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The Impact of Operation Bushmaster on Medical Student Decision-making in a High-Stress, Operational Environment

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ABSTRACT

Introduction:

Operation Bushmaster is a high-fidelity military medical field practicum for fourth-year medical students at the Uniformed Services University. During Operation Bushmaster, students treat live-actor and mannequin-based simulated patients in wartime scenarios throughout the five-day practicum. This study explored the impact of participating in Operation Bushmaster on students' decision-making in a high-stress, operational environment, a crucial aspect of their future role as military medical officers.

Materials and Methods:

A panel of emergency medicine physician experts used a modified Delphi technique to develop a rubric to evaluate the participants' decision-making abilities under stress. The participants' decision-making was assessed before and after participating in either Operation Bushmaster (control group) or completing asynchronous coursework (experimental group). A paired-samples *t*-test was conducted to detect any differences between the means of the participants' pre- and posttest scores. This study was approved by the Institutional Review Board at Uniformed Services University #21-13079.

Results:

A significant difference was detected in the pre- and posttest scores of students who attended Operation Bushmaster ($P < .001$), while there was no significant difference in the pre- and posttest scores of students who completed online, asynchronous coursework ($P = .554$).

Conclusion:

Participating in Operation Bushmaster significantly improved the control group participants' medical decision-making under stress. The results of this study confirm the effectiveness of high-fidelity simulation-based education for teaching decision-making skills to military medical students.

INTRODUCTION

As the United States' only federal medical school, the Uniformed Services University (USU) executes a military-unique curriculum (MUC) that prepares medical students for their future careers as military medical officers. Within this curriculum, there are four medical field practicums in which students engage in hands-on, experiential learning that aims to equip them with the knowledge and skills they need to become leaders and skilled practitioners upon graduation.[1] The MUC curriculum's overarching goals are to teach students leadership, officership, and military field medicine, while providing an opportunity to apply their newfound knowledge and skills in a series of progressive laboratory and field practicums. The field practicums allow the students to treat simulated patients in highly realistic environments and to make critical decisions while facing the stress and chaos inherent in those environments.

Past research has explored students' leadership abilities, teamwork, and identity formation as a result of participating in Operation Bushmaster, the culminating field practicum during the medical students' fourth year.[2–4] However, no studies to date have explored the effect of USU's MUC on students' medical decision-making during stressful situations. Making decisions while stressed is a key skill for military physicians while deployed, as they are regularly called upon to make critical choices regarding leadership and patient care in complex, chaotic, and resource-limited environments.[5,6] We therefore conducted this experimental study

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to explore the effect of participating in Operation Bushmaster on students' decision-making in a stressful operational environment.

Operation Bushmaster is a high-fidelity, immersive, 5-day simulated combat experience. The fourth-year medical students treat live-actor and mannequin-based simulated casualties that present with a variety of combat trauma and disease non-battle injury conditions.[7,8] On the final day of the practicum, teams of medical students treat more than 30 patients at once in a mass casualty event. By the end of Operation Bushmaster, each student has treated more than 150 unique simulated patients. In addition to experiencing the stress of the high operations tempo, the students continually face an austere, resource-constrained environment. They must utilize critical thinking skills to conserve these resources as they make critical decisions that impact themselves, their platoon, and their patients.[7] The students are also undergoing multiple summative performance assessments throughout the exercise, which further adds to their stress.[3]

Operation Bushmaster is an expensive, complicated, and time-consuming exercise to execute. For example, the practicum requires a cadre of hundreds of people to serve as faculty, planners, support personnel, patient actors, and various other roles. Currently, it is not known if the exercise is superior to lower-cost, simpler options for teaching high-stress decision-making. In order to assess Operation Bushmaster's effectiveness as an educational tool for decision-making, we compared it with low-fidelity, less-expensive, and less time-consuming online asynchronous learning. We hypothesized that Bushmaster will produce a greater improvement in medical students' decision-making skills than online asynchronous learning.

METHODS

We used a randomized, blinded, pre–post comparison of educational interventions for medical decision-making under stress. The data collection portion of our study occurred in three phases.

Phase 1. Develop Rubric. Prior to study enrollment, a panel of military emergency medicine physician experts created two critical care patient scenarios, septic shock and hemorrhagic shock, with associated scoring rubrics for the study (see Appendices A and B). According to this rubric, the participants received a positive point value for making accurate decisions or a negative point value for making inaccurate decisions.[9] The point values for each decision were weighted based on the medical importance of the decision, which was determined by the panel. The total number of points that the participants earned during each scenario served as the participants' final score. The participants' final score became the outcome measure for this study. Using a modified Delphi technique, the rubrics were reviewed and edited in multiple rounds until a consensus was reached on the final version used in this study.[10]

Phase 2. Develop Experimental Group Coursework. Our research team developed online, asynchronous coursework based on the Operation Bushmaster practicum. The goal of the online curriculum was to present the asynchronous learners with similar didactic material to what the experiential learners would receive in the Bushmaster field setting. It consisted of online materials focusing on evidence-based best practices for performing tactical combat casualty care and critical care in the operational environment. The materials first provided background information on prehospital care, including statistics regarding injury, death, and illness on the battlefield. Then, the objectives, elements, and phases of care of tactical combat casualty care were covered in depth with specific examples provided. The students were also provided with step-by-step written instructions with graphics regarding procedures such as hemorrhage control, airway management, needle decompression, chest tube insertion, and other skills needed for managing critically ill or injured patients. In addition to these written materials, the students received online resources related to operational medicine in the deployment environment. The experimental group completed this coursework while the control group was attending Operation Bushmaster Iteration 1.

Phase 3. Conduct Pre- and Posttests (see Figure 1). Each year, half of the fourth-year medical students at USU participate in Operation Bushmaster during 1 week in October and then the other half of the students participate the following week. These students are assigned by their course director to attend either Iteration 1 (first week) or Iteration 2 (second week) of Operation Bushmaster. There is no reason to suspect a difference in students assigned to the first or second week of Bushmaster. The assignments are based on the students platoon organizational structure that is created when the students initially matriculate to USU. In this study, 20 volunteer participants assigned to Iteration 1 served as the control group and 10 volunteer participants assigned to Iteration 2 served as the experimental group (before they attended Operation Bushmaster) (see Table I for participant demographics).

Both groups completed their pretests in a simulated high-stress operational environment at USU and then completed the posttest at an operational military field training facility at Fort Indiantown Gap, PA. At both sites, the participants were subjected to loud helicopter and gunfire noises as well as hot and windy weather conditions as they treated the patients.

Students in the control group completed their pretests the week prior to attending Operation Bushmaster and then completed their posttests immediately at the conclusion of Operation Bushmaster. Students in the experimental group completed their pretests the week prior to completing their asynchronous course work and then completed their posttests immediately after completing the asynchronous course work. Both groups of students eventually completed the field practicum version of Operation Bushmaster.

When completing their pre- and posttests, the participants were randomly assigned to treat either a septic shock patient

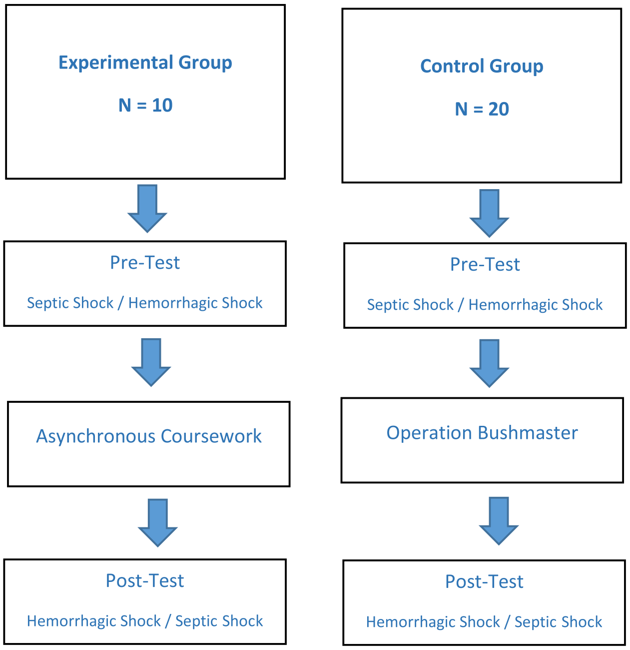

FIGURE 1. Study flow.

or hemorrhagic shock patient, simulated by 3G high-fidelity SimMan mannequins (Laerdal; Wappingers Falls, NY), which we used in order to add to the realism of the scenario. The research team selected the septic shock and hemorrhagic shock cases due to their frequency of occurrence in operational field settings. The participants who treated hemorrhagic shock patients in the pretest then treated patients with septic shock in the posttest, and vice versa. We began each scenario by reading the patient scenario prompt to the participants, who viewed the patients' vitals on a screen connected to the 3G mannequins. The participants then independently assessed and treated the patients. The research team instructed all students about how to use the 3G mannequins prior to commencing the study.

These pre- and posttest procedures were recorded via GoPro cameras that were set up on site and then reviewed and scored by the primary investigator (PI) and the research team, using the decision-making rubric developed for this study. The research team consisted of four board-certified emergency medicine experts (a Navy Captain, a Navy Commander, an Air Force Lieutenant Colonel, and an Army Major), who were blinded to the participants' status as members of the experimental group or control group.

Data Analysis

Because the data in this study consisted of ratings of the participants' decision-making based on a rubric, we calculated intraclass correlation (ICC) in order to estimate interrater reliability between two raters (the PI and an emergency medicine expert) for both the pretests and the posttests in the control and experimental groups (see Table II).[11,12] Our calculations included ICC estimates and their 95% confidence intervals.[13] We analyzed our data using a single-measurement, consistency, one-way random effects model. For the control group pretests, ICC = 0.716, which is a moderate degree of reliability. For the experimental group pretests, ICC = 0.566, which is also a moderate degree of reliability. For the control group posttests, ICC = 0.940, which is a high degree of reliability. For the experimental group posttests, ICC = 0.920, which is also a high degree of reliability.[12] Overall, our calculations demonstrated that the degree of reliability was moderate for both the control and experimental group pretests and it was high for both the control and experimental group posttests.

Assumption Checks

Next, before conducting our data analysis, we verified that our data met the three assumptions of a t-test: (1) the observations were independent of one another, (2) the groups were similar, and (3) the dependent variable showed a normal distribution.[14,15] Our data met the first assumption because the control group and experimental group did not influence one another in any way. In addition, both groups uniformly consisted of fourth-year medical students attending USU, meeting the second assumption. In order to test the third assumption, we conducted a Shapiro–Wilk's test to determine if the data for each group was distributed normally.[16] The P-value for the

TABLE I. Participant Demographics

	Gender	Age range	Ethnicity	Uniformed service	Prior military service
Experimental group	Male: 3; Female: 7	25–27: 4	White: 6	Army: 2	Yes: 2
		28–30: 2	Hispanic: 1	Navy: 2	
		31–33: 3	Black: 1	Air Force: 6	No: 8
		34+: 1	Asian: 2	PHS: 0	
Control group	Male: 11; Female: 9	25–27: 16	White: 13	Army: 2	Yes: 2
		28–30: 4	Hispanic: 3	Navy: 8	
		31–33: 0	Black: 2	Air Force: 7	No: 18
		34+: 0	Asian: 1	PHS: 1	

PHS, U.S. Public Health Service.

TABLE II. Intraclass Correlation (ICC) Value Calculations at 95% Confidence Level

Group	ICC value	Lower bound	Upper bound	Degree of reliability
Experimental group pretest	0.566	−0.254	0.853	Moderate
Control group pretest	0.716	0.178	0.904	Moderate
Experimental group posttest	0.920	0.768	0.963	High
Control group posttest	0.940	0.827	0.980	High

TABLE III. Paired-Samples *t*-Test Results for Experimental and Control Groups

	Pretest	Posttest	*P* values
Experimental group	$M = 11.00$, SD 1.15	$M = 10.00$, SD 5.94	$P = .554$
Control group	$M = 11.00$, SD 3.04	$M = 19.35$, SD 5.29	$P < .001$

Significant at the $P < .05$ level.

pretest scores in the control group was .186 and the *P*-value for the pretest scores in the experimental group was .065. In addition, the *P*-value for the posttest scores in the control group was .059 and the *P*-value for the posttest scores in the experimental group was .570. Because all values were greater than .05, we were 95% confident that the dependent variable was normally distributed and all *t*-test assumptions were met.

RESULTS

The results of our study demonstrated a significant change in the means of the control group but not the experimental group (see Table III). Students in the Operation Bushmaster control group demonstrated a statistically significant improvement between their pretest ($M = 11.00$, SD 3.04) and posttest ($M = 19.35$, SD 5.29) scores ($P < .001$). Comparatively, the paired-samples *t*-test revealed that there was not a statistically significant difference in the pretest ($M = 11.00$, SD 1.145) and posttest ($M = 10.00$, SD 5.94) scores of students in the experimental group who completed the asynchronous coursework, $t(9) = 0.615$, $P = .554$.[17] Because the *P*-value was greater than 0.05, we concluded that the differences in the means of the experimental group's test scores were likely due to chance.[14,17]

In order to further investigate the significant results in the control group results, we calculated Cohen's *d* (*d*) to estimate the magnitude of the difference of the pretest and posttest means.[18] The effect size for this data analysis ($d = 1.94$) was considered to be a large effect size and signified that the differences in the means between the pre- and the posttest scores exceeded 2 SD.[18,19]

Discussion

In-person participation in Operation Bushmaster proved superior for teaching decision-making skills to medical students compared to an asynchronous, online learning experience. The findings of the study align with those in the medical education literature regarding the benefits of experiential simulation-based education, which has been found to improve students' skills, knowledge, and ultimately patient outcomes.[20,21]

These findings likewise support the value of, and continued need for, high-fidelity practicums and training exercises for military medical students in order to prepare them for their first deployment where they will serve as leaders and key decision makers in the full range of military and medical operations. Just as medical students move from classroom didactics to clinical rotations, so too should military medical students have the opportunity to implement and practice their classroom-based military and medical studies in a higher fidelity environment where they are challenged in real time with gathering, interpreting, and acting on data relevant to the situation at hand; in this case, a complex multiday military combat operation. Past research has shown high-fidelity simulation training to positively impact military medical students' ability to handle stress,[22] develop emotional intelligence,[6,23] and function as a team in the operational environment.[23]

The results of this study regarding the control group's ability to successfully navigate both clinical and logistical scenarios while in an unfamiliar, stressful environment contribute directly to a student's professional identity formation as a military medical officer. While traditional medical schools focus on, among other things, a student's ability to connect with a patient, perform a physical examination, order appropriate tests, make the diagnosis, and communicate with family members and consultants shortly after graduation, USU students are also expected to plan medical operations in support of military missions, assess a variety of personal and public health risks, develop plans to mitigate those risks, and brief senior nonmedical officers on said plans.

As a federally funded institution, USU has a responsibility to the Department of Defense and U.S. taxpayers to assure them that graduates are competent in military-specific knowledge, skills, and attitudes (KSAs) due to the unique work environment and organizations these students will soon be operating within. With successful completion of Operation Bushmaster as a graduation requirement, this medical field practicum serves as an important milestone for students to demonstrate an adequate level of competence in military medical knowledge, skills, and attitudes, as well as helping them identify personal strengths, weaknesses, and gaps for further development and implementation as they progress in their career as a military medical officer.

Limitations

This study's small sample size and focus on a single field practicum may limit the generalizability of our findings.

In addition, the loud background noises to include gunfire, helicopter, and generator sounds sometimes made it difficult for our research team to hear exactly what the participants were saying in the videos during our review of the data. However, given the high interrater reliability, we do not suspect that these noises interfered with our data analysis process. The differences in opportunities for repetitive hands-on practice with simulated patients between the experimental and control group may have also affected the outcomes. Finally, although we developed our rubric with a rigorous consensus process, it was not externally validated at the time of the study.

CONCLUSION

Students' immersion into a high-fidelity military field practicum was superior compared to asynchronous, web-based education for teaching high-stress decision-making to medical students. This study's findings affirm the utility of simulation-based education for teaching key skills to military medical students.

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CONFLICT OF INTEREST STATEMENT

None declared.

Appendix A

Prompt used in the simulated scenario

Table A1

Scenario script: HEMORRHAGIC SHOCK
Brief: You are called to assess 19-year-old Private First Class Meyers, who was struck with shrapnel from an improvised explosive device explosion. He is conscious but anxious, restless, and confused. The patient was found in a large pool of blood and brought in by his team, limited initial case was provided. You are in the Role 1 facility. Your objectives are to evaluate the patient, treat as indicated, and make a disposition (what next, where to?). Manikin: Single combat applied tourniquet to right upper extremity, bloody lacerations below the tourniquet.
Patient Characteristics Respiratory rate: 36 RR Heart rate: 124 bpm Blood pressure: 90/60 Temperature: 37.0 Chest clear. Normal bilateral expansion, rapid breathing. Pupils reactive to light. Normal heart sounds.

Rubric used to score the participants' decision-making

Table A2

Decision	Weighted score
Identify source(s) of blood loss	3
Assessed airway, respiration, and circulation	3
Failure to assess airway, respiration, and/or circulation	−3
Assess tourniquet to control bleeding	5
Failure to assess tourniquet to control bleeding	−5
Intravenous (IV)/intraosseous access	1
Appropriate IV site (any place other than arm with tourniquet)	1
Identify hemorrhagic shock	3
Administer Tranexamic acid 2 g	4
Administer blood	4
Failure to administer blood	−4
Administer calcium 1 g	3
Call for evacuation	3
Correct transmission of a 9-line report (communicated with casualty, tactical leadership, evacuation system, and medical providers)	3
Total	33 (−12)

Appendix B

Prompt used in the simulated scenario

Table B1

Scenario script: SEPTIC SHOCK
Brief: You are called to assess 19-year-old Private First Class Meyers, who has been complaining of not feeling well for the past 5 days. He complains of constant nausea, diarrhea, and a bad cough (nonproductive). You are in a Role 1 facility. The patient was brought in by his battle buddy. Your objectives are to evaluate the patient, treat as indicated, and make a disposition (what next/where to?).
Patient stats (as seen on monitor) Oxygen saturation: 93% on air (96% on oxygen) Respiratory rate: 28 RR Heart rate: 124 bpm Blood pressure: 92/60 Temperature: 102.4 Chest not clear. Normal expansion/percussion. Normal card sounds. Rapid, thready radial pulses. Pupils reactive to light.

Rubric used to score the participants' decision-making

Table B2

Decision	Weighted score
Assessed airway, respiration, and circulation	3
Failure to assess airway, respiration, and/or circulation	−3
IV fluids	5

(continued)

Table B2 (Continued)

Decision	Weighted score
Appropriate site #1	1
Administer O_2 (by any method)	3
Interpret correctly "Septic Shock"	3
Administer antibiotic	3
Correct antibiotic selected	3
Incorrect antibiotic selected	−3
Correct antibiotic dose	2
Correct antibiotic route	1
Unsafe dose/route	−3
Administer albuterol	3
Unsafe dose	−3
Call for evacuation	3
Correct transmission of a 9-line report (communicated with casualty, tactical leadership, evacuation system, and medical providers)	3
Total	33 (−12)

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