

Protecting Workers in Large-Scale Emergency Responses

NIOSH Experience in the Deepwater Horizon Response

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On April 20, 2010, the Deepwater Horizon (DWH) semisubmersible Mobile Offshore Drilling Unit, located 45 miles southeast off the Louisiana coast, suffered a massive explosion and subsequent fire that ultimately led to the sinking of the Unit. Eleven workers lost their lives as a result of the explosion and fire, and seventeen other workers were injured. Oil from a subsea blowout began flowing into the Gulf of Mexico soon after the explosion, and continued to flow until the well was finally capped on July 15, 2010.

Since that day in April, tens of thousands of workers have engaged in the on- and offshore containment and cleanup activities as part of the DWH response. These workers were deployed by a wide array of response organizations from various federal, state, and local agencies, as well as private businesses and contractors and volunteer organizations. The workers were geographically spread throughout the Gulf of Mexico region in Louisiana, Mississippi, Alabama, and Florida, and were engaged in a range of potentially hazardous activities. Such circumstances presented significant challenges to those who had responsibility for protecting the workers' health and safety.

As part of the response effort, National Institute for Occupational Safety and Health (NIOSH) supported the Unified Area Command (UAC)^a by leading several initiatives. These activities included the rostering of workers, conducting health hazard evaluations, providing technical guidance and communication/educational materials, conducting health surveillance activities, and performing toxicity testing on samples of the oil dispersant and the crude oil itself. This article describes these activities and illustrates how the DWH response experience has greatly added to the knowledge previously gained from other large-scale disaster responses, including the World Trade Center terrorist attack and Hurricane Katrina.

BACKGROUND

Following the World Trade Center attacks, NIOSH and the RAND Corporation's Science and Technology Policy Institute undertook a study to analyze safety management in disasters and develop recommendations to improve safety plans and practices for emergency responders. The report from that study,¹ as well as the Government Accountability Office report on Lessons Learned from

the Responder Health Programs,² emphasized the previously identified need for better planning and improved protection practices for emergency responders before, during, and after an event. Prior to the Government Accountability Office report, NIOSH had begun plans to sponsor an interagency workgroup to address some of these difficult issues for the nation's responders. The workgroup consisted of a consortium of federal agencies, state health departments, and volunteer organizations whose common goal was to create a more comprehensive and systematic approach to responder safety and health.

For two years prior to the DWH response, this interagency group worked to develop a guidance document that addresses the need for an improved approach to health monitoring and surveillance of emergency responders. Recently, the workgroup sought public comments on a draft guidance document titled *Emergency Responder Health Monitoring and Surveillance (ERHMS)*.³ The objective of the *ERHMS* document is to help ensure that only medically cleared, trained, and properly equipped personnel are selected for deployment, that their work environment and health is effectively monitored and tracked throughout the event, and that provisions are made for post-event health monitoring and surveillance when indicated. It provides strategies to help employers, medical personnel, and health and safety professionals develop pre-incident plans. The document contains two main sections: (1) a "Guidance" section that includes guidance and recommendations during all stages of deployment; and (2) a "Tools" section that provides links to relevant documents and examples of materials that could be used during a response such as surveys and standardized questionnaires, checklists, and databases. The various areas addressed by *ERHMS* include: health screening, rostering, training, credentialing, exposure assessment and controls, medical monitoring, and medical surveillance.

Because of the work already done by the *ERHMS* workgroup, and well-established collaborations with partners, such as the Occupational Safety and Health Administration (OSHA) and the Department of Homeland Security, NIOSH was in an advantageous position to respond to the DWH disaster and put into practice for the first time some of the recommendations outlined in the draft *ERHMS* document.

OVERVIEW AND OBSERVATIONS FROM NIOSH DWH RESPONSE

National Institute for Occupational Safety and Health's contribution to the DWH response involved the implementation of several new initiatives that required significant Institute staff and resources. After the height of the response, a comprehensive internal assessment of activities was conducted by multidisciplinary NIOSH staff from across the Institute to identify successes and areas of improvement for future response efforts.

Roster

The World Trade Center experience highlighted the difficulties of retrospectively identifying workers involved in a response. The May 2008 Government Accountability Office Report² specifically outlined the need to account for all responders during a disaster to potentially improve future implementation of screening and mon-

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^aThe UAC is an application of incident command system used when there is more than one agency with incident jurisdiction or when incidents cross political jurisdictions. Agencies work together through the designated members of the Unified Command to establish a common set of objectives and strategies and a single Incident Action Plan.

itoring services. During the DWH response, NIOSH supported the UAC by developing a prospective roster of workers and volunteers. The DWH roster was designed to: (1) be a record of those who participated in response activities and the training they received before engaging in response work; (2) serve as a repository of information on the nature of each responder's work assignments during the response; and (3) establish a means to contact responders during and after the response about possible work-related exposures, and/or symptoms of illness or injury.

While many workers had an opportunity to be rostered during safety training that was conducted at official training sites prior to being hired, many workers had already completed safety training and begun working in the field before NIOSH began the rostering effort. This necessitated an intensive effort to deploy NIOSH staff across the Gulf Coast to worker staging areas in Louisiana, Mississippi, Alabama, and Florida where rostering could be accomplished in the field. To ensure that as many workers as possible could be recorded, rostering forms were made available in the languages most common to this workforce—English, Spanish, and Vietnamese, and steps were taken to protect the privacy of the information provided. A web-based roster system was developed to reduce data entry demands associated with paper forms; however, this format was used by only a small percentage of the responder workforce, primarily federal employees with ready access to computers. A report describing the information collected from the roster will be posted on the NIOSH Web site as soon as completed and will address the demographics of the population as well as their work activities.

The total number of workers that participated in the cleanup effort is unclear. BP reported a number of approximately 48,000 participating workers and the Unified Area Command indicated a highest weekly staffing level during the response to be about 45,000 workers. Although more than 55,000 workers were rostered between May 2010 and January 2011,^b some of those workers may have been trained but not actually hired. Our experience suggests that rostering efforts would benefit by incorporating new measures into future planning. First, the response leadership should begin planning for worker rostering immediately upon establishing an Incident Command System (ICS) structure and integrate rostering into response activities as soon as possible to ensure that all workers have the opportunity to be included. Second, it is important that the ICS leadership have a ready-to-use roster form pre-prepared that can be quickly adapted and approved for use. Third, the ICS could improve efficiency by incorporating rostering into existing response programs such as at the time of training or when worker credentials are verified. Fourth, the ICS should develop mechanisms to encourage and facilitate employer participation such as training on rostering for ICS managers and potential employers. Fifth, the rostering process would benefit by using technology to reduce data entry demands whenever possible, e.g., through a web-based roster system and hand-held data entry devices.

Health Hazard Evaluations

The NIOSH Health Hazard Evaluation (HHE) program conducts investigations of potential workplace health and safety problems in response to requests from workers, labor representatives, or employers.⁴ On May 28, 2010, BP, the global oil and gas company, member of the established UAC and the designated responsible party, requested that NIOSH conduct HHEs for DWH responders involved in both on- and offshore response activities. The objective of the HHEs was to collect exposure and health symptom information from response workers in six work task categories. These categories

included: (1) source control activities (activities and vessels closest to the source of the well head); (2) offshore activities (burning, skimming, and booming operations); (3) shoreline cleanup activities (eg, manual removal of tar balls and tar patties); (4) decontamination activities (involving cleaning of equipment and vessels), (5) wildlife cleaning and rehabilitation; and (6) waste stream management activities.

Utilizing the HHE program to assess worker hazards provided critical independent on-site observations and field data during the DWH response. The HHE teams collected hundreds of worker breathing zone air samples and other industrial hygiene samples; information about health symptoms, injuries, and hospitalizations; and observed work processes and practices at worksites. The HHE teams attempted to access groups of workers in all six categories, across four states, under differing work conditions to assess the range of exposures. While NIOSH had broad access to various work activities, it was not logistically possible to evaluate work settings representing the complete range of times and locations associated with the cleanup site. For each work setting evaluated, the HHE teams conducted industrial hygiene sampling on as many workers as possible and attempted to collect injury and health symptom surveys from all workers at a given site. As information from the HHEs was analyzed, the findings were reported to the requestor, BP, the UAC, and other employers, workers, and agency representatives. Each of the nine interim HHE reports was posted to the NIOSH Web site as they were completed to ensure the exposure monitoring results and recommendations were available as quickly as possible.⁵ Exposure monitoring and health survey data were compiled in electronic spreadsheets and also posted to the NIOSH Web site.

Preliminary results from HHE investigations were communicated to health and safety professionals and policy makers who were involved in the response by emailed letter reports and by web posting. These types of individuals serve as critical intermediaries in applying HHE recommendations and in communicating technical information to non-technical audiences. However, during the DWH response two main factors limited the ability of these professionals and policymakers to effectively relay the information to the workers themselves. Response workers in the field generally did not have readily identified representatives or Internet access available to them. In addition, other means for disseminating information in a timely manner such as flyers or handouts, especially in remote locations, were not readily apparent. Lengthy technical reports were geared toward a technical audience and shorter, plain language documents, although posted on the NIOSH Web site, did not make their way to workers in a timely manner to affect work practices. National Institute for Occupational Safety and Health needs to give consideration in the future to novel communication approaches. These could include working through local media operating in the area (eg, radio) and distributing or displaying written materials in easy to read format (eg, large posters) in common areas, such as dining and recreation tents.

National Institute for Occupational Safety and Health used a brief survey form to gather information about responder health symptoms and injuries and a checklist for workplace observations. Because pre-developed forms were not readily available, NIOSH investigators quickly developed the tools for survey work in the field early in the response. These "field-developed" survey tools will be useful templates that could be easily modified to meet specific needs of future events and are included in the *ERHMS* guidance document.³ When the situation allows, conducting initial qualitative field evaluations can be helpful to gain situational awareness and refine survey tools to focus on the most important health and safety issues.

On the basis of the HHE findings, NIOSH produced recommendations pertinent to most of the important ongoing occupational health and safety issues associated with the DWH response. National

^bResearchers can contact NIOSH about recruiting rostered individuals for participation in investigative studies. Interested researchers can find additional information on the NIOSH website, available at <http://www.cdc.gov/niosh/topics/oilspillresponse/recruiting.html>.

Institute for Occupational Safety and Health recommendations included (1) ways to improve work practices and personal protective equipment use; (2) heat stress management and the role personal protective equipment may play in adding to a worker's risk of heat stress; (3) work practices and the use of hand-held tools for beach cleaning; and (4) routine reporting of exposures, illnesses, and injuries. Many workers were involved in unfamiliar work under extreme environmental conditions so an emphasis was placed on the need for preplacement medical evaluations to ensure preexisting conditions did not place individuals at risk and that workers were best matched to job activities. In addition, NIOSH outlined steps for employers and workers to take to minimize fatigue, and the potential impact of work organization on stress and mental health.

Technical Guidance and Communications Activities

The development and rapid dissemination of relevant and practical safety and health information during a response is critically important to the protection of emergency responders. This information and guidance can assist employers, workers, and health professionals in recognizing and preventing acute illness and injury and mental distress, as well as in identifying potential long-term physical and mental health concerns. To be most effective, safety and health information must be developed in a timely manner, be geared to the intended audiences, and be distributed efficiently to a wide audience of decision-makers and stakeholders, including incident commanders, safety officers, federal entities, state and local public health agencies, employers, workers, and labor representatives.

For the DWH response, NIOSH adapted existing documents and developed new guidance to communicate potential risks associated with the DWH response. This included guidance on preplacement evaluations to avoid exacerbating underlying chronic illness or injuries, managing the extremely hot and humid work environment, handling exposures to crude oil and dispersant chemicals, managing incident stress and fatigue, and devising sampling strategies for exposure monitoring. More than 20 interim guidance documents and communication products were developed and maintained on the NIOSH Web site. Continued efforts to adapt off-the-shelf boilerplate documents, templates, and guidance are needed to ensure that information will be rapidly available for different types of responses.

Through a collaborative effort between NIOSH and OSHA, a comprehensive guidance document was produced specifically for the DWH response titled *NIOSH/OSHA Interim Guidance for Protecting Deepwater Horizon Workers and Volunteers*. This guidance was published on both agencies Web sites simultaneously—<http://www.cdc.gov/niosh/topics/oilspillresponse/protecting/> and <http://www.osha.gov/oilspills/interimguidance.html>—and was updated as necessary on basis of evolving information and circumstances, particularly in the realm of industrial hygiene sampling results and extreme concerns regarding heat stress. Joint NIOSH-OSHA branding improved the visibility of the guidance and ensured uniformity in Federal messages.

In a complex, sustained response such as the DWH response, fatigue can be a significant contributing factor to responder illness and injury. In the NIOSH/OSHA Interim Guidance described above, steps to minimize fatigue were highlighted. These recommendations were presented in detail to emphasize the need for regular rest and adequate sleep time, rest breaks, shift length, workload, and scheduled days off from work.

While it was helpful that various organizations posted their industrial hygiene sampling results online to enhance transparency, NIOSH, other agency scientists, and stakeholders noted that these data were sometimes difficult to interpret. For example, information on sampling protocols, analytical methodologies, and/or explanatory

text, such as job activity or work location relative to the presence of oil, often were not provided in sampling reports. Although standardization of data collection and information posting and the inclusion of this type of specific information is challenging, it would significantly enhance proper interpretation of the sampling results and information sharing among groups. The ICS should serve to ensure that exposure assessment data from all available sources is presented in a standard format allowing straightforward interpretation of the data.

Health Surveillance

During the DWH response, NIOSH collaborated with UAC safety personnel to analyze surveillance data gathered from staging sites located in the affected areas of the Gulf region. The summary reports of injury and illness generated through these efforts helped to provide a more complete and ongoing picture of the hazards experienced by the responders. The data utilized for these reports was abstracted from safety incident forms that were completed by on-scene safety officials throughout the Gulf region, and then transferred by BP into a central electronic database. The database contained incidents that occurred to a wide array of responders, including federal responders, contractors, BP employees, and volunteers. The database was shared with NIOSH epidemiologists, who then coded the data using a standard occupational health classification system known as the Occupational Injury and Illness Classification System (OIICS).^{6,7} National Institute for Occupational Safety and Health analyzed this coded data for significant trends in responder injury and illness, and produced a series of summary reports that graphically displayed the results of their analysis. These reports were made available to various safety and health stakeholders, including UAC safety officials, federal partners such as OSHA, state health departments, unions and other worker groups, as well as to the general public on the NIOSH Web site.⁸

Surveillance data collected and collated by BP was the most abundant source of information available to analyze in real-time. In addition, maximum advantage was taken of existing data streams such as the OSHA 300 logs of responding agencies, reports from state and local health departments, as well as the logs of occupational health clinics, first aid stations, and other treatment facilities.

Carrying out occupational safety and health surveillance during a disaster is a challenge. Where surveillance systems exist, they generally have been established to help scientists and public health professionals track specific types of illnesses and injuries. These systems often are mutually exclusive of one another, may rely on different definitions and information technologies, and generally are designed to monitor well-recognized or acute conditions, such as infectious diseases or poisoning cases. Although these systems perform well for their respective purposes on an independent basis, they may not be designed to complement each other and data systems may not be compatible. Furthermore, most disaster surveillance systems, including most syndromic surveillance systems, are not designed to specifically address occupational health and safety outcomes. Fatalities, traumatic injuries, heat stress, psychological and behavioral correlates of distress, musculoskeletal injuries, and other adverse exposure events may not be captured, providing an incomplete picture of responders' injuries and illnesses in a large-scale emergency such as the DWH response. There is a clear need to develop adaptable standardized surveillance instruments in advance of a response to better track occupational health outcomes during events.

The psychological impact of disasters on the health of responders and community members should also be incorporated into surveillance and health monitoring.⁹ Although mental and behavioral health activities were addressed across multiple agencies during the DWH response, there is still fundamental work to be done to comprehensively address behavioral health of worker populations in a common, integrated framework during an emergency response.

Strategies and dissemination platforms to incorporate these issues in health and medical guidance and response/recovery should be emphasized in every response.

Toxicity Testing Related to the Deepwater Horizon Response

During and after the DWH response, in public meetings, press interviews, and other forums, many observers expressed a great deal of concern regarding the extent and potential effects of worker and community exposures to crude oil, the dispersants used to break down the crude oil, and mixtures of the two. To contribute to the body of science describing potential health effects, NIOSH initiated acute animal toxicity studies designed to study the effects of the most commonly utilized dispersant, Corexit 9500A (obtained from the manufacturer [NALCO Holding Company, Naperville, IL]), crude oil obtained from the well head (uncontaminated by dispersant), as well as dispersant/crude oil mixtures. Studies in laboratory rodents included inhalation studies to measure pulmonary, cardiovascular, and central nervous system outcomes and dermal exposure studies to assess hypersensitivity and immune-mediated responses.

A new, novel inhalation system was developed to expose animals to a constant level of aerosol and outcomes were measured at 1 and 7 days. Effects of Corexit 9500A included signs of breathing difficulty and increased responsiveness to drugs that increase cardiac function at 1 day postexposure, and changes in proteins involved in brain function that lasted 7 days, but there were no signs of lung inflammation at either time. Corexit 9500A also was shown to be a potent dermal irritant and elicited a hypersensitivity response in experimental animals. Dermal exposure to crude oil was found to be immunosuppressive. Although the findings alone do not provide sufficient information for definitive risk assessment, they do provide insight into the effects of crude oil and Corexit 9500A and suggest avenues for additional research. Additional details on the toxicity testing can be found on the NIOSH Web site.

PROTECTING FUTURE RESPONDERS

The principles and tools devised during the development of the *ERHMS* guidance document enhanced NIOSH preparedness for the DWH response, facilitated NIOSH response efforts, and improved the ability of NIOSH to work with its partners during the response. The occupational safety and health community, including the state and local health departments, demonstrated that coherent and collaborative efforts have the potential to improve worker safety and health in emergency responses. However, to be truly effective, the safety management practices and processes outlined in the *ERHMS* guidance, in addition to routinely being carried out by independent agencies, need to be incorporated into the ICS.

Two specific areas, addressed within the *ERHMS* document, identify where unanswered challenges persist. First, in large-scale disasters involving potential chemical exposures, questions revolve around the feasibility and value of biological monitoring. Second, the need for longer-term health studies and scientific research initiatives following the disaster response is often difficult to determine.

Biological Monitoring

Questions invariably arise about the need for baseline and post-exposure testing, such as spirometry or worker symptom surveys to evaluate exposure, health effects, or both that may result from exposure. In the DWH Response, the collection of biological specimens was a particular topic of discussion. Determining when biological monitoring should be conducted can be difficult in part because it may not be clear whether a scientific rationale exists for biological monitoring in a given situation, or whether the monitoring results can provide meaningful and/or reliable information regarding health impact. In addition, it may not be clear how such information would ultimately benefit the worker, a fundamental tenet in the decision to

recommend biological monitoring for public health investigations, as opposed to research studies. In some situations it may be argued that biological monitoring serves a broader scientific benefit. Although NIOSH staff, as well as other organizations, held ongoing discussions regarding the need for biological monitoring during the DWH response, the existence of a pre-developed decision matrix would have been helpful. Such a matrix, used early in a response, could help answer questions about (1) the purpose of biomonitoring and how the results will be used; (2) the likelihood and impact of dermal and respiratory exposures that are not easily assessed by traditional industrial hygiene methods; (3) the efficacy of personal protective equipment; (4) the health risk associated with exposure(s); (5) the consideration of future health outcomes; and (6) the existence of feasible biomarkers.

Longer-Term Studies of Responder Health

In many emergency responses, NIOSH and others have been faced with the question of whether longer-term health studies of workers are warranted. Longer-term studies of workers following an event can be costly and difficult to design, thus it is important to carefully consider whether such studies will produce useful, reliable results.

To facilitate this decision-making process, it would be helpful for scientists and others to pre-identify the factors that would most likely influence the need for longer-term studies of responder health. Such factors may vary depending on the event and on the purpose of the longer-term study. For example, a study may be conducted for the purpose of medical monitoring, surveillance, or for characterizing possible health effects of a novel exposure. The need for longer-term studies can be considered in terms of three study types: (1) documented exposures to novel hazardous agents whose health effects are under studied (etiologic study); (2) documented exposures that are known to result in adverse health effects and for which early interventions have been shown to be effective (medical monitoring and treatment program); and (3) a combination of etiologic research and medical monitoring. Factors that can affect the need, value, and feasibility include the uniqueness and magnitude of the event, the ability to clearly define the exposed population and an appropriate comparison population, pre-identified areas of research interest, potential chronic effects, unique vulnerability of a worker population, and toxicological properties of the involved materials.

On the basis of clear, pre-event scientific criteria, the need for longer-term studies should be assessed early in the course of the event by a panel of independent scientists. Initial criteria should then be periodically revisited because worker job activities, safety hazards, exposures and response events may change significantly during the course of the event.

CONCLUSIONS

Every disaster and emergency response is characterized by a series of unanticipated challenges that present themselves through an initially limited but evolving knowledge base. The unique qualities of a particular response can be difficult or impossible to ascertain in advance. Nonetheless, certain basic tenets can be applied to provide a framework for a successful response. Ensuring plans contain sufficient flexibility and developing generic tools in advance of a disaster are two key planning functions that serve to streamline the response and prevent missteps. National Institute for Occupational Safety and Health and its partners, and stakeholders strive to improve strategies following each response to incorporate new knowledge into planning for the next response. The DWH response contributed greatly to the occupational safety and health community's body of knowledge and provides critical insight to both future response events and our every day obligation to protect the nation's workers.

REFERENCES

1. Jackson BA, Baker JC, Ridgely MS, Bartis JT, Linn HI. Protecting emergency responders: Volume 3. Safety management in disaster and terrorism response. DHHS (NIOSH) Publication No. 2004-144, RAND Publication No. MG-170. 2004. Available at: <http://www.cdc.gov/niosh/docs/2004-144/pdfs/2004-144.pdf>. Accessed May 6, 2011.
2. United States Government Accountability Office. September 11: HHS needs to develop a plan that incorporates lessons from the responder health programs. Publication No. GAO-08-610, May 2008. Available at: <http://www.gao.gov/new.items/d08610.pdf>. Accessed May 6, 2011.
3. National Institute for Occupational Safety and health. Emergency responder health monitoring and surveillance. Available at: <http://www.cdc.gov/niosh/docket/review/docket223/>. Accessed May 6, 2011.
4. National Institute for Occupational Safety and Health. NIOSH health hazard evaluation program. Available at: <http://www.cdc.gov/niosh/hhe/HHEprogram.html>. Accessed May 6, 2011.
5. National Institute for Occupational Safety and Health. Deepwater Horizon response: NIOSH health hazard evaluations. Available at: <http://www.cdc.gov/niosh/hhe/default.html>. Accessed May 6, 2011.
6. United States Department of Labor, Bureau of Labor Statistics. Occupational injury and illness classification system manual. Available at: <http://www.bls.gov/iif/osh/iics.htm>. Accessed May 6, 2011.
7. National Institute for Occupational Safety and Health. Occupational injury and illness classification system. Available at: <http://wwwn.cdc.gov/oic/>. Accessed May 6, 2011.
8. National Institute for Occupational Safety and Health. NIOSH reports of Deepwater Horizon response/unified area command illness and injury data. Available at: <http://www.cdc.gov/niosh/topics/oilspillresponse/data.html>. Accessed May 6, 2011.
9. Reissman DB, Schreiber MD, Shultz JM, Ursano RJ. Disaster mental and behavioral health. In: Koenig KL, Schultz CH, eds. *Disaster Medicine*. New York, NY: Cambridge University Press; 2010:103–112.