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## Facing the Challenges of Bioterrorism Education

# BIO preparedness

ANNENBERG CENTER FOR HEALTH SCIENCES AT EISENHOWER

APRIL 2010 • VOLUME 27 • SUPPLEMENT 2

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APRIL 2010 • VOLUME 27 • SUPPLEMENT 2

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The authors are fully responsible for the methodology, analyses and interpretation of data and opinions and conclusions expressed in this manuscript, which are independent of and do not necessarily reflect those of the study funder. The authors had full access to all data, reviewed each manuscript draft, and approved the final manuscript. GW and GH served as principal investigators of the study; GW, GH, and DR-S designed the study and oversaw the implementation; RH and SL chaired the educational activities' Steering Committee and oversaw content development; PD was responsible for study oversight and direction; AM was responsible for study implementation and data collection; and BS, SB, and CR analyzed the data and confirmed the accuracy of the data interpretations in the manuscript.

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# TABLE OF CONTENTS

APRIL 2010 • VOLUME 27 • SUPPLEMENT 2

## Facing the Challenges of Bioterrorism Education

# Introduction

Gordon F. West, PhD, CCMEP

CME activities focused on bioterrorism ensure that health care providers are knowledgeable about the issues surrounding a bioterrorism attack. Educational initiatives, therefore, must be as effective and efficient as possible.

Today's health care practitioners face myriad compelling public health issues. Emerging health and disease challenges appear in the news daily, and urgent, persistent, or worsening public health crises dominate headlines in the popular media almost as often. Among the most frightening of the current issues faced by health care practitioners is terrorism in all forms, including bioterrorism.

Federal, state, and other web sites now provide the average citizen with information, lists, and tools to increase their general preparedness for any type of disaster, and these sites are promoted actively in the media. Scenes from recent disasters make us stop and think about our individual readiness, how we would react, and where we would turn in such situations. While we all face the vague and personal threat of becoming victims of any form of terrorism, health care practitioners are required to view these potential crises differently from professionals who work in other fields. Pushing aside the common individual fear response, health care providers must view these situations in terms of the specific assessment and response actions that might be required of them according to their professional training. They understand better than most people that preparedness can mean the difference between crisis management and crisis chaos, and for these professionals, education *is* preparedness.

CME activities—educational activities designed to maintain or improve the knowledge or skills physicians use in their professional practice—may hold the key to full and effective use of our health care system in the event of a bioterrorism attack. The ability to recognize, diagnose, treat, and manage the conditions that patients may face when affected by such an attack requires educational activities that address current gaps in health care practitioners' knowledge and performance, but the effectiveness and efficiency of these activities is paramount.

The articles contained herein attempt to establish and address the urgent educational needs of this group as well as the critical need for these activities to be effective and efficient. To this end, we looked at bioterrorism in an historical context, reviewed results of a recent literature search and survey data, and examined data from numerous education studies to determine which educational approaches might work best for this particular topic and in this audience of learners. We hope that this analysis will serve not to sensationalize the issue of bioterrorism education for health care professionals, but instead, to offer practical advice to both learners and educators to enable and ensure preparedness in the face of the threat of bioterrorism.

> ***Health care providers...understand better than most people that preparedness can mean the difference between crisis management and crisis chaos.***

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# Bioterrorism Education: What Has History Taught Us?

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History tells us that U.S. health care providers must be prepared for future bioterrorism attacks. But what are the current trends in bioterrorism education, and are these activities designed optimally?

The term bioterrorism—terrorism through the use of biologic agents—only entered the English lexicon in the past few decades, and the earliest Medline-indexed article using the term was published in 1996.[1,2] Biological weapons (or bioweapons)—weaponized infective agents—have been used throughout history by nations and individuals.[3] As early as the 15th to 12th century BC, records indicate that the Hittites (an Indo-European empire of Mesopotamia) drove infected animals and people into enemy territories in an attempt to spread contagion, suspected to have been tularemia.[3–5] In 1346 AD, attacking Tartar forces in the present day Ukraine catapulted plague-ridden bodies over the walled city of Kaffa.[3,6,7] In 1763, British forces intentionally distributed blankets from a smallpox hospital to Native Americans in the Fort Pitt area (present day Pittsburgh).[4]

Although the effectiveness of these early approaches is debatable,[4,6,7] modern bioweapons undoubtedly are capable of inflicting major damage on a population. The World Health Organization estimates that the release of only 50 kg of aerosolized anthrax spores in a city of 500,000 could result in 95,000 deaths and 125,000 illnesses,[8] and the Office of Technology Assessment of the U.S. Congress estimates that a strategic release of 100 kg of anthrax spores in the Washington, DC area could result in 130,000 to 3 million deaths.[9] In 1979, a release of 1 g or less of *Bacillus anthracis* aerosols from a Soviet bioweapons facility in Sverdlovsk, Russia is believed to have led to an anthrax outbreak linked to the deaths of more than 60 individuals.[10] It is estimated that only a few milligrams to a gram of anthrax was released. A study by the CDC in 1997 estimated an economic impact of $26.2 billion per 100,000 persons exposed after a major bioterrorist attack with anthrax.[11]

More alarming, because biological agents are economical and relatively easy to procure, they could become the weapon of choice for terrorists.[12] They are difficult to detect, the perpetrators could escape well in advance of detection because of the incubation time of the diseases, the disease could be spread well beyond the release zone, and only a small amount can have significant short- and long-term consequences.[6,12–15] In 1984, restaurant salad bars in Dalles, OR were contaminated intentionally with *Salmonella typhimurium*; a total of 751 confirmed cases of Salmonella gastroenteritis emerged.[16] In 1993, the Japanese sect of the Aum Shinrikyo, known for the deadly sarin nerve gas attack in the Tokyo subway system that killed 12 people and injured thousands, released a "Sterne-like" strain of anthrax that was aerosolized from the roof of an eight-story building near Tokyo; fortunately, the agent chosen for this attack was not capable of endangering human life.[17–19]

Despite these incidents, the threat of bioterrorism with infective agents did not become a particular concern to U.S. health care professionals until the 2001 anthrax letter attacks,[6,14,20,21] which resulted in 22 confirmed cases of anthrax (11 inhalational and 11 cutaneous) from October 4 to November 20, 2001.[21] Five deaths linked to inhalational anthrax occurred within about a week of symptom onset.[21] Although none of the cutaneous cases proved to be fatal, diagnosis

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was delayed by up to one month in some cases. This delay underscores the difficulty of detecting covert release of a biological agent unfamiliar to most health care professionals.

In January 2010, the U.S. Commission on the Prevention of Weapons of Mass Destruction Proliferation and Terrorism gave the White House and Congress failing grades for their failure to build rapid response capabilities.[22] The report stated that the United States is still unprepared[22] despite the commission's November 2008 warning that the threat of such an attack is growing.[15] Early recognition and containment are essential to any response plan for a bioterrorism attack, and health care professionals are central to proper public health preparedness.[6,23]

Health care professionals must be familiar with the signs and symptoms associated with bioterrorism agents. They also must be aware of steps for proper diagnosis of resultant diseases and notification of the authorities responsible for effective management of such diseases, including patient treatment and isolation procedures, if necessary. Most clinicians, however, have limited knowledge of and experience with these diseases.[24,25] This review examines publication activity on bioterrorism—particularly, infective agents—over the past decade to provide perspective regarding bioterrorism and educational interventions for health care professionals.

## INFECTIVE AGENTS ASSOCIATED WITH BIOTERRORISM

The CDC has ranked the overall risk of agents and diseases associated with bioterrorism using three categories: A, B, and C.[26,27] Category A agents pose the greatest risk, as they are disseminated easily or are highly contagious, have high mortality rates, may have a major public health impact by causing public panic and social disruption, and require special action for public health preparedness. Category B agents are moderately easy to disseminate, are associated with moderate morbidity rates and low mortality rates, and require enhancements to disease surveillance and the CDC's diagnostic capacity. Category C agents are emerging infective agents that could be engineered for mass dissemination in the future because of availability; ease of production and dissemination; and potential for a high morbidity, mortality, and major health impact.[26,27]

Category A diseases (agents) include anthrax (*B. anthracis*), smallpox (*Variola major*), plague (*Yersinia pestis*), viral hemorrhagic fever (including Ebola and Lassa viruses), tularemia (*Francisella tularensis*), and botulism (*Clostridium botulinum*). Category B diseases (agents) include Q fever (*Coxiella burnetii*), viral encephalitis (such as eastern equine encephalitis alphavirus), and others. Category C diseases (agents) include viral encephalitis (such as Nipah virus), hantavirus pulmonary syndrome (hantavirus), and influenza (influenza A virus subtypes).[14,26–28]

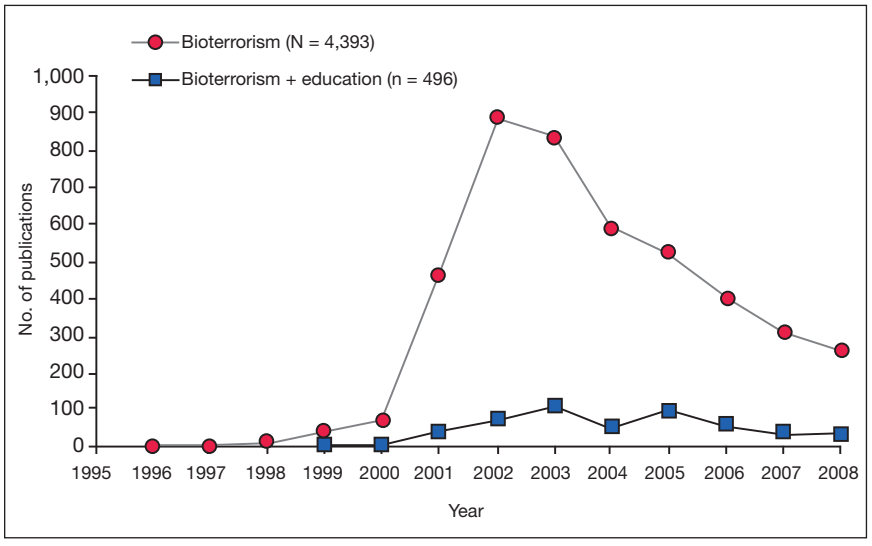


Figure 1. Medline publication activity for overall bioterrorism articles and bioterrorism articles discussing education in some manner.

## LITERATURE REVIEW

### Search methodology

We conducted a literature search in February 2009 using Medline to review publications on bioterrorism, especially the use of infective agents. The search was intended as a snapshot of publication activity to discern any recent trends, and data are limited by the methodology of using only one database. Although preliminary searches for "biological weapons" identified pre-1996 publications, we used the term "bioterrorism" to identify publications of interest since it is a somewhat newer term.[2] A main literature database on bioterrorism was generated using specific bioterrorism terms ("bioterror" or "bioterrorism"), and a sub-database was then generated for publications that discussed education ("CE," "CME," or "education"). The two databases were then probed for publications

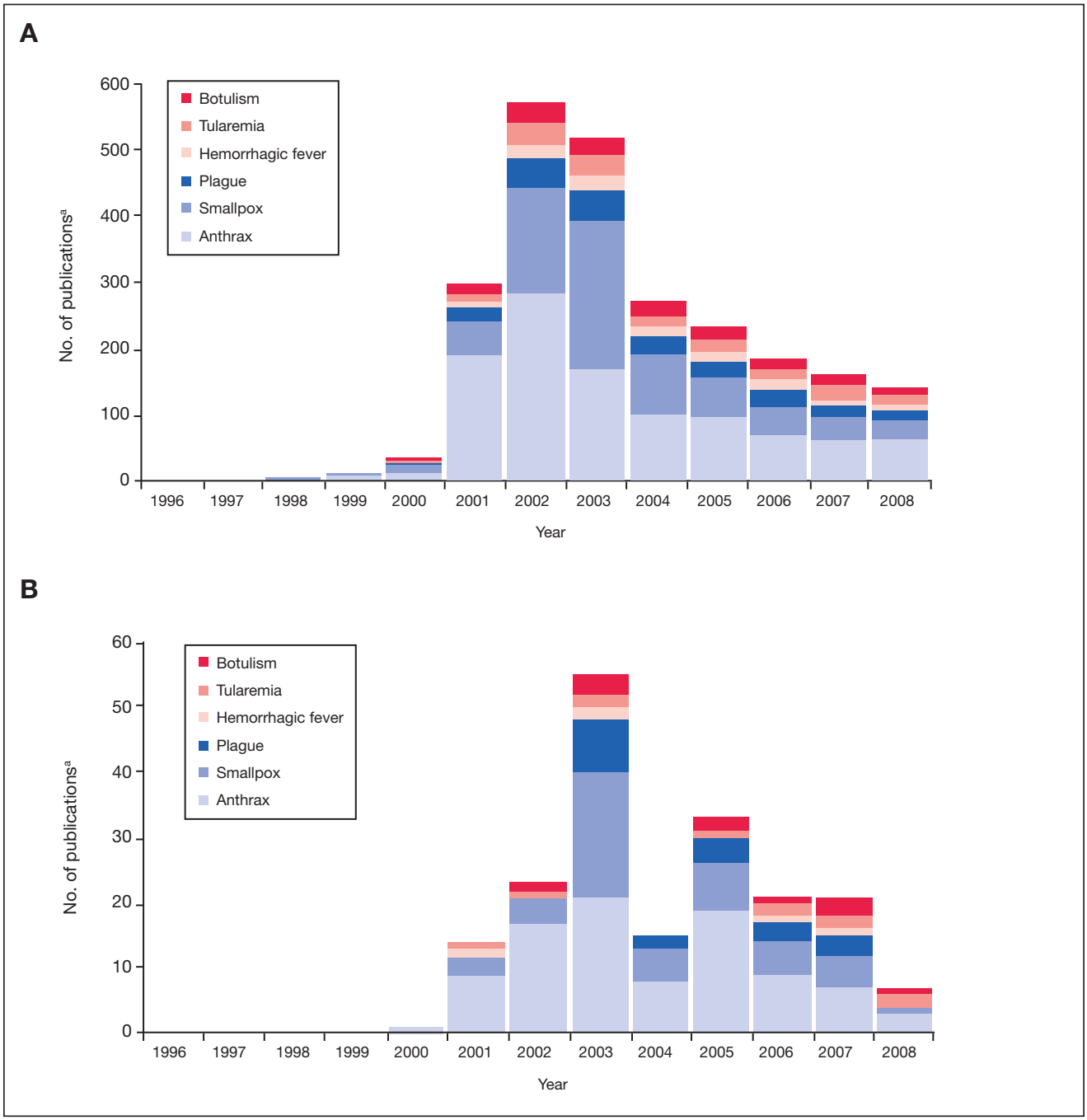


Figure 2. Medline publication activity for bioterrorism articles on category A diseases (A) and for bioterrorism education articles on category A diseases (B). [a]Publications were counted more than once if they covered multiple category A topics.

on specific category A bioterrorism agents and diseases ("anthrax," "smallpox," "plague," "tularemia," "viral hemorrhagic fever," "botulism," and thesaurus terms for each agent and disease).[26]

## Overall results

Results of the literature search revealed infrequent but growing interest

**Table 1. Results of surveys on bioterrorism training**

| Reference | Date of survey | Scope of survey | Discipline (N) | Participation in training, % |
|---|---|---|---|---|
| Pesik et al[29] | 1998 | National | U.S. emergency medicine programs (76) | 53[a] |
| Shadel et al[43] | Oct 2000–Aug 2001 | National | Infection control practitioners (1,260) | 56 |
| Chen et al[32] | Oct 2001 | National | Family physicians (614) | 18 |
| Alexander et al[31] | 2003 | National (training within a year prior to the survey) | Primary care physicians (373)<br>ED[b] physicians (371) | 33<br>56 |
| Candiotti[45] | 2003 | National | U.S. anesthesiology programs (90) | 37[a] |
| Niska et al[25,46] | 2003–2004 | National | Office-based physicians[c] (2,235)<br>Staff: nurses (1,990)<br>Staff: PAs[d]/ NPs[e] (2,056) | 42<br>14<br>9 |
| Katz et al[47] | 2004 | Hawaii | Physicians (115)<br>Nurses (146) | 21<br>20 |
| Moye et al[30] | 2005 | National | U.S. emergency medicine programs (112) | 98[a] |
| Rebmann and Mohr[48] | July 2006 | Missouri | Nurses (474) | 40 |

[a]Bioterrorism training part of residency programs. [b]ED = Emergency department. [c]Specialty categories included family medicine, other primary care, medical, and surgical. [d]PAs = physician assistants. [e]NPs = nurse practitioners.

in the subject before 2001. Overall, bioterrorism publication activity increased from one article in 1996 to 43 articles in 1999 and 71 articles in 2000 (Figure 1). As would be expected, activity jumped to 460 articles in 2001, 885 articles in 2002, and 832 articles in 2003. Subsequently, there was a notable decrease in annual publication activity, with 588 articles in 2004 and 254 articles in 2008. For the subset of articles that discussed education in some manner, the highest activity was observed in 2003 (102 articles), followed by a drop in 2004 (53 articles), a recovery in 2005 (93 articles), and a subsequent decline from 2006 to 2008.

Results of searches for publications on specific category A diseases were consistent with those of the overall bioterrorism literature search. These publications were generally focused on anthrax and smallpox, while other diseases (such as tularemia and hemorrhagic fever) have not been extensively addressed in the literature (Figure 2).

## Status of bioterrorism training and preparedness

Our search results included U.S. bioterrorism training and preparedness surveys conducted before and after the 2001 anthrax attacks (Table 1). Overall, there was no definitive trend by year, but there did appear to be an increase in training for emergency medicine physicians and primary care or family physicians.

A 1998 survey conducted by researchers from Emory University, Atlanta, GA evaluated bioterrorism training at emergency medicine residency programs (n = 118) throughout the United States.[29] Of the 76 responding programs, 53% reported inclusion of formal training on bioweapons.[29] Results of a 2005 follow-up survey showed significant improvements, with 98.2% of respondents reporting bioterrorism training.[30]

In addition, training methods appeared to have changed. In 1998, only 11% of the emergency medicine residency programs included field exercises or rotations specific to bioterrorism, whereas in 2005, 41% of the programs used these "hands on" training methods.[29,30]

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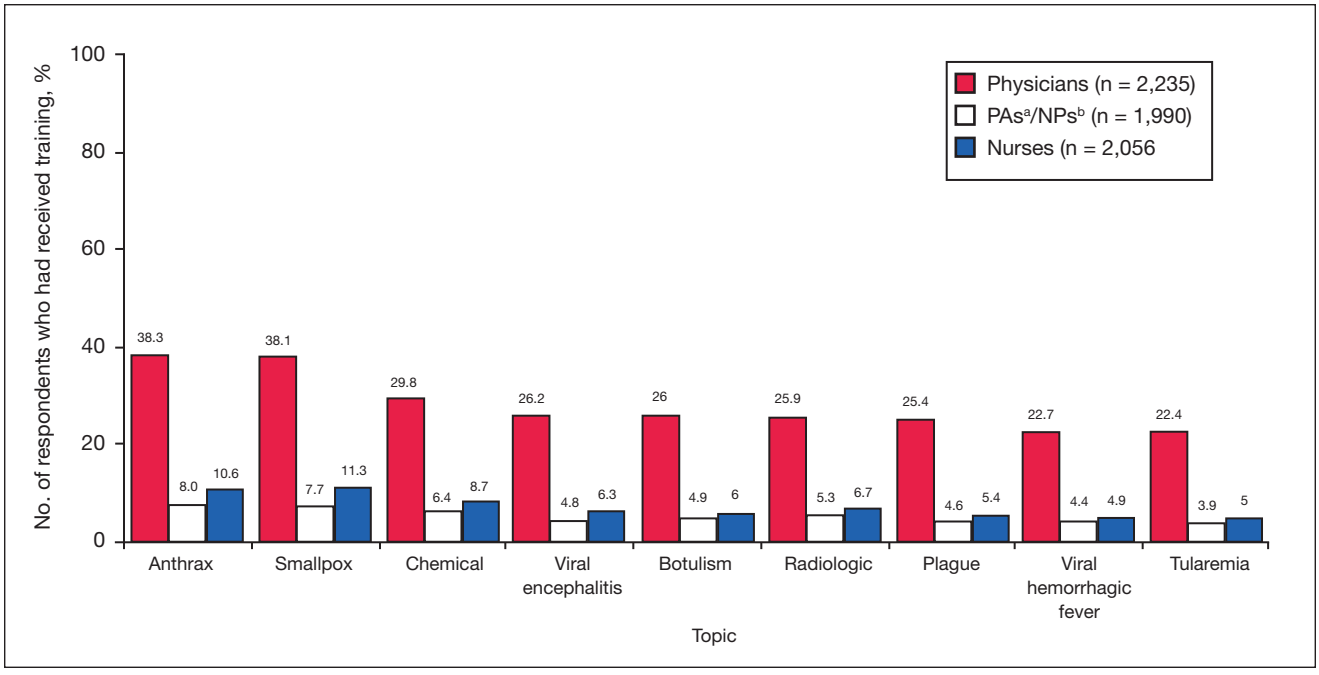


Figure 3. Bioterrorism training in selected exposures among office-based physicians, PAs or NPs, and nurses, according to the National Ambulatory Medical Care Survey, 2003–2004.[25] [a]PAs = physician assistants. [b]NPs = nurse practitioners.

While training increased for emergency physicians in the Emory studies, other surveys suggest that training for other health care professionals has lagged behind. In a 2003 survey of 744 primary care and emergency physicians, 45% of the physicians had received bioterrorism training within a year of the survey, yet only 32% felt well prepared to respond to a bioterrorism attack.[31] Emergency physicians had more training than primary care physicians (56% versus 33%, respectively, $P < .001$) and were more likely to feel prepared to respond to an attack (43% versus 21%, respectively, $P < .001$).[31]

In 2003 and 2004, a CDC national survey of office-based physicians and their staff assessed terrorism preparedness training.[25] The survey asked these clinicians if they had received training for chemical and radiologic exposures and infectious diseases associated with bioterrorism since the attacks of 9/11. Of the 2,235 physicians who responded, 42% reported receiving training for at least one terrorism topic (Figure 3). The physicians' staff had significantly less training, with only 9% of physician assistants or nurse practitioners and 14% of nurses reporting they had received training for at least one topic.[25]

Surveys also have been conducted to ascertain the bioterrorism knowledge base of health care professionals.[32–34] The American Academy of Family Physicians National Network for Family Practice and Primary Care Research conducted a national survey in October 2001 to assess self-reported preparedness of family physicians.[32] Only 27% of the 614 family physicians who responded believed the U.S. health care system could respond effectively to a bioterrorism attack, 26% felt they would know what to do as a physician in the case of a bioterrorism attack, and 18% reported prior bioterrorism training. (It should be noted that physician self-assessment generally has been shown to be less accurate than external assessment.[35])

Another survey of primary care and emergency physicians conducted from December 2002 to January 2003 at a large, urban, academic medical center assessed the physicians' perceived ability to diagnose smallpox, as early diagnosis is critical for control of transmission.[34] Only 17% of the 178 respondents felt comfortable diagnosing smallpox, with the level of confidence in diagnosing the disease related to the level of experience.

## MEETING THE CHALLENGES OF BIOTERRORISM PREPAREDNESS WITH EDUCATION

The literature search and survey results reviewed here indicate important gaps in the bioterrorism

training, knowledge, and preparedness of health care professionals. Studies indicate that, despite the anthrax letters in 2001, many health care professionals remain inadequately prepared for a bioterrorism attack.[24,25] Many of these professionals have not received proper training,[25] and while bioterrorism educational activities appear to be effective for knowledge acquisition, knowledge retention is problematic.[36] In moving forward, educational activities must address these challenges. While the overall knowledge base and level of preparedness remain deficient, training opportunities appear to have increased, and supplemental education curricula on bioterrorism, including CME activities, have been developed to address these gaps.

These challenges are not insurmountable, but because diseases associated with bioterrorism are not managed routinely in clinical practice, routine reinforcement with longitudinal CME curricula will be needed to improve knowledge retention and facilitate application when it is necessary.[37–42] Furthermore, educational activities will need to reach a wider spectrum of health care professionals, and this may require curricula designed for specific audiences.

Addressing these issues likely will increase the cost of CME program development and implementation. Discipline-specific content that is designed for a more narrow audience than is normally targeted may require faculty and education planners to duplicate efforts to reach all of their targeted learners with very similar content. Additionally, the serial design of longitudinal curricula that are planned specifically to enhance knowledge retention, particularly live activities, would increase the development costs simply by requiring more activities.

As it is unlikely that most learners actually will need to use this training, the efficiency of these curricula is essential. For a traditional CME activity to be deemed efficient, it should facilitate a change in practice patterns that improves health outcomes, reduces medical costs, or both, and is easy and quick to obtain. Such criteria are impractical, however, for bioterrorism education. Knowledge gained—and retained—without wasting time may be a more appropriate measure of efficiency.

*While bioterrorism educational activities appear to be effective for knowledge acquisition, knowledge retention is problematic.*

## OBSERVATIONS AND CONCLUSIONS

In reviewing the literature, it would appear that opportunities for bioterrorism training and education on infectious disease have increased over the past decade. On the other hand, these opportunities may be inefficient. It is important that educational activities for bioterrorism address the generally poor retention of acquired knowledge. Maintaining a minimal level of preparedness likely will require periodic reinforcement and reassessment over the long term. Knowledge retention and the time to access and acquire the knowledge should be major endpoints for future studies assessing the efficiency of these educational activities.

It is interesting to note that, although surveys report nearly all physicians believe bioterrorism to be a significant threat to the United States as a whole, only about half believe it is a local threat.[32,43,44] While health care professionals generally acknowledge that more training and education on bioterrorism topics are needed, some believe that such diseases as influenza pose a greater threat than bioterrorism and that preparing for a bioterrorism attack diverts funds and resources from more important and immediate public health problems.[31] It would appear that the magnitude of the consequences of a bioterrorism attack may be underrecognized and underappreciated among health care professionals.[45]

The U.S. health care system has improved its bioterrorism response capabilities since the attacks of September 2001, but it is unlikely to be prepared for a major attack. While many public health care problems are of immediate concern, bioterrorism preparedness should not be neglected. Steps must be taken to advance training and education further and to address the challenges of bioterrorism preparedness and some of its misperceptions. Bioterrorism preparedness is needed both nationally and locally—and sooner rather than later.

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Continued on next page

Continued from previous page

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# Efficiency of Bioterrorism CME for Health Care Professionals: Live versus Web-based Activities

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Given the inherent complexities of delivering bioterrorism education, specific research into whether the educational delivery mode addresses knowledge acquisition and retention is essential.

While a number of studies and reports have focused on improving preparedness of health care professionals through CME activities,[1–7] bioterrorism education presents educators with a unique set of challenges. Most health care professionals have never managed bioterrorism-associated diseases. As such, longitudinal series of educational activities are needed, with reinforcement strategies to enhance knowledge retention and to facilitate knowledge application should the need arise.[8] Furthermore, rapid deployment of these activities may be necessary in the event of an attack.[6] Although it is difficult to assess practice improvement after CME for bioterrorism—because acquired knowledge will be employed rarely by learners—such activities must be effective, efficient, and readily accessible when needed.

Recently, an exploratory study was conducted by the Annenberg Center for Health Sciences at Eisenhower, Rancho Mirage, CA to evaluate the effectiveness of common bioterrorism education delivery modes, including live and web-based activities.[9] The study provided a number of insights into the challenges of developing effective CME for bioterrorism and indicated that web-based activities for bioterrorism were generally as effective as live activities. To address the challenges presented by bioterrorism and the advantages and disadvantages of common educational approaches, this article examines common CME strategies and reviews data from studies evaluating the effectiveness and efficiency of CME for bioterrorism, including the exploratory study.[9]

## EFFECTIVENESS AND EFFICIENCY OF CME ACTIVITIES

The effectiveness of CME activities depends on their ability to address specific knowledge and performance deficits through the use of multiple sequenced interventions that include clinically relevant, interactive, and reinforced contextual learning activities.[10] Use of the predisposing-enabling-reinforcing instructional framework[11] is associated with effective CME,[12–15] and, while live events have been the gold standard for CME, web-based events have become more common.[16,17] According to the 2008 Annual Physicians Preferences in CME Survey, there has been a steady increase in the proportion of physicians utilizing web-based CME, from 7% in 2006 to 11% in 2007 and 15% in 2008.[18] The survey also indicated that more physicians likely will limit travel to meetings because of budget constraints and earn CME

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credits via methods not requiring travel.[18] Asynchronous online education offers health care providers schedule flexibility, can save time for both educators and learners,[19–21] and makes geographic barriers nearly obsolete.

Literature reviews and controlled studies have reported that web-based CME activities generally are as effective as live events with respect to knowledge acquisition and participant satisfaction,[16,22–25] but important limitations to web-based activities should be recognized. Although cost is often cited as an advantage of web-based activities, few data are actually available to support such a claim.[26,27] Learners may require computer training for web-based events,[20,28] and some health care professionals prefer traditional live activities over web-based CME.[29–32] Web-based CME somewhat limits interaction among educators and learners,[17,33–35] and studies have demonstrated that an interactive learning environment is more effective than pure lecture.[12,36–39] As web-based CME has evolved, however, course design has improved the level of interactivity to address this important issue.[16,22,40]

## CME FOR BIOTERRORISM

In 2001, Chen and colleagues conducted a national survey of 614 family physicians.[41] While 95% of the physicians felt that bioterrorism was a real threat to the United States, only 27% reported knowing what to do in the case of an attack and only 18% reported having any training for bioterrorism preparedness (Table 1).[41] Less than a third of the physicians were confident they could diagnose bioterrorism-related illness properly.

In comparison to the 2001 survey,[41] a subsequent survey in 2003 (of 744 primary care and emergency physicians) indicated that the proportion of health care professionals who received bioterrorism training had increased (33% for primary care physicians and 56% for emergency physicians).[42] Nonetheless, only 21% of primary care physicians and 43% of emergency physicians felt well prepared to respond to a bioterrorism attack.[42] As time passes since 9/11, there may be a greater, rather than lesser, urgency to increase clinical proficiency for response to such attacks.[43]

The results of these surveys[41,42] highlight the significant gap between the recognized need for bioterrorism training and actual preparedness. CME could advance bioterrorism preparedness significantly. Few studies have examined the effectiveness of CME strategies for bioterrorism,[1,2,44] however, and it is difficult to extrapolate results from CME studies in other therapeutic areas because of differences in practical application of the acquired knowledge.

The recent exploratory multicenter study conducted by the Annenberg Center for Health Sciences assessed the efficacy of common CME formats for bioterrorism with respect to the acquisition and retention of knowledge.[9] The study, conducted between August 2006 and August 2008 with 472 civilian and military health care professionals (physicians, nurses, pharmacists, and clinical personnel), was a 2 x 2 design with two delivery modes and two levels of interactivity. Participants could register for a live or an online course. The live courses covered four topics: anthrax, smallpox, avian influenza, and toxins. There were three topics for the online courses: smallpox, avian influenza, and toxins (anthrax was deemed too complex for a web-based activity). Following registration, participants

**Table 1. Results of a 2001 national survey of primary care physicians on bioterrorism[41]**

| Survey category | % of respondents self-reporting yes |
|---|---|
| **Risk assessment** | |
| Believe bioterrorism is a threat in the United States | 95 |
| Believe terrorism is a threat locally | 39 |
| **Preparedness** | |
| Know what to do in case of bioterrorism attack | 26 |
| Could respond to a natural disaster | 65 |
| Could respond to an infectious disease outbreak | 66 |
| **Capabilities** | |
| Know whom to call for a suspected attack | 57 |
| Know how to get information about an attack | 56 |
| Know how to get information on bioterrorism | 54 |
| Recognize signs and symptoms | 24 |
| Received prior training | 18 |
| Have excellent/very good knowledge | 5 |

**Table 2. Description of live and web-based delivery modes and level of instructor-participant interaction[9,37–39,45]**

**Live classroom activity**

**Didactic**
- Participants paid a registration fee
- Learners attended formal sessions taught by an instructor(s)
- Format was modeled after a classroom presentation
- Participants were free to ask the instructor(s) questions at the end of each session, allowing participant-instructor interaction

**Interactive**
- Participants paid a registration fee
- Learners attended formal class sessions taught by an instructor(s)
- Format allowed greater opportunity for instructor/participant interaction, eg, instructor addressed participant questions or had participants engage in discussion as to whether a particular answer to a technical question was right or wrong
- Mode also included clinical cases, panel/audience discussions, audience response technology, and other active learning techniques[37–39,45]

**Web-based (asynchronous/archived) activity**

**Didactic**
- No registration fee charged
- Format involved a prepared (archived) presentation watched by learners at their convenience
- Presentation included instructor commentary and slides highlighting important focal points
- Learners had no interaction with presenters during the course
- Participants were asked to complete pretest, posttest, and follow-up tests online

**Interactive**
- No registration fee charged
- Format was similar to that of the web-based didactic activities, but during the presentation, participants were asked to respond to multiple choice and true/false questions
- Participants were asked to complete pretest, posttest, and follow-up tests online
- As learners answered questions throughout the activity, in-depth interactions occurred to allow responses/discussions to specified questions
- Participants had the opportunity to follow embedded hyperlinks to additional information on specific topics outside of the educational activity and subsequently return to the activity

were assigned randomly to either an interactive or a didactic format (Table 2).[9,37–39,45] They were asked to complete a pretest, a posttest to assess knowledge acquisition, and follow-up tests at three and six months to assess knowledge retention.

A total of 472 health care professionals registered for the courses. There was, however, notable attrition for the follow-up tests (26% of health care professionals completed the six-month follow-up test: 44% for live and 17% for web-based activities) (Table 3).[9]

Knowledge acquisition clearly and significantly increased for all four topics (pretest to posttest, $P < .0001$ for all topics)—avian influenza (58% to 72%), smallpox (49% to 78%), toxins (39% to 63%), and anthrax (50% to 77%). Subsequently, there were significant decreases in test scores from the posttest to the three-month follow-up test for all topics, with no further erosion notable at six months. For example, test scores for anthrax decreased from 77% at posttest, to 67% at the three-month follow-up ($P < .0001$), to 62% at the six-month follow-up (not significant compared with the three-month score). Generally, test scores did not

**Table 3. Number of participants completing the posttest and follow-up tests for the live and web-based activities for all four bioterrorism topics[9]**

| Topic | No. of participants completing test (N = 472) | |
|---|---|---|
| | Live | Web-based |
| Avian influenza | | |
| Posttest | 137 | 156 |
| 3 months | 91 | 38 |
| 6 months | 66 | 21 |
| Smallpox | | |
| Posttest | 141 | 86 |
| 3 months | 94 | 29 |
| 6 months | 70 | 20 |
| Toxins | | |
| Posttest | 141 | 70 |
| 3 months | 113 | 24 |
| 6 months | 69 | 11 |
| Anthrax | | |
| Posttest | 140 | – |
| 3 months | 94 | – |
| 6 months | 68 | – |

*While there is no clinical urgency in the absence of a bioterrorism threat, the best approach may be to have updated CME resources available when needed in a format or design that is readily accessible.*

differ statistically between the live and web-based delivery modes (Figure) or between interactive and didactic formats.[9]

Cost analyses from this exploratory study[9] found that the development cost per participant for a web-based activity was 35% less than that of a live activity. The lower development cost is not the biggest advantage over a live activity, however, as a web-based activity theoretically can accommodate a nearly unlimited number of learners. Additionally, once developed, web content can be delivered quickly, easily, and repeatedly, while costs for a live activity will be incurred each time an activity is presented.

## LESSONS LEARNED AND FUTURE DIRECTIONS

It is not unexpected that test scores prior to the educational interventions were notably low and improved significantly following the interventions in most of the bioterrorism studies reviewed here.[2,9,46] Unfortunately, while there was knowledge retention in the exploratory study (see "Bioterrorism CME Knowledge Acquisition and Retention: What Works?" on page 16),[9] it appeared to be lower than that observed in studies of other therapeutic areas.[22,47] Since health care professionals generally are unfamiliar with bioterrorism-associated diseases, reinforcement strategies involving immediate application of knowledge to clinical practice are impractical. Learners will lose some of their newly acquired knowledge over time, particularly if they do not put that knowledge to use routinely or if there is no reinforcement of content.[13,14,48,49] The authors of one recent review article proposed a conceptual model for planning and assessing CME. In this model, reinforcing activities and materials are said to strengthen the "cognitive imprint" of what was learned so the knowledge can be available more readily for recall during patient interactions.[50]

The high attrition rate in the post-activity portion of the exploratory study[9] and the poor test scores associated with passive interventions[1] indicate significant barriers to learners' participation in bioterrorism CME activities. While there is no clinical urgency in the absence of a bioterrorism threat, the best approach may be to have updated CME resources available when needed in a format or design that is readily accessible. Asynchronous web-based CME activities might reduce attrition by offering health care professionals time saving activities with a flexible schedule.[19–21] Data from the exploratory study, however, suggest otherwise.[9] In the event of a bioterrorism attack, efficiency (rather than cost-effective-

ness) will be the most critical consideration. For example, web-based training activities could be deployed quickly and accessed by a large number of learners, whereas live activities would have to be planned, scheduled, and promoted.

## NOVEL MODES OF CME: SIMULATION TRAINING

It is difficult to measure the impact of bioterrorism CME on clinical practice patterns or health outcomes without analysis of response to an attack. Simulation training can provide a no-risk learning environment for a range of medical skills (from intravenous needle insertion to trauma surgery procedures)[51] that could enhance limited hands-on training opportunities for bioterrorism and potentially revolutionize the way health care professionals train in peace time to deliver health care in a time of war. The lack of fundamental science to allow realistic representations of medical procedures as a basis for simulation in bioterrorism events may limit its practical application,[51] but simulation training has shown promise in cost-effectively improving the speed of military medics to stop simulated severe extremity hemorrhages.[52] Additional research may demonstrate the technology's practicability and utility.

## THE FUTURE OF BIOTERRORISM CME

In moving forward, it will be important to develop CME activities for bioterrorism that are efficient and readily available to address the typically poor retention of knowledge and high attrition rates. Clinicians must be aware that the health care system is ill-prepared for a major bioterrorism attack and that even a minimal level of preparedness must be reinforced periodically in order to be sustained. Standards that are coordinated across health care disciplines are needed for the prevention and recognition of bioterrorism, infection control strategies, disease management, postevent patient isolation procedures, and public stress management,[44] and effective bioterrorism CME modules must include multiple contextual learning activities that are clinically relevant, interactive, and reinforced.[10]

A number of experts have proposed competency programs for bioterrorism[4,8,44,53,54] that would establish a career-progression pathway to lifelong learning. Individuals would work toward academic degrees specializing in bioterrorism and postgraduate certification and maintenance of certification. Knowledge, skills, attitudes, and progress from basic to more advanced knowledge would be assessed. The University of Minnesota School of Public Health, Minneapolis has been developing bioterrorism and emergency readiness competencies that include disaster preparedness, understanding bioterrorism agents, crisis communication, surveillance, law, and impact on community health.[8] CME activities will be an essential component in helping individuals achieve and maintain such competencies.

The role of simulation in providing more robust training experiences

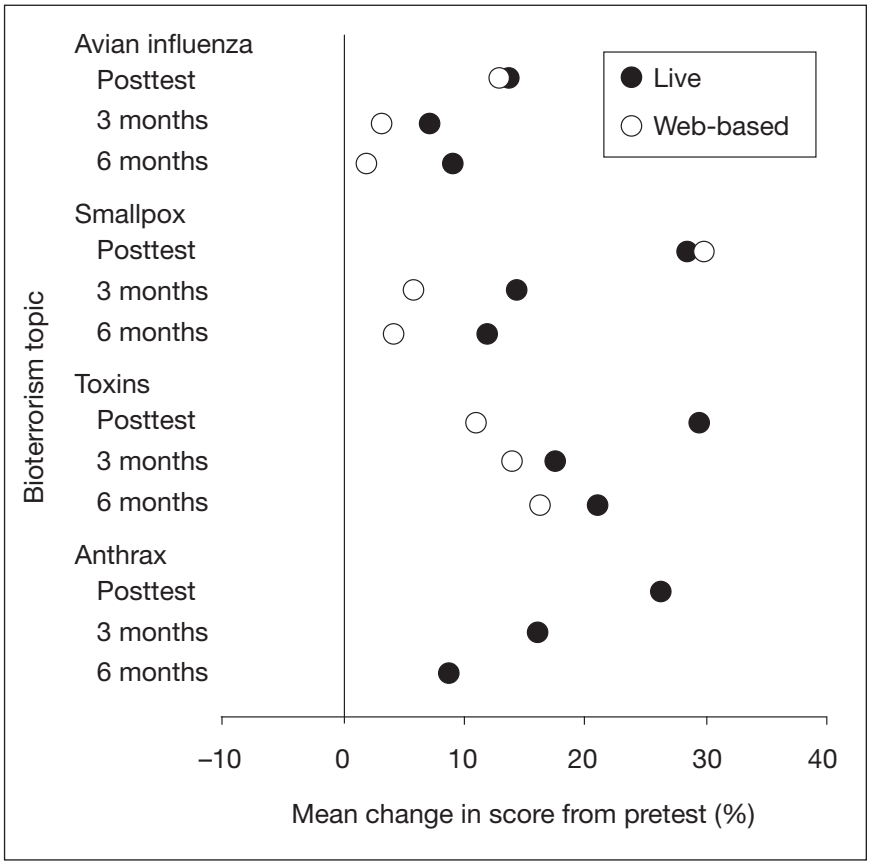


Figure. Mean change in score from the pretest to the posttest and three-month and six-month follow-up test scores for the live and web-based activities for all four bioterrorism topics.[9]

# Bioterrorism CME Knowledge Acquisition and Retention: What Works?

One data subset of the exploratory study conducted by Annenberg Center for Health Sciences at Eisenhower compared effectiveness of the live and web-based educational approaches on knowledge acquisition and retention. Participants' mean scores over time were compared, and differences based on delivery mode or level of participant-instructor interaction were evaluated.[1]

Participants achieved significantly higher levels of knowledge acquisition as shown by differences between pretest and posttest scores in both the live and web-based courses (Figure 1).[1] With regard to knowledge retention, learners in the live activities had statistically significant increases in mean scores from pretest to posttest, from pretest to the three-month follow-up test and from pretest to the six-month follow-up test (all $P < .0001$; Figure 2). In comparison, learners in the web-based courses had statistically significant increases in mean scores from the pretest to posttest ($P < .0001$) and from the pretest to three-month follow-up test ($P = .01$), but the difference in mean scores from pretest to six-month follow-up test was not statistically significant ($P = .03$). The overall level of interaction in the toxins courses did not result in statistically significant differences in test scores between didactic and interactive formats.[1]

Continued on next page

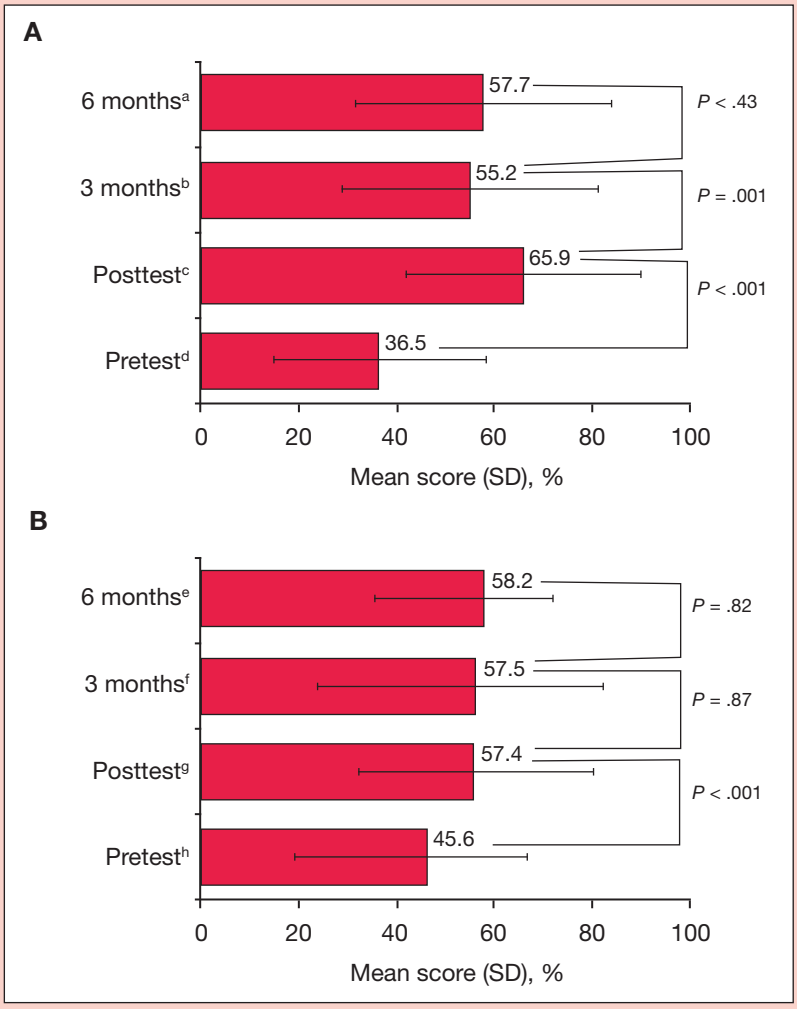


Figure 1. Changes in mean test scores of study participants over time for the live (A) and web-based (B) toxin courses.[1] [a]n = 70. [b]n = 113. [c]n = 144. [d]n = 155. [e]n = 11. [f]n = 24. [g]n = 70. [h]n = 72.

also should be explored. Virtual reality environments, such as Play-2Train (Linden Research, Inc., San Francisco, CA), already are in active use to train health care professionals in bioterrorism and other forms of emergency preparedness.[55] Play-2Train, which is overseen by the Idaho Bioterrorism Awareness and Preparedness Program in conjunction with Idaho State University, Pocatello, administers and delivers CME classes relevant to bioterrorism preparedness to health care professionals in rural Idaho.[55] Play2Train creates virtual reality environments to simulate disasters ranging from smallpox outbreaks to explosions as a result of terrorist attacks and uses a wide range of technology (such as magnetic resonance imaging)

# Bioterrorism CME Knowledge Acquisition and Retention: What Works?

Continued from previous page

In this study, educational interventions resulted in learning regardless of delivery mode or level of participant-instructor interaction.[1] Medical educators, public health officials, and health care professionals must be aware that both live and web-based activities appear to be effective in facilitating bioterrorism knowledge acquisition and retention[1] because of these agents' potential for causing devastating health consequences even when used in small amounts.[2]

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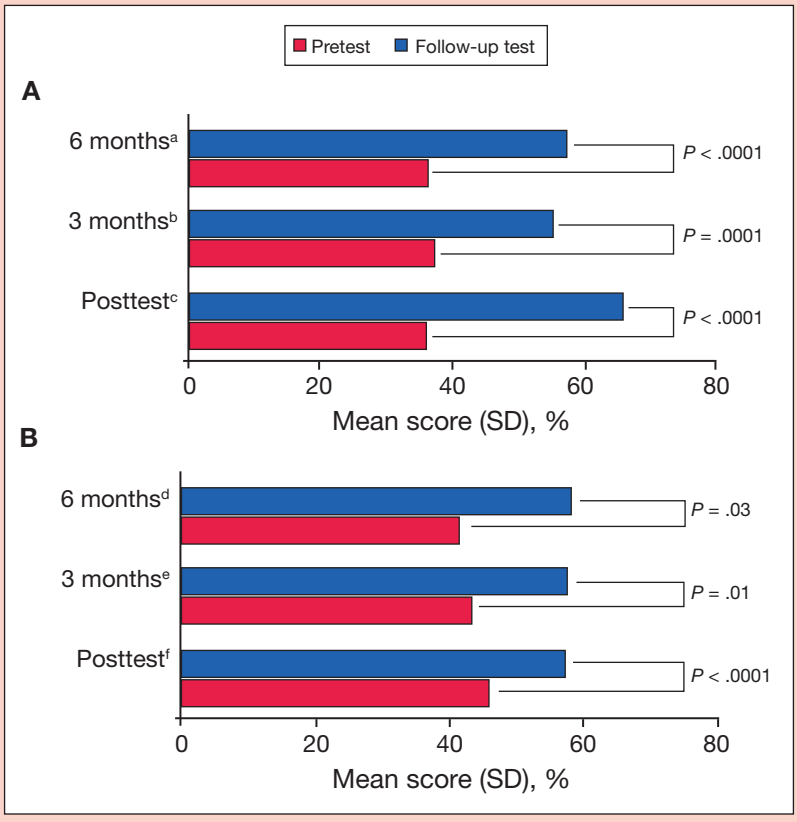


Figure 2. Changes in mean test scores of study participants from pretest to posttest and three- and six-month follow-up tests for live (A) and web-based (B) toxin courses.[1] [a]n = 69. [b]n = 113. [c]n = 141. [d]n = 11. [e]n = 24. [f]n = 70.

and medical teaching tools (such as virtual mannequins, videos, and medical journals).[55] Standards also have been developed to guide the construction of medical simulation within the Accreditation Council for Graduate Medical Education competency framework.[56]

New tools and methods of CME must address the needs and preferences of a variety of learners and limit costs while optimizing learning opportunities. Standards for evaluating bioterrorism CME activities are needed to better understand which strategies are more efficient and effective in the immediate time frame (knowledge acquisition) as well as in the long term (knowledge retention).[57] Developing goals and standards for efficient bioterrorism education must be balanced with the challenges facing health care professionals every day.


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# Educational Effectiveness of a Bioterrorism CME Program by Printed Monograph

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With web-based CME activities becoming more prevalent, the number of print activities is decreasing. Is there still a role for print monographs in bioterrorism education?

According to the 2008 *World at Risk* report by the Commission on the Prevention of WMD Proliferation and Terrorism, the United States needs to act decisively to limit the threat of a bioterrorism attack.[1] Among the recommendations of this commission is "to enhance the nation's capabilities for rapid response to prevent biological attacks from inflicting mass casualties,"[1] and the education of health care professionals about the diagnosis and management of symptoms and conditions caused by bioterrorism agents is an important element of this capability.

Surveys conducted in the immediate aftermath of the 9/11 attacks and two years later indicated that U.S. physicians felt underprepared to diagnose and manage illness caused by bioterrorism agents,[2,3] and a number of organizations have developed and implemented bioterrorism education initiatives to address this knowledge gap. Between August 2006 and August 2008, the Annenberg Center for Health Sciences at Eisenhower assessed bioterrorism learning and knowledge retention via a variety of different CME media utilizing either interactive or didactic information delivery modes.[4] One of the options for delivery of the didactic information in the study was a printed monograph. With the advent of web-based education, the print format has been discredited increasingly as a vehicle for CME, resulting in a diminished role for printed materials in CME. In this report, we present the study's data on knowledge acquisition and retention after completion of the monograph CME activity and suggest a utility for this educational format, both for the topic of bioterrorism and among specific, well defined segments of the medical professional audience.

## STUDY DESIGN AND PARTICIPANTS

Civilian and military health care professionals (including physicians, nurses, nurse practitioners, pharmacists, public health officials, physician assistants, certified laboratory scientists, respiratory therapists, and psychologists) were invited to participate in the research program via printed brochures, online banner advertising, e-mail, phone calls, direct mail, and fax blasts. Recruitment began in August 2006, and the study was completed in August 2008. Over the initial nine months, participants had a choice of delivery mode (live, web-based, personal digital assistant [PDA], or monograph). Those who chose web-based activities were assigned randomly to interactive or didactic modes, but only didactic information delivery was available to participants choosing the PDA or monograph modes. The monograph content was modeled on a classroom presentation and included information about the recognition, diagnosis, and management of symptoms and diseases caused by avian influenza and smallpox. Course materials were provided free of charge to all participants who selected web-based, PDA, or print monograph delivery modes.

Participants were sent the monograph with a pretest and posttest and were asked to complete the pretest prior to taking the course and the posttest after course completion. All tests were returned to the Annenberg

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Center for Health Sciences at Eisenhower by mail and fax. The participants were then sent follow-up tests at three months and six months after the receipt of the original tests. Participants were asked to complete two tests at each time point, one test each for avian influenza and smallpox at three months and six months. The same test was used at each time point for each topic.

Analysis of test scores was undertaken at each time point to evaluate knowledge acquisition with the monograph in the whole cohort of participants, as well as in specific subgroups based on gender, locality (urban versus rural), profession (physician versus nonphysician), and age (younger than 50 years versus 50 years and older).

## Statistical analysis

All data in this study were descriptive, and analyses were conducted using various statistical approaches. Changes in level of knowledge over time were evaluated by analyzing participants' summed pretest and posttest scores, posttest and three-month scores, and three-month and six-month scores; the summary outputs were expressed as aggregate mean (SD) scores. The participants' mean scores over time were compared, but the paired-difference analysis excluded participants who did not complete both of the tests under comparison. Paired differences in mean scores over time also were evaluated in the participant subgroups: men and women, urban and rural, physician and nonphysician, and age younger than 50 years or 50 years and older. Differences based on delivery mode, level of interaction, or demographic/occupational variables were evaluated by independent sample *t* tests, which were used to compare the change in knowledge from pretest to posttest or from posttest to follow-up tests (at three months and six months), with an $\alpha$ value of .01.

**Table. Description of study participants[4]**

| Characteristic | Participants (N = 369) |
|---|---|
| Gender, no. (%) | |
| Male | 197 (54) |
| Female | 170 (46) |
| Age in years, median (range) | 53 (19–84) |
| Age groups, no. (%) | |
| < 30 years | 6 (2) |
| 30–49 years | 118 (36) |
| ≥ 50 years | 205 (62) |
| Status, no. (%) | |
| Civilian | 264 (72) |
| Military | 9 (2) |
| Declined to state | 96 (26) |
| Locality, no. (%) | |
| Urban | 314 (85) |
| Rural | 40 (11) |
| Super-rural | 13 (3) |
| Declined to state | 2 (1) |
| Profession, no. (%) | |
| Physician | 283 (77) |
| Other | 85 (23) |

## STUDY RESULTS

Three hundred and sixty-nine health care professionals participated via the printed monograph. Most participants resided in urban areas (85%), were physicians (77%), were civilians (72%), and were aged 50 years or older (62%) (Table).[4] Overall, 368 participants completed the posttests for avian influenza and smallpox, but fewer participants (283 [76.7%]) completed the pretests for both. The completion rate for the pretest was similar for both avian influenza and smallpox, but there was a drop-off in the completion rate for the follow-up tests: 137 (37.1%) and 139 (37.7%) participants completed the three-month avian influenza and smallpox tests, respectively, and the corresponding numbers of participants completing the six-month tests were 66 (17.9%) and 69 (18.7%), respectively. The completion rates remained similar among the avian influenza and the smallpox tests.

Scores for avian influenza activities increased significantly from a mean (SD) of 42.3% (13%) in the pretest to 57.2% (11.5%) in the posttest (Figure 1). Mean scores for smallpox activities also increased significantly from 51.2% (20.4%) to 75.2% (15.4%) for the pretest to posttest. There was a statistically significant decrease in knowledge over time, with a clear decrease in mean scores between the posttest and the three-month follow-up tests for both topics ($P < .0001$). There was no significant change between the three-month and six-month scores for either topic, however ($P > .1$). The six-month scores were slightly higher than the pretest scores for both topics,

indicating some evidence of long-term knowledge retention.

Within each predefined demographic or occupational subgroup, the change in mean test scores at each time point was consistent with the overall results. There was a significant increase in mean test scores between the pretest and posttest scores for both topics in each subgroup ($P < .0001$). There was also a decrease in mean scores for both topics between the posttest and three-month follow-up test, which was statistically significant at $\alpha = .01$ for avian influenza in all subgroups ($P < .003$), and for smallpox in all subgroups ($P < .01$) except for those from rural areas ($P = .014$).

Initially, pretest scores for avian influenza were lower for participants who completed the monograph module than for those participating in the live or web-based activities (Figure 2), but the pretest scores for smallpox were similar across all learning modes (live, web-based, PDA, and monograph). The change in mean score for either topic at each time point, however, was similar regardless of the educational medium.

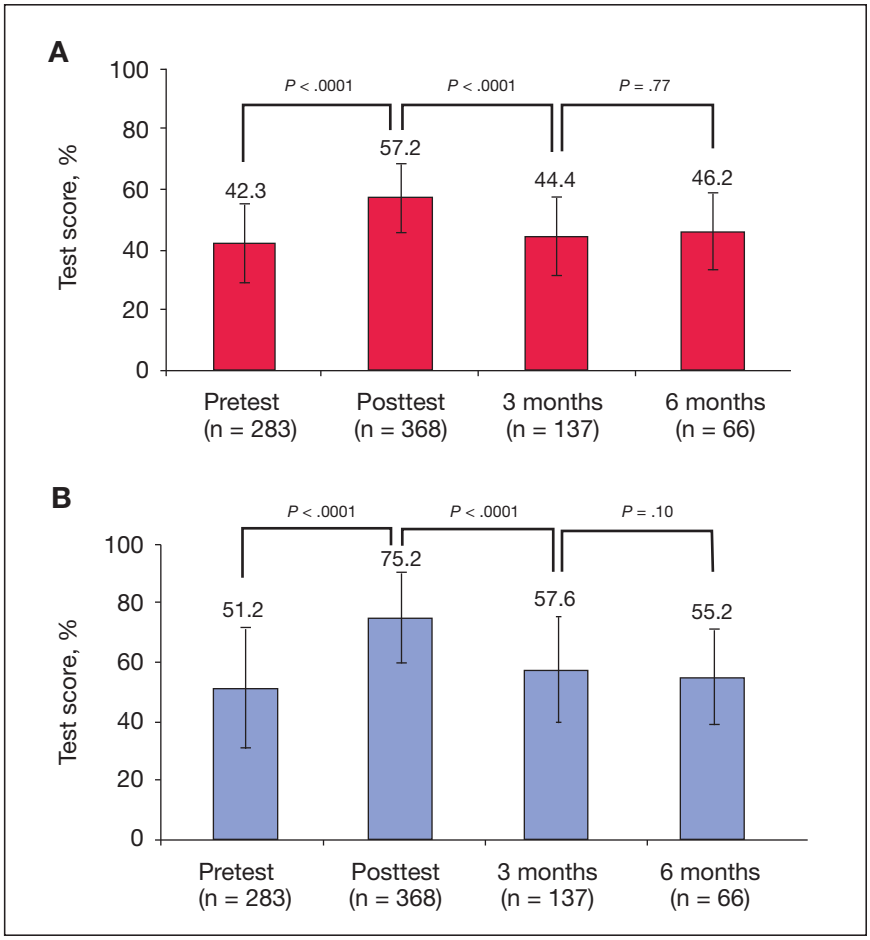


Figure 1. Knowledge retention of bioterrorism agents with monograph-based CME: Overall test score averages at each time point for the avian influenza tests (A) and smallpox tests (B).

## DISCUSSION

This exploratory study showed that: (1) a didactic print format educational activity was effective in increasing knowledge about avian influenza and smallpox for a range of health care professionals and (2) the effectiveness of this format was similar to that of live or web-based educational activities. We also found that all subgroups of participants showed similar acquisition of knowledge regardless of age, gender, profession (physician versus nonphysician) or locality (urban versus rural), although it seemed that younger participants and women did not retain their knowledge of smallpox as well as older participants and men did.

Consistent with other studies of printed CME activities, our study showed that physicians demonstrate significant improvements in knowledge over the short term, but these gains are not maintained.[5] Previous data have indicated that when learning is not regularly accessed or reinforced in clinical practice the information is lost rapidly.[6] This probably explains the significant decline in test scores between the posttest and three-month assessment in this analysis and in our live and web-based CME programs.[4] It is encouraging, however, that there was no significant further erosion of knowledge between the three-month and six-month assessments. In this respect, our data are similar to those from other studies of bioterrorism CME, in which knowledge acquired immediately after an educational activity is lost over subsequent months, even when physicians receive regular web-based updates.[7]

Although this was not a randomized comparison, our data suggest that printed materials are at least as effective for knowledge acquisition as live or web-based learning techniques. Randomized studies comparing

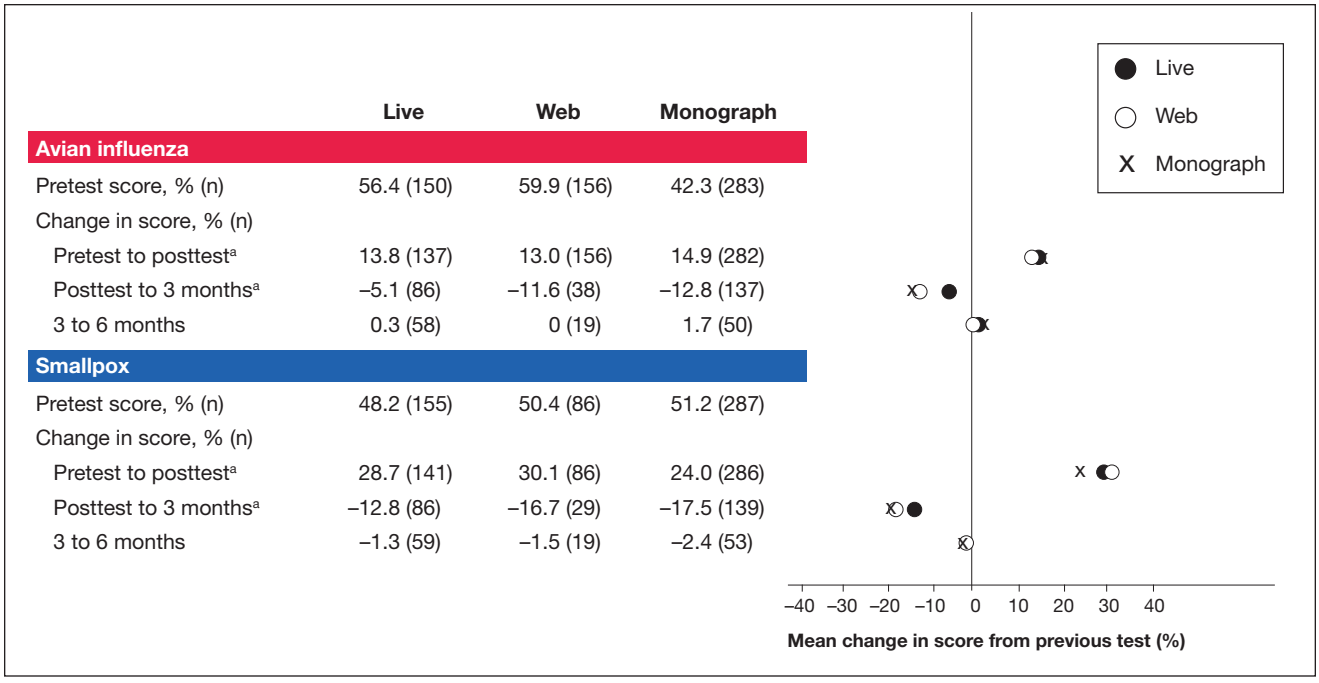


Figure 2. Change in test scores with monograph-based CME compared with live or web-based CME. [a]Significant change ($P < .01$) within each activity (ie, live, web, and monograph).

knowledge acquisition with printed versus web-based education have had mixed results.[8–10] Results of two of these randomized studies showed no difference in test scores between self-study with printed materials and web-based education,[8,10] whereas results of another study indicated improved scores with web-based versus printed materials.[9] In the latter study, knowledge acquisition also may have been influenced by differences in the content delivery of the two programs since the web-based program included interactive components that provided instant feedback, more color images, and real-time video sequences.[9] In the only one of these studies to examine long-term knowledge retention, the printed and online activities were associated with similar reductions in test scores at four to six months after the activity.[8] This is also consistent with our findings that knowledge erosion over time does not vary between printed and web-based learning approaches.

Reviews of CME effectiveness have suggested that the provision of information alone (in the form of printed materials) is one of the least effective means of educating physicians when measured by changes in physician care processes or patient health outcomes[11] and is less effective than live education activities.[12,13] These reviews did not compare the effectiveness of these two delivery media, however, in terms of knowledge acquisition or when used as a sequential reminder. It is impossible to determine the impact of bioterrorism CME on care process or patient outcomes until a bioterrorism event occurs, so evaluation can take place only at the level of knowledge acquisition, and, as described earlier, our data on this are consistent with some of the randomized studies comparing print and web-based delivery.[8,10]

In our study, participants could choose the CME delivery mode (live, web-based, monograph, or PDA) they preferred and found most accessible. The monograph option was chosen by the largest number of participants (38.4%), followed by the web-based (32.8%), live (16.5%), and PDA (12.3%) modes. A number of factors may affect the health care professional's choice of CME delivery mode, including learning style preference, convenience, timing, locality, and technological capability. The preference for the monograph option in our study may reflect its convenience, since previous data have indicated that convenience is an important factor in determining physician preferences for participation in CME.[14] A monograph is a familiar learning format, can be transported easily and undertaken in the health care professional's own time and at his or her own pace, and provides a

printed record for future reference. While printed materials do offer convenience and portability, web-based programs are updated more readily, can incorporate interactive and video elements, and are accessible to an almost unlimited number of participants for a single upfront investment in development. Live events carry a cost each time the event takes place, and printed materials incur printing and mailing costs, while web-based activities become more cost-effective as participant numbers increase. Moreover, as wireless technology evolves, so does the portability of web-based programs, especially those that can be accessed with devices other than computers, such as PDAs.

One notable finding in our study was the lower pretest scores for avian influenza in the monograph group compared with scores of participants attending live activities or using the web-based mode. It is not clear why this might be the case, but it may reflect the different demographic composition of our cohort. For example, if the live and web-based activities included more health care professionals involved with public health or infection containment programs, they might have been more aware of the characteristics of avian influenza. The difference also may be a statistical artifact arising from the small number of questions in the assessment tests, whereby a small difference in the number of questions answered correctly translates to a large difference in percentage of correct answers.

## STUDY LIMITATIONS

Our study has a number of limitations. First, assignment to CME delivery mode was not randomized; participants could choose which they preferred, and 38% chose the monograph option.

Second, the study of monograph effectiveness involved a time series before/after design without control or comparison groups. Because participants choosing the live meeting or web-based delivery modes were assigned randomly to didactic versus interactive instructional techniques, we were able to make comparisons in our previous analysis.[4] There were insufficient test scores at each time point, however, to allow a meaningful comparison between the monograph and PDA delivery modes.

Third, approximately one quarter of participants omitted the pretest and completed only the posttest in order to obtain credit, so the number of participants with pretest and posttest scores was diminished. In addition, there was considerable attrition over time, with decreasing numbers of participants completing the three- and six-month follow-up tests. This reduced sample size affected the statistical power of the later comparisons, particularly in the subgroup analyses.

Finally, our evaluation tests included only a limited number of questions. For example, a single additional correct answer on a test that included seven questions would increase the score by 14%, yet it is unclear whether this represents a meaningful increase in knowledge. The restricted range of the scores makes the practical significance of the statistical analysis problematic.

***A monograph is a familiar learning format, can be transported easily and undertaken in the health care professional's own time and at his or her own pace, and provides a printed record for future reference.***

## CONCLUSIONS

Current evidence-based guidelines for CME activities recommend the use of more than one medium for delivery of the information, more than one instructional technique, and multiple exposures to the content of the education program.[15] Our study indicates that this approach may be as effective as live or web-based instruction for knowledge acquisition. While printed materials do have a role in bioterrorism CME, we believe they should be part of an ongoing program involving multiple media, different instructional techniques (both didactic and interactive), and a sequential series of CME events.

*Author disclosures*

*The authors report no actual or potential conflicts of interest with regard to this article.*

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# NOTES


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