Disaster Response to the Release of Biohazardous Agents: Instrument Development and Evaluation of a Firefighter's Exercise

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HAZMAT = hazardous material
RKI = Robert Koch Institute
SOP = standard operating procedures

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Abstract

Introduction: The release of biohazardous agents could affect many people. Preparedness is crucial for adequate responses to accidental or deliberate release of biohazardous agents. It is believed that exercises based on simulated incident scenes are effective methods for the training of firefighters and biohazard response teams. Structured evaluations are important methods used to identify areas of ineffectiveness and to assure the quality of responses to releases of biohazards.

Methods: A local fire department conducted a full-scale biohazard exercise in an elementary school. The firefighters practiced prohibiting entry to the area, establishing security zones, evacuating victims, assessing hazards, preventing further dissemination, and sampling and keeping the suspicious material in safe custody. Trained observers systematically evaluated the exercise following a standardized evaluation protocol. A set of data collection templates were created based on standard operating procedures extracted from current guidelines.

Results: There were 60 firefighters, eight members of the incident command, 16 simulated victims, and 18 trained observers that participated in the exercise. Out of 31 standard operating procedures, 20 were in accordance with the guidelines, 10 were performed incorrectly, and one was not applicable. Major problems related to the assessment and handling of the suspicious material, the use of protective equipment, and decontamination of victims. Reasons for incomplete and/or conflicting documentation included insufficient knowledge and training of observers, imprecise instructions about documentation, and the size of observation zones.

Conclusions: Intensive education and training of response activities is necessary. Each fire department should perpetually reassess their technical equipment and specific skills and their communication and command structures. The applied documentation system performed well in disclosing discrepancies between observed response activities and current recommendations. Using external observers provided transparent and independent data. However, intensive observer training is necessary. Observer training should include detailed, written instructions and short guidelines that could be available during the exercise.

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Introduction

In recent years, the threat posed by bioterrorism has aroused public and political interest. Though accidental or deliberate release of biohazardous materials have been rare in Germany, the threat is present. The releases of biological biohazardous agents could affect many people. In 2002, the German Ministry of the Interior commissioned the development of an expertise on preparedness.[1] Subsequently, the Federal Office of Civil Protection and Disaster Assistance[2] (Bundesamt für Bevölkerungsschutz und Katastrophenhilfe (BBK)) and the Center for Biological Safety[3] (Zentrum für Biologische Sicherheit

(ZBS)) were established. The BBK introduced a research-based, national preparedness plan including anti-epidemic measures, diagnostics, and vaccination and treatment strategies to guarantee adequate management of bioterrorist attacks.[2]

Disaster preparedness is crucial for an adequate response. The BBK published a policy on the primary potential bioterrorist agents for use by healthcare professionals and police and fire departments—the groups that most likely will be confronted with bioterrorist attacks.[2] The Robert Koch Institute (RKI) and the Committee on Affairs of Fire Departments, Disaster Control and Civil Defense (Ausschuss für Feuerwehrangelegenheiten, Katastrophenschutz und zivile Verteidigung (AFKzV)) published guidelines on the management of released bio-hazardous agents (radiological, biological, and chemical) for fire departments and special hazardous materials response teams (HAZMAT teams).[4,5]

Klein *et al* categorizes disaster management exercises into three major types: (1) tabletop; (2) functional; and (3) full-scale.[6] A *tabletop exercise* typically is conducted in a room, without the involvement of outside parties. *Functional exercises* may involve multiple sites, and typically are conducted in the emergency operations center or its equivalent. The scope of activity includes more policies and coordination of personnel than usually are involved in a tabletop exercise. *Full-scale exercises* involve extensive amounts of resources and large numbers of personnel. The purpose of the exercises is to evaluate the responding organizations' operational capabilities in an interactive manner. The exercises are characterized by a high degree of realism typically including simulated incident scenes involving dummies of hazardous material and simulated victims. The utility of exercises using simulated incident scenes for improving the response performance has been reported by a limited number of publications.[6–12] Methods of monitoring and evaluation of response activities include: (1) a post-exercise self-assessment questionnaires for rescue workers;[7,11] (2) post-exercise questionnaires filled out by simulated victims;[11] and (3) the use of trained, external observers.[11,13] However, the methods used for documentation and evaluation usually are kept confidential.

Preparedness training must be evaluated by independent and trained observers to discover areas of ineffectiveness and to assure the quality of the responses.[6] A data collection instrument was developed to evaluate the performance of fire departments during public disaster exercises. The instrument aims to generate specific and constructive feedback on institutional and individual levels, which allows disaster coordinators to improve planning and training strategies. This report describes the rationale and first prospective application of the data collection instrument used to evaluate the response performance of a local fire department during a bioterrorism exercise.

Methods

In Germany, the RKI recommends the use of guidelines for the safe handling of suspicious agents during critical bio-hazardous incidents.[4] Fire service directives specify the response activities.[5] Firefighters and HAZMAT teams have received continuous training to follow these guidelines. A reference list of standard operating procedures (SOPs) was constructed that catalogued key features of both guidelines (Table 1). A total of 31 items defined the operational skills required for an adequate response. Since appropriateness and efficiency of victim rescue, staff safety, and pollution containment are the most relevant in biohazard response,[4,5] this evaluation primarily focused on these activities.

Data Collection

The data collection followed the standardized protocol outlined in Figure 1. A set of data collection templates was created based upon the reference list of SOPs. Since observers were to be located in different areas of the exercise, the data collection templates were tailored to area-specific response activities.

Each area of the incident scene requires specific response activities. The incident command (fire department) established three main security zones (Figures 1 and 2) according to the degree of contamination (black zone = contaminated environment; grey zone = security zone for decontamination; and white zone = uncontaminated environment). For evaluation purposes, the disaster scene was divided into five observation zones referring to specific response activities. The observation zones did not necessarily overlap with the security zones.

Trained observers monitored the response activities and each movement between security zones. In order to facilitate the documentation, numbered stickers were used to label firefighters and victims. Independent observers, using video, monitored specific response activities (such as sample taking and containment and decontamination procedures) in order to clarify misinterpretations or conflicting documentation. For transparency reasons, all observers were instructed to record the exact time of an activity. The data collection templates were piloted during a radiation exercise in August 2006. The pilot-testing was conducted to evaluate the documentation procedures, applicability of the templates, and positioning of the observers. The templates used included SOPs that are relevant for radiological, biological, and chemical exercises. After the piloting, SOPs specifically relevant for the management of released bio-hazardous agents were added.

Exercise Scenario

The local fire department of Norderstedt conducted a full-scale biohazard exercise in September 2006. Norderstedt has approximately 75,000 inhabitants and is part of a greater metropolitan area of Hamburg, Germany. The exercise took place near the center of the town in the area of an elementary school. The local firefighters are mainly auxiliary staff. Volunteers simulated the accident victims.

The exercise included: (1) prohibition of entrance to the area; (2) establishment of security zones; (3) evacuation of possibly contaminated pupils to an external area for decontamination (decon-area); (4) assessment of hazards related to suspicious material; (5) prevention of further dissemination; and (6) sampling and keeping the suspicious material in safe custody. The exercise did not include medical rescue. The firefighters knew that an exercise was planned, but received no information about the time of alarm or the type of hazard.

Data Processing

The documented activities were compared with the reference list of SOPs. The guidelines differ in some recommendations (Table 1).[4,5] Activities were considered as correct if

Fire Service Directive 500	Robert Koch Institute Guideline
Shut down the area	Shut down the area
Keep anyone who may have been exposed to the suspicious substance in temporary quarantine until further proceedings are arranged	Keep anyone who may have been exposed to the suspicious substance in temporary quarantine until further proceedings are arranged
Request special hazardous materials response team (HAZMAT) personnel	Request special hazardous materials response team (HAZMAT) personnel
Give precise instruction to anyone who may have been exposed to the suspicious substance	--
Do not move the suspicious agents	Do not move the suspicious agents
Do not contact the suspicious substance directly	Do not contact the suspicious substance directly
Prevent further dissemination of suspicious material. Keep the material in safe custody until further proceedings are arranged	Prevent further dissemination of suspicious material. Keep the material in safe custody until further proceedings are arranged
Establish security zones (red, green, black, and white)	Establish security zones (black, grey, and white)
Red Zone	**Black Zone**
The active HAZMAT personnel wears full protective overalls including full masks and particle filters	The active HAZMAT personnel wears full protective overalls including full masks and particle filters
--	Disposable gowns are worn under the full protective overall
Green Zone	**Grey Zone**
Decon Area, Black Zone (Contaminated)	**Decon Area (Contaminated)**
Each full protective overall is cleaned before unclothing	Each full protective overall is cleaned before unclothing
Adequate disinfectant is used	Disinfection is done using disinfectant-saturated cloths
The decon personnel wear masks, disposable gloves, and disposable gowns against the used disinfectants	The decon personnel wear masks, disposable gloves, and disposable gowns against the used disinfectants
Anyone who touched the suspicious substance disinfects and washes hands, hair, and other contaminated parts of the body	Anyone who touched the suspicious substance washes hands with soap
--	High-pressure cleaners are not in use
--	Decon personnel changes their gloves before unclothing contaminated persons
Used protective overalls are sealed and labeled adequately	Used protective overalls and other potentially contaminated objects are sealed and labeled adequately
Decon Area, White Zone (Uncontaminated)	**White Zone (Uncontaminated)**
Decontaminated staff completely unclothes used full protective overall	--
--	Decontaminated staff unclothes used full protective overall, but do not unclothe the disposable gowns
The suspicious substance is assembled by HAZMAT personnel only	The suspicious substance is assembled by HAZMAT personnel only
The suspicious substance is assessed by HAZMAT personnel only	The suspicious substance is assessed by HAZMAT personnel only
Evaluate the hazard due to the suspicious substance	--
Coordinate further proceedings with appropriate law enforcement (e.g., public health department)	Coordinate further proceedings with appropriate law enforcement (e.g., public health department)
Use adequate material for sample taking	Use adequate material for sample taking
Cover the suspicious substance using adequate containment assembly	Cover the suspicious substance using adequate containment assembly
Label the used containment assembly according to location, date, and time of finding	Label the used containment assembly according to location, date, and time of finding
--	Use pulp or something similar and adequate disinfectant to cover and bind suspicious agents that are widely spread over the area

Table 1—Reference list of standard operating procedures: Operational skills required for an effective response extracted from the Fire Service Directive 500[5] and the Robert Koch Institute Guideline[4]

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Development of documentation
- Describe the situation that is intended to be assessed
- Define the objective(s) of the assessment (e.g., technical skills, communication, chronological order of activities)
- Search and review recommendations (e.g., guidelines) critically
- Identify key activities that are planned to be observed
- Generate items for monitoring

Organization of exercise monitoring
- Define adequate observation zones
- Assemble documentation templates according to each observation zone (fill in the items for monitoring into the templates)
- Schedule observation (e.g., activities, observers, time-table)
- Conduct structured observer-training

Evaluation of the exercise
- Assess documentation according to the objectives
- Determine strengths and weaknesses
- Feedback

Figure 1—Checklist of a structured exercise

performed according to one of the guidelines. The technical performance of single procedures was not evaluated.

Data Collection and Analysis

Eighteen trained observers were located in six different observation zones. Two observers were assigned to the incident command. Four observers were assigned to the grey zone and four to the black zone. Two observers monitored each movement between the security zones. Two additional checkpoint observers were located at the entrance to the grey zone and near the decontamination area. Two independent observers monitored specific response activities (such as sample taking and containment and decontamination procedures) by video. The two authors (University of Hamburg) supervised the process. The documentation partially was not concordant. The observers resolved discrepancies in documentation by consensus and/or video recordings.

Results

The exercise began at 09:56 hours (h) and ended 11:47 h. The incident command terminated the exercise after the main response activities were completed. Sixty firefighters (including HAZMAT-personnel), eight members of the incident command, and 16 simulated victims participated. All 31 activities of the reference list of SOPs were assessed (Table 2); 20 were in accordance with the guidelines; 10 were performed incorrectly; one was not applicable (for details, see Table 2).

Problems related to the assessment and handling of the suspicious material, protective equipment, and decontamination were identified (Table 2); these included:

1. The personnel did not identify the suspicious substance correctly. It was treated as chemical, not as biological bio-hazardous;
2. Decontamination personnel performed the initial cleaning unprotected using brushes and water instead of using soap and disinfectant-saturated cloths;
3. The personnel did not adequately bind and cover the suspicious substance; a street drain near the substance remained uncovered;
4. The personnel did not place all protective overalls and other potentially contaminated objects in containment boxes; and
5. The personnel did not label all used containment boxes.

The personnel did not perform all of the required SOPs during the exercise; the incident command explained that the following SOPs were not part of the training, but would have been performed in a real incident: (1) consideration of the wind direction; (2) coordination of further proceedings with appropriate law enforcement; (3) sending a sample of the substance to a laboratory; and (4) unclothing contaminated victims for decontamination

Discussion

The Exercise

The purpose of the exercise was to gain experience in managing an event involving a biohazardous substance. Most of the response activities were performed correctly. Nevertheless, lapses were identified. Possible reasons for discrepancies between the reference list of SOPs and performed response activities were: (1) problems due to incomplete available technical equipment; (2) insufficient training of required technical skills; (3) problems in communication or command structures; and (4) limiting factors of the exercise (e.g., exercise artificialities).

The personnel inadequately performed some procedures because of incomplete technical equipment (e.g., plastic tarp or enough containment boxes were not available). In these cases, the firefighters initially reacted in accordance to the recommendation, but improvised when needed equipment was lacking. The personnel inadequately performed specific activities such as the prevention of dissemination, decontamination, and disinfection. Sample taking of the suspicious substances was done too soon and without consultation with the incident command. These problems might be due to the fact that exercises or real incidents in this context are rare. The personnel performed some activities incompletely because of the limited timeframe (e.g., assembling of the suspicious material that was spread over a wide area). Other activities regarding the distress for the simulated victims (e.g., taking a decontamination shower) were not performed. However, the major problem was the incorrect assessment of the suspicious material. Hence, the personnel reacted as if it were a chemical accident. This could have severe consequences during a real biohazardous incident. This misinterpretation might be explained by the fact that training for biological biohazardous events has been rare so far.

Item	Activity	Performed	Comment
1	Shut down the area.	Yes	
2	Temporary quarantine for anyone who may have been exposed to the suspicious substance.		
3	HAZMAT personnel requested.	Yes	
4	Precise instructions to anyone who may have been exposed.	Yes	
5	Suspicious agents not moved.	No	Sample taking of the suspicious agents was done too soon and without consultation of the incident command.
6	Suspicious substance not directly contacted.	Yes	
7	Further dissemination prevention. Material kept in safe custody.	No	Wind direction considered. HAZMAT team did not assemble the suspicious substance until termination of the exercise. The substance was widely spread over the area, time was too short to pick up the substance.
8	Security zones (black, grey, and white) established.	Yes	
9	**Black Zone**	Yes	
10	Full protective overalls worn including full masks and particle filters.	Yes	Active HAZMAT personnel wore gas-proof full protective overalls (chemical—body form 3, type 1a ET).
11	Disposable gowns worn under the full protective overall.	No	
12	**Grey Zone**	Yes	
13	**Decon Area** (Contaminated)	Yes	
14	Full protective overalls cleaned before unclothing.	Yes	
15	Disinfection using disinfectant-saturated cloths.	No	Disinfection not done. Decon personnel used scrubber and pure water for cleaning.
16	Decon personnel wears masks, disposable gloves, and disposable gowns against the used disinfectants.	No	First cleaning procedures were done unprotected. Later, full protective overalls were worn.
17	Anyone who touched the suspicious substance disinfects and washes hands, hair, and other contaminated parts of the body.	No	Victims showered but did not disinfect hands, hair, and other contaminated parts of the body. Active HAZMAT personnel wore gas-proof full protective overalls.
18	High-pressure cleaners not used.	Yes	
19	Decon personnel change their gloves before unclothing contaminated victims.	No	First cleaning procedures were done unprotected. Later, full protective overalls were worn.
20	Used protective overalls and other potentially contaminated objects sealed and labeled adequately.	No	After containment boxes were filled, used protective overalls and other potentially contaminated objects remain partially unpacked. Containment boxes were not labeled.
21	**White Zone** (Uncontaminated)	Yes	
22	Decontaminated staff completely unclothes used full protective overall.	Yes	
23	Decontaminated staff unclothes full protective overall, but do not unclothe the disposable gowns.	NA	Disposable protective gowns not worn.
24	Suspicious substance assembled by HAZMAT personnel only.	Yes	
25	Suspicious substance assessed by HAZMAT personnel only.	No	Substance not identified until termination of the exercise.
26	Hazard due to the suspicious substance identified.	Yes	Labeled packages assessed by HAZMAT team, type of substance not identified.
27	Further proceedings coordinated with appropriate law enforcement.	Yes	
28	Adequate material for sample taking.	Yes	Used material: spoon, bottle, simple refuse bag, and adequate assembly box.
29	Adequate containment assembly used.	No	HAZMAT team did not assemble the suspicious substance until termination of the exercise. The substance was widely spread over the area, time was too short to pick up the substance; sample containment was technically adequate.
30	Containment assembly labeled according to location, date, and time of finding.		
31	Pulp or something similar and adequate disinfectant used to cover and bind suspicious agents that are widely spread over the area.	No	Suspicious substance was covered using plastic tarp. A street drain near the substance remained uncovered.

Table 2—Response activities, which were explored and documented (HAZMAT = hazardous materials)

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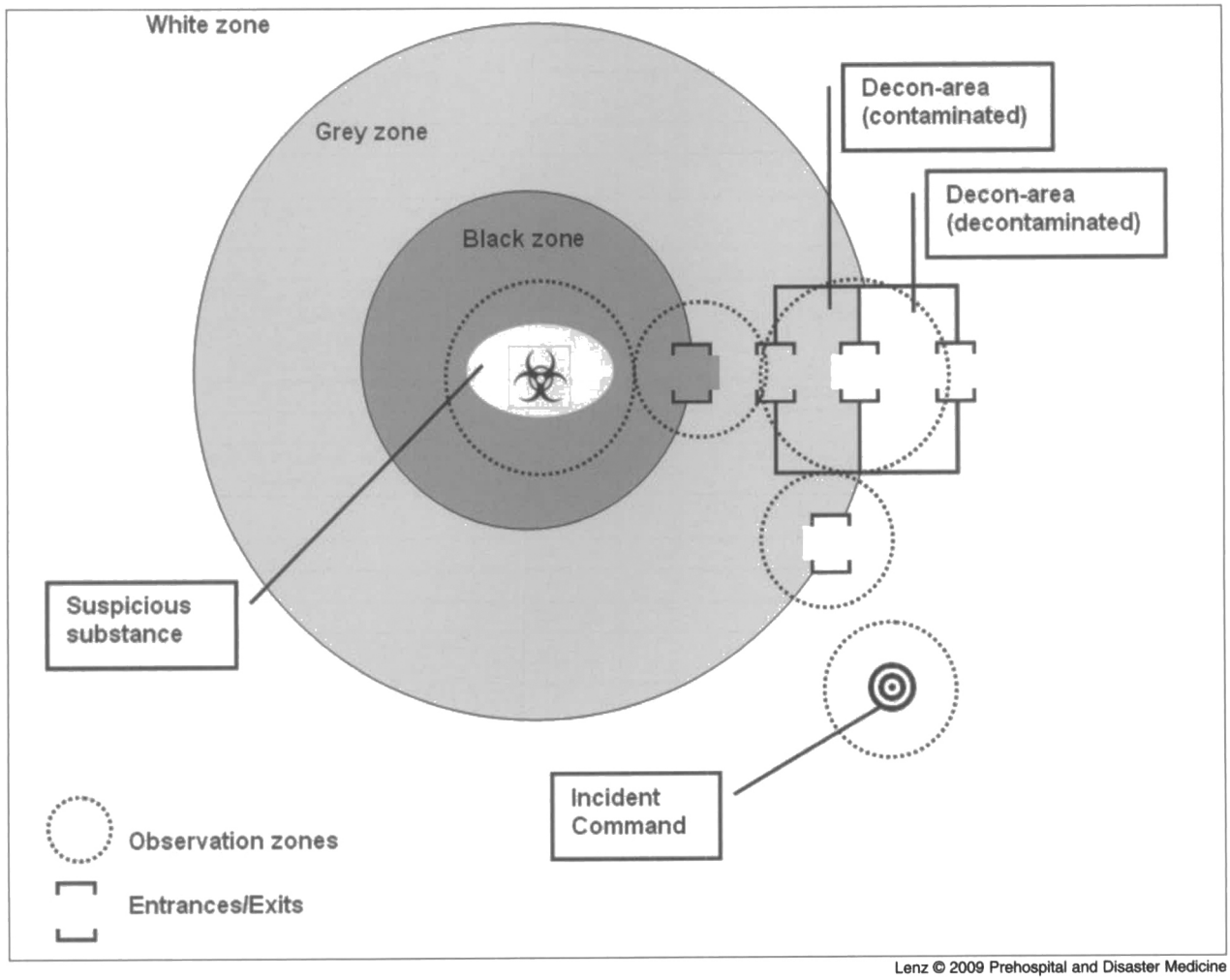

Figure 2—The incident area

Data Collection and Analysis

The purpose of the documentation system was to provide specific and constructive feedback. The objective was to evaluate whether this system is adequate to identify discrepancies between performed response activities and current recommendations. As has been shown previously, using external observers provided transparent and independent data.[6] The positioning of the observers was adequate to monitor all key activities. In particular, the use of video cameras helped to resolve conflicting documentation.

Reasons for incomplete and/or conflicting documentation included: (1) insufficient training of observers; (2) imprecise instructions about what must be documented; and (3) large observation zones or not enough observers. Consequently, observers must be better trained. Observer training should include detailed written instructions and short guidelines that could be on-hand during an exercise or real-time event. The observers must be well-informed about guidelines and SOPs and should be precisely instructed about the case-specific situations to be observed.

The observation zones must not be too large. Fixed observation zones primarily were used in this study. An alternative could be to use mobile observation zones to adequately react on changing situations. However, mobile observation might be difficult to coordinate. It should be used with caution, since important activities could be missed.

The observations might have influenced the performance of the response activities.

It became apparent that, as with any exercise, there were a number of exercise artificialities. The high number of observers, their positioning, and the use of video cameras were believed to detract from the "reality" of the incident. Members of the senior management commented that some response activities were not overly ambitious because of the simulated conditions. Avoiding exercise artificiality seems to be crucial to avoid detracting from the lessons to be learned. This always should be considered when evaluating response performance.

Conclusions

Intensive training of responses to biohazardous incidents is necessary. Each fire department should perpetually reassess their technical equipment and specific skills as well as their communication and command structures.

Disaster responses should be target-orientated and require the consideration of several specific SOPs. Guidelines for disaster management are designed to guide response teams through complex and stressful situations. However, guidelines give planners a sense of security and

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reassurance known as the "paper plan syndrome".[6] Guidelines often are incongruent with what people involved in major emergencies are most likely to do. It seems difficult to construct guidance that fits to such multifarious situations. Exercises are suggested to be the only way to predict if guidelines will be efficient during an actual disaster or emergency.[6]

The applied documentation system was effective in disclosing discrepancies between the performed response activities and current recommendations. However, for the documentation of an exact time course of response activities, the data collection templates require adaptation. Using external observers provided transparent and independent data, though intensive observer training is necessary. The training should include detailed, written instructions and short guidelines that could be on-hand during the exercise. A revision of the documentation templates used should include simplification of structure and layout.

Further research is needed. This evaluation system should be developed further in order to allow for the evaluation of exercises with the same or similar objectives. Furthermore, it should be evaluated whether the system can be applied to exercises with different objectives or according to different guidelines (e.g., large-scale operations during disasters caused by fire, chemical, nuclear, or natural hazards).

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Editorial Comments—Disaster Response to the Release of Biohazardous Agents: Instrument Development and Evaluation of a Firefighters' Exercise

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Authors Lenz and Richter have written a paper describing a collection instrument used to evaluate the responses of a local fire department during a bioterrorism exercise. Specifically, the authors evaluated the utility of the observer-based data collection tool in observing the firefighters' ability to follow protocols developed by the Robert Koch Institute and the Committee on Affairs of Fire Departments, Disaster Control and Civil Defense. The authors concluded that the tool and use of observers are effective. However, they note that the tool may benefit from revision as the firefighters were found to not be fully adherent to protocols. This paper describes the organization of structured exercise monitoring. What can be learned from this manuscript?

Case Reports and Evaluations

This drill and evaluation tool was similar to others. What the authors failed to mention was what is new and different in their report and what makes it unique. What has changed in their city's fire department since the drill? Based on their research, what was different about this situation and this scenario? This lack of follow-up is common in disaster and preparedness research. Whether a drill or an actual event, the same dogma is reported: "we failed" or "came up short". Rarely if at all has there been a description of successful changes, answers to problems, or new guidelines that have since been implemented and tested as a result of the research.

What Do We Know?

Why do we believe that drills and exercises work for disaster training? In many disciplines, drills have been beneficial. Drills are conducted for a multitude of reasons, including: enhancing personal and team capabilities, identifying areas of need of improvement, and validating existing plans.

The main reason that most disaster and preparedness drills are performed is because they show the public and most importantly, funding agencies that there is a "commitment" to preparedness. Additionally, for many healthcare systems, drills satisfy the regulatory requirements that provide necessary funding.[1] So why are the majority of drills and deployments discussed in the literature unsuccessful? Participants and evaluators perform disaster and preparedness drill expecting failure, in order to learn from what went wrong/right.

Most plans, including the ones used to construct the evaluation tool described in this report, are an "illusion" because they are neither based on valid assumptions about human behavior, nor incorporate normal patterns of the organization.[2] What was interesting in this paper was that at some time after the drill, the evaluators were able to have a discussion with the fire service incident commanders who when confronted with their short-comings in adherence to the protocols, felt that in a real situation they would have done things differently and would adhere to the plans as written. However, countless case reports have shown this to not be the case; incident commanders/firefighters will not follow the outlined plan, as they have not drilled it to memory. To their credit, the authors do discuss that guidelines are incongruent with what people are most likely to do, and that exercises can be

used to predict if the use of such guidelines will be efficient in an actual incident.[3] A firefighter colleague once stated, "We work like we train and train like we work".

In the discussion section, the authors mention that the firefighters did not recognize the biological threat and treated the incident as a chemical threat. Why did this happen? Why would it *not* have happened? The evaluators and plan writers expected that the firefighters would react with a heightened awareness to the presence to a powder and presume that it was a biological agent. In actuality, the firefighters did what they should have done. As studies report, people often perceive low-probability events to have zero likelihood and would not be taken seriously in a drill scenario.[4] In this case, a bio-event is low probability for a firefighter who normally trains, drills, and responds to chemical spills, car crashes, and buildings burning and/or collapsing. Response personnel are trained to react and not always to think abstractly. When describing the South Canyon wildfire disaster, Usseem, Cook, and Sutton noted that when leaders decided to inform and empower their work team, performance was more effective.[5] With this in mind, a different way to have conducted the drill and test the protocols, might have been to give to the incident commander the information that the substance was a "white-powder" biological substance with an asymptomatic exposed population, then observe their response to this particular scenario. In the next drill, a similar scenario is presented but the incident commander is not informed about the white powder being biological. If the response by the incident commander is to treat the white powder as a chemical agent rather than a biological agent, then perhaps expectations and protocols must be reevaluated to reflect that assumption.

How to Walk Away with Success

Lenz and Richter described the shortcomings of their tool, observers, and subjects, but shied away from what would really make a difference to the drill community: drills should be based on reality and response plans rewritten and based on what people are likely to do, rather than what they should do.[6] To this a more innovative paper, they should have recommended how to take what they learned to make a more helpful evaluation tool. In addition, they could have described how they were able to take what they learned in this drill and were able to rewrite their protocols so that the next drill was successful. Their next paper should be a case report of firefighters responding to a biological drill and how well they responded based on the recommendations.

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