Administering Needs-assessed Bioterrorism Curricula to Public Health Professionals Using Active-learning Strategies

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Abstract

Acts of bioterrorism, such as the “anthrax letters” in 2001, exposed public health professionals to potentially high concentrations of unknown biological organisms. After an event such as the “anthrax letters,” it became apparent that public health professionals require continual training and knowledge about proper biological safety level 3 (BSL-3) practices and procedures. To assess specific content areas where training was needed, public health professionals in northeast Ohio were given an original assessment. Prior needs assessments had warranted the development of three 2-day courses based on BSL-3 practices and government regulations. These courses stimulated learning by combining open-ended questioning and hands-on exercises to promote group discussion. Testing instruments were administered before and after the courses and analyzed by paired t-test to assess improvement in participant knowledge. Five questions from this test were used as content measures to assess learning in specific content areas. Learner attitudes were assessed following course completion via survey data. Participants averaged 67.7% ± 9.2 on testing instruments prior to courses as compared to 86.0% ± 8.6, following course completion (p < 0.001). Improvement was significant (p < 0.05) in all content areas measured. Eighty-two percent of participants responded that they would change their practices based on information learned from the course. These data coupled with learner attitudes demonstrate a significant increase in participant knowledge among public health professionals and a willingness to change existing practices through the integration of new concepts.

Keywords
Biosafety, laboratorians, active-learning, continuing education, and bioterrorism

Introduction

Incidents of bioterrorism worldwide over the past 2 decades have propelled people into varying states of awareness and fear (Klietmann & Ruoff, 2001). The 2001 anthrax letters alone impacted 5 states and 17 cities, and resulted in the death of at least five people, elevating bioterrorism vigilance to chronic levels (Jernigan et al., 2001; Jernigan et al., 2002; Steinbruner & Harris, 2003). While high quantities of anthrax and other select agents are typically limited to the confines of high-security biosafety level 3 (BSL-3) laboratories, the anthrax attacks on the U.S. postal system changed this. During this time of chaos, “white powders” suspected to be anthrax were shuttled through hospitals and health departments where personnel were ill-prepared to handle them (Snyder, 2003).

The vulnerability of the United States to bioterrorist attacks led to increased government spending for and oversight of select agent research and containment facilities (Atlas, 2005; Schwellenbach, 2005). The National Institutes of Health’s (NIH) biodefense research funding alone increased from $25 million in 2001 to $1.7 billion in 2011 (Atlas, 2005; Kaiser, 2011), funding an increasing number of investigators working with select agents (Schwellenbach, 2005). Increased funding spurred recommendations from scientific organizations to: 1) increase laboratory biosecurity; and 2) increase laboratory safety and better train laboratory personnel to prevent accidental releases and laboratory-acquired infections in the event of natural outbreaks of emerging diseases or acts of terrorism. The American Society for Microbiology (ASM) made recommendations to the Energy and Commerce Subcommittee on Oversights and Investigations to: 1) require mandatory NIH and Centers for Disease Control and Prevention (CDC) training for individuals involved with BSL-3 and BSL-4 laboratories; 2) form NIH Regional Centers for Excellence serving roles in biosecurity training and information; 3) follow strict adherence to NIH regulations and guidelines set forth in Biosafety in Microbiological and Biomedical Laboratories (U.S. Department of Health and Human Services, 2009); and 4) provide better surveillance and reporting of laboratory-acquired infections (ASM, 2007).

Legislation more stringently regulating access and use of select agents quickly ensued (Marmagisu et al., 2003). Among this new legislation were policies enacted through the Public Health Security and Bioterrorism Preparedness and Response Act of 2002 (U.S. House of Representatives, 2002) requiring investigators possessing, transporting, or using agents or toxins (deemed a threat to public, animal, or plant health) to notify the CDC or the Department of Agriculture’s Animal Plant Health Inspection Service (APHIS) to increase the monitoring of select agent use. Additionally, Senate Bill 485 (U.S. Senate, 2009), known as the Select Agent Program and Biosafety Improvement Act of 2009, proposed requiring all users of BSL-3 laboratories to have extensive, mandated training. However, mandated training of select agent users has been slow to follow as S. 485 was never passed into law.

As a consequence of this hyper-vigilance and the increased number of personnel working with select agents, increased from $25 million in 2001 to $1.7 billion in 2011 (Atlas, 2005; Kaiser, 2011), funding an increasing number of investigators working with select agents (Schwellenbach, 2005). Increased funding spurred recommendations from scientific organizations to: 1) increase laboratory biosecurity; and 2) increase laboratory safety and better train laboratory personnel to prevent accidental releases and laboratory-acquired infections in the event of natural outbreaks of emerging diseases or acts of terrorism. The American Society for Microbiology (ASM) made recommendations to the Energy and Commerce Subcommittee on Oversights and Investigations to: 1) require mandatory NIH and Centers for Disease Control and Prevention (CDC) training for individuals involved with BSL-3 and BSL-4 laboratories; 2) form NIH Regional Centers for Excellence serving roles in biosecurity training and information; 3) follow strict adherence to NIH regulations and guidelines set forth in Biosafety in Microbiological and Biomedical Laboratories (U.S. Department of Health and Human Services, 2009); and 4) provide better surveillance and reporting of laboratory-acquired infections (ASM, 2007).

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As a consequence of this hyper-vigilance and the increased number of personnel working with select agents,
the almost six-fold increase in federal funding for bioterrorism preparedness included funds for training laboratory personnel (Baker Jr et al., 2005; Berger et al., 2009; McHugh et al., 2004). One avenue for increased preparedness education and training came through CDC-funded Centers for Public Health Preparedness, originally developed in 2000 and reorganized as the Preparedness and Emergency Response Learning Centers (PERLC) in August 2010 (CDC, 2012; Fink, 2003).

The vast amount of funding dedicated to and the abundance of recommendations directed toward enhanced safety and security within BSL-3 laboratories resulted in an abundance of content-heavy curricula released via the internet. Although some laboratory personnel sought and completed trainings based on this curricula, the continued reporting of laboratory-acquired (Harding & Byers, 2006) and research-acquired (Kaiser, 2007; Lawler, 2005) infections suggests that limited numbers of training opportunities are available or that a disconnect exists when translating the theoretical constructs of lab safety into best practices that are incorporated into the workplace. In a changing work environment with the potential threat of select agent exposure, public health professionals must continually train throughout their careers to assimilate new information to remain competent, proficient, and safe in the workplace (Fiester et al., 2010).

Curricula for laboratory professionals should develop critical thinking skills in adult learners, allowing them to adapt in a rapidly changing workplace (Kiltz, 2009). One way to promote this critical thinking in laboratory workers is to employ an active learning environment (Paul & Binker, 1990; Severiens & Schmidt, 2009), similar to strategies successfully used in the undergraduate science classroom, that supports public health professionals in obtaining “up-to-date” content in a way that encourages them to integrate the best practices into their workplace. The authors have previously demonstrated the use of active learning and peer education as effective teaching and learning methods for hospital laboratorians (Fiester et al., 2010; Paul & Binker, 1990). Peer education gives students the opportunity to share experiences and knowledge with one another, thus providing real-life examples of course material. While peer education was the primary teaching style used to deliver content in this study, a facilitator is still needed to maintain the continuity of course material and to ensure all content is delivered effectively. The facilitator guides, monitors, and directs peer interactions by selecting the material for group discussions and facilitating the course of these discussions (Damon, 1984).

Needs assessments were utilized in this study to establish the need for bioterrorism preparedness training among public health professionals. A need for training was perceived from these data, resulting in 2-day bioterrorism preparedness courses being designed. To test the efficacy of using active-learning strategies to teach bioterrorism curricula, a course was created in which hands-on activities, case studies, and personal experiences were utilized to create an active-learning environment for adult learning. Pre-tests, post-tests, and post-course evaluations were performed to assess learning and gauge learner attitudes, respectively.

**Methods**

**Needs Assessment Survey**

One hundred and eight public health laboratory workers and 15 public health administrators were surveyed to evaluate: 1) confidence in performing tasks associated with biological agents and BSL-3 practices and procedures; 2) need for training associated with biological agents and BSL-3 practices and procedures; 3) likelihood of participation in courses; 4) previous training; 5) training preference; 6) requirement for continuing education credit; 7) timing restrictions; and 8) other demographics specific to survey participants. Survey questions evaluating confidence performing tasks and training needs were coded to a five-point Likert scale: highly confident or highest priority for training (value = 1); confident or high priority for training (value = 2); somewhat confident or somewhat of a priority for training (value = 3); not very confident or not a very high priority for training (value = 4); or have not addressed/not at all confident or no need at all for training (value = 5). The Likert values obtained for administrators and laboratory workers were averaged and reported as the mean ± standard deviation. A priority for training was perceived if a mean score of 3 or less was obtained from training priority polling data. The confidence of surveyed public health professionals to complete tasks was considered weak if a mean value of 3 or more was obtained from confidence polling data. Both administrators and laboratory workers were also polled to ascertain the degree to which they felt prepared for a bioterrorist event. Possible responses were prepared at an “advanced” level, “intermediate” level, “awareness” level, or not prepared.

**Curriculum Development and Delivery**

BSL-3 curricula were developed based on training needs determined by survey data and recommendations and guidelines from the CDC, NIH, ASM, and Ohio Department of Health. Three courses were held that consisted of group activities, peer-to-peer teaching, and hands-on components. PowerPoint (Microsoft Corporation, Redmond, WA) content slides were developed as reference material and used to direct open-ended discussions, facilitating problem-based and scenario-based learning. As a scenario-based learning strategy, students were instructed to conduct experiments with an “unknown” sample (Glo Germ™ powder, Moab, Utah) using proper practices and procedures. These experiments involved proper procedures for donning and doffing personal protective equipment (PPE) and using and maintaining biological safety cabinets (BSCs). Another scenario was introduced in which the “unknown” sample was spilled, allowing students to practice decontamination strategies. Molecular microbiological techniques for pathogen identification (rt-PCR) and toxin quantification were
also included in the practice-based curriculum. As an adjunct to these exercises, interrupted case studies of lab risks and mitigation strategies were utilized. Students were allowed to work with peers to perform experiments, as they would in their own laboratories. These exercises were videotaped, and footage was edited, made anonymous, and shared with students. Videotaping allowed facilitators to cite specific areas where proper practices and procedures were not followed, thereby tailoring course content to the students’ needs. Following facilitator-based instruction, students repeated the experiments, allowing them to integrate new knowledge and concepts. The combination of open-ended questioning, peer-to-peer teaching, group exercises, and hands-on activities was specifically designed to create an active-learning environment for adult learners in which transformative learning would elicit critical thinking in the workplace (Marbach-Ad et al., 2009; Severiens & Schmidt, 2009).

Curriculum Efficacy
A multiple-choice testing instrument was designed and administered to participants before and after the courses. This assessment tool was used to gauge knowledge both before and after training. By comparing scores of the identical pre-test and post-test using a paired t-test, the efficacy of the course could be analyzed. Selected questions focusing on select agents, N-95 masks, secondary barriers, HEPA filters, and glove use were used as content measures and individually analyzed to assess learning in these areas of the curricula. Examples of these content measure questions were: 1) “Which of the following is true regarding the N-95 mask?” a. protects as well as a surgical mask; b. should be replaced after each use; c. supplies oxygen; d. reduces allergens and pathogens with a 95% efficiency; or e. filters out chemicals; and 2) “HEPA filters exclude…” a. gases and vapors only; b. particles only; c. gases, vapors, and particles; d. air; or e. none of the above. Statistical analyses were conducted using GraphPad InStat (GraphPad Software, Inc., San Diego, CA). Significance was set a priori at $p \leq 0.05$.

Learner Attitudes
Participants completed the evaluations after the courses. Questions on the evaluations were multiple-choice in nature and coded to a five-descriptor (strongly agree = 5, to strongly disagree = 1) Likert scale. These questions were used to measure learner attitudes pertaining to certain aspects of the training. Participants were asked if they were in agreement with the following statements: 1) instructional materials were beneficial to learning; 2) the hands-on portion met training needs; and 3) I will change my practices and procedures after participation in this course. Participants were considered to be in agreement with a statement if the geometric mean of responses was greater than or equal to three. Analysis of the evaluations was conducted using GraphPad InStat (GraphPad Software, Inc., San Diego, CA).

Results

Needs Assessment Survey
Data obtained from the needs assessment survey were used to develop course content, structure, and delivery. The majority of polled administrators felt that they were prepared only at the “awareness” level or not prepared at all for a bioterrorist attack, with 40% responding preparedness at the “awareness” level and 13.3% responding a complete lack of preparedness. Laboratory workers also felt unprepared, with 30.8% responding preparedness at the “awareness” level only and 44.9% responding a lack of preparedness. The majority of laboratory workers did not express confidence in any of the areas polled (Table 1). The lack of confidence is complimented with the majority of administrators responding a priority for training in all areas polled (Table 2). Laboratory workers felt training was needed for the detection of biological agents and weapons, laboratory readiness preparing for bioterrorism, and the Public Health Security and Bioterrorism Preparedness and Response Act of 2002 (Table 2). While 80% of administrators had previous education or training that addressed issues related to bioterrorist threats, only 26.4% of laboratory

<table>
<thead>
<tr>
<th>Area of Bioterrorism</th>
<th>Mean Administrator Response ± Standard Deviation</th>
<th>Mean Laboratory Worker Response ± Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detecting biological agents and weapons</td>
<td>3.3 ± 1.0</td>
<td>4.1 ± 1.1</td>
</tr>
<tr>
<td>Detection and diagnosis to rule out select agents</td>
<td>2.9 ± 1.2</td>
<td>4.0 ± 1.2</td>
</tr>
<tr>
<td>BSL-3 laboratory procedures</td>
<td>3.0 ± 1.5</td>
<td>4.1 ± 1.3</td>
</tr>
<tr>
<td>Laboratory readiness (preparing for bioterrorism)</td>
<td>2.9 ± 1.1</td>
<td>3.7 ± 1.2</td>
</tr>
<tr>
<td>Public Health Security and Bioterrorism Preparedness and Response Act of 2002</td>
<td>3.5 ± 1.6</td>
<td>4.5 ± 1.0</td>
</tr>
</tbody>
</table>

*Scale ranges from highly confident (value = 1) to not at all confident (value = 5).
workers had similar training. When polled on their likelihood of participating in trainings conducted using traditional classroom instruction, less than half (41.1%) of the laboratory workers answered they would be likely to participate.

Curricula Efficacy

Student knowledge of BSL-3 concepts improved, as evidenced by post-test scores. Scores increased significantly from 67.7 ± 9.2% on pre-tests to 86.0 ± 8.6% on post-tests (p < 0.001) (Table 3). All measured content areas significantly improved between pre-tests and post-tests (Table 3). Most notable were improvements in knowledge of containment, including secondary barriers and HEPA filtration. The number of students responding correctly to the secondary barrier and the HEPA filtration content measures increased from 28% to 88% and 48% to 80%, respectively (Table 3). While improvement in knowledge of glove use was not as striking, significant improvement did occur. Eighty-eight percent of students responded correctly to the glove use content measure on pre-tests and 100% of students retained this knowledge on post-tests (Table 3).

Learner Attitudes

Post-course evaluations were administered to students to assess the efficacy of curricula structure. Questions were designed to assess behavioral change. Possible responses for each question ranged from strongly agree (value = 5) to strongly disagree (value = 1). Participants agreed with the statements, “the BSL-3 laboratory exercises were appropriate and met my training needs,” and “the provided instructional materials were beneficial to my learning,” answering with mean responses of 4.73 ± 0.45 and 4.92 ± 0.28, respectively (Figure 1). More importantly, students agreed they would “change their laboratory practices and procedures based on what they learned in the course,” replying with a mean response of 4.45 ± 0.82 (Figure 1).

Discussion

While the majority of administrators polled in this report had education or training that addressed issues relating to bioterrorist threats, only a fraction of laboratory workers had similar training. This is troublesome considering laboratory workers are at a greater risk of being in contact with harmful agents. A training deficit among public health professionals is supported further by pre-test data obtained during this study and the lack of confidence expressed by both administrators and laboratory workers on the needs assessment survey. Specifically, there was a lack of knowledge of secondary containment and HEPA filtration in 72% and 52% of participants, respectively.

Ongoing assessment of preparedness suggests that the United States and other countries are far from mounting successful responses to events of bioterrorism. The American Association for the Advancement of Science (AAAS), ASM, and individual researchers have cited the need for training the public health community (Berger et al., 2009; Fiester et al., 2010; Kiltz, 2009). Compounding the lack of preparedness among public health professionals is the lack of a standardized accreditation process for BSL-3 workers. No standards or accreditation currently exist for BSL-3 professionals; however, 70% is the standard required of BSL-2 medical technologists on the American Medical Technologists (AMT) examination. The Bioterrorism Training and Curriculum Development program (created in the Public Health Security and Bioterrorism Preparedness and Response Act of 2002) addressed the lack of standardization and accreditation, making recommendations for uniform training standards and certifications. These recommendations led to the inclusion of requirements for standardization and accreditation in the Weapons of Mass Destruction (WMD) Prevention and Preparedness Act of 2009 (Berger et al., 2009). The WMD Prevention and Preparedness Act of 2009 called for: 1) training standards; 2) risk assessment standards; 3) security standards; and 4) accreditation of training programs by the Secretary of Health and Human Services.

Whether exposure originates from an unintentional release of a select agent or, more likely, from a natural disease outbreak such as pandemic influenza, deficits in training must be addressed through continual training (Hartwig et al., 2009; Schwellenbach, 2005; Sewell, 2006; Weisfuse, 2009).
Based on survey data outlining the public health professionals’ disinterest in traditional classroom instruction, the education literature, and the effectiveness demonstrated in this study, training using active-learning teaching strategies appears a plausible avenue to achieve increased preparedness amongst public health professionals. AAAS cites active teaching methods as the most successful method for educating public health workers (Berger et al., 2009). The aforementioned select agent preparedness course effectively utilized these active-learning techniques in the form of group activities, case studies, peer-to-peer teaching, hands-on components, and dynamic lectures directed by open-ended questioning to facilitate problem-based and scenario-based learning. Not only was significant improvement documented between overall pre-test and post-test scores (Table 3), but also significant improvement was demonstrated in knowledge within all measured content areas (Table 3). These data demonstrate that active-learning methods, such as the exercises involving manipulation of the “unknown” sample, allow students to collaboratively utilize critical thinking and affirm active-learning methods as an effective way to teach bioterrorism-related material.

An increase in participant knowledge post-course is not surprising considering that the high number of laboratory-acquired infections and the possibility of bioterrorism events spur adult learners’ interest and participation in

### Table 3
Content measures analyzed to assess learning.

<table>
<thead>
<tr>
<th>Content Measure</th>
<th>% Students Meeting Content Measure Pre-test</th>
<th>% Students Meeting Content Measure Post-test</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select agents</td>
<td>76</td>
<td>92</td>
<td>0.031</td>
</tr>
<tr>
<td>N-95</td>
<td>68</td>
<td>96</td>
<td>0.001</td>
</tr>
<tr>
<td>Secondary barriers</td>
<td>28</td>
<td>88</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>HEPA filters</td>
<td>48</td>
<td>80</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Glove use</td>
<td>88</td>
<td>100</td>
<td>0.032</td>
</tr>
<tr>
<td>Total Test Score Mean</td>
<td>66.4 ± 9.9</td>
<td>83.4 ± 8.3</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

### Figure 1
Post-course evaluation of curricula structure. After completion of trainings, participants were asked if the instructional materials were beneficial, if exercises met training needs, and if they would change their practices based on knowledge gained from the trainings. Possible responses for each questions were strongly agree (SA, value = 5), agree (A, value = 4), neutral (N, value = 3), disagree (D, value = 2), or strongly disagree (SD, value = 1).
courses pertaining to select agents. Adult learners seem to prefer a learning atmosphere in which they can build off of one another’s experiences while incorporating new concepts. It is, therefore, not surprising that following active learning-based courses, 96% of participants scored greater than 70% on post-tests. In addition to an overall improvement in test scores, participants responded with positive feedback to laboratory exercises and instructional materials (Figure 1). While the needs assessment demonstrated public health professionals’ lack of confidence in performing tasks, these participants also expressed that training was a priority. Once training was offered, knowledge of concepts associated with biological agents and BSL-3 practices and procedures increased significantly. In fact, the majority of students participating in the evaluation stated that they would change their laboratory practices and procedures based on the knowledge gained from the course. This implies that learners developed critical thinking skills that encouraged them to change their work practices to increase safety and security.

Bioterrorist attacks, increases in select agent research, as well as continual reports of laboratory- and research-acquired infections spur the public health professional to seek continual education to maintain competency and safety in the workplace. Survey and testing data led to the recommendation that continuing education be used to maintain workplace competency among public health professionals and that yearly needs assessments be completed to determine deficient areas for future course development. For future courses, the authors also recommend sending course participants an online testing instrument, consisting of questions equivalent to those used in the pre- and post-tests, 6 weeks after completion of the course. This instrument could more efficiently assess improvement in knowledge of the course material than the identical pre- and post-tests used in this study, where improvements in test scores could be partially attributed to familiarity with test questions. This follow-up test would also provide a way to gauge curricula retention, allowing for changes in curricular delivery and thus course improvement.

This study suggests training public health professionals using an active teaching model where case studies, group and hands-on activities, peer-to-peer teaching, and lectures directed by open-ended questioning are combined to ingrain creative problem-solving skills. This teaching style seems not only preferred by public health professionals, since the majority do not prefer traditional teaching styles, and effective as demonstrated by increases in participant knowledge following the course, but also transformative as the majority of participants intended to improve their laboratory practices and procedures based on the knowledge gained from the course. Data from this study demonstrate that an interactive teaching style not only increases knowledge of biological safety concepts among public health professionals, but also consequentially results in a changed workplace as workers integrate new concepts introduced in this educational setting.

Acknowledgments

This project was approved by the Kent State University Institutional Review Board for the study of human subjects. *Correspondence should be addressed to Shannon Helfinstine at shannon.helfinstine@aultmancollege.edu.

References


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**Training Announcement—Principles & Practices of Biosafety (PPB)**

This is a comprehensive, interactive, 5-day course that introduces the essential elements of biosafety and provides extensive resource lists for use after the course. Interactive exercises are used throughout to provide hands-on experience and to encourage networking and problem solving among participants and instructors.

Upon completion of the course, participants will be able to: describe potentially hazardous biological materials, the risks associated with their use, and the means to minimize risk and to protect against or prevent release or exposure; discuss ways to provide effective technical expertise in situations involving potentially hazardous biological materials; and, identify, locate, and efficiently use key biosafety resources.

This course is designed for persons who are entering the profession and those with up to three years experience in biosafety. It is also suitable for persons who supervise biosafety professionals and for those who will benefit from additional knowledge of biosafety as a complement to their primary responsibilities.

To register for the PPB at the Embassy Suites Orlando—Lake Buena Vista South in Kissimmee, Florida from February 24 to March 1, 2013, visit www.absa.org/eduppb.html.