical knowledge analysis, all students were given a pre-test on each of the topics prior to the educational experience. These questions, although not a component of the student's course grade, were then incorporated into the clerkship's final course exam. Test questions were based on the department's previously established examinations with known data analytics reflecting consistent exam score means and standards of deviation from the prior three years of evaluation. Sample size calculations were derived from the means and standards of deviations, based on a continuous endpoint of two independent sample calculation for an alpha of

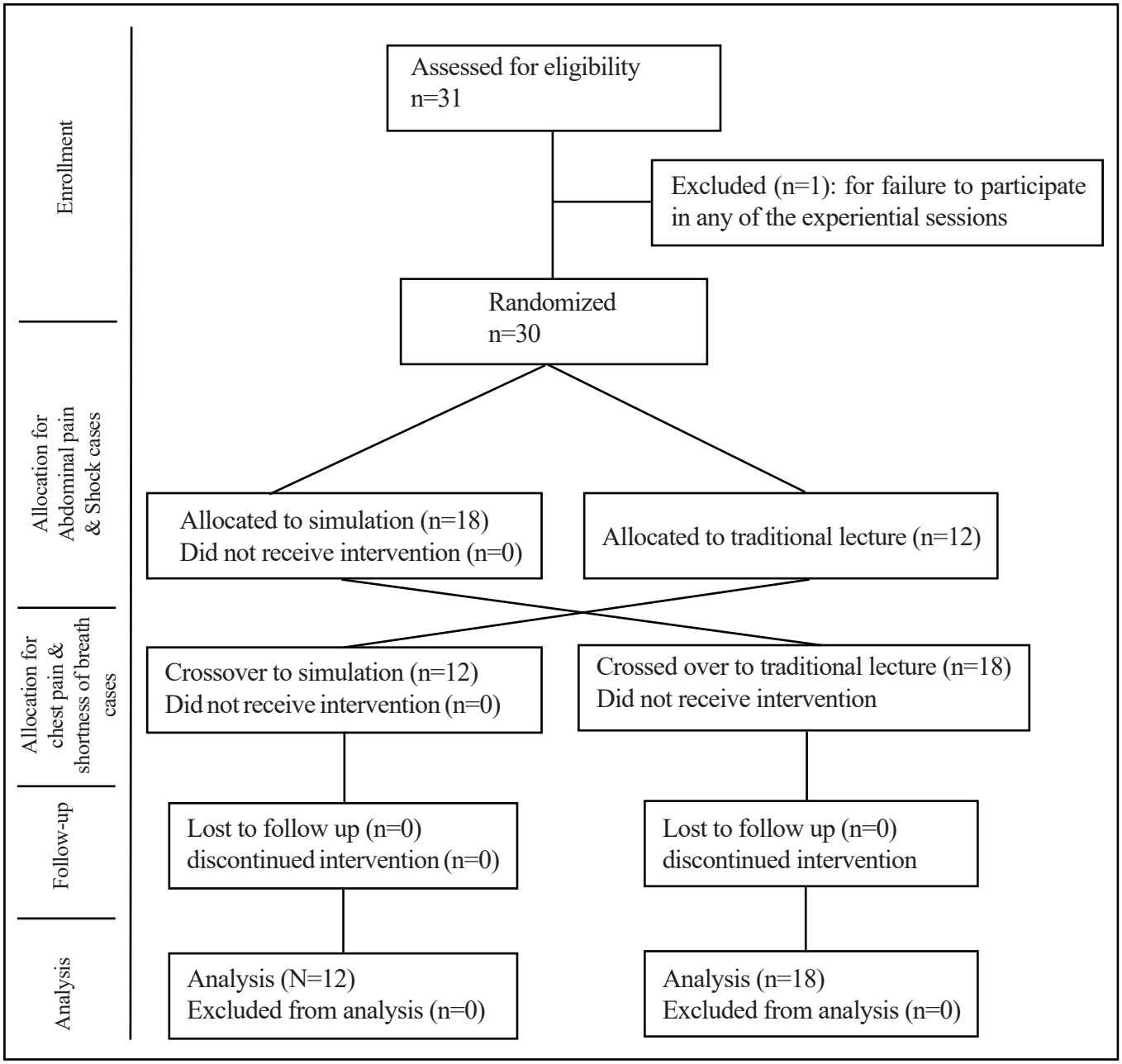

Figure 2 Study design

0.05 and beta of 0.2. Calculations showed a needed sample size of at least 15 participants in each study arm. Effectiveness of the experimental learning modality was demonstrated by improvement on the post-test examination compared to those who learned the topic with the control learning modality. In addition to quantitative testing, all participating students were asked to fill out a survey asking them to compare the experimental learning modality as compared to the control.

Selection of Participants

All fourth-year medical students participating in the emergency medicine clerkship from August through December 2018 participated in the experimental curriculum and the elective's primary educational didactic. The formal research study included the final four clerkship cohorts of the 2018 academic year. Data from these cohorts were only incorporated into the study for those students who had consented to participate in our research.

Students were not required to participate in all four activities for their responses and test results to be included, however, only post-test data that had a completed corresponding pretest was incorporated into the final study. The program's simulation experience was available to all clerkship participants. They were informed that their clerkship evaluation would not be affected by their participation, or decision not to participate, in the research study. Also, students' performance on the research study's activities (including both pre and post-tests) had no impact on their clerkship evaluation or grading.

Study Measurements

The experimental learning modality was evaluated through three measures corresponding to progressing levels of the Kilpatrick rankings.[15] Knowledge acquisition was assessed via ten pre and post-test examination questions for each of the medical education subjects. Limited past research has considered the use of pre and post knowledge-based questioning to be effective in evaluating medical knowledge acquisition through simulated teaching modalities.[16,17] Students would sit for the pre-test prior to either their experimental or control learning experience. These same questions would then be asked to the students as an ungraded portion of their final exam. Analysis involved evaluating the change in pre and post-test performance between subjects taught via the control and experimental modalities.

The second and third evaluation markers were incorporated into a single end of course, anonymous, survey. The first four questions asked students to evaluate each learning session on a 1-5 scale. Analysis involved evaluating the change in evaluation scores between subjects taught via the control and experimental modalities. The final assessment were five Likert scale questions asking students to directly evaluate the experimental modality.

Analysis

The data from the results of the pre-test, post-tests, session evaluations as well as survey questions were converted into .xls files and analyzed with Microsoft Excel 365 (Version 1905; Microsoft Office, Redmond, Washington). Needed sample size was determined using an inference from mean calculation based on previously established known standard deviation and sample averages.

We performed the following analysis:

1- For the primary outcomes, we compared improvement pre-test to post test in each group using a two-tailed t-test. These results are reported as mean difference with 95%CI.

2- We reported the answers to the Likert questions as mean with 95% CI.

3- We used independent samples T-test to compare lecture evaluations between the groups and report means for each group and p values.

RESULTS

A total of 31 students participated in the clerkship during the period in which the study was conducted. One of those students missed the majority of the didactic sessions and their testing data and survey responses were not included in the final study. All of the participating students were in their fourth year of medical school. The majority were rotating students from outside universities.

Our primary outcome was to look at whether improvement of scores, from the pre-test to the post-test, was more significant in the experimental table-top simulation group as compared to the control lecture groups. Medical knowledge improvement from pre-test to the post-test did

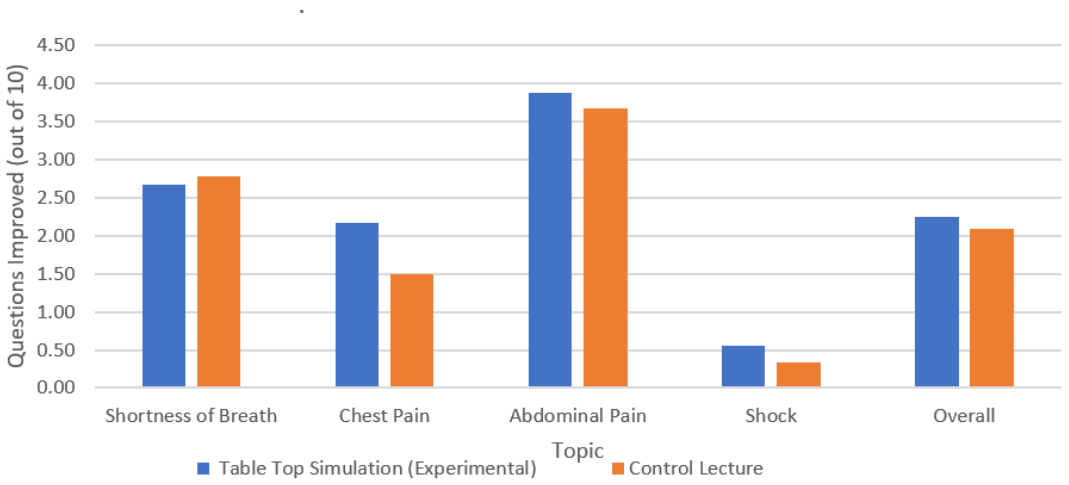

Figure 3 Improvement from pre-test to post test, table top simulation versus traditional lecture

not show a statistical difference in the table top simulation versus traditional lecture. Test scores in the experimental group improved an average of 2.24 questions, between pre and post-test examinations as compared to a 2.08 change in the control group (p=0.68). Selected topics did demonstrate better learning outcomes with the experimental table-top simulation while others showed improvement with the control lecture format (Figure 3).

The two secondary outcomes were based on lecture evaluations as well as Likert scale (-2 to +2) surveys asking participants if they preferred low fidelity simulation in contrast to traditional lectures. Participants preferred the simulation modality over the traditional lectures (Likert scale 1.25, p<0.001). Low fidelity simulation was rated as more interactive, a more effective format for teaching medical knowledge information (Likert scale 1.18, p<0.001). and a more effective format for teaching applicable clinical information (Likert scale 1.50, p<0.001). when compared to the traditional lecture-

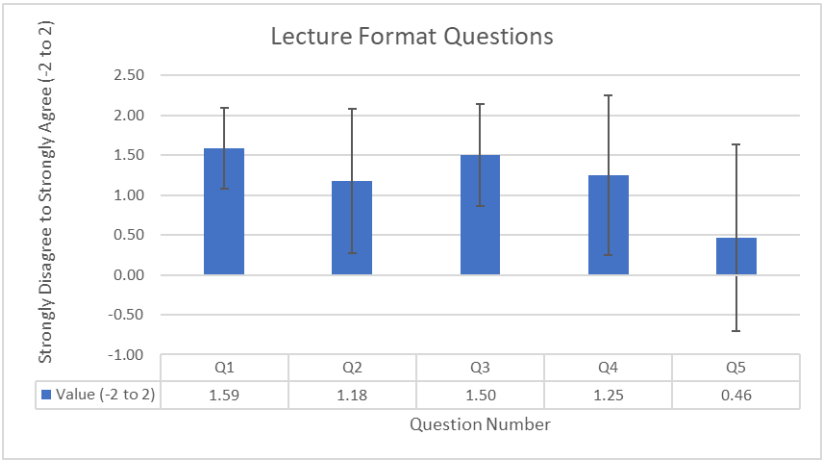

Figure 4 Average Likert Scale from questions about Teddy Sim when compared to traditional

Q1: I found the Teddy Sim sessions to be more interactive than the traditional lecture-based sessions (p <0.001)

Q2:I found the Teddy Sim sessions were more effective formal for teaching medical knowledge information than the traditional lecture-based session(p <0.001)

Q3:I found the Teddy Sim sessions were a more effective format for teaching applicable clinical information than the traditional lecture-based session(p <0.001)

Q4:I preferred the Teddy Sim sessions format over the traditional lecture format(p <0.001)

Q5: I would prefer that all the rotations didactics ('classroom activities') be done in the teddy Sim format (p=0.045)

based sessions (Figure 4).

Furthermore, students were asked to evaluate the presented topics on a 1-5 scale. The evaluations for low fidelity simulation was 4.79/5 and 4.66/5 for traditional lecture (p=0.12). There was no statistically significant difference between the groups (Table 1).

DISCUSSION

Emergency medicine is a dynamic and interactive field mandating a multifaceted education that addresses knowledge content, procedural aptitude and decision-making skills. Simulation, a modality well recognized for its ability to address these diverse objectives, has been widely accepted throughout the emergency medicine community.[18] At the undergraduate clerkship level, however, offering simulation experiences remains a logistical and financial challenge. Recognizing the benefits of simulation, we designed a low fidelity simulation curriculum that was well received by learners.

We conducted a prospective, crossover study looking out quantitative learning outcomes and measures of learner experience. Primary medical knowledge learning outcomes were based on a series of questions that had been designed based off previous learning cohort outcomes. Additionally, qualitative and quantitative surveys were conducted to evaluate for the study's secondary outcome focusing on learner experience.

Our primary outcome sought to evaluate differences in learning outcomes based on pre and post-test knowledge evaluations. Our simulation curriculum demonstrated comparable knowledge acquisition.

The study's two main secondary outcomes were based on the student's perception of their own learning experience and were assessed via survey response. Topics that were taught by the experimental modalities were rated higher than those taught via the control, though these did not reach statistical significance. However, our experimental learning modality was preferred by the students over traditionally small group didactic formats. We were able to conclude that students did perceive this low fidelity simulation modality to offer a more interactive learning experience and a more effective learning format for disseminating scientific and clinical knowledge. Students would also rather participate in a low fidelity simulation experience than a traditional format and felt that all didactic sessions should be delivered via this experimental modality.

As with previous studies the use of simulation modalities, even those that were considered to be low fidelity, enabled a more interactive end more well received learner experience than traditional lecture-based small group activities. To date, although high fidelity simulators have been shown to improve primary learning outcomes, there have only been limited, and equivocal, evaluations of low fidelity modalities.[19,20] This study, in line with the current literature pertaining to the impact of the degree of simulation fidelity, especially the low fidelity experiences, emphasizes need for case-by-case assessment, and continued research, pertaining to learner engagement and learning outcomes.[21]

Our study was limited by the number of students enrolled in the clerkship during the study period. Ultimately, consistent with precalculated needed sample sizes, there were not enough students evaluated to provide sufficient power for the primary knowledge acquisition outcome.

Both the control and interventional sessions were taught by the same person who was not blinded to the study or its objectives, which may have influenced study findings. Furthermore, students were not blinded to the study's objectives. Survey questions were not designed to be neutral and asked students to directly evaluate their perception of the experimental modality from the perspective of its hypothesized impact on learner experience.

As acquisition of medical knowledge remains a core aspect of undergraduate medical education the study was designed to focus on medical knowledge learning outcomes. Our findings, therefore, do not reflect the two modalities' efficacy with regard to clinical outcomes.

CONCLUSIONS

We designed and implemented a low fidelity didactic simulation curriculum for an emergency medicine clerkship that students preferred. Our findings suggest that this low fidelity simulation format could provide an improvement over existing didactic curricula but would require additional studies to further assess its impact on learning outcomes.

Conflicts of Interest

Authors declare no conflicts of interest or sources of funding.

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