Disaster Day: A Simulation-Based Disaster Medicine Curriculum for Novice Learners

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ABSTRACT

BACKGROUND: Mass casualty and multi-victim incidents have increased in recent years due to a number of factors including natural disasters and terrorism. The Association of American Medical Colleges (AAMC) recommends that medical students be trained in disaster preparedness and response. However, a majority of United States medical students are not provided such education.

OBJECTIVE: The goal of this study was to evaluate the effectiveness of a 1 day, immersive, simulation-based Disaster Day curriculum.

SETTINGS AND DESIGN: Learners were first and second year medical students from a single institution.

MATERIALS AND METHODS: Our education provided learners with information on disaster management, allowed for application of this knowledge with hands-on skill stations, and culminated in near full-scale simulation where learners could evaluate the knowledge and skills they had acquired.

STATISTICAL ANALYSIS USED: To study the effectiveness of our Disaster Day curriculum, we conducted a single-group pretest-posttest and paired analysis of self-reported confidence data.

RESULTS: A total of 40 first and second year medical students participated in Disaster Day as learners. Learners strongly agreed that this course provided new information or provided clarity on previous training, and they intended to use what they learned, 97.6% and 88.4%, respectively.

CONCLUSIONS: Medical students' self-reported confidence of key disaster management concepts including victim triage, tourniquet application, and incident command improved after a simulation-based disaster curriculum. This Disaster Day curriculum provides students the ability to apply concepts learned in the classroom and better understand the real-life difficulties experienced in a resource limited environment.

KEYWORDS: Simulation, disaster, education, mass casualty

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Introduction

Mass casualty and multi-victim incidents have increased in recent years due to a number of factors including natural disasters and terrorism.[1,2] Physicians play an important role in disaster management and contribute to all stages of the disaster cycle. The Association of American Medical Colleges (AAMC) recommends that medical students be trained in disaster preparedness and response.[3] This includes education for chemical, biological, radiological, nuclear and environmental agents by having a didactic and experiential learning component in their medical school training curriculum.[4,5] However, a survey of interns representing 42 medical schools from 20 states in the United States found that only 47% received any type of disaster preparedness training in medical school.[5]

Physicians are expected to lead or respond during a disaster, and can find themselves in situations to render aid even before first responders arrive. Although programs such as Community Emergency Response Team (CERT) are focused on training

members of a community for providing immediate response during a disaster, there is a similar need to train healthcare providers in disaster principles as well.[6] Medical students early in their training have an opportunity to learn the basic principles of disaster medicine.[6] This education can then be applied in hospital settings during clinical years, or in the prehospital setting should such an event occur. The number of disaster events, both natural and man-made, are on the rise.[3] These types of events often result in mass casualty incidents that require quick and thoughtful action. As our culture changes, it is important to highlight disaster training for our future physicians to ensure they are properly equipped for the challenges they will face. These trained medical students can be a valuable asset and can be utilized as a resource during disasters or mass casualty incidents.

Previous work has suggested the use of a 1-day training curriculum model that utilizes both didactic presentations and as well as experiential learning for disaster preparedness and mass casualty response training.[4,6-8] Simulation has become a central component of medical education, allowing learners to experience high-risk low-frequency situations in a safe learning environment.[9] We sought to create a 1-day multi-victim and mass casualty educational curriculum for first and second year medical students that could be executed to minimize disruption to the existing academic schedule. The goal of this study was to evaluate the effectiveness of this immersive simulation-based Disaster Day curriculum. The learner objectives for this disaster medicine curriculum were as follows:

By the end of this session learners will be able to: (1) Demonstrate the ability to respond to mass casualty incidents; (2) Execute safe search and rescue of victims; (3) Apply appropriate triage techniques; (4) Administer first-aid to victims on the scene.

Materials and Methods

Study design and setting

The Emergency Medicine Interest Group at our local medical school requested education for medical students from the university. The university, in partnership with our hospital system, developed a team of disaster medicine content experts, education specialists, and simulation professionals to work with the medical students to develop the goals and objectives, as well as the content of the education.

Given that the target audience was medical students with little to no background in disaster medicine we sought to follow Bloom's taxonomy for providing the education.[10] The education would begin with remembering and understanding disaster medicine concepts. It would then progress to application of this knowledge with hands-on skill stations. Finally, the day would culminate with near full scale simulations where the learners could analyze and evaluate their execution of the knowledge and skills they had learned.

Selection of participants

A total of 40 first and second year medical students participated in Disaster Day as learners. These students had responded to an email from the student president of the Emergency Medicine interest group. Approximately half of the learners were members of the Emergency Medicine Interest group, and the other half were other students in the class. The education was voluntary and was conducted on a Saturday when no other education was scheduled.

Interventions

The structure for a 1 day disaster medicine curriculum was developed from expert consensus (Table 1).

The first 2 hours leveraged local resources to provide basic education about disaster medicine. This included review of federal, state, and local resources. In addition, we discussed rudimentary incident command structure both at the scene of an incident, as well as hospital-based incident command. Triage principles using Simple Triage and Rapid Treatment (START) were discussed. The final aspect of the didactic education was reviewing rapid treatment and first aid. This included Stop the Bleed® education along with other first aid principles.

Following a short break the learners were separated into 2 groups. The groups were comprised of a mix of first and second year medical students. Each group then participated in 2 hands-on skills stations that allowed the learners to apply the concepts from the education they had received earlier in the morning. Station 1 included application of tourniquets and other principles from Stop the Bleed®. In addition, we reviewed other first aid concepts such as chin-lift jaw-thrust, c-collars, backboards, and splinting. Station 2 consisted of "teddy bear triage." This exercise involved 80 teddy bears that served as simulated mass casualty victims. The bears had tags affixed to them that outlined their injuries that could be assessed just by looking at the victim and placing a hand on the patient (Table 2).

The bears were scattered around a room. Learners then had to organize themselves (using incident command structure), find the victims, and triage the victims (using START triage). In addition, using their command structure, learners had to determine in what order the victims should be transported to local hospitals. Over the course of this 30-minute skill station, learners were able to perform this skill 2 different times.

Lunch was provided and during this time the learners had a facilitated discussion with prehospital providers. The prehospital providers reviewed their experiences with mass casualty incidents, examined lessons learned, and answered questions from the learners.

Finally, the day culminated with 2 large-scale simulations. The learners remained in their groups and were presented with 2 different scenarios. Each scenario lasted a total of 1 hour, with 30 minutes to perform the simulation and 30 minutes to debrief with simulation and content experts. The structured

Table 1. Disaster Day curriculum outline.

07:30-07:50	Breakfast, sign-in, welcome
08:00-08:30	First presentation – National Incident Management System Federal/State Response, Local Mass Casualty event discussion
08:30-09:15	Second presentation – Incident command (on scene and at hospital), roles, resource mobilization, triage basics
09:15-10:00	Third presentation – Stop the bleed, basic first aid, acute interventions, decontamination
10:00-10:15	Break
10:15-11:15	Hands-on
	Trauma/first aid (c-collar, backboard, stop-the-bleed, equipment)
	Group A – 10:45-11:15
	Group B – 11:15-11:45
	Triage practice/incident command (teddy bear triage, tagging, organization)
	Group B – 10:45-11:15
	Group A – 11:15-11:45
11:15-12:00	Lunch & learn: Med flight ground crew presentation
12:00-12:15	Break & pre-brief
12:15-14:15	Mass casualty simulations
	Scenario 1: Structural collapse – bombing
	Group A – 12:30-13:30
	Group B – 13:30-14:30
	Scenario 2: Organophosphate – explosion/fire
	Group B – 12:30-13:30
	Group A – 13:30-14:30
14:15-14:30	Wrap-up, evaluation, acknowledgements, pictures

debriefing was conducted by simulation and debriefing experts in conjunction with other subject matter experts and followed the 4E (Events, Emotion, Empathy, Explanations) model. The simulated disaster scenarios included both mannequin victims (n = 6) as well as standardized patient (SP) (n = 29) victims. The standardized patients were students, faculty, and staff volunteers from the medical school. SPs arrived 1 hour prior to the simulated scenarios. They were provided information on the victim they would be portraying, including reviewing their injuries and how these injuries would present clinically. In addition, the SPs underwent moulage and a safety briefing prior to the scenarios. Scenario 1 involved a bombing and resultant structural collapse. Learners had to mitigate scene safety concerns while providing first aid to victims. As triage continued a secondary explosive device was discovered and learners had to mitigate this threat while victims remained

Table 2. Sample teddy bear triage tag.

AIRWAY	MOANING
Breathing	Chest rise only on left side
Circulation	Central pulses weak, slow capillary refill
Disability	Bleeding left upper extremity amputated at the elbow

Figure 1. Learners work to extricate victims of a simulated bombing.

trapped inside (Figures 1 and 2). Scenario 2 was based in a large cooperative farming complex. This scenario began with an explosion and resultant fire in a barn housing pesticides. Victims had not only blast and thermal injuries, but also organophosphate exposure symptoms as well (Figure 3).

This education was performed at the local fire department administrative building and training center. This location was chosen as it provided ample space and allowed for set-up and tear-down that did not interfere with the daily operations and education at the medical school. In addition, the training facilities included a training tower for firefighters that could be darkened and filled with simulated structural materials. This training tower was the site of one of the scenarios and the other was conducted in a large garage bay. The administrative building had one large conference room, and one small conference room that were the locations of the didactic portions of the education.

The faculty requirements consisted of 2 fellowship trained simulation experts that also served as content experts. In addition, subject matter experts were local firefighters/paramedics (n = 8) who were on duty the day of the training, a local disaster preparedness expert, and a fellowship-trained emergency medical services physician. The simulation staff consisted of 4 simulationists that were present for the final 5 hours of the day. This project was reviewed by the OhioHealth Institutional Review Board and was deemed not human subjects research as it was a quality improvement project.

Measurements

We used a Likert scale based survey to measure the outcomes and impact of this training. The surveys were completed after the education. The measurement was focused on (1) demonstrating

Figure 2. Learners triage victims and render aid to victims of a simulated bombing.

improvement in the learner's attitude or self-confidence from their baseline levels; (2) determining if the training was relevant for the learners, any new information gained, and whether they are willing to apply the skills and knowledge learned in their workplace; and (3) evaluating the quality of training in terms of the training environment, the realism of the simulation, technology, and quality of the instructors. These evaluations are part of our standard learner assessment and training program evaluation that is based on levels of Phillips return on investment (ROI) methodology.[11]

To evaluate the realism of the simulations, we asked learners to rate the simulation situations and injuries encountered. Six questions assessed the usefulness of the simulation training using a five-point modified Likert scale ranging from "Strongly agree" to "Strongly disagree" and 3 open-ended questions that allowed learners to provide feedback not captured elsewhere.

To evaluate the usefulness of this education, we assessed learners' confidence in their ability to handle disaster situations. We administered a questionnaire immediately after the training targeted for medical student learners. To study the effectiveness of our Disaster Day curriculum, we conducted a single-group posttest study. The questionnaire consisted of 15 questions for the learner to self-report their confidence in managing disasters on a 5-point modified Likert scale with 5 for "high" confidence to 1 for "low" confidence. These questions on the post-education survey asked how confident they were before the education as well as after the education.

Analysis

A paired analysis of the data was done on SPSS (ver. 25). We ran Wilcoxon signed-rank sum test to determine if there was any significant improvement in the mean confidence level of the learners between the retrospective pre-assessment and the post-assessment.

Results

The data analysis suggests that there was a significant increase in the mean score of the learner's self-confidence for the various knowledge and skill components of this training ($P < .001$) (Table 3). The analysis of the training evaluation indicated strong agreement from the learners of the relevance of training to their work (73.8%), provided new information (97.6%), realism of the scenarios (83.3%), and for their intention to apply the knowledge learned in the future (88.1%). Similarly, the learners rated the overall quality as very good for the training (97.6%) and the instructors (100%).

Figure 3. Learners triage victims, render aid, and begin to coordinate transport to hospitals for victims of a simulated explosion and organophosphate exposure.

Discussion

The one-day disaster training day curriculum provided learners with foundational knowledge on key disaster management concepts including incident command structure, START triage, rescue techniques, and field management of contaminated victims. Learners self-reported confidence of key disaster management concepts significantly improved after a simulation-based disaster curriculum. Despite these disaster concepts being included as part of the curriculum recommended for medical school,[4,5] 97.6% of participants felt that the material presented was new or that it was able to clarify prior knowledge. This is consistent with previous research which reports the majority of medical students do not receive adequate disaster preparedness training.[5]

The preparation for a disaster day of this scale required the development of clear curricular goals and objectives for the learners. Once these were developed and agreed upon, this provided a roadmap that facilitated the recruitment of non-physician subject matter experts (firefighters, critical care transport, medics, special operations personnel, etc.). These experts joined the team and contributed further guidance and shared resources

Table 3. Learner assessment results.

ASSESSMENT OF LEARNER'S SELF-CONFIDENCE	LEVEL OF CONFIDENCE (N = 42) *(CONFIDENCE WAS MEASURED BY USING A LIKERT SCALE: VERY LOW = 1 TO VERY HIGH = 5)*		
	PRE-COURSE MEAN ± SD	POST-COURSE MEAN ± SD	*P*-VALUE
Respond to a disaster	1.9 ± 0.9	3.8 ± 0.6	<.001
Utilize incident command structure	1.6 ± 1.0	4.0 ± 0.8	<.001
Demonstrate START triage for victims of disaster	2.0 ± 1.6	4.1 ± 0.6	<.001
Apply safe search and rescue techniques	2.0 ± 1.0	4.0 ± 0.8	<.001
Perform basic first aid skills	3.2 ± 0.8	4.3 ± 0.6	<.001
Utilize a tourniquet to stop bleeding	3.1 ± 1.3	4.7 ± 0.5	<.001
Safely manage victims of a hazardous material	1.6 ± 0.8	3.5 ± 0.8	<.001
Care for victims with blast injuries	1.8 ± 1.0	3.6 ± 0.8	<.001
EVALUATION OF TRAINING			
RELEVANCE AND APPLICATION *(MEASURED BY USING A LIKERT SCALE: STRONGLY DISAGREE = 1 TO STRONGLY AGREE = 5)*	STRONGLY AGREE % (N)		
The course will be relevant to my work	73.8 (31)		
The course provided me with new information (or clarified old information)	97.6 (41)		
The scenarios presented in the course were realistic	83.3 (35)		
I intend to use what I learned from this course in the future	88.1 (37)		
OVERALL QUALITY OF THE TRAINING AND INSTRUCTORS *(MEASURED BY USING A LIKERT SCALE: VERY POOR = 1, VERY GOOD = 5)*	VERY GOOD % (N)		
Training (environment, technology and case scenarios)	97.6 (41)		
Instructors	100 (42)		

to facilitate the most immersive and high-fidelity experience for the students. Local government personnel provided permission for a large fire engine to be on the scene, a local ambulance, and a critical care transport helicopter. This provided the learners with an opportunity to explore all 3 emergency vehicles and speak to their respective personnel and ask questions related to disaster management during a lunch break. The addition of a variety of subject matter experts, their equipment, and their active involvement in the day long training was a major differentiator for this disaster day versus other similar programs at other academic facilities.

The curriculum was designed to build on simple introductory concepts that progressively became more challenging, interactive, and immersive. Lectures transitioned to skill stations reinforcing important concepts which then transitioned to full on immersive disaster simulation scenarios executed by an interprofessional group of subject matter experts providing immediate feedback on the strategies utilized by the students during the debriefing period. This was designed to ensure the learners were provided a challenging curriculum within their zone of proximal development.[12] The curriculum provided enough of a challenge to make them nervous, excited, and feel challenged, but not so overwhelmed that they would not be able to reasonably attempt to handle the simulated crisis.

A cornerstone teaching method in medical simulation, deliberate practice, provides learners immediate expert feedback to refine skills and increase their mastery. Through deliberate practice learners purposefully exercise newly acquired skills via hands on activities in an effort to rapidly increase proficiency.[13-16] The subject matter experts provided management strategies, constructive feedback, and examined lessons learned in a supportive manner. Additionally, the use of the local city firefighters training facility also provided an ideal environment for the use of smoke machines, screaming standardized patient actors, mass casualty triage, multiple emergency vehicles, simultaneous drills in different parts of the facility, and plenty of space to debrief.

Many of the nuanced obstacles that can create barriers to effective disaster management were recreated and experienced in a safe simulated environment. The bombing case was used to

highlight explosion injury patterns, situational and scene awareness. The organophosphate case was used to simulate similar concerns yet added another layer of complexity requiring decontamination, in addition to organization and awareness. Each case resulted in large amounts of injured and wounded individuals that quickly overwhelmed available resources requiring effective triage, crisis resource management, communication, and leadership. At the end of each session the learners were provided with the opportunity to emotionally decompress and discuss their shared experience prior to the debriefing from subject matter experts. This was done to ensure the learners were emotionally ready to receive feedback on their team performance.

Previous scholars have demonstrated that medical students had increased confidence and skill improvement compared to their traditionally trained peers when exposed to simulated education in addition to disaster management lectures.[17,18] Post-curricular feedback demonstrated that the learners had a statistically significant increase of self-confidence to respond and manage disaster victims. In addition, learners showed a statistically significant increase in their confidence to use safe search and rescue techniques while managing victims in the field with blast injuries or those contaminated by a hazardous material. This is likely a manifestation of the carefully developed phases of the curriculum building upon each phase with feedback from subject matter experts at every phase. Previous scholars have demonstrated that medical students had increased confidence and skill improvement compared to their traditionally trained peers when exposed to simulated education in addition to disaster management lectures.[17,18]

This study had several limitations including a small sample size and participants from a single institution, thereby limiting generalizability. In addition, the data was obtained through self-reporting questionnaires that can present reporting bias. Future research should include a larger sample size over multiple institutions with validated assessment tools to increase the generalizability. Future iterations of this curriculum will explore a variety of disaster presentations with the potential for incorporation of a more formal incident command structure for the students. Longitudinal data is needed to assess participants confidence throughout their residency training in addition to retention of skills and knowledge.

Conclusion

Medical students' self-reported confidence of key disaster management concepts including victim triage, tourniquet application, and incident command improved after a simulation-based disaster curriculum. This single day Disaster course can be replicated for novice learners that are new to disaster management. Finally, high fidelity training provides students the ability to apply concepts learned in the classroom and better understand real-life difficulties experienced in a resource limited environment.

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Authors' criteria for inclusion

All authors were involved in the design of the curriculum. In addition, Drs. Gable, Misra, Hughes, Clayton, and Ahmed contributed to executing the education. Drs. Gable and Misra performed the data acquisition. All authors analyzed and interpreted the data. All authors contributed to the drafting and final approval of the work.

Authors' statement of approval

The manuscript has been read and approved by all the authors, that the requirements for authorship as stated earlier in this document have been met, and that each author believes that the manuscript represents honest work.

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