Assessing and Improving Bioterrorism Preparedness Among First Responders: A Pilot Study

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Abstract

Following the September 11 terrorist attacks, the vulnerability of the United States became apparent. It also became evident that there was a need for respiratory protection. The purpose of this study was to determine the prior knowledge and perceptions of emergency medical technicians with respect to bioterrorism and to enhance their current knowledge to better prepare them for possible future events. The study was also designed to create a certified pool of trainers who would be capable of fit-testing all squad members with N-100 respirators. Representatives were recruited from each of the Hunterdon County, New Jersey, rescue squads. Participants attended a train-the-trainer session. Before the session and after, they were tested on knowledge and perceptions about relevant bioterrorism issues and were given an educational presentation on bioterrorism, threatening agents, respiratory health, and proper protection, along with being introduced to the fit-test steps for N-100 respirator masks. The response rate for the training was 94 percent. The authors measured and compared responses on the pre-test and the post-test with respect to knowledge, behaviors, and perceptions, and the results indicated a change following the training. The study thus provided evidence that the train-the-trainer program is an effective method of providing public health preparedness training to members of community organizations and agencies.

Introduction

During the October 2001 anthrax attacks, it became evident that the United States lacked an effective preparedness protocol for biological threats. Effective protocols should indicate the proper way of dealing with both exposed and sick populations. A variety of first responders, ranging from law enforcement to emergency medical technicians (EMTs), must have up-to-date training in exposure assessment and protection from biological agents (Waeckerle et al., 2001). The Centers for Disease Control and Prevention (CDC), state health departments, and county and local departments have begun to initiate awareness and preventive measures for issues such as influenza, smallpox, and toxic chemicals. As part of bioterrorism-and-all-hazards-public-health-preparedness plans, other agencies and organizations have started forming collaborative groups to prepare communities to protect themselves. Partnerships with community agencies such as local law enforcement, social services, senior services, mental health services, and other agencies were made to better manage the public and successfully operate a mass clinic.

Protection of the respiratory system has become of growing importance. Events such as SARS, the anthrax attacks, the Tokyo subway attacks, and September 11 have increased the need for proper respiratory protection (Seto et al., 2003). Biological agents such as smallpox, plague, and SARS, which may be used in a terrorist attack, can be dispersed as mists via aerosol (Karwa, Currie, & Kvetan, 2005). Respiratory facemasks are an effective means of protecting against exposure to contaminants in that form. These masks give first responders a first line of defense for their respiratory health while they are on the job providing emergency medical services to someone who may be contagious or are working in an area in which the air is contaminated with particulates.

Hunterdon County, New Jersey, established its Respiratory Protection Program (RPP) in April 2004, developing its protocol using the OSHA Respiratory Protection Program as a model. All Hunterdon County public health employees were required to go through a medical-qualification process and fit-testing, with annual reassessment in accordance with OSHA standard 29 CFR 1910.134 regarding respiratory protection.

N-100 respirators are one of nine types of disposable particulate respirators that are available (Yassi et al., 2005). Hunterdon

County provides N-100 respirator masks for all Health Department, Prosecutor's Office, and Public Health Nursing and Education staff. These respirators were chosen for use for several reasons: N-100 respirator masks have been approved by NIOSH as providing at least 99.7 percent filtration efficiency against solid and liquid aerosols that do not contain oil (3M Occupational Health and Environmental Safety Division, 2004), and they are protective against biological agents, whether manmade or naturally occurring, that can take the form of aerosols, mists, or fumes (Lange, 2003; Martyny, Glazer, & Newman, 2002). On the basis of reports from the manufacturer of Model 8233 N-100 respirators, it has been determined that use of these masks is a preventive measure, in that the masks reduce exposure to biological agents (3M Occupational Health and Environmental Safety Division, 2004).

The purpose of the study reported here was to provide training and education on the importance of respiratory protection, via N-100 respiratory-protective face masks, in the event of a chemical or biological communicable event; on implementation of an RPP; and on proper fit-testing for usage safety. The program was divided into three phases designed to include three first-responder target populations: Phase I (rescue squads), Phase II (police departments), and Phase III (fire companies). This article focuses on Phase I. The results of the study will be used in the preparation and protection of county rescue squads, fire companies, and police squads to ensure prompt response to disaster and emergency situations.

This study aimed to recruit a subset of volunteers from each squad since the pool of volunteers is large and dispersed. A train-the-trainer program was developed and offered to a limited number of participants to create a smaller pool of certified trainers. These trainers were assigned the responsibility of instituting an RPP within their respective squads. The study project was designed not only to provide training and education, but also to create a structured organizational trainer capacity, thus providing EMTs with the capability of educating and training their organizations. The train-the-trainer program was selected as the best way to accomplish these goals because it allows for education of the large target population in a time-efficient and manageable way. The training would prepare participants to institute an RPP within their organization, including the ability to fit-test others, and also provide them with the equipment and resources necessary to complete the task with little to no cost and continual support from the health department (which is a New Jersey Local Information Network and Communication System [LINCS] agency) (Bashir, Brown, Dunkle, Kaba, & McCarthy, 2004). As of 2003, Hunterdon County had approximately 706 active rescue squad members.

Another key factor in the development of the program was the arrangement of successful collaboration among local physicians for medical review and rescue squads. Over the past year, the Hunterdon County Health Department has been working to organize its own Medical Reserve Corps (MRC) unit, a federally initiated and funded program. The MRC was established by the Office of the Surgeon General "to serve citizens and communities throughout the United States by establishing local teams of volunteers to strengthen the public health infrastructure and improve emergency preparedness" (MRC, 2005). The Hunterdon County coalition provided a bank of licensed physicians and nurses from whom volunteers were recruited to be involved as medical reviewers. A key barrier to fit-testing and medical review within local rescue squads can be the expense of obtaining physicians for medical review and consultation. The volunteers of the Hunterdon County MRC served their communities by offering their medical professional services, at no expense, to the rescue squads.

Methods

The first objective was to recruit a subset population containing at least one volunteer from each of the county's 18 rescue squads. These participants will later be referred to as "trainers" and will be involved in the "train-the-trainer" program. The rationale for voluntary participation was that the squads are volunteer organizations and that there are thus no compliance standards.

It is critical that local public health strengthen the local infrastructure to increase response capacity and bioterrorism preparedness (Fraser & Brown, 2000). As part of the county's public health preparedness initiative, directed by state and federal agencies, it is in the best interests of the community to involve the Office of Emergency Management (OEM), rescue squads, and all first responders in the public health infrastructure and the preparedness plan facilitated by the Hunterdon County Department of Health, Division of Public Health Preparedness & Epidemiology.

One possible weakness of the study design was the possibility of low participation because of the voluntary nature of the efforts. Low participation could lead to a low rate of establishment of RPPs and squad fit-testing. The design did, however, have strengths that outweighed the possibility of low participation rates. It allowed the target population to regain control via a train-the-trainer model so that each individual squad organization could institute its own programs with its own trained individual and the necessary tools.

The resources that are used to support establishment of an RPP are as follows: support from the county health department and members thereof; 3M Corporation, which produces the masks and is a corporate partner in the county; fit-test kits and supply of Bitrex available to all trainers, on loan status; and the collaboration of the MRC medical reviewers.

Sample

For the purposes of this study the target population was identified as all county rescue squads and their members. Hunterdon County currently has 18 functional squads with approximately 706 active members. Of those 18, four large squads serve nearly 70 percent of the county. Initially, squads were asked to volunteer at least one member each, which would have given an initial sample size of 18. The participants varied in age, sex, educational background, socioeconomic status, and health status. All participants were certified emergency medical technicians, and each participant belonged to one of the 18 Hunterdon County rescue squads.

Instrumentation

According to the OSHA standard specified in the Code of Federal Regulations (CFR) (Volume 29, Part 1910.134), a medical questionnaire must be used to determine the health status of each individual and whether the individual is medically qualified to participate in fit-testing and wearing of a face mask respirator (Respiratory Protection Standard, 1998). OSHA recommends the use of a questionnaire that can be found within the standard; therefore, the questionnaire used for the purposes of the study was an adaptation of the one provided by OSHA, which can be obtained on the OSHA Web site (http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=STANDARDS&p_id=9783). Certain sections were omitted, and other sections were tailored to meet the needs of the study, to match the target population, and to elicit responses pertinent to N-100 respirators.

A pre-test and a post-test were also used to assess whether participants had acquired

new information and changed their attitudes and perceptions after the training experience. A single test was adapted from Thorne and co-authors (2004) and used for both before and after the training for evaluation purposes. The questionnaires used for pre-test and post-test evaluations are available from the corresponding author upon request. The instrument contained 20 statements, comprising knowledge, perception, and behavior statements. Possible responses to the test items were 1 (strongly agree), 2 (agree), 3 (disagree), and 4 (strongly disagree).

Implementation

The OSHA Respiratory Protection Standard (29 CFR 1910.134) (1998) requires that if respirators are used in an employment or agency, a program or respiratory protection policy (RPP) must be developed (1998). In Hunterdon County, once the RPP was developed, the health officer, who oversees all operations at the county health department, reviewed and approved the program.

A finalized version of the RPP was completed in April 2005. Research was compiled to include the history of bioterrorism worldwide, biological agents, respiratory health, and respiratory masks. This compilation supplemented the program and increased the overall knowledge so that the program administrator would be fully capable of educating others.

Participants were sent packets containing an invitation to a train-the-trainer session, an explanation of the process, and medical questionnaires. The medical questionnaires, which were a main source of data, posed standard questions about an individual's respiratory health, prior medical conditions, medications, and other health-related issues.

Upon arrival at the training, participants read and signed consent forms, acknowledging their participation in a volunteer training. They were also asked to complete the pre-test. Concurrently, a volunteer medical reviewer from the MRC was on hand to meet with any participant who had not previously been medically qualified.

An educational presentation was made, followed by a question-and-answer session and discussion period. Concerns ranged from proper identification of hazardous-agent contamination to the question of which governing agency would alert responders about when to wear the masks. Questions of proper maintenance were raised, as well as issues regarding the county's role in replenishing masks after use and disposal.

The second half of the training involved fit-testing of the participants. This process began with a sensitivity test conducted to ensure that the participant could detect the taste of a Bitrex solution (chemical name: denatonium benzoate, sodium chloride, and water) at low levels. Next, proper application of the respirator was taught. Each participant was then qualitatively fit-tested by means of a head hood and a nebulizer filled with undiluted Bitrex solution. The nebulizer was inserted through a hole in the hood, and a mist was sprayed. A fit-test-steps sheet was created to help trainers follow along and be prepared to ensure proper testing procedures.

Upon completion, the program administrator and the participant signed the fit-test log for record-keeping purposes. The training concluded with all participants completing a post-test. RPP templates were distributed to one representative per squad.

Data

The primary data were collected through three mediums; a pre-test, a post-test, and a medical questionnaire. The pre-test results served as baseline data. Comparison of these results with those of the post-test served as a way to measure changes in knowledge, perceptions, and attitudes (Gershon et al., 2004). The medical questionnaire, used for fit-testing approval, was used to collect medical data, including data on health status, past exposures, and demographics for all participants.

Analysis

Differences in attitudes and perceptions before and after training were tested with a two-tailed probability *t*-test (Table 1). Differences in knowledge for the same time period were also tested with the *t*-tests (Table 2). Data were analyzed with SPSS V11.5. The *t*-tests were used to indicate change for each response.

A mean and a standard deviation were calculated for each array of responses per question on both pre-test and post-test. Attitude and perception responses remained the same, where 1 = "strongly agree," 2 = "agree," 3 = "disagree," and 4 = "strongly disagree". Knowledge responses were collapsed into two categories: "1" indicated a correct response, and "0" indicated an incorrect response. When "strongly agree" was the best answer, the variables 2, 3, and 4 were recoded to equal 0. When "strongly disagree" was the appropriate response, variable 4 was recoded to 1, and variables 1, 2, and 3 were recoded to 0.

The responses to the medical questionnaires were also analyzed with SPSS V11.5. Health risks, behaviors, and diseases were analyzed with frequencies. Height and weight were used to calculate body mass index (BMI). The BMI score was then categorized according to ordinal classifications for weight: underweight, normal, overweight, and obese. Cross-tabulations were used to look at connections between paired variables, usually a health behavior and a correlating disease (e.g., BMI and diabetes).

Results

The comparison of pre-test and post-test results measured change or lack of change in knowledge, perceptions, and attitudes (Table 1). Mean response was calculated for each question. The change following the training had less statistical significance than anticipated. This outcome may be the result of a population that was more informed than expected. It may also be the result of a Type II error. The training may not have addressed the issues being measured well enough for a visible change to have occurred in knowledge, behaviors, and perceptions. A slight increase was seen in the participants' feeling of being prepared to respond. There was a statistically significant change in participants' level of confidence, as shown in Table 1, related to their feeling more prepared to use a mask in a bioterrorism event.

Knowledge changes are presented in Table 2. This table outlines the differences in mean and standard deviation for knowledge-based questions. Growth was also measured in the responses to questions about the proper use of the respirator and fit-testing. After the training, participants showed a statistically significant change in questions regarding N-100 masks, the protection they offer, and the process of fit-testing. Although not statistically significant, changes in responses to other questions did show some change from before training.

The medical questionnaires provided data on the demographics and health status of the study population. Nineteen questionnaires were submitted; two participants were not present for the training. Participants' ages ranged from 23 to 64 years. All participants in attendance were Caucasian. The gender ratio was 12 males (63 percent) to 7 females (37 percent). Forty-two percent of the participants were current smokers. Of these, several suffered from prior respiratory illnesses, including asthma, wheezing, and breathing

TABLE 1

Attitudes and Perception Changes After Training*

Questions	Evaluations		Probability 2-Tailed Test
	Pre-training	Post-training	
1. I believe I'm highly susceptible to contracting a biological agent in my line of work as an EMT.			
Mean =	2.00	1.80	
n =	15	15	0.57
SD =	0.76	0.92	
2. My squad has the equipment to protect its responders from exposure to a BT agent.			
Mean =	2.33	2.25	
n =	16	16	0.20
SD =	0.93	0.92	
3. I would volunteer to respond to an emergency disaster event.			
Mean =	2.00	1.90	
n =	15	15	0.19
SD =	0.80	0.57	
4. I feel prepared to respond to a BT/NBC event.			
Mean =	1.00	2.05	
n =	15	15	0.65
SD =	0.94	0.69	
5. EMTs are offered the most up-to-date training.			
Mean =	1.33	2.25	
n =	16	16	0.55
SD =	0.62	0.42	
6. I believe a respiratory mask is not necessary in my line of work.			
Mean =	3.50	3.70	
n =	15	15	0.66
SD =	0.63	0.48	
7. My squad gets frequent updates on BT preparedness.			
Mean =	2.50	2.55	
n =	15	15	0.96
SD =	0.99	0.83	
8. I feel prepared to use a respiratory mask in the event of a BT/NBC emergency.			
Mean =	2.50	1.80	
n =	15	15	0.00**
SD =	0.83	0.42	
9. Respiratory protection masks are expensive and inefficient.			
Mean =	3.00	3.50	
n =	15	15	0.64
SD =	0.15	0.53	
10. I believe N-100 masks are highly protective against BT/NBC agents.			
Mean =	2.50	1.90	
n =	15	15	0.17
SD =	0.70	0.57	
20. My squad currently has a respiratory protection program.			
Mean =	2.00	1.95	
n =	15	15	0.18
SD =	0.92	0.90	

*1 = strongly agree, 2 = agree, 3 = disagree, and 4 = strongly disagree.
**Statistically significant difference by training ($p < .05$).

TABLE 2

Knowledge Changes After Training*

Questions	Evaluations		Probability 2-Tailed Test
	Pre-training	Post-training	
1. All facemasks offer the same protection.			
Mean =	0.67	0.40	
n =	16	16	0.17
SD =	0.48	0.52	
2. Fit testing is not necessary.			
Mean =	0.67	1.00	
n =	16	16	0.33
SD =	0.25	0.00	
3. N-100 masks can protect me from anthrax, smallpox, and more.			
Mean =	0.00	0.50	
n =	15	15	0.03**
SD =	0.26	0.53	
4. Biological agents are not contagious.			
Mean =	0.00	0.50	
n =	15	15	0.88
SD =	0.52	0.53	
5. Biological agents can be terrorists' weaponry.			
Mean =	0.97	0.70	
n =	16	16	0.55
SD =	0.40	0.48	
6. The only agents that are biological are influenza and smallpox.			
Mean =	0.33	0.80	
n =	16	16	0.35
SD =	0.50	0.42	
7. Fit testing is something an individual can do alone.			
Mean =	0.00	0.80	
n =	15	15	0.02**
SD =	0.49	0.42	
8. Lungs are the organs with the most surface area.			
Mean =	0.50	0.10	
n =	15	15	0.08
SD =	0.51	0.32	
9. Respiratory masks are used by firemen, farmers, and health care workers.			
Mean =	0.00	0.40	
n =	15	15	0.52
SD =	0.46	0.52	

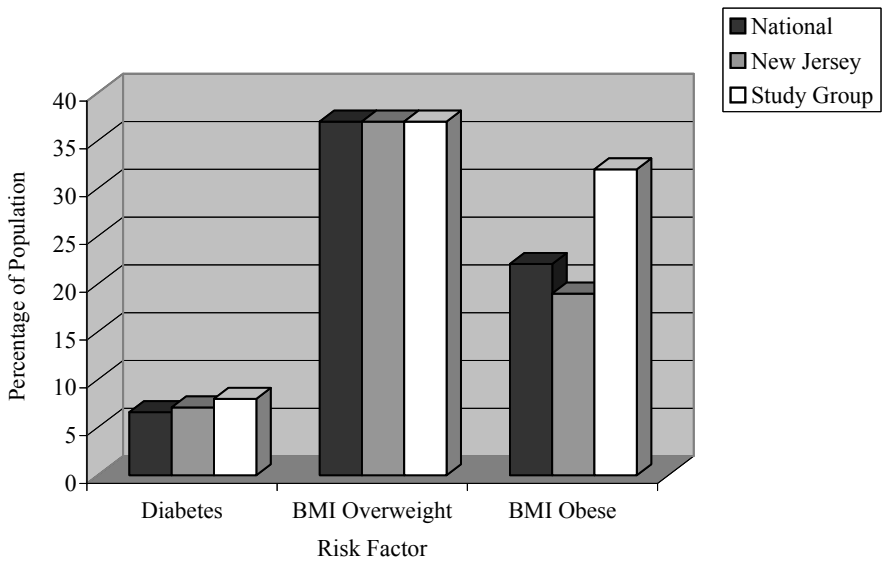
*0 = incorrect; 1 = correct.
**Statistically significant difference by training ($p < .05$).

problems. These data are interesting when the public health/emergency-medical population is considered. The participants had a high incidence of smoking. Responders could have problems when they respond to events and become short of breath. The use of a respirator may increase this response. The implication is that EMT workers need interventions to support their own healthy behaviors.

Participants provided their height and weight. These data were calculated with the online tool of the National Heart, Lung, and Blood Institute (http://nhlbisupport.com/bmi/bmicalc.htm). Thirty-two percent of participants were in the normal weight zone, 37 percent were overweight, and 32 percent were obese. In total, 68 percent of participants were overweight or obese. Although only 8 percent of this group

FIGURE 1

National, State, and Study Group Trends



BMI = body mass index.

reported having diabetes, several complained of shortness of breath, back injuries, and other difficulties in daily activities that could be related to their weight. Figure 1 illustrates national and state trends for diabetes and weight in comparison with the study population. As shown, the study group had the highest percentages in each of these categories.

Discussion

The training was successful, with 17 participants in attendance representing 15 of the 18 county rescue squads. Thus, 83 percent of the county squads now have a certified RPP trainer within their unit. Each of these trainers can properly establish an RPP within the squad and can fit-test members. Of the initial sample of 18, 17 participants completed the training, for a 94 percent participation and completion rate. One hundred percent of attending participants were qualified for fit-testing and wearing of a respirator. One representative per squad received an RPP template for establishment in their respective squads.

Although the medical evaluations found above-average body mass indices (BMIs) and smoking status, participants were not disqualified from the use of N-100 respirators. OSHA does not give specific quantitative guidelines by which medical reviewers can determine a participant's ability to be fit-tested and wear the N-100 respirator. This decision is left up to the reviewing physician's judgment. Unfortunately this disconnect between what should be regarded as a true health concern and what is actually deemed acceptable for medical qualification may be a disservice to the first responders and the communities they serve. Future discussions should address the issue of quantitative guidelines for medical qualifications. These guidelines could include cutoff limits for BMI levels, disqualification of smokers and those with respiratory problems, and more awareness among those in the field regarding individuals with illnesses that could inhibit the proper use of a respirator or inhibit the ability to breathe with a respirator. These guidelines could help raise awareness among those involved in medical reviewing so that they understand the health concerns that can truly inhibit an individual's ability to safely wear a respirator.

Pre-test and post-test data analyses showed statistically significant changes in knowledge, perceptions, and behaviors. Before the start of the training, participants reported that they were not confident about using a respiratory mask to respond to a biological event. Post-test scores indicated that they were more prepared. The change from pre-test to post-test mean scores for this question was statistically significant, with $p = .00$.

Participants were more knowledgeable following the training with respect to two key concepts. First, the data analyses showed a significant increase in the participants' knowledge about the protective factors of the N-100 mask, including some biological threats it is protective against. Second, participants gained knowledge of fit-testing protocol. Before the training, most participants did not know what fit-testing was or how to do it; post-test results showed that over 75 percent of the participants had gained this knowledge.

These data suggest that this training method does have validity. The training provided information that increased knowledge in the areas of fit-testing and biological-threats protection. It also improved perceptions and attitudes, thereby increasing the confidence with which first responders would be able to conduct themselves in the event of disastrous outcomes.

Implications of these data point to the importance of the health status of the individuals wearing the respirators. Wearing a respirator is work for the respiratory system. The majority of the study participants suffered from weight or respiratory issues, and this issue may become a matter of serious concern in the future. If the goal is to have public health preparedness through use of face mask respirators, one must first have a healthy group of first responders.

In the future, data will be available on the percentage of squads who successfully establish RPP and the rates of fit tests among members. To date, seven of the county's rescue squads have established an RPP. Approximately 93 emergency medical technicians (EMTs) in Hunterdon County are now equipped and fit-tested with N-100 respirators.

The success of this train-the-trainer program may lead to future program developments on a broader level, reaching out to county organizations other than rescue squads. Phases II and III will involve police squads and fire companies. Following those phases, the program can reach out to public school officials and other community agencies and organizations.

Conclusion

Sharp and co-authors stated that even with extensive pretraining, complete preparedness is a difficult feat (1998). The complexities presented by terrorist attacks with biological and chemical agents and the complex arena of facilitating an extensive preparedness plan leave room for considerable improvement in developing preparedness (Trust for America's Health, 2003). There are still a great number of issues that will need to be resolved if capabilities in disastrous times are to increase.

First responders are a high-risk population for a bioterrorism or infectious-disease-outbreak event. They need to be trained on topics of public health preparedness, from identification of agents to personal protection. To better protect our communities, those organizations that are involved with the human and public health infrastructure need to receive the most up-to-date training and support.

Recommendations

Future studies like this one might benefit if more funding were available to support the volunteer organizations in the provision of respiratory equipment and other necessary materials. Most participant concerns were about how equipment would be replenished once it had been worn and disposed of, or once it had been contaminated. In addition, fit-test kits, which are necessary for testing, are expensive. The current study allowed trainers to borrow the county health department's supply. Municipal and county policies with respect to protocol for respirator usage may also need to be considered.

Another recommendation is for more background data and baseline data that would benefit a study similar to this one. Because of increased concerns regarding bioterrorism, there is a need for more published literature and data.

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