

BIOTERRORISM: DEVELOPMENT OF LARGE –SCALE MEDICAL READINESS USING MULTIPOINT DISTANCE-BASED SIMULATION TRAINING

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Abstract. Accordingly to HIRSA, 35,000 health professionals need to be trained in recognition and acute field treatment of victims of bioterrorism within year 2004 alone The Department of Defense anticipates even larger numbers. Training of very large number of healthcare workers is particularly daunting in the context of "just-in-time" education. The paper presents utilization of simulation-based distance training as a particularly useful tool in rapid development of readiness in a large population of widely distributed medical and lay personnel facing imminent threat of a chem/bioterrorism incident.

1. Introduction

The alleged threat represented by the Iraqi weapons of mass destruction (WMD) was the principal cause of the "Third Gulf War" (Operation Iraqi Freedom). While the actual presence of WMD in Iraq is now the subject of intense debate, and the veracity of the original intelligence data and their interpretation increasingly doubtful, the threat posed by WMD in the hands of terrorist organizations remains as real as ever [1]. Worldwide destabilization caused by regional conflicts is, unquestionably, the most significant factor that amplifies the plausibility of employment of WMD in acts of national- and international terror [2,3]. Among the considerable range of "tools" available on the legal and illegal international markets, the biological agents represent the most readily accessible and, at the same time, potentially most devastating form of weaponry suitable for terrorist action. Easily manufactured, concealed, and transported across borders [4], biological agents can be disseminated among the unsuspecting target population with minimal difficulties. Incubation periods of days to weeks allow the perpetrators sufficient time to escape immediate capture, and the virulence of many of the pathogens suitable for bioterrorist use may lead to massive casualties [4,5]. Importantly, in addition to the immediate consequences of the acts of bioterrorism, their long-term and indirect health and economical effects present a continuously unexplored challenge [6].

Despite the events of September 2001, US plans of defense against bio- and other forms of terrorism remain in disarray [7,8,9] even if billions of dollars continue to be spent on the

improvement of readiness against a likely attack [10,11,12]. With singular exceptions [e.g. Israel, see ref. 13,14], similar lack of coordination of effort can be found among other Western nations that may serve as the potential targets [15,16,17]. Unsurprisingly, efforts at national and international levels are made to address these deficiencies [18-28]. The results of studies performed as part of these efforts show persistent concern in the areas affected by the anthrax outbreak in 2001 [29], and indicate substantial fear and confusion (particularly among media personnel – ref. 30], indicating, at the same time, reliance on the advice from family physicians if another outbreak of an infectious disease occurred [29]. Other studies show substantial deficiencies in national and international triage systems that would be used following mass-casualty events [31-36]. All reports stress consistently one of the most essential elements among the measures proposed as the response to the ever-growing threat of bioterrorism - the need for education and continuous training [37-52].

Unquestionably, the strongest rationale for the establishment of training to address preparedness against bioterrorist assault rests in the fact that, despite unceasing effort to change the current status quo, America is essentially still unprepared either for bioterrorism or any other form of a large scale public health emergency [53-57]. A recent study indicated that in the USA alone, the number of civilian public health professionals (physicians, nurses, PAs), who constitute the first line of defense against bioterrorism reaches 448,254 [58]. Additional 3,000,000 personnel provides relevant medical support (EMTs, police, firefighters, etc.) Hence, it is an alarming fact that 70% of responders to recent survey [59] indicated they would be unable to deal with a victim of a chem-/bioterrorism. Clearly, a bioterrorist attack against the US may have devastating consequences [60].

Bearing the issues of inadequacies in education, training, and readiness to deal with the consequences of a bioterrorism event, and the difficulties in accessing training facilities resulting either from physical isolation or work overload, we decided to test the potential value of distance-based simulation training as a solution to many of these dilemmas. To approach the realism of bioterrorism, the experiment was performed in a setting of a major international conference, with no prior preparation of the participants, involved transatlantic distances, and tested responses of both civilian and military lay and medical personnel to a suddenly occurring bioterrorism event requiring immediate medical intervention.

2. Methods

2.1 Sites

Four sites participated in the experiment. Simulation facilities of MedSMART, Inc. in Ann Arbor served as the headquarters supervising all technical aspects of the experiment (i.e., simulator control, visualization control, connectivity, multimedia support, etc). Air National Guard Station, Alpena, MI served as the site evaluating the suitability of the proposed training approach in military the context of military operations. Simulation facility at the College of Health Sciences at Central Michigan University, Mt. Pleasant, MI, served as a secondary control station and a local training site equipped with the “state of the art” medical training and education technology. Finally, SSGRR Training Center of Telecom Italia in L’Aquila, Italy, served as the primary overseas training site. The maximum distance involved during the exercise (Ann Arbor-L’Aquila) was approximately 6,500 km.

2.2 Technology

The details of the technologies used during the experiment have been already described [61, see also FIG. 1]. Three High Fidelity Patient Simulators (HFPS) were used: Laerdal’s SimMan stationed in Ann Arbor and Mt Pleasant, and METI in Alpena. L’Aquila had the remote access to the machines at the US sites. The remote participants (L’Aquila, Alpena) had the capability of

distance control of HFPS units both at the main site in Ann Arbor and the secondary site in Mt. Pleasant HFPS. Real-time interactivity and simulator control were accomplished by using high-end video conferencing systems at all locations, ADSL Internet connection providing the telecommunications bridge between Ann Arbor, Mt. Pleasant and L'Aquila sites. Contrary to the previous work when dedicated ISDN lines were routinely used, ADSL Internet was selected during the present operation to test the performance of this relatively unsophisticated telecommunication link. Yet, its simplicity makes it an increasingly common choice at technically less advanced locations due to the straightforward set-up and an acceptable stability in long-range operations..

Due to the security concerns posed by civilian traffic over a military network, all interactions with the Medical Readiness Training Center of the Air National Guard in Alpena training were conducted using a dedicated, commercial wireless access.

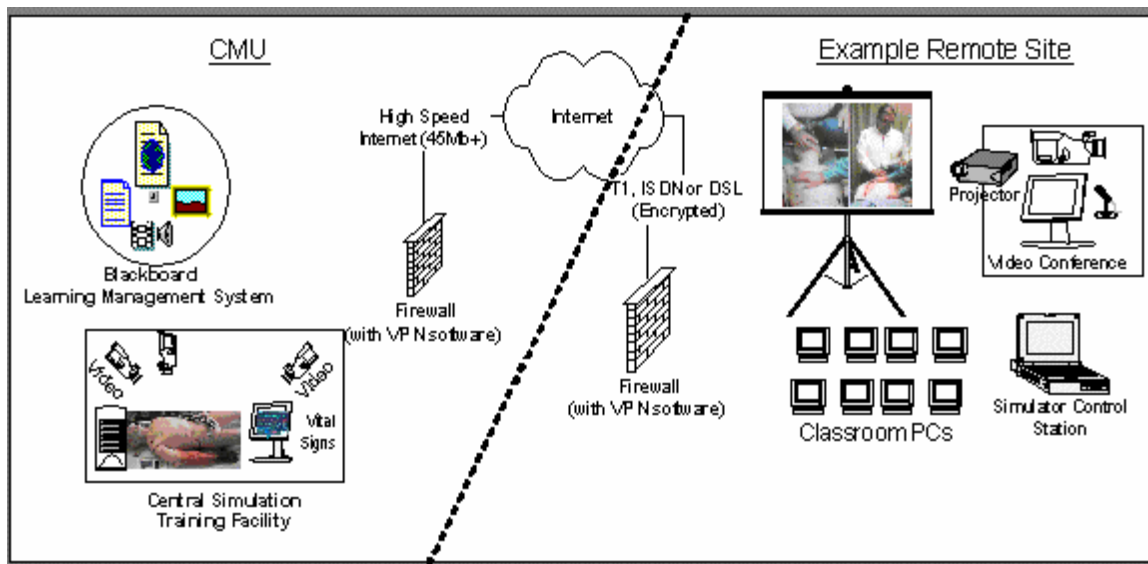


FIG. 1 Simplified diagram of operational relation among the sites (© MedSMART/CMU 2003)

During Internet-based operations, one of the critical factors was the dependence of the overall quality and correlation of the sound and image on the bandwidth (speed) and latency (delay) of the Internet connection. A minimum of 128 kilobits per second sustained transfer rate is required for real-time video conferencing. With round-trip latencies in excess of 200 milliseconds the conference participants notice a delay in the conversation (similar to the delay during satellite telephone calls.) Constant measurements of latency and bandwidth variation between L'Aquila and Ann Arbor indicated average latency below 100 milliseconds round trip, with the average sustained bandwidth >300 Kb/sec. As a result, we were able to conduct uninterrupted 70 min session providing high quality learning experience based on interactive distance simulation technology.

All HFPS units could operate under local or full remote control from either Ann Arbor or Mt. Pleasant site. Control of remote HFPS units could be seamlessly transferred between simulator operators in Ann Arbor and Mt. Pleasant. Multi-site remote control of the machines was made possible through the implementation of proprietary software developed by MedSMART. The software based on the digitized physiological outputs of one simulator (the controlling element driving the remote unit) was loaded into the memory of the HFPS units at all locations. The machines were then programmed to allow either concerted or independent action depending on the directions provided by the remote control site. The approach allowed a significant degree of

flexibility permitting, if needed, the introduction of unpredictable and confounding events. Vital signs and all other pertinent patient data generated by the HFPS units could be projected either from a single or, simultaneously, from all units onto large diameter split-screen displays located at any of the participating sites.

2.3 Execution of the experiment

The study was conducted as a part of the International Conference on Business, Education, Science, Medicine and the Internet, held at academic training center of Telecom Italia (SSGRR) in L'Aquila, Italy in August 2003. The maximum capacity of this annual "by-invitation only" event is 250 participants. The invitees hold senior positions within academia, industry, armed forces (NATO), and medicine. Many of them are professionally involved in telecommunications, information technology, and advanced technology-based education.

The experiment was performed in two stages. The first stage served as a test of the concept and of the telecommunication platforms. During that stage, a brief lecture on chemical/biological warfare agents was given to the remote audience consisting of a mix of lay and medically trained participants (N=46 total) located in L'Aquila and Alpena. During the lecture, stress was placed on the description of the effects of sarin or smallpox. The lecture was followed by HFPS simulation of the exposure to sarin or chicken pox. At the end of the scenario, the participants were requested to identify the agent and also describe in qualitative terms their attitude to the presented form of training. Stage 1 test was performed 1 month prior to Stage 2 of the experiment.

During the second, quantitative stage, the participants of the SSGRR conference in L'Aquila (N=153) were given a 30 min a key-note address on medical readiness and advanced training technology presented by one of the authors (DvL) who participated in the meeting. Symptoms of smallpox infection and sarin exposure were mentioned several times during the address. The lecture was then "unexpectedly" interrupted by a live video-transmission from Ann Arbor. During the transmission, a medical specialist in Ann Arbor provided immediate medical history of the "patient" represented by HFPS. The simulator showed characteristic clinical signs of either sarin exposure (salivation, lachrymation, seizures – Ann Arbor HFPS) or chicken pox (centripetal and asynchroneous lesions – Mt. Pleasant HFPS.) Appropriate vital signs were displayed on a separate screen. The L'Aquila audience was then requested to provide assistance in the management of the distant "patient." Mt. Pleasant and Alpena acted as passive participants.

Following simulation, participants in L'Aquila were given a questionnaire requesting them to provide self-assessment of their ability to diagnose the medical problem, their ability to cope with the problem as a first responder, their attitude toward distance training, its educational value as a medium for the realistic development of large-scale medical preparedness, and its cost effectiveness in the context of mass training. After the questionnaires were collected, a brief lecture on the recognition of organophosphate poisoning and recognition of smallpox/chicken pox was given. The lecture was based on HFPS interactive simulation provided by Ann Arbor site.

3. Results

3.1 Study population

Altogether 86 persons (38% women) returned the questionnaire. The mean age of the participants was 42 years. Medical degree (M.D.) was held by 33%, Ph.D. by 38%, other degrees (M.B.A., D.J, M.Eng.) by 15%, while 14% of the responders failed to provide the level of their education. Specialties of infectious diseases, critical care, or emergency medicine were not represented among the participants with medical degrees, most practicing general medicine, surgery, pediatrics, or pathology. Information technology, advanced education, and computer engineering were the predominant specialties among the participants with a Ph.D. degree.

3.1 Questionnaire – the medical responses

DIAGNOSIS	Medical background	Non-medical background
<i>Smallpox (instead of correct chicken pox)</i>	61%	89%
<i>Chicken pox (instead of correct chicken pox)</i>	12%	5%
<i>Recognition of organo- phosphate/sarin poisoning</i>	38%	12%
<i>Confident in the ability to provide suitable initial ("field") care</i>	32%	5%

Contrary to the lay participants in both Alpena and L'Aquila, the military medical personnel in Alpena had no difficulties in recognizing sarin poisoning and in its field management. Chicken pox was misdiagnosed as smallpox by all lay participants at both sites. Approximately 20% of the military medical personnel misdiagnosed it as well.

3.2 Questionnaire - the value and potential impact of distance-based simulation training

Response to the following statements was requested on a 10 point scale with "0" as the most negative, and "10" as most positive response

Statement	All Participants	Medical Personnel (Mean +/- S.D)
Distance simulation is useful to train large numbers of people	7.6 (1.8)	7.3 (1.4)
Distance simulation is useful in skills development	8.3 (1.9)	7.6 (2.1)
Distance simulation is useful in cognitive task training	7.5 (2.5)	8.1 (2.5)
Distance simulation is useful in crisis management training	7.3 (2.1)	8.0 (2.4)
Distance simulation confuses issues	2.3 (2.1)	1.3 (0.5)
Distance simulation reduces cost of training	7.5 (1.7)	7.6 (2.1)
Distance simulation is "just another gimmick"	1.7 (2.2)	1.3 (1.0)
I learned something new today	8.7 (1.9)	8.1 (2.0)

4. Discussion and conclusions

From the technological point of view, the experiment described in this paper indicates that a successful HFPS training network can be created with a moderate ease, and that the network can perform effectively at very large distances (over 6000 km between L'Aquila and Ann Arbor.) and simultaneously affect a large numbers of personnel. Hence, distance-based simulation training can provide a viable approach to sophisticated training of a broad range of personnel involved in

bioterrorism responses. As evidenced by the responses of the participants, implementation of this training method form provides a powerful tool required for the mastery of cognitive and management skills. Training is realistic, fast paced, and presents the trainee with choices similar to those that would be faced in real life situations. Moreover, even a brief training session appears to impair new knowledge as indicated by the answers to the query about learning “something new.” Equally importantly, applied in the context of mass training, distance-based simulation significantly reduces the often staggering cost of advanced technology-rooted medical education.

In concordance with previous studies [see above], the experiment showed persistent lack of familiarity among non-specialist physicians with the medical manifestations of WMD agents that may be used in acts of terrorism. However, in view of the international mix of the medical participants, it appears the problem does not relate to the national approaches in the US but rather to general attitudes toward training in bioterrorism issues in the non-specialist physician community.

The significance of the impact of information selectively provided immediately prior to the crisis has been also clearly demonstrated. Thus, despite widely available and easily accessible facts on the characteristic presentation differences of chicken pox (varicella) and smallpox (variola) [for resources, see ref. 4], the emphasis on smallpox that has been placed during the lecture that preceded the simulation segment was the most likely cause of striking misdiagnosis of varicella even of the prominent differences in the distribution and character of skin lesions on the moulaged simulator were readily visible. Many of the infectious diseases that are potential candidates for bioterrorist use have clinical manifestations that are much subtler form than the ones simulated in our experiment. Hence, unless training reaches beyond the “standard” infectious diseases (anthrax, smallpox, plague) and extends beyond the currently used static, descriptive, and boringly didactic methods, the defense against bioterrorism will remain largely ineffective at the most critical level – that of the first responders.

Finally, the experiment indicated fundamental lack of preparedness among the lay elements of even highly educated segment of the population. Despite the intensity of media interest in the issues of WMDs, and despite sources of popular knowledge on the medical manifestations of chemical/biological terrorism terrorism-relevant diseases, the competency of lay public is, essentially, non-existent. With the ever-increasing popularity of concepts like the Citizen or Freedom Corps [61,62], the issue of rapid training of a large number of volunteers in even rudimentary aspects of appropriate triage, field medical diagnosis, and field interventions assumes a new level of significance that adds vast complications to the problem of training large numbers of the already existing first responders. In such context, distance-based simulation training may be a solution worth further consideration.

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