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JEPM Special Article

A Multidisciplinary Approach to Teach Responses to Weapons of Mass Destruction and Terrorism Using Combined Simulation Modalities

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Study Objective: *To reinforce concepts presented in the lectures; understand the complexity and speed of casualty and information generation during a Weapons of Mass Destruction and Terrorism (WMD/T) event; experience the novelty of combined weapons' effects; recognize the time course of the various chemical, biological, and radiation agents; and make challenging decisions with incomplete and conflicting information.*
Settings: *Two environments simulated simultaneously: one a major trauma center emergency room (ER) with two patient simulators and several human actors; the other an Emergency Operations Command Center (EOC).*
Target Audience: *Students for this course included: clinicians, scientists, military and intelligence officers, lawyers, administrators, and logistic personnel whose jobs involve planning and executing emergency response plans to WMD/T.*
Simulation Script: *A WMD/T attack in Washington, D.C., has occurred. Clinical students performed in their real life roles in the simulated ER, while nonclinical students did the same in the simulated EOC. Six ER casualties with combined WMD/T injuries were presented and treated over 40 minutes. In the EOC, each person was given his or her role title with identification tag. The EOC scenario took cues from the action in the ER via two television (TV) news feeds and telephone calls from other Emergency Operations Assets.*
Performance Expectations: *Students were expected to actively engage in their roles. Student performances were self-evaluated during the debriefing.*
Debriefing: *The two groups were reunited and debriefed utilizing disaster crisis resource management tools.*
Assessment of Effectiveness: *Students answered an 18-point questionnaire to help evaluate the usefulness and acceptance of multimodality patient simulation.*
Lessons Learned: *Large-scale multimodality patient simulation can be used to train both clinicians and nonclinicians for future events of WMD/T. Students accepted the simulation experience and thought that scenario was appropriately realistic, complex, and*

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overwhelming. Difficulties include the extensive man-hours involved in designing and presenting the live simulations. EOC-only sessions could be staged with only a few video cassette recorders, TVs, telephones, and callers.

Introduction

The recent world events remind us that Weapons of Mass Destruction and Terrorism (WMD/T) have been, and will continue to be, used around the world. Preparing for these events is limited. Numerous high-risk professions use simulation to train for high acuity low frequency disasters.[1–4] The aviation industry has used Crew Resource Management (CRM) to train aircrews for crisis events.[5] Like the aviation industry with CRM, medicine trains in high fidelity simulated crisis scenarios with courses such as Anesthesia Crisis Resource Management (ACRM).[6] The principles of ACRM have also been used to teach Medical Team Crisis Management (MTCM).[7] Most recently, simulated exercises have been used by local and federal agencies to train personnel in the management of WMD/T crises. We combined the teaching principles of ACRM with the creative freedom of high-fidelity simulation to present the key issues of a WMD/T event to both clinical and emergency management personnel.

Educational Objectives

The primary educational objective was for clinicians and nonclinical disaster managers to experience the complexity and uncertainty of WMD/T events. Specific objectives were to 1) reinforce concepts presented in the lectures, 2) understand the complexity and speed of casualty and information generation during a WMD/T event, 3) experience the novelty of combined weapons' effects (such as combined chemical, radiation, biological, and traditional explosive ordinance) with individual patients suffering from multiple injuries and multiple agents, 4) recognize the time course of the various chemical, biological, and radiation agents, and 5) make challenging decisions with incomplete and conflicting information.

Course and Faculty

The Patient Simulation Laboratory (PSL) at the Uniformed Services University of the Health Sciences (USU), a division of the Department of Anatomy, Physiology, and Genetics and of the Department of Anesthesiology, has used simulation for training in WMD/T for the Department of Pathology's course "The Scientific, Domestic and International Policy Challenges of Weapons of Mass Destruction and Terror, Part 1 and 2." Part 1 is titled, "The Emerging Threat of Biological Weapons and Bioterrorism" and Part 2 is titled "Nuclear, Radiological, High Explosives, Chemical Agents, and Unusual Weapons." These courses are a joint effort by the Department of Pathology, USU, and the Armed Forces Radiobiology Research Institute with sponsorship by the Naval War College and the Joint Military Intelligence Colleges.

Faculty for the course includes experts with backgrounds in trauma medicine; chemical, biological, and radiological warfare; emergency medicine; and disaster medicine from the Department of Defense, the Justice Department, the State Department, various intelligence agencies, and governmental and private medical and scientific research centers. This article limits the discussion to a simulation used in Part 2 of the course. This course was designed to provide students an understanding of the various agents of potential use in warfare, terrorism, or criminal activities in the context of the medical, social, legal, diplomatic, and political implications of such weapons and their potential for deployment against humans, animals, and plants.

Target Audience

Students for this course included physicians, nurses, paramedics, professional scientists, military officers, lawyers, career politicians, consultants from nongovernmental organizations, administrators, intelligence officers, and logistic personnel. Students were exposed to crisis events involving WMD/T and played roles similar to those they expect to fill in the future. Students who come from the health care professions performed direct, hands-on care of multiple patients presented by both mannequin-based simulators and human actors in an emergency room (ER), whereas students who were not health care workers functioned as crisis management staff in an Emergency Operations Command Center (EOC). Twenty-five nonclinicians and five clinicians participated in this course.

Simulation Script and Performance Expectations

Disorientation was intentionally inflicted upon the course participants from the earliest moment possible. Course scheduling listed a demonstration by the PSL on the day of the exercise. Students were not apprised of the specific content of the simulation session prior to the event to prevent planning for the exercise; however, this simulated WMD/T experience was purposely scheduled for the last class prior to their final exam. Although no grading took place during or after the simulation experience, the session was designed to incorporate all the major teaching objectives of the entire 4-month course. To enhance medical interaction by the clinical staff on the mannequin-based simulators, a standard introduction tape on the simulators capabilities and limits used by the PSL in briefing all new groups was played in the students' classroom. Immediately following the introduction tape, the course instructor stated, "There has been a emergency and all students must leave this area." The students were escorted from their classroom to the PSL.

The students were divided into the 25 nonclinicians who were escorted into the EOC (PSL briefing room) and the 5 clinicians who were taken to the ER (PSL clinical space) after changing into surgical scrub attire. Nonclinicians were briefed on the situation: "it is the 4th of July in Washington, D.C., there has been an explosion during the fireworks display on the mall, and you have been mobi-

Table 1. Roles Performed by Participants in the EOC

EOC Director	Capitol Hill Police	D. C. Mayors Office
EOC Deputy Director	Federal Bureau of Investigations	Liaison, Secretary of Defense
District of Columbia Fire and Rescue	Secret Service	Liaison, Congress
District of Columbia Police	Virginia State Police	National Security Agency
National Park Police	Maryland State Police	Defense Intelligence Agency
Liaison, White House		Public Relations
Center for Disease Control		International Observer (WHO)
United States Public Health Service		National Institute of Health
United States Coast Guard		Federal Emergency Management Agency
Washington Metropolitan Area Transit Authority		National Oceanographic and Atmospheric Agency

lized to the Emergency Operations Command Center (EOC)." Each person was given his or her role title with ID tag for the scenario (*Table 1*). The clinicians were told "you have been attending a lecture at 'The Washington, D.C. Hospital' when an emergency call came for all medical personnel to prepare for mass casualties." The five clinicians, prior to presenting to the ER were told to perform their clinical duties as they would in real life. A trauma surgeon and an emergency room nurse, knowledgeable to the planned scenarios, guided the action in the ER.

A timeline of the six patients (*Figure 1*) served as the framework for information presented to the clinical students within the ER and remotely to the nonclinical students within the EOC. The patient timeline itself was predetermined by the instructors' desired flow of information to the students. Following the development of the patient timeline, the information flow into the EOC (*Table 2*) was then integrated into the patient timeline to orchestrate the simulation scenario for the nonclinicians.

The patient timeline illustrates the presentation types and times of appearance for the six ER patients: Patients 1 and 4 were performed by an MPL-Laerdal SimMan (Gatesville, TX) patient simulator, Patient 2 was performed by a MedSim-Eagle (Binghamton, NY) patient simulator, and Patients 3, 5, and 6 were performed by human actors. These simulators and the human actors were matched to the different patients based on the injuries sustained by the patients, and the capabilities of the simulation modality. Patients 1 and 2 were in the emergency room as the clinicians arrived. Both had severe traumatic blast injuries. Patient 1 did not respond to advanced trauma life support protocols (ATLS), whereas Patient 2's blast injuries did respond to ATLS protocols.[8] However, Patient 2 had also been exposed to VX nerve agent (o-ethyl s-diisopropylaminomethyl methyl-phosphonothiolate) and had uptake of the VX agent through his wounds and skin. Five minutes into the scenario, Patient 3, a "walking wounded" with no obvious external injuries was sent into the ER bay. At the 10-minute point, Patient 1 succumbed to his traumatic injuries, and Patient 3 started to seize due to exposure to nerve agent. After several minutes, Patient 3 was removed from the room by the ER/PSL staff. During the distraction by and attention to Patient 3, PSL personnel converted Patient 1 (now deceased) to become Patient 4. At the 15-minute point, Patient 2 showed signs and symptoms of VX poisoning including bronchospasm, worsening pulmonary compliance, and increase body secretions. Patient 2 responded appropriately to the treatment of nerve agents with 2-PAM chloride, atropine, and decontamination. After Patient 3 was removed, students were redirected to the newly arrived Patient 4, who was a 58-year-old police officer complaining of shortness of breath. He was wheezing and bradycardic on physical exam. If questioned appropriately by students, Patient 4 had a history of asthma and was on a beta-blocker for hypertension and coronary artery disease. This patient had not been exposed to nerve agent. If treated with atropine for suspected exposure, the respiratory symptoms improved, however, the increase in heart rate resulted in myocardial ischemia, which required treatment. At the 30-minute point, Patient 5, who was an aide sitting in the VIP section viewing the fireworks, presented in the ER bay. This patient, a "worried well," had no obvious injuries but arrived demanding loudly she be treated or she will die immediately because she is contaminated with radiation, chemical agents, and all kinds of deadly poisons from the blasts. Soon after she is removed from the ER, a hospital radiation safety officer enters and surveys everyone in the ER. He announces that patients and staff alike are all contaminated with radioactivity. Patient 6, the ER nurse who had been handling all the patients from the start but did not follow Universal Precautions, complained of feeling nauseous and began vomiting. This was to clue in the students that they were at risk from contact contamination from their patients, and, thus, decontamination of themselves as well as their patients should be part of the treatment.

Connections and information flow to and from the ER, EOC, Simulation Control Center, and Remote Observation room are shown in *Figure 2*. Within the ER, scenarios were collected and recorded by a mobile camera crew. Two cameras recorded action in the EOC for debriefing and real-time display to the simulation control staff and those in the Remote Observation room. In the EOC, participants were provided information from several sources while managing the situation. A prerecorded simulated television newscast presented as "live from the scene" delivered specific information at specific times into the EOC for decision-making as desired by the instructors. A live-news feed (the mobile camera crew in the ER) from

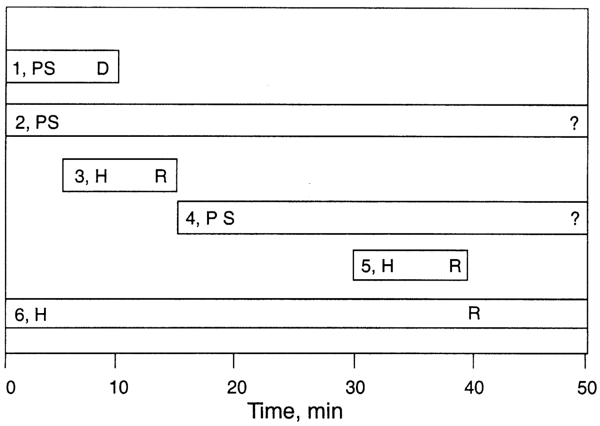

Figure 1. Time courses for six patients, their types, and fates. Patient 1 (performed by MPL-Laerdal SimMan patient simulator): Time 0 = in emergency room (ER) with severe blast trauma injuries; Time 10 min = dies despite intensive advanced trauma life support (ATLS) protocol treatment. Patient 2 (performed by MedSim-Eagle patient simulator): Time 0 = in ER with severe blast trauma injuries; Time 10 min = responds to intensive ATLS protocol treatment; Time 15 min = signs and symptoms of VX poisoning; Time 25 min = stronger signs and symptoms of VX poisoning; Time 35 min = severe signs and symptoms of VX poisoning; Time 40 min = dies if treatment specific for chemical agent not provided. Patient 3 (performed by human actor): Time 5 min = walks into ER and sits in chair; Time 10 min = seizes on floor due to VX poisoning; Time 15 min = picked up and removed from ER by ER/Patient Simulation Laboratory (PSL) staff. Patient 4 (performed by SimMan patient simulator; replaces Patient 1): Time 15 min = "brought" into ER by ER/PSL staff; Time 16 min = bradycardic, wheezing, and complaining of shortness of breath; Time 20 to 40 min = recovers if treated for preexisting conditions, worsens if treated for chemical agent poisoning. Patient 5 (performed by human actor): Time 30 min = bursts into ER loudly complaining of contamination; Time 40 min = subdued and removed from ER by ER/PSL staff. Patient 6 (performed by human actor): Time 40 min = ER nurse succumbs to chemical agent, contaminated by other ER patients. PS = patient simulator, H = human, D = dies, R = recovers, ? = depends upon treatment.

"The Washington, D.C. Hospital" allowed EOC personnel to view the situation as it developed in the hospital ER. Telephone calls from other Emergency Operations Assets were placed into the EOC providing information for student action (*Table 2*). Course instructors and guests viewed all the proceedings via closed circuit televisions in the Remote Observation room.

More than a dozen people contributed to the design and execution of this scenario (*Table 3*). A professional two-person mobile camera crew appeared and functioned as a news camera crew in the ER. Also in the ER, a trauma surgeon and an ER nurse played themselves, challenging the clinical participants in their choices in managing their patients. In the EOC, an "observer" provided similar guidance to the crises management decisions of those participants. Behind the scenes in the Simulation Control Center, six people "ran" the entire scenario: two instructors used the telephones to continuously make challenging calls into the EOC, two operators guided the performances of the two mannequin patient simulators, and two clinicians provided the simulator operators with on-the-fly clinical navigation as needed. In addition, these two clinicians doubled as ER staff to move human actor patients in and out, as well as reconfigure one of the mannequins from Patient 1 into 4.

Debriefing

Following the scenario, the two groups were reunited and debriefed as to what happened at both sites. Confusion was clarified, and performance at each site was evaluated utilizing disaster crisis resource management objectives that included team performance, team dynamics, leadership, cooperation, communication, data management, logistic support, resource allocation, calls for additional resources, emergency declaration, assessment and reevaluation of the situation, medical triage, medical diagnosis, medical treatment, containment of the outbreak or agent, and appropriate notification of other officials. As much as possible, debriefing was a self-evaluation process with instructors serving as facilitators.

Assessment of Effectiveness

Following the scenario, students answered a questionnaire to help evaluate the usefulness and acceptance of multimodality, high-fidelity patient simulation (*Table 4*). Overall acceptance of the session was high, with students agreeing that the simulation was realistic, it helped reinforce concepts learned during the course, it added to the educational value of the course, it will help them in future crises management, and it should remain a component of the course. They agreed the simulation session presented students with the appropriate level of complexity in medical simulation and available information, the information regarding the type and number of casualties was conflicting, and the medical system seemed overwhelmed. Overall, students agreed that they would like to have more of this type training in other courses.

Faculty-observed student performance was above expectations. For example, nonclinician participation in the EOC was extraordinary, with students taking actions to assess, analyze, and control the situation. They engaged in interactions involving advanced command and control processing between their role-played agencies. Actions included containment of the area to prevent further contamination outside the scene and to help retain any evidence within the scene. They took into account onset and types of injuries to determine possible agents used to help with testing, evacuation, and decontamination. Wind conditions determined evacuation routes with Metro Rail inbound services being closed while coordinating outbound services for evacuation after personnel were taken though decontamination screening. Certain bridges were used for outbound evacuation, while other routes were

Table 2. Information Presented to EOC via "live" television (CBRN News) and telephone calls (all others)

Time (min)	Source of Information	Type of Information
1	CBRN News	Fireworks rocket explodes on the Mall
2	CIA Langley	Assassination attempt on President anticipated
3	CBRN News	Extreme confusion and hysteria on Mall
4	White House	What is happening? What assets deployed? Should President and Vice President be moved from White House?
5	DOD	Has the Mayor requested National Emergency Response?
6	Mayor's Office	Police Report Explosions—Moving to seal off the Mall from all vehicle traffic except EMT
7	Hospital	DOA and running out of capacity—What is happening?
8	CBRN News	Conflicting reports—fires breaking out in buildings lining Mall—National Gallery of Art threatened
9	ABC News	Conflicting reports—explosions followed by hundred dropping dead or unconscious
10	CBRN News	Assassination attempt on President anticipated
11	Reuters	What kind of attack—is the President threatened?
12	Mayor's Office	Several explosions in SW Washington report to Mayor's office. Evacuate buildings within 0.5 mile of Mall—police diverted for traffic/crowd control away from mall
13	DOD	What assets deployed to protect DOD National Command Authority?
14	White House	President and Vice President are being moved from White House
15	WMATA (Metro)	Chemical attack in Metro
16	NBC News	DC Officials Say "Keep Calm"
17	Mayor's Office	Denies NBC report
18	NBC News	Explosions but few injured—no sightings of "hundreds" being affected. Relatively few police present. Incident over. Mayor appeals for calm dispersal from Mall
19	CBS News	Boats exploding on Potomac
20	CBRN News	A new Ground Zero: The Washington D.C. Mall
21	Mayor's Office	Denies NBC report
22	CBRN News	Commercial message break
23	DC Police	Panic on Mall
24	CBRN News	Summary update: fireworks explosion, injuries, evacuation
25	Mayor's Office	What WMD teams being deployed?
26	National Park Police	People fleeing Mall—What force to use to allow EMTs access? DC Police units insufficient
27	CBRN News	Update: bombs, not fireworks
28	CBRN News	Field report: nuclear explosion at east end of Mall at the Capitol
29	CBRN News	Field report: boats in Potomac River exploding
30	DOD	WMD units have been told to stand down
31	EMT	Positive radiological readings obtained on the Mall
32	CBRN News	Commercial message break
33	DC Police	Explosions at various sites around city
34	CBRN News	Expert Consultant: defending against suicide bombers
35	Capitol Hill Police	Attack on Capitol
36	DOD	Request information
37	White House	Security for White House as thousands flee past White House grounds
38	CBRN News	Explosions seen, but experts say gas not likely—too open an area
39	CIA Langley	Positive radiological readings obtained on Mall

DOD = Department of Defense, EMT = emergency medical team, DOA = dead on arrival, SW = southwest, WMD = weapons of mass destruction.

used for inbound emergency services equipment and personnel.

Discussion

The reported simulation scenario was specifically created to exercise the participants at the end of a 4-month course "The Scientific, Domestic and International Policy Challenges of Weapons of Mass Destruction and Terror, Part 2: Nuclear, Radiological, High Explosives, Chemical Agents, and Unusual Weapons." In the previous 2 years, simulation scenarios were included in Part 1: "The Emerging Threat of Biological Weapons and Bioterrorism." Experiential simulation experiences were used as one of several teaching methods to fulfill the objectives of these WMD/T courses. For each course, we subjected individuals to a single simulation experience after extensively preparing them with the subject matter content. Each subsequent year the preparation and performance effort as well as student participation expanded extensively over the previous year.

One benefit of simulation is for teaching method evaluation. Now that we have determined the feasibility and acceptance of this teaching method, we can present a scenario at the beginning and then again at the end of

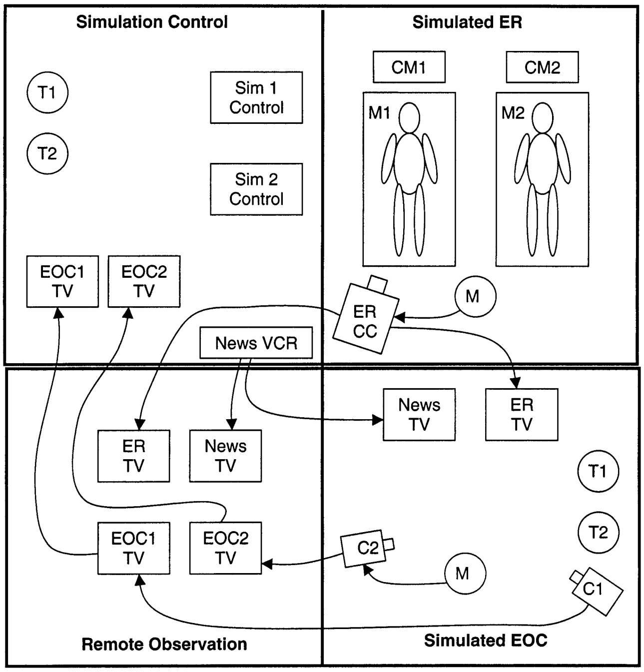

Figure 2. Information flow between four rooms used in WMD/T simulation. Simulation Control: Sim 1 and Sim 2 Control = controls for patient simulators 1 and 2; News VCR = source of "live" news broadcast; EOC1 and EOC2 TV = televisions 1 and 2 from EOC; T1 and T2 = telephones 1 and 2. Simulated ER: M1 and M2 = mannequins 1 and 2; CM1 and CM2 = clinical monitors 1 and 2; ER CC = mobile ER camera crew; M = microphone. Simulated EOC: News and ER TV = televisions showing news broadcast and ER; T1 and T2 = telephones 1 and 2; C1 and C2 = cameras 1 and 2; M = microphone; Remote Observation: ER TV, News TV, EOC1 TV, and EOC2 TV = televisions showing ER, news broadcast, and two views of the EOC.

these courses to see improvements among the participants. This will be beneficial not only from the perspective of teaching method evaluation, but also from an instructional one as well: the participants may have a richer experience of how well they mastered the subject matter than they might receive from taking a written final exam.

Table 4. WMD Survey Questions and Average Response

Question		Average
1	The medical simulation was appropriately complex	4.2
2	The available information was appropriately complex	4.0
3	The information presented as to what happened and the type and number of casualties was conflicting	4.3
4	The onset of casualties was rapid	4.2
5	The medical system seemed overwhelmed	4.5
6	The EOC was overwhelmed	3.8
7	The simulated patients were realistic	3.4
8	The overall simulation scenario was realistic	4.3
9	The simulation session helped reinforce concepts learned during the didactic portion of the course	4.1
10	The simulation session taught me new material not previously covered in the course	3.7
11	The simulation session added to the educational value of this course	4.4
12	This course is significantly improved with the simulation session	4.3
13	The simulation session taught me information that will help me during future job positions	4.1
14	Simulation should remain a component of the course	4.4
15	I would like to have this type training in other courses	4.3
16	I would like to have had more simulation training	4.1
17	The simulation scenario was unrealistic	1.6
18	The simulations session should be removed from the course	1.4

Note: Scale: 1 = highly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = highly agree.

Secondly, this study was designed as a feasibility and acceptance study. Now that that has been determined, a second study designed to test the performance improvement using simulation, crisis resource management prin-

Table 3. Production Roles, Positions and Players

Role	Player	Position	Player
CBR News Anchor	N. Cuesta	MedSim Operator	R. Kyle
ER Physician	J. Goff	Clinical Guide	D. Via
ER Nurse	K. Moffitt	SimMan Operator	T. Ritchie
Walking Wounded	J. Madsen	Clinical Guide	R. Pauldine
Worried Well	N. Boriack	Telephone Caller 1	R. Lowy
ER Tech 1	D. Via	Telephone Caller 2	S. Smith
ER Tech 2	R. Pauldine	Camera Director	B. Richardson
Rad Safety Officer	S. Crail	Camera Operator	S. Rose
		Director	D. Via
		Producer	R. Kyle

ciples, and debriefing techniques to improve student performance can be undertaken.

Finally, WMD/T courses such as these could benefit from numerous simulation-based exercises presented in concert with the lectures. The simulations could stress desired behaviors in both the clinical and operational control settings and allow the participants repetitive practice to gain competence and confidence.

Summary

Multimodality patient simulation can be used to train both clinicians and nonclinicians for future WMD/T events. This type of training adds realism, places students in roles similar to positions they may fill in future operations, and allows them to think about decisions and actions made in a real-time simulated event so that their first time for real is not their first time.

Lessons Learned

Limitations of this method of education included the man-hours required to write, rehearse, and present the session, and the large number of persons to fill the scripted roles and positions. Synchronizing the schedules of a large number of professionals was difficult. Other limitations were the extensive medical expertise required from multiple disciplines to write a realistic session. Finally, to reproduce this session elsewhere, other simulation facilities would also need the technical knowledge and service to create and support the audio/visual systems used.

Because this simulation facility has now produced this multimodality simulation session on WMD/T, man-hour requirements for future sessions would be greatly reduced. Classes with teaching objectives of emergency command and control, along with patient diagnosis and treatment would be given this simulation course in its current format. Given the television and telephone methods to communicate with the command center, courses focusing only on emergency command and control objectives would be given in an abridged format. With recordings from our first session, we could stage an EOC-only session with only a few VCRs, TVs, telephones, and callers.

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