THE HEALTH AND ENVIRONMENTAL CONSEQUENCES OF SEPTEMBER 11

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The attacks on the World Trade Center produced the greatest acute environmental health disaster that ever has befallen New York City.
Dust and smoke from the fires
Dust from materials transfer
The Medical and Public Health Response to 9/11
Mount Sinai’s Response to 9/11 Builds on the Legacy of Dr. Irving Selikoff

Professor Irving J. Selikoff, M.D.
1915-1992
The Father of Occupational Medicine in the United States
The Public Health Response to 9/11: Three Phases

Phase I: Immediate aftermath
Phase 1. Tens of thousands of public servants rushed in to help...
Phase 1. Tens of thousands of private sector workers and volunteers also rushed in.
An estimated 100,000 local workers and residents were in the area.
Over the weeks after 9/11, as rescue, recovery and restoration of essential services occurred, concerns and controversies began to mount over the potential health effects of the disaster.
Controversy developed

• There was substantial disagreement over the nature and risk of exposure to airborne contaminants
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- In a press release and in statements to the media on September 18, 2001, the EPA announced that the “air was safe to breathe.”
Controversy developed

• While few argued that there might be substantial mental health consequences from the disaster, there was substantial disagreement over the nature and risk of exposure to airborne contaminants

• In a press release and in statements to the media on September 18, 2001, EPA announced that the “air was safe to breathe”

• But many public health experts and clinicians on the front lines were seeing evidence that the air was not as safe as claimed

This was when epidemiology and environmental science began to make essential contributions
To resolve this controversy, medical and public health teams began working to identify:

- What were the exposures?
- Who was exposed?
- How could hazardous exposures be prevented?
- What were the health effects?
  - To workers and volunteers involved in rescue, recovery, and restoration of essential services
  - To local workers, many of whom evacuated but returned to work soon after the disaster
  - To community residents

*These questions were addressed in phases 2 and 3*
Phase II. Assessment of Environmental Exposures
Components of Exposure Assessment

• High-altitude imaging of the atmospheric plume
• Meteorological modeling of the plume
• Chemical analyses of settled dust
• Indoor sampling of buildings near Ground Zero
• Ambient air sampling
WTC Plume – Aviris imagery, September 16, 2001

Visible Color Composite (RGB = 0.66/0.55/0.44 μm)
Visible Blue Band (0.44 μm)
Near Infrared Ratio (0.94 μm / 0.86 μm)
Sampling of Exterior Settled Dust near Ground Zero

Goals:

1. To determine the chemical and physical characteristics of the mass of material in the initial plume.

2. To assess the presence or absence of contaminants that could have acute or chronic effects on human health.

Lioy et al, 2002
Collecting Settled Dust Samples

Components of Settled Dust from the WTC

- Chrysotile Asbestos (0.8-3.0%) - used in construction of North Tower to 40th story
- Cement dust (pH 10.0-11.0)
- Glass fibers
- Lead and other Heavy Metals
- Polychlorinated biphenyls (PCBs)
- Toxic Products of Combustion
  1. Benzene and other VOCs
  2. Polycyclic Aromatic Hydrocarbons (PAHs)
  3. Dioxins
  4. Diesel fumes
  5. Sulfur dioxide
Organic Compounds Detected in Settled Dust

- Polycyclic Aromatic Hydrocarbons (>0.1%) (e.g., benzo(a)pyrene)
- Phthalates (100’s of ppm)
- Other Combustion Products (100’s of ppm)
- PCBs (100’s of ppb)
- Unburned Jet Fuel (10’s of ppm)
- PBBs, PBDEs (10’s of ppb)
- Organochlorine pesticides (10’s of ppb)
- Dioxin and Furans (10’s, 100’s of ppt)

Lioy et al, 2002 – Buckley, Weisel, Hale, and Eisenreich- organic analyses
General Appearance of Bulk Dust Collected at the Cortlandt, Cherry, and Market Street Locations East of the World Trade Center

Lioy et al, 2002
Chrysotile Asbestos in Market Street Dust Sample

Lioy et al, 2002 – Millette, MVA micrograph
Indoor Dust Sampling

Lioy et al., 2002, Sampling Indoors
Indoor Deposition of Dust and Smoke

Lioy et al. 2002
Chrysotile Asbestos in an Indoor Sample

Lioy et al, 2003, Millette, MVA Micrograph
Ambient Air Sampling near Ground Zero

Goals:

- To measure time trends in airborne contaminant levels
- To build a composite picture of the geographic pattern and components of low altitude airborne contamination (in conjunction with settled dust data)
Atmospheric Levels of Elemental Carbon (Soot) Lower Manhattan, 9/15 – 10/15/2001

FIGURE 1. Elemental carbon (soot) levels (September 15-October 15, 2001) were elevated in lower Manhattan at night in the weeks following the disaster, but declined over time as the fires diminished.

Thurston and Chen
Mean airborne concentration of PAHs at Ground Zero and at 290 E. Broadway, Manhattan, New York
Principal airborne toxins in lower Manhattan after 9/11

- Silica
- Pulverized Cement and Gypsum (pH 10-11)
- Asbestos
- Glass
- Heavy Metals
- Soot
- VOC’s
- Acid Mists
- Organic Products of Combustion (PAH’s etc)
**Toxicology Studies.** Numbers of cells recovered by bronchoalveolar lavage from mice one day after aspiration of WTC particulate matter samples.

Gavett et al. 2003
## Summary Time Course of Environmental Exposures Following the Attack on the World Trade Center – Four Periods (Lioy et al. 2002)

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Predominant Sources of Pollution</th>
<th>Airborne Pollutants</th>
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<tbody>
<tr>
<td><strong>Period 1</strong>&lt;br&gt;First 12 hours post collapse (September 11, 2001)</td>
<td>• Burning jet fuel&lt;br&gt;• Fires&lt;br&gt;• Collapse of the Twin Towers</td>
<td>1. Combustion products – gaseous and particulate&lt;br&gt;2. Evaporating gases from the collapse of the Towers&lt;br&gt;3. Coarse particles</td>
</tr>
<tr>
<td><strong>Period 2</strong>&lt;br&gt;Day 1 evening through Day 2</td>
<td>• Burning jet fuel&lt;br&gt;• Re-suspension of settled dust/smoke</td>
<td>1. Combustion products – gaseous and particulate&lt;br&gt;2. Gases evaporating from piles&lt;br&gt;3. Re-suspended coarse particles</td>
</tr>
<tr>
<td><strong>Period 3</strong>&lt;br&gt;Day 3 through Day 13</td>
<td>• Smoldering fires&lt;br&gt;• Re-suspension of settled dust/smoke</td>
<td>1. Combustion products – gaseous and particulate&lt;br&gt;2. Coarse particle re-suspension&lt;br&gt;3. Diesel exhaust</td>
</tr>
<tr>
<td><strong>Period 4</strong>&lt;br&gt;Day 14 through December 20, 2001</td>
<td>• Smoldering fires with occasional flare-ups&lt;br&gt;• Removal of debris by trucks and other heavy equipment</td>
<td>1. Combustion products – gaseous and particulate&lt;br&gt;2. Diesel exhaust</td>
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</tbody>
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Phase III.

Assessment of Health Effects in Exposed Populations
Deaths at the World Trade Center

- 2,726 total
- 343 firefighters
- 60 police officers
- Residents of 26 states
- Residents of 8 foreign nations
- 77% males; 23% females
- Median age, 39 yrs (range 3-85 yrs)
Populations at Greatest Risk of Toxic Exposures and in Need of Medical Follow-Up

- First responders – Firefighters, EMTs, Police, Volunteers
- Other workers and volunteers in and near Ground Zero - Construction Workers, Transit Workers, Cleaners
- Office workers in Financial District
- Residents of lower Manhattan, especially children
- Pregnant Women
World Trade Center Cough

- Defined as persistent cough that developed after September 11 and lasted at least 4 weeks
- Apparently caused by intense airways irritation resulting from inhalation of alkaline cement dust (pH=10.0-11.0) and glass fibers
WTC Cough in Firefighters

• 10,116 firefighters were followed for 6 months by FDNY physicians
• Prevalence of WTC cough was exposure-related:
  ➢ 128 (8%) of 1636 heavily exposed
  ➢ 187 (3%) of 6958 moderately exposed
  ➢ 17 (1%) of 1320 least exposed
• 1 case of eosinophilic pneumonia

Prezant et al, 2002
Rom et al, 2002
WTC Cough in Firefighters

Prezant et al. 2002
Respiratory Symptoms in Ironworkers (n=97), Autumn, 2001

Upper airway disorders

- Rhinitis
- Sinusitis
- Pharyngitis
- Laryngitis

Lower Airway Disorders

- Asthma
- Chronic dry cough
- Aggravation of pre-existing lung disease
- Pneumonia

Effects most common and severe in earliest arrivers
Psychological and Socioeconomic Consequences in Ironworkers

Autumn, 2001

- **Psychological effects**
  - PTSD
  - Anxiety
  - Depression

- **Social and economic consequences**
  - Loss of employment
  - Impact of families
  - Increase in substance/alcohol use
Based on Mount Sinai’s and FDNY’s Initial Clinical Findings,
Need Became Clear for Larger Scale Clinical Programs
The WTC Worker and Volunteer Screening Program (2002-2004)

- Began at Mount Sinai in July 2002 with funding by NIOSH. Goal: to rapidly establish a clinical program to provide free standardized screening exams to WTC responders.

- Examination purposes:
  - To identify current WTC-related physical and mental health problems
  - To serve as baseline for future exams

- Parallel program at FDNY
The Mount Sinai World Trade Center Worker and Volunteer Medical Screening Program

Examinations include:

- Standardized medical and exposure interviews
- Mental health assessment
- Chest x-ray
- Spirometry (pre and post bronchodilator)
- CBC, blood chemistries, UA
Initial Findings of WTC Screening Program

High rates of persistent symptoms:

- 50% had WTC-related lower airway symptoms
- Spirometry: 33% abnormal
- Mental Health: 12.9% met criteria for PTSD

These findings made clear the need for ongoing monitoring beyond one-time screening.

MMWR, September 10, 2004
The Mount Sinai WTC Medical Monitoring Program

• Began on July 15, 2004, succeeding and replacing the screening program.

• Provides baseline exams and follow-up exams every 18 months for a period of five years, to WTC responders.

As of January 2008,

• >23,000 patients have received a baseline examination of these, 74% were seen at Mount Sinai.

• >10,000 patients have received a follow up examination; 82% at Mount Sinai.
WTC Medical Screening Program
July 2002- August 2004

Findings

• 69% of all responders reported experiencing either a new or an aggravated respiratory symptom while working at the WTC.

• At the time of examination (12-30 months after starting work), 59% remained symptomatic.

• 27% had abnormal spirometry, a rate twice the US national background.

• The prevalence of low FVC (20%), a measure of pulmonary restriction, was 5 times the US background.
The Mount Sinai
WTC Health Effects Treatment Program

A philanthropically funded program which provides medical care and advocacy without charge for responders

Needed because 40% of responders in our treatment program lack health insurance.

From January 2003 to the present, the HETP has provided:

• 7249 medical services to 2019 patients
• 4732 social work services to 1524 patients
• Extensive referrals to other Departments (15,000 referrals/year currently and 27,000/year projected)
The Mount Sinai WTC Health Effects Treatment Program

Initial funding:
- American Red Cross Liberty Fund
- The September 11th Fund
- The Bear Stearns Charitable Foundation
- The Robin Hood Foundation

From 2005-2007, additional funding was provided through the American Red Cross Recovery Grant

Federal funding began in September, 2006
The WTC Health Effects Treatment Program

The most common diagnoses among all HETP patients are:

- **Upper-airway disorders** - rhinitis, sinusitis, pharyngitis, and laryngitis;
- **Lower-airway disorders** - asthma and aggravated pre-existing chronic lung disease;
- **Mental health conditions** - prolonged Post-Traumatic Stress Disorder and chronic depression; and
- **Gastrointestinal illnesses** - predominantly GERD.
Studies of Pregnant Women
Two complementary prospective studies

Mount Sinai
- 187 women
- All in or within 10 blocks of WTC
- Time-activity logs
- Biomarkers during pregnancy
- Continuing follow-up of growth and neurodevelopment

Columbia
- 329 women
- Gave birth in lower Manhattan
- Biomarkers at delivery
- Continuing follow-up of growth and neurodevelopment

Berkowitz et al
Perera et al
## Pregnancy outcomes in relation to the attack on the World Trade Center

### Mount Sinai Study

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<tr>
<th></th>
<th>WTC GROUP</th>
<th>CONTROL GROUP</th>
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<tbody>
<tr>
<td><strong>Number</strong></td>
<td>187</td>
<td>2,367</td>
<td>--</td>
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<tr>
<td><strong>Mean Gestational Age</strong></td>
<td>39.1 weeks</td>
<td>39.0 weeks</td>
<td>0.55</td>
</tr>
<tr>
<td><strong>Mean Birth Weight</strong></td>
<td>3,203 gm</td>
<td>3,267 gm</td>
<td>0.14</td>
</tr>
<tr>
<td><strong>Frequency of Pre-Term Birth</strong></td>
<td>9.9%</td>
<td>9.2%</td>
<td>0.76</td>
</tr>
<tr>
<td><strong>Frequency of Low Birth Weight</strong></td>
<td>8.2%</td>
<td>6.8%</td>
<td>0.47</td>
</tr>
<tr>
<td><strong>Frequency of SGA Infants</strong></td>
<td>8.2%</td>
<td>3.8%</td>
<td>&lt;0.01</td>
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</tbody>
</table>
Conclusions

- Mount Sinai’s response to 9/11 would not have been possible without our strong, pre-existing base in environmental and occupational medicine – the Selikoff legacy.

- Respiratory and psychological symptoms are prevalent, severe and persistent in WTC responders.

- Respiratory effects are most likely due to inhalation of alkaline dust.

- Assured long-term follow-up will be required to deal with persistent and delayed effects in these heroic men and women – lung disease, mental health problems, and possible cancers.
Thank you