Instrument Development and Evaluation of Domestic Preparedness Training for First Responders

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Abbreviations:
DOD = Department of Defense
DP = domestic preparedness
DPQ = domestic preparedness questionnaire
EMS = emergency medical services
EMT = emergency medical technician
NBC = nuclear, biological, or chemical
WMD = weapons of mass destruction
WTC = World Trade Center

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Abstract

Introduction: In the wake of domestic terrorists attacks on 11 September 2001 and subsequent bioterrorist events employing anthrax, there no longer can be any debate about the potential for attacks employing Nuclear, Biological, or Chemical (NBC)/Weapons of Mass Destruction (WMD). As one way of acknowledging this long-standing threat and, in a concerted effort to mitigate the effects of possible future domestic NBC/WMD terrorist attacks, the US Department of Defense (DOD) and other US governmental agencies already had mounted an effort to provide Domestic Preparedness Training for First Responders in urban centers throughout the USA.

Methods: A paper and pencil questionnaire specifically designed to evaluate the effectiveness of Domestic Preparedness Training for Emergency First Responders has been developed. An earlier version of this instrument was piloted with a convenience sample of firefighters and paramedics (n = 78) in a northwest state. Based on replies to the pilot questionnaire, a pool of 27 items based on the objectives and content of the NBC/WMD Domestic Preparedness Awareness and Operations courses (plus additional background and appraised competency items) were selected for inclusion in a Domestic Preparedness Questionnaire (DPQ).

Results: This paper first describes the essential psychometric properties of the DPQ based on replies from baseline and follow-up samples (n = 206 and n = 246 respectively) of urban firefighters and paramedics employed by a metropolitan city in a northwest state. The DPQ was employed to evaluate the outcomes of Domestic Preparedness training provided to a sample of urban fire-service personnel. The DPQ documented significant improvements in a group of "DP trained"-urban firefighters (n = 80) both in their awareness and operations content knowledge as well as in their perceived competencies to respond to acts of biological, chemical, or nuclear terrorism "in their own community" at four months post-training. A comparison group of "Not DP-trained" firefighters (n = 78) showed no statistically significant changes on these DPQ indices, suggesting that the documented improvements in the "DP-trained" firefighters on the DPQ were not due to "test reactivity" or to "historical" factors.

Conclusion: The findings suggest that the DPQ has adequate inter-item and test-retest reliability, possesses concurrent validity, and appears to be a sensitive measure of the Domestic Preparedness Training provided for urban firefighter and paramedic First Responders.

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Introduction

For some time, the United States Government has recognized the potential for terrorists attacks employing Weapons of Mass Destruction (WMD) on "U. S. soil".[1] In the wake of the domestic terrorist attacks on 11 September 2001, and the subsequent bioterrorist events employing anthrax, there no longer can be debate about the potential for attacks on US targets that employ nuclear, biological, or chemical (NBC)/WMD. As one way of acknowledging this long-standing threat, and, in a concerted effort to mitigate the effects of future domestic terrorist attacks, the US Department of Defense (DOD) and other US governmental agencies mounted an effort to provide NBC/WMD Domestic Preparedness Training for First Responders in urban centers throughout the United States. First Responders include fire, police, paramedics, and other emergency medical services personnel who are likely to be summoned to provide initial care in such an emergency.[2]

In 1996, the US Department of Defense admitted to a lack of preparedness and an inability to provide assistance to local emergency agencies in the event of domestic terrorism employing NBC/WMD.[3] Shortly thereafter, the [US]Congress enacted the Defense Against Weapons of Mass Destruction Act of 1997. This Act funded federal programs designed to prevent and respond to domestic terrorism, and also directed the Department of Defense to develop and implement domestic preparedness training at the local, state, and federal levels.[4] The goal of this "Train the Trainer: Domestic Preparedness Training" was to inform and educate every urban First Responder in the US to the basic level of "awareness and operations response" and specifically to: (a) recognize the signs/symptoms of a WMD attack employing NBC weapons; and (b) recognize and implement the "delta" operations response to an NBC/WMD attack that differs from "everyday Hazardous Materials" or community-wide, mass disaster events.[5]

Health professionals in the US including emergency First Responders and hospital emergency department personnel, are faced with the unprecedented threat of caring for victims of a NBC/WMD terrorist attack.[6] Terrorist attacks already have occurred on US soil including the 11 September, 2001 attacks on the World Trade Center (WTC) and the Pentagon with thousands of fatalities and thousands of casualties, and the subsequent bioweapon anthrax terrorist "attacks".[7] Although the 11 September 2001 attacks did not involve recognized NBC weapons, they were consistent with other WMD incidents in that they targeted sites and individuals for their symbolic and psychological value.

The sarin nerve agent attack on Tokyo's subway system in 1995 highlighted many of the challenges that will confront First Responders and the community in the aftermath of a NBC/WMD attack. Although the chemical sarin nerve agent were of poor quality, the dissemination method inefficient, and only a small amount of the toxic nerve agent were released, 13 people died, >1,000 victims experienced some degree of acute or chronic nerve gas exposure, and another 4,500 persons have become psychological casualties. The latter only thought they were experiencing symptoms of sarin exposure. According to one Associated Press report, >50% of those involved in the 1995 sarin nerve gas attack still suffered some form of physical or mental disability more than three years after the sarin gas attack.[8] Since the event was not recognized as a nerve agent for several hours, mass decontamination was not performed. As a result, 135 firefighters and EMS personnel (10% of the responders) suffered secondary contamination, and 20% of the hospital staff suffered effects from secondary exposure (outgasing).[9] Thus, the benefits of preparedness for first responders for the care of themselves and for US citizens, is of paramount importance.

The Tokyo subway toxic chemical attack and the 11 September 2001 terrorist attacks on the World Trade Center and the Pentagon both illustrated three important features of any act of domestic terrorism involving NBC/WMD: (1) There are very real dangers to First Responders who will be expected to assist victims of the terrorist attack as was validated in the 11 September 2001 attack on the WTC with 344 firefighter fatalities;[10] (2) Biological and chemical agents are readily available at little cost, require a minimum of scientific knowledge, and with much of the information needed already accessible on the Internet, domestic terrorists acts employing chemical agents or bioweapons easily can be perpetrated;[11] and (3) there are certain hazards associated with such domestic terrorist incidents that differ from generic community disasters and associated disaster preparedness training. As a consequence, several US federal agencies including the DOD, were charged with the mission of providing NBC/WMD Domestic Preparedness training for all urban First Responders in the US. The goal of this training was to teach basic Domestic Preparedness Awareness and Operations procedures and protocols, so that First Responder fatalities and casualties in the event of a NBC/WMD incident, could be avoided or at least minimized; so that associated civilian fatalities can be held to a minimum, and, finally; so that civilian causalities can be decontaminated safely and effectively, triaged, treated, and transported.[12]

One aim of this research report was to test the effectiveness of this Domestic Preparedness training. However, prior to conducting an outcome evaluation of Domestic Preparedness training, the basic psychometric properties of the DPQ, obtained with the baseline and follow-up samples, will be enumerated and described. Thus, the goals of this paper are two-fold:

1. *Instrument Development*—to describe the reliability, validity, and sensitivity of a paper and pencil questionnaire that was designed specifically to assess Domestic Preparedness Awareness and Operations Training content knowledge in First Responders; and
2. *Domestic Preparedness Training Outcome Evaluation*—to assess the improvements, if any, in NBC/WMD awareness and operations content knowledge (and their self-assessed competencies to respond to NBC terrorist attacks) in a sample of urban First Responders (urban fire service personnel) who participated in a DOD sponsored Domestic Preparedness Train-the-Trainers training program.

Methods

The sample and sampling procedures as well as the instrument development of the Domestic Preparedness Questionnaire (DPQ) follow. Human subject participation in this research investigation was conducted with Institutional Review Board (IRB) approval.

Samples and Sampling Procedures

Pre-training Baseline Sample—Pre-training baseline data were obtained from professional firefighters (n = 206) employed by an urban fire department in a Northwest US state who participated in an ongoing survey of occupational health and safety. The demographic and background characteristics of this firefighter sample were similar to those noted in previously published articles.[13–16] Baseline data on the DPQ were obtained approximately one month prior to the DOD Domestic Preparedness Training that was provided for some, but not all, of the firefighters in this urban fire department. The baseline sample (n = 206) consisted primarily of married (73%), male (93%) firefighters (82%), or paramedics (14%), who averaged approximately 40 years of age; who possessed an average of 12.6 years of service as a firefighter, and approximately 14 years of formal education. Some one-third of the baseline sample held the rank of lieutenant or above, while nearly two-thirds of the baseline sample were line firefighters. The demographic and job characteristics of the baseline sample (which represented about a 50% response rate) were similar to those of the universe of all potential respondents in the participating department.

Greater than 50% of the pre-training baseline sample reported that they had no prior NBC/WMD Domestic Preparedness Training. Approximately one-third of the sample reported that they had between 0–20 hours of prior NBC/WMD Domestic Preparedness Training, and only 6% reported that they had >20 hours of prior Domestic Preparedness training. Most individuals (72%) in the respondent baseline sample reported that their level of Hazardous Materials Training was "First Responder Operations", while 17.2% and 10.2% indicated that their level of Hazardous Material training was either at the Hazardous Material Technician or at the Hazardous Material Specialist levels, respectively.

Follow-up Post-training Sample—The follow-up (post-training) sample consisted of fire service personnel in the same urban fire department who completed the DPQ approximately four (4) months following the Domestic Preparedness Training. The post-training, follow-up sample (n = 246) also consisted of male (93%) firefighters (84%), or paramedics (12%) who averaged approximately 40 years of age and possessed 12.4 years of service as a firefighter and approximately 14 years of formal education. Approximately 20% of the follow-up (post-training) sample consisting of fire service officers with a rank of lieutenant or above and the other 80% of the follow-up sample were line firefighters. The demographic and job characteristics of the post-training follow-up sample also were similar to the universe of potential respondents in the participating department with the sole exception of the percentage of officers that was lower in the follow-up sample.

Domestic Preparedness Trained Firefighter Sub-sample—The participating department selected individuals to participate in the DOD Domestic Preparedness training. This sub-sample of Domestic Preparedness-Trained ("DP-Trained") firefighters (n = 80) completed at least eight hours of DP Awareness and Operations Training during September 2000, and up to a total of 30 hours of DP training. The subsample of "DP-Trained" firefighters also completed the DPQ at pre-training baseline and at the pre-training follow-up. The "DP-Trained" firefighters sub-sample (based on their baseline replies) consisted primarily of male (95%) firefighters (81%) (or paramedics (15.5%)), averaged 41.4 years of age and possessed an average of 13.8 years of service as a firefighter and 14.5 years of formal education. Approximately 43% of the "DP-Trained" firefighters sub-sample possessed a rank of lieutenant or above.

Sub-sample of Firefighters who were Not Domestic Preparedness Trained ("Not-DP-Trained")—The "Not-DP-Trained comparison" sub-sample of firefighters did not receive any of the DOD-DP Training offered during September 2000, nor did they receive any subsequent DP training either within or outside the department over the next four months. The Not DP-Trained comparison sample also completed the DPQ at baseline and at follow-up. The Not-DP-Trained comparison sub-sample (n = 78) consisted largely of male (90%) firefighters (87%) or paramedics (9%) averaging 38.2 years of age, and who possessed an average of 11 years of service as a firefighter and 14.2 years of formal education.

Differences between DP-Trained and Not-Trained Comparison Sub-samples

Although the DP-Trained and Not-DP-Trained comparison samples did not differ from one another in terms of years of education (t = 1.00; df = 155; p >0.05), the DP-Trained sample was older (t =-2.68; df = 157; p >0.01), and reported significantly more years of service (t = -2.15; df = 157; p >0.05) compared to the Not-DP-Trained comparison sub-sample. The proportion of males and female firefighters in the DP-Trained and Not-DP-Trained comparison samples did not differ significantly (χ^2 = 1.6; df = 1; p >0.05), but the percentage of fire service officers (with a rank of lieutenant or above) in the DP-Trained sample was significantly greater statistically than was the percentage in the Not-DP-Trained sample (χ^2 = 10.6; df = 1; p = 0.001). The DP-Trained and Not-DP-Trained comparison samples did not differ at baseline in terms of the number of reported hours of prior Domestic Preparedness training, but did differ in terms of their levels of hazardous materials training. The DP-Trained sample had proportionally more firefighters who had been trained as higher level Hazardous Materials Technicians and/or who had training in First Responder Hazardous Materials Operations (χ^2 = 13.4; df = 2; p <0.001).

Preliminary Instrument Development

A 50-item pilot version of the Domestic Preparedness Questionnaire (DPQ) was developed by the senior author in consultation with DOD personnel and NIOSH

Measure	Mean	Standard Deviation	Maximum Possible	Score Range	Reliability
DPQ total score	13.01	5.52	27	0–23.03	0.89[1]
Perceived Competency for:					
Bioweapon	15.7	11.2	100	0–80	0.57[2]
Chemical Weapon	17.1	12.5	100	0–80	0.54[2]
Nuclear	9.2	15.9	100	0–90	0.45[2]

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Table 1—Psychometric properties of DPQ total score and perceived competency scores at baseline (except for test-retest reliabilities) in firefighter sample(s)
[1]Internal reliability – Cronbach's a was calculated for DPQ Total Score in baseline sample.
[2]Test-retest reliabilities based on item VAS scores at baseline and at six month follow-up in Non-DP-Trained sample (n = 71–72) not receiving Domestic Preparedness training.

	DPQ Total Score	Biohazard Competency	Chemical Competency	Nuclear Competency
DPQ Total Score	-			
Biohazard Perceived Competency	0.12	-		
Chemical Perceived Competency	0.24**	0.85**	-	
Nuclear Perceived Competency	0.00	0.61**	0.61**	-

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Table 2—Pearson inter-item correlations of DPQ Total Score and Competency Items at Baseline
**p <0.01

	DPQ Total Score	Biohazard Competency	Chemical Competency	Nuclear Competency
DPQ Total Score	-			
Biohazard Perceived Competency	0.30**	-		
Chemical Perceived Competency	0.32**	0.88**	-	
Nuclear Perceived Competency	0.22**	0.71**	0.70**	-

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Table 3—Pearson inter-item correlations of DPQ Total Score and competency items at follow-up
**p <0.01

Research Scientists. The pilot version content items were derived from a review of DOD Domestic Preparedness Training materials, and focused on the explicit training objectives for First Responders Awareness and Operations course objectives/content knowledge. The pilot version of the DPQ was administered to a convenience sample of firefighters employed by a metropolitan fire department in a northwest state. This pilot respondent sample comprised approximately one-half of the pilot department's fire service personnel (n = 78). Based on replies from this pilot sample, a total of 27 content items were selected for inclusion on the DPQ; those content items retained were those that differentiated between respondents, and were neither "too easy" nor "too hard".

The resultant instrument, a 32-item Domestic Preparedness Questionnaire (DPQ) and Assessment of First Responder Awareness and Operations Training, consisted of four sections:

1. 27-item, content section designed specifically to measure First Responders knowledge of NBC/WMD Awareness and Operations content (derived from Domestic Preparedness Training objectives;
2. Single item that assessed the participant's present level of hazardous materials training;
3. Single item estimate of the total hours of prior NBC/WMD domestic terrorism preparedness training; and finally
4. Three separate items asking First Responder participants to indicate how "prepared/competent" they presently feel in responding to either a chemical, biological, or nuclear act of terrorism in their community using three separate 0–100 variable analog scales (VASs) with the following anchors: "0" = not at all prepared/competent, "50" = somewhat prepared/competent, and "100" = completely prepared/competent.[17]

Evaluation of Domestic Preparedness Training

The Domestic Preparedness Training curriculum provided through the DOD offered courses that addressed various content arenas including a First Responder, NBC/WMD Awareness and Operations course (eight hours), Hazardous Material Responses training (16 hours), as well as Emergency Medical Technician (EMT) (eight hours), and Incident Command classes (eight hours). The series of DP-Training courses was taught on-site by content experts, and included didactic lectures, slides and multimedia presentations, as well as demonstrations and a course handbook. According to administrators of the participating

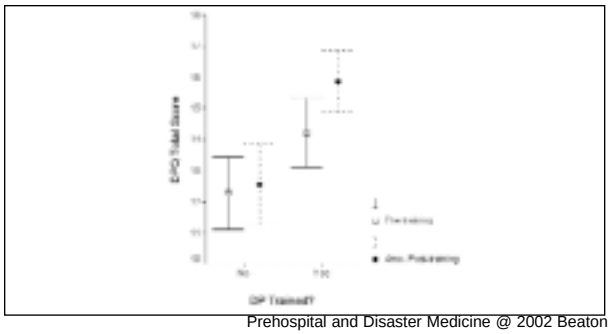

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Figure 1—DPQ mean total scores (and ±95% confidence intervals) at pre-training and at four months post-training in both DP-Trained (yes) and Not-DP-Trained (no) samples

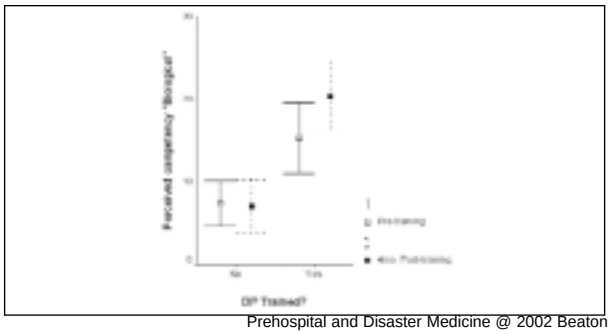

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Figure 2—Mean perceived competency to respond to biological terrorist event (and ±95% confidence intervals) at pre-training and at four months post-training in both DP-trained (yes) and Not-DP-Trained (no) samples.

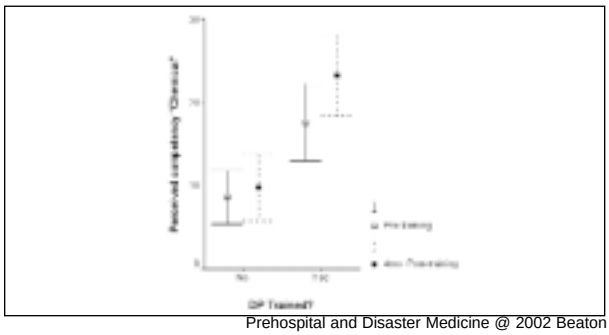

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Figure 3—Mean perceived competency to respond to chemical terrorist event (and 95% confidence intervals) at pre-training and at four months post-training in both DP-Trained (yes) and Not-DP-Trained (no) samples

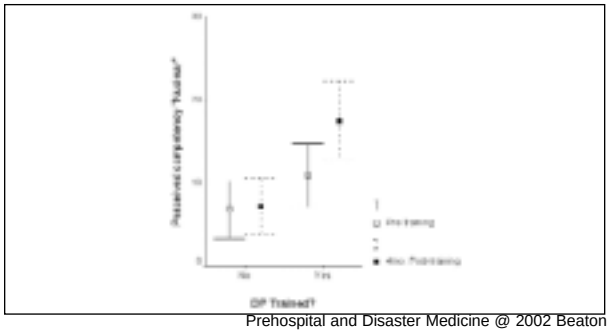

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Figure 4—Mean perceived competency to respond to nuclear terrorist events (and ±95% confidence intervals) at pre-training and at four months post-training in both DP-Trained (yes) and Not-DP-Trained (no) samples

department, approximately 45% (n = 136) of field Fire Personnel enrolled in at least eight hours of the DP Awareness and Operation courses in September 2000. (Not all of these DP-Trained firefighters participated as subjects in the DP-Trained sub-sample described earlier in this paper.)

Results

Instrument Development: Psychometric Properties of Domestic Preparedness Questionnaire

The mean values, standard deviations and other psychometric properties of the DPQ (total score) as well as for the three separate perceived competency items — bioweapon, chemical and nuclear — described above are provided inTable 1. The Cronbach α for the total DPQ score was 0.89 for the baseline sample (n = 206).[18] The test-retest reliability for the DPQ total score was 0.49 for the Not-DP-Trained sample (n = 75) and was 0.64 for the DP-Trained sample (n = 80).[19] The six-month test-retest reliabilities for the Not-DP-Trained sample for the self-appraised competencies to respond to biological, chemical, and nuclear events (in their communities) were 0.57, 0.54, and 0.45, respectively. Parallel test-retest reliabilities for these competency items in the DP-Trained sample were 0.48, 0.63, and 0.62, respectively.

The inter-correlations between the DPQ total scores and perceived competency items in the baseline and follow-up samples, respectively, are provided in Tables 2 and 3. The inter-correlations between the perceived competency items were rather robust, and all statistically significant (r = 0.61–0.88; each had p-values <0.01) in both the baseline and follow-up samples. The Pearson correlations between the DPQ total score measure of content knowledge and the perceived competency items in the baseline sample ranged from 0.00–0.32. For the follow-up sample, all of these correlations were significant statistically (r = 0.22–0.32; all p-values = <0.01), but of relatively low magnitude.

Evaluation of Domestic Preparedness Training Effects

Figures 1–4 illustrate the mean scores and 95% confidence intervals for the Not-DP-Trained and DP-Trained samples at baseline and at the four month post-training follow-up assessment for DPQ total scores, as well as the biological, chemical, and nuclear terrorism event response perceived competency items, respectively.

The mean value for the total DPQ scores at the four month follow-up DP-Trained samples (n = 79) was greater than was the mean value for their total DPQ score at baseline (t = 3.6; df = 78; p = 0.001) (Figure 1), and for the Not-DP-Trained sample (n = 75), the mean value for the DPQ was not significantly different statistically at the four month follow-up.

The mean values for the Perceived Competency to

respond to a biological act of terrorism at the four month follow-up Not-DP-Trained sample (n = 73) were not significantly different statistically from their baseline mean values (t = 0.00, df = 72; p >0.05) (Figure 2). However, the mean values on the same item, DP-Trained sample (n = 78), their perceived competency to respond to a bioweapon attack, at the four month post-training follow-up were significantly greater (t = 2.16; df = 77; p <0.05) (Figure 2).

The mean values for the perceived competency to respond to a chemical act of terrorism item at the four month follow-up, Not-DP-Trained sample (n = 73) were not significantly different from their baseline means (t = 0.78; df = 72; p >0.05)(Figure 3). However, the mean values for the DP-Trained sample (n = 78) on the identical item — their perceived competency to respond to a chemical act of terrorism in their community — at the four month follow-up (following their DP Training) were significantly greater (t = 2.57; df = 77; p <0.05) (Figure 3).

Finally, the mean values for the perceived competency to respond to a nuclear act of terrorism at the four month follow-up, the Not-DP-Trained sample (n = 72) was not significantly different from their baseline mean values (t = 0.28; df = 71; p >0.05) (Figure 4). In contrast, the mean value for this same item — the perceived competency to respond to a nuclear act of terrorism — DP-Trained sample (n = 76) was significantly greater at the four month follow-up compared to their baseline mean score (t = 3.3; df = 75; p = 0.001) (Figure 4).

Discussion

The Domestic Preparedness Questionnaire (DPQ), designed to assess First Responder content knowledge of NBC Awareness and Operations, appears to possess adequate internal reliability, as well as content and concurrent validity.[19] The total score on the DPQ correlated with the participants' perceptions of their own competency to respond to a terrorist, chemical event in their community at baseline. And, at the follow-up assessment, after DP Training had been provided for approximately half of the department's personnel, the total score on the DPQ correlated significantly with the participant's perceptions of their competencies to respond to a terrorist, chemical attack, to a terrorist biological attack, as well as to a terrorist nuclear attack. Perhaps these competency–knowledge correlations at four months post-training were enhanced by the DP Training itself, which had been provided for the participating department.

The single item measures of perceived competency also appeared to possess adequate test-retest reliability and, especially following DP Training, their self-reported perceptions of competency significantly correlated with what respondents actually knew about Domestic Preparedness Awareness and Operations as measured by their DPQ total scores. It is worth noting that the VAS means for each of these N, B, and C competency items at baseline was less than 20 on a 100 point variable analog scale where 0 = not at all prepared/competent and 100 = completely prepared/competent. Even following DP Training in the First Responders receiving training, the VAS mean values for each of the self-assessed "competency to respond" items were approximately 20. These First Responder self-assessments paralleled the findings of a survey of hospital personnel in FEMA Region III. In that study, none of the hospital personnel respondents felt their sites were "fully prepared" to handle a biological incident, and 73% believed they were not prepared to handle a chemical weapon or a nuclear incident.[6]

It also was worth noting that the mean values for each of the self-assessed competency items increased significantly following Domestic Preparedness Training only in the DP-Trained group; that is, those firefighters who received DP Training. This suggested that the self-assessed competency items each possessed psychometric sensitivity, and it also reflected training effects. The effect sizes for each of the perceived competency items, reflecting the magnitude of the training-related changes, however ranged from 0.24–0.37, and are considered "small" effect sizes.[20]

The DPQ total score, similarly, increased significantly following DP Training only in the group receiving DP Training. This suggested that the incremental improvements in the DPQ total score were due to training effects per se, and were due neither to test-taking reactivity nor to historical effects.[21] The effect size reflecting the magnitude of the training-related changes for the DPQ total score was 0.41 reflecting a small – moderate range effect size.[22]

While this research suggested that the DPQ does measure First Responder content knowledge of DP Awareness and Operations, and reflects training effects, it did not assess whether the scores attained using this measure necessarily would predict their actual competencies or actions in response to an actual N, B, or C terrorist event in their community. In fact, it did not even assess whether the DPQ correlated with first Responder performance during a simulated NBC/WMD street exercise or a table top exercise. Another limitation of this measure was that it does not assess the First Responders' psychological and emotional concerns and reactions in responding to these terrorist events, but it was not designed to do so. However, in theory at least, it would seem that some understanding of basic NBC awareness and operations principles, terminology and protocols would assist First Responders in the event an actual WMD event to form an appropriate index of suspicion, to make decisions on scene, and to communicate these in a timely fashion to others on scene, to dispatch, and/or the incident commander, and/or the control operations center.[23] A Parallel Domestic Preparedness training program developed by Occupational Safety and Health Administration (OSHA) and the National Fire Protection Association (NFPA), also emphasizes hazard awareness, self-protection, preventive measures, and defensive roles for firefighters at NBC/WMD incident scenes.[23]

Conclusion

The US government long has recognized the need to prepare for terrorist attacks involving weapons of mass destruction. Presidential Decision Directive 39 in 1995, initiated activities in several national agencies.[4] The US Congress approved the Defense Against Weapons of Mass Destruction Act of 1996, requiring development of a Domestic Preparedness Program including efforts to

improve the capabilities of local emergency responders.[24] The DOD's Domestic Preparedness Training program was developed specifically for local first responders, and was scheduled to train First Responders in >100 US cities by the end of 2001.[25] Thus, this Domestic Preparedness training for First Responders was both strategic and timely.

This paper describes the development of a reliable and valid paper and pencil test—The Domestic Preparedness Questionnaire—that documented the effectiveness of this Domestic Preparedness training program for a sample of firefighter and paramedic First Responders. Importantly, a significant increase in content knowledge of NBC/WMD Awareness and Operations was documented at four months following training in the sample of First Responders studied. Furthermore, urban firefighter and paramedic First Responders who completed at least eight hours of the DOD Domestic Preparedness Train-the-Trainer training, also reported significant improvement in their self-appraised competencies to respond to "acts of biological, chemical, or nuclear terrorism" in their community at four months post training.

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