Natural and Man-Made Disasters: The Public Health Response

John Howard
National Institute for Occupational Safety and Health
U.S. Department of Health and Human Services

COEH Lela Morris Annual Symposium 2012
2 March 2012
Disasters Are Us

- **Terrorist Attacks in US**
  - Oklahoma City
  - 9/11
  - Anthrax Contamination

- **Natural Disasters**
  - Hurricanes
  - Tornados

- **Man-Made Disasters**
  - Deepwater Horizon Oil
  - Radiation Leaks After Japanese Tsunami
The number of events in the United States in 2010 set a new record.
OVERVIEW

• September 11th 2001 Terrorist Attacks

• United States Government (USG)
  – National Response Plan
  – National Response Framework

• Some Other Post 9/11 Events
  – Deepwater Horizon

• Responder Safety & Health Guidance
  – National Response Team
  – ERMS
WTC DUST: Particle Size

Large particles >> Small (respirable)

Alkaline pH (lye)

Larger the size, the more alkaline the pH

1-4% by mass were respirable particles PM$_{2.5}$

Even large particles reached lower airways
  - High concentrations
  - Mouth breathing

Particle Size (MMAD $\mu$m)

<table>
<thead>
<tr>
<th>Particle Size (MMAD $\mu$m)</th>
<th>2.5</th>
<th>10</th>
<th>53</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>~8.1</td>
<td>&gt;10.0</td>
<td></td>
</tr>
</tbody>
</table>

Gavett et al; Environ Health Perspect 2003;111:981-91
ESTIMATE EXPOSED POPULATION: 526,269

- Responders: 91,500
- Residents: 57,500
- Students and Staff: 15,200
- Building Occupants & People in Transit: 362,000
WTC Response Issues

- No initial toxicology
- No master list of responders
- No real time exposure monitoring
- Spotty compliance with respiratory protection
- No perimeter control for responder entry/exit
- No centralized safety management
- ? Did exposures lead to adverse health effects
WTC Exposure and Health Effects: Temporal or Causal Association?

1. Biologic Plausibility
2. Exposure-Response Relationship
3. Temporal Relation—Exposure & Health Effect
4. Replication in Other Groups or Cohorts

Longer Latency Health Effects

• Persistent PTSD
• Lung function decrements
• Cancer?
Lung Function in Rescue Workers at WTC after 7 Years

Principal Findings

- Lung function was measured in firefighters and EMS workers who responded to the collapse of the World Trade Center towers in New York on September 11, 2001.

- There was initial marked loss in lung-function measures in a substantial minority of study subjects (20% range) without substantial recovery during the following 7 years.
Early Assessment of Cancer

- **STUDY:** Assessed 9853 men who were employed as firefighters on Jan 1, 1996 and 926 non-WTC-exposed firefighters. *Lancet 2011;378:898-905.*

- **FINDINGS:** Cancer incidence in WTC-exposed firefighters was 1.10 (95% CI 0.98-1.25). When compared with non-exposed firefighters, the SIR of cancer incidence in WTC-exposed firefighters was 1.19 (95% CI 0.96-1.47) corrected for possible surveillance bias and 1.32 (1.07-1.62) without correction for surveillance bias.

- **INTERPRETATION:** Modest excess of cancer cases in the WTC-exposed cohort.

- **ISSUES:** Time since 9/11 is short for cancer outcomes, reported excess of cancers is not limited to specific organ types & effects in the exposed group might be due to unidentified confounders.
World Trade Center Health Program

Legislation Passed by Congress on 23 December 2010
Signed by President Obama on 2 January 2011
Effective 1 July 2011
10. Unify safety management under one command even though multiple government agencies are respond.

9. Provide unified safety and health guidance through centralized expert independent rapid-action peer-review.

8. Use hazard mapping coupled with personnel locators with measures of exposure intensity, duration and proximity for each responder.
My Top Ten Lessons Learned From 9/11

7. When doing exposure assessment, think physical and emotional exposures.

6. When doing exposure assessment, also think about toxic mixtures.

5. Provide sufficient number of competent personnel during the response to support exposure assessment, health surveillance, physical and mental health support, and planning for post-deployment medical assessments.
4. Monitor *individual* responder exposures *during* the response, record those exposures in a unified database, assess exposure to community members *as exposure occurs* in order to take mitigation actions.

3. Know each of the community populations affected, how they are affected (what cleanup did they have to do and how did they do it), and provide resources for them to protect themselves from activities triggered by the event during the event.
My Top Ten Lessons Learned From 9/11

2. Know by name and contact demographics who participated in response activities: professional responders and volunteer—both affiliated and unaffiliated.
My Top Ten Lessons Learned From 9/11

1. Like all of the rest of us in government agencies have to do by Presidential Executive Order, when decisions are made by leaders about the risks associated with re-entry or other such critical decision making surrounding a national incident, require that the decision maker:

   – describe & communicate the specific decision making process used;

   – any assumptions made to bridge data gaps; and

   – level of uncertainty associated with the final decision.
Post 9/11: Some of What USG Plans For

Fire, bridge collapse, air show disaster, pandemic influenza, human stampede, mine explosion, aircraft hijacking, severe heat wave, nuclear detonation, earthquake, vesicant agent attack, rocket-propelled grenade attack, tornado, massive power outage, commercial aircraft crash by laser, *weaponized* anthrax, hurricanes, train derailment, volcanic eruption, cholera, massive oil spill, tsunami, nerve agent attack, refinery explosion, improvised explosive device, ecological terrorism, ionizing radiation with dispersal, nuclear power plant meltdown, aircraft crash into a high-rise building, subway suicide bombing, and an asteroid collision with the earth.
United States: Federalist System

- Under U.S. Constitution:
  - States primarily responsible for controlling disease spread within their borders
    - “Police Power” under 10th Amendment
  - Federal government responsible for controlling disease spread from foreign countries and interstate
    - Regulate foreign and interstate commerce
    - In practice, concurrent jurisdiction is common
    - Federal government has special obligations internationally and with respect to Indian Tribes
History: National Response Plan

- **1992** (Original USG response plan called *Federal Response Plan or FRP*)
  - Grew out of wildland fire service – 1st to use ICS
  - Focused only on Federal roles & responsibilities
- **1995** (Oklahoma City Bombing)
- **2001** (World Trade Center)
  - Need for common incident management practices
- **2004** (DHS established in 2003)
  - *New National Response Plan (NRP)* replaced FRP
- **2005** (Hurricane Katrina)
  - NRF *Notice of Change* (Katrina)
- **2006** – Newer version of NRP
History: National Response Plan

Even though “improved,” the National Response Plan was criticized as:

- Too bureaucratic
- Internally repetitive
- Insufficiently national in its focus
- Not a true operational plan
- Content inconsistent with its title
- Disaster operational planning matured since
National Response Framework

• January, 2008
  – National Response Framework released
  – Current operational plan for USG
  – Activation depends on Presidential Declaration

• Commits Federal government to:
  – Work with other governments & private sector
  – To finalize interim operational plans for incident scenarios specified in National Preparedness Guidelines.
National Incident Management System

- Comprehensive, nationwide systematic approach to incident management.
- Core set of doctrine, concepts, principles, terminology, and organizational processes for all hazards. It is not a detailed operational or resource plan.
- Scalable, so it may be used for all incidents (from day-to-day to large-scale).
- Essential principles for a common operating picture and communications interoperability.
- Standardized resource management procedures for coordination among different jurisdictions & organizations.
ICS: Safety Officer

- Monitors incident operations and advises the IC on all matters relating to operations safety, including the health and safety of emergency personnel.

- Has emergency authority to stop and/or prevent unsafe acts during operations.
National Contingency Plan

- National Contingency Plan (NCP) is used to respond to thousands of incidents annually that never rise to the level of an Incident of National Significance
National Contingency Plan

• NCP is the USG’s blueprint for responding to oil spills and hazardous substance releases.

• 1st NCP developed and published in 1968
  – Massive oil spill in 1967 from tanker Torrey Canyon coast of England

• Congress has broadened the NCP scope over the years.
  – In Clean Water Act of 1972, the NCP was revised to include a framework for responding to hazardous substance spills as well as oil discharges.
  – Following the passage of Superfund legislation in 1980, the NCP was broadened to cover releases at hazardous waste sites requiring emergency removal actions.
  – The latest revisions to the NCP were finalized in 1994 to reflect the oil spill provisions of the Oil Pollution Act of 1990.
Deepwater Horizon: Explosion & Fire

• 20 April 2010

• Refers to Deepwater Horizon Semi-Submersible Mobile Offshore Drilling Unit (MODU)

• Situated about 60 km SE of LA coast
  – Macondo Prospect Oil Field
  – Owned and operated by Transocean

• 11 workers died; 17 other injured
  – out of 126 crew on board at the time

• When the blowout occurred, 4 BP and Transocean executives were on board the platform to congratulate the senior staff of the rig for 7 years of operations without a lost time incident

• No OSHA Jurisdiction – beyond the 3 mile territorial limit of the US
NCP: High Level Organizations

1. Federal On-Scene Coordinators (FOSC)

FOSC is a federal official, pre-designated by EPA for inland areas and by the Coast Guard for coastal or major navigable waterways.

2. National Response Team (NRT)

NRT's membership consists of 16 federal agencies with interest and expertise in various aspects of emergency response to pollution incidents.

3. Regional Response Team (RRT)

RRTs are the next organizational level in the federal response system. Currently, there are 13 RRTs, one for each of the ten federal regions, plus one each for Alaska, the Caribbean and the Pacific Basin.
NCP: Special Force Components

- Coast Guard National Strike Force
- Coast Guard Public Information Assist Team
- EPA Environmental Response Team
- Scientific Support Coordinators
  - National Oceanic and Atmospheric Administration (NOAA) provides SSC in coastal and marine areas. The SSC serves on the FOSC staff as the lead of a scientific team. This support team provides expertise in environmental chemistry, oil slick tracking, pollutant transport modeling, natural resources at risk, environmental tradeoffs of countermeasures and cleanup, information management, contingency planning and liaison to the scientific community and the natural resource trustees.
NIOSH Activities

- Rostering
- Health Hazard Evaluations
- Technical Guidance
- Health Surveillance
- Toxicity Testing
DEEPWATER HORIZON RESPONSE

NIOSH Voluntary Roster of Deepwater Horizon Response Workers

NIOSH is developing a voluntary roster of response workers to create a record of those who have participated in cleanup activities and a mechanism to contact them about possible work-related symptoms of illness or injury, as needed. The Unified Command and BP support the roster and the goal of identifying all workers, including volunteers, involved in all response/cleanup activities. Workers have the opportunity to be rostered during training and at established staging areas (locations to which trained workers report for duty each day) in Louisiana, Mississippi, Alabama, and Florida. NIOSH also is rostering response workers online through a secure web site. NIOSH has provided the secure link to multiple federal agencies and BP, and has asked them to refer workers to the web site to complete the rostering form electronically.

The number of workers that have been rostered as of 10/14/10 are as follows:

<table>
<thead>
<tr>
<th>Staging</th>
<th>Training</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>16,206</td>
<td>39,306</td>
<td>55,512</td>
</tr>
</tbody>
</table>

- NIOSH Deepwater Horizon Data Use and Disclosure
- NIOSH Deepwater Horizon Initial Roster Form
- Letter of Support from the Unified Command and BP for the NIOSH Worker Roster

Photo credit: Aaron Sussell, NIOSH
Deepwater Horizon Response Worker Rostering

Paper & Electronic Records
As of 10-1-10
Total Collected: 55,512

Targeted Workers
- BP Staff
- BP Contractors
- Volunteers
- Federal
- State & Local

<table>
<thead>
<tr>
<th>Percentage</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>81%</td>
</tr>
<tr>
<td>Female</td>
<td>19%</td>
</tr>
<tr>
<td>Asian</td>
<td>2%</td>
</tr>
<tr>
<td>Hispanic</td>
<td>9%</td>
</tr>
<tr>
<td>Black</td>
<td>38%</td>
</tr>
<tr>
<td>All Others</td>
<td>52%</td>
</tr>
</tbody>
</table>
Occupational Hazards in the Gulf
Populations of Concern

- General Public
- Community
- Beach Clean Up Workers
- Water Clean Up Workers
- Workers at or near plume

Anxiety/Concern

Exposure

Highest

Lowest
BP Requested Health Hazard Evaluations: Six Work Categories

• Off Shore
  – Source Control
  – Burning
  – Booming, Skimming and Dispersant

• On Shore
  – Beach and marsh cleanup
  – Wildlife rehabilitation
  – Equipment decontamination and waste stream
Burning

• An aerial photo of one controlled burn operation.
Burning and Risk
HHE: Burning
HHE: Booming & Skimming
HHE: Beach Cleanup
HHE: Equipment Cleanup
HHE: Vessel Decontamination
HHE: Air Sampling Results

- 2,577 air sample points were collected
  - 840 (33%) were personal breathing zone air sample points
  - 1,737 (67%) were general air sample points
- Personal breathing zone was conducted on 69 individuals on 15 vessels and at 2 ports
  - Only 1 (0.1%) of the 840 personal breathing zone sample points exceeded any occupational exposure limit (CO)

<table>
<thead>
<tr>
<th></th>
<th>Personal Breathing Zone</th>
<th>General Area</th>
<th>Total Samples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Booming</td>
<td>46</td>
<td>150</td>
<td>196</td>
</tr>
<tr>
<td>Decontamination</td>
<td>249</td>
<td>12</td>
<td>261</td>
</tr>
<tr>
<td>Dispersant application</td>
<td>123</td>
<td>856</td>
<td>979</td>
</tr>
<tr>
<td>In-situ burning</td>
<td>59</td>
<td>575</td>
<td>634</td>
</tr>
<tr>
<td>Skimming</td>
<td>81</td>
<td>100</td>
<td>181</td>
</tr>
<tr>
<td>Work at the source</td>
<td>282</td>
<td>44</td>
<td>326</td>
</tr>
</tbody>
</table>
On-Shore Personal Exposure Monitoring

261 sampling points -- Personal breathing zone sampling was conducted on 24 individuals

154 of the 261 (59%) samples were non-detect

25 of the 107 (23%) detectable samples were less than the minimum quantifiable concentration

- Although detectable, samples less than the minimum quantifiable concentration have more uncertainty associated with their result than samples above the minimum quantifiable concentration

None of the individuals’ chemical exposures exceeded any occupational exposure limit

In addition to chemical exposures, we evaluated noise exposures at one of the two sites

- Noise exposure calculations estimated that individuals performing pressure washing or working near the pressure washers are likely to have exposures that exceed the NIOSH REL
### Personal breathing zone results for compounds above the minimum quantifiable concentration

<table>
<thead>
<tr>
<th>Compound</th>
<th>OSHA PEL</th>
<th>Lowest OEL* (Country)</th>
<th>Maximum Personal Breathing Zone Sample Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Butoxyethanol</td>
<td>50 ppm</td>
<td>2 ppm (France)</td>
<td>0.28 ppm</td>
</tr>
<tr>
<td>Anthracene</td>
<td>N/A†</td>
<td>N/A</td>
<td>0.0029 mg/m³</td>
</tr>
<tr>
<td>Benzene</td>
<td>1 ppm</td>
<td>0.1 ppm (US)</td>
<td>0.0059 ppm</td>
</tr>
<tr>
<td>Carbon monoxide (ceiling)</td>
<td>N/A</td>
<td>200 ppm (US)</td>
<td>220 ppm</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>50 ppm</td>
<td>20 ppm (EU)</td>
<td>3 ppm</td>
</tr>
<tr>
<td>Chrysene</td>
<td>N/A</td>
<td>N/A</td>
<td>0.011 mg/m³</td>
</tr>
<tr>
<td>Dipropylene glycol butyl ether</td>
<td>N/A</td>
<td>N/A</td>
<td>0.063 ppm</td>
</tr>
<tr>
<td>Ethyl benzene</td>
<td>100 ppm</td>
<td>20 ppm (France)</td>
<td>0.0086 ppm</td>
</tr>
<tr>
<td>Fluoranthracene</td>
<td>N/A</td>
<td>N/A</td>
<td>0.00014 mg/m³</td>
</tr>
<tr>
<td>Fluorene</td>
<td>N/A</td>
<td>N/A</td>
<td>0.001 mg/m³‡</td>
</tr>
<tr>
<td>Limonene</td>
<td>N/A</td>
<td>20 ppm (Germany &amp; Switzerland)</td>
<td>0.085 ppm</td>
</tr>
<tr>
<td>Naphthalene</td>
<td>10 ppm</td>
<td>10 ppm (all reported)</td>
<td>0.11 ppm</td>
</tr>
<tr>
<td>Phenanthrene</td>
<td>N/A</td>
<td>N/A</td>
<td>0.012 mg/m³</td>
</tr>
<tr>
<td>Propylene glycol</td>
<td>N/A</td>
<td>N/A</td>
<td>0.17 mg/m³</td>
</tr>
<tr>
<td>Pyrene</td>
<td>N/A</td>
<td>N/A</td>
<td>0.0041 mg/m³</td>
</tr>
<tr>
<td>Toluene</td>
<td>200 ppm</td>
<td>20 ppm (Japan)</td>
<td>0.074 ppm</td>
</tr>
<tr>
<td>Total hydrocarbons</td>
<td>N/A</td>
<td>N/A</td>
<td>9.1 mg/m³</td>
</tr>
<tr>
<td>Total PAHs</td>
<td>N/A</td>
<td>N/A</td>
<td>0.020 mg/m³</td>
</tr>
<tr>
<td>Total particulates</td>
<td>15 mg/m³</td>
<td>10 mg/m³ (Canada)</td>
<td>0.18 mg/m³</td>
</tr>
<tr>
<td>Xylene</td>
<td>100 ppm</td>
<td>25 ppm (Denmark)</td>
<td>0.046 ppm</td>
</tr>
</tbody>
</table>

*Lowest OEL listed in the German Institute for Occupational Safety and Health database of international OELs (available at [www.dguv.de/bgia/en/gestis/limit_values/index.jsp](http://www.dguv.de/bgia/en/gestis/limit_values/index.jsp) updated August 2010)

†N/A = not applicable
‡Concentration is between the minimum detectable concentration and the minimum quantifiable concentration
Off-Shore Exposure Monitoring

- 2,316 sampling points; Personal breathing zone sampling was conducted on 45 individuals
- 1,426 of the 2,316 (62%) samples were non-detect
- 196 of the 890 (22%) detectable samples were less than the minimum quantifiable concentration
- 1 individual’s exposure to carbon monoxide exceeded the NIOSH ceiling REL of 200 parts per million
  - This exposure occurred at an in-situ burn site while the gasoline-powered igniter boat was idling, suggesting that the exposure was a result of engine exhaust rather than from burning surface oil
- Although detectable, samples less than the minimum quantifiable concentration have more uncertainty associated with their result than samples above the minimum quantifiable concentration
DEEPWATER HORIZON RESPONSE

Interim Guidance for Protecting Deepwater Horizon Response Workers and Volunteers

07/26/2010

National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention, U.S. Department of Health and Human Services and Occupational Safety and Health Administration, U.S. Department of Labor

Recommendations contained in the Interim Guidance will be updated as more information about exposures is collected and assessed in relationship to the incidence and prevalence of symptoms, illnesses and injuries.

The recommendations provided in this Interim Guidance focus on issues specific to the Deepwater Horizon Response and do not address issues common to all disaster response work activities. For more information on general disaster response, consult the NIOSH Emergency Response Topic Page at http://www.cdc.gov/niosh/topics/emergency.html.
Dispersants
Dispersants: Surface, Subsea & Aerial
Dispersants: Purposes

– Enhance amount of oil that physically mixes into the water column:

• **Reduces risk** that oil will contaminate shoreline habitats or to come into contact with fish, birds and sea mammals

• **Increases exposure** of water-column and benthic biota to spilled oil

• Use represents a **trade-off** decision to increase the hydrocarbon load on the water column while reducing it on the coastal wetland
Dispersants: Chemical Actions

• Dispersants function like detergents to break up oil into small droplets that mix easily with water.
• They contain a combination of surfactants and solvents.
• Surfactants are compounds that have lipophilic groups, which mix with non-polar substances like oil, and hydrophilic groups, which mix with polar substances like water.
• By combining lipophilic and hydrophilic groups, surfactants can lower surface tension to allow water and oil to mix more easily.
• The solvents help the surfactants pass through the oil to reach the oil-water boundary where the surfactants operate.
Dispersant Composition: Corexit 9500A

- Petroleum distillates (30% by volume)
- Prophylene glycol (1,2 propandiol)
- Organic sulfonic acid salt
- Butanedioic acid
- Sorbitans
- 2-Propanol, 1-(2-butoxy-1-methylethoxy)
- 2-Butoxyethanol
  - Causes hemolysis, kidney and liver toxicity
  - Found in Corexit 9527 in worrisome concentrations
  - Use discontinued by EPA early in spill because of toxicity fears
Toxicity Testing

Corexit drum delivered from Nalco

Dispersant generation system, animal exposure chamber and computer controls
NIOSH Toxicity Studies on Corexit


National Commission Report

- Nat’l Commission on BP DWH Oil Spill
  - January 2011
- BP DWH Accident Investigation
  - September 2010
- NOAA Report
  - December 2011
- Other Reports
NIOSH Lessons Learned

- General Deployment Issues
- Roster Activities
- HHEs
- Guidance and Communication
- Health Surveillance
- Biologic Monitoring
- Longer Term Health Studies

Emergency Responder Monitoring and Surveillance

- Guidance developed by a 2-year WorkGroup:
  - Federal and State Interagency Group
  - Convened and led by NIOSH

- Purpose
  - Adoption by National Response Team

- ERMS covers all three phases of emergency response:
  - Pre-deployment
  - Deployment
  - Post-deployment
Emergency Responder Monitoring and Surveillance

• Essential principles:
  – Only qualified, trained, and properly equipped personnel should be selected for deployment
  – Applies to employees, contractors or volunteers
    • Unaffiliated volunteers must be trained before deployment
  – All receive sufficient health and exposure monitoring
  – Decisions are made whether long-term monitoring or surveillance is needed during deployment based on real-time data
  – Addresses how to assess long-term health effects in responders

Longer Term Studies

• 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.
Post 9/11 NIOSH Responses
Thank You!
Selected References

- Decker J. A decision process for determining whether to conduct responder health research following disasters (in press).
- EPA. National Oil and Hazardous Substances Pollution Contingency Plan. Available at [http://www.epa.gov/OEM/content/lawsregs/ncpover.htm](http://www.epa.gov/OEM/content/lawsregs/ncpover.htm)
- Middlebrook AM. Air quality implications of the *Deepwater Horizon* oil spill. *PNAS* 28 December 2011 online. Available at [http://www.pnas.org/content/early/2012/01/04/1110052108](http://www.pnas.org/content/early/2012/01/04/1110052108)
Selected References 2

- National Oil and Hazardous Substances Pollution Contingency Plan. Available at http://www.nrc.uscg.mil/nrsinfo.html