

The WTC Environmental Health Program “Survivor program”

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NEW YORK CITY
HEALTH AND
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WTC destruction as an environmental disaster

- Community at risk for WTC dust/fume exposure**
- 60,000 residents south of Canal Street alone**
- 300,000 area workers/office workers, commuters, teachers**
- 15,000 students**



- Disaster exposure science and a community at risk
- Background history of the WTC EHC program
- Clinical findings of WTC EHC program
- Unanswered questions

Environmental human exposure science

- Basic tenets of human exposure science:
 - Does an exposure factor have a potential health risk (biologic plausibility)
 - Exposure assessment
 - Human disease assessment
 - Estimate dose-response relationships

Environmental disaster exposure science

- Systems in disarray
- Politics and economics complicate questions of potential health risk
- Exposure assessment may not be feasible
- Disease assessment systems not available

Did WTC dust/fume exposure pose a health risk to the community

- Risk denied by EPA
- Residents told to damp mop
- Local workers returned to work 7 days after event
- Concept of potential health risk to surrounding community only accepted after delay

Exposure assessment – toxic agents?



- 1.2 million tons of building materials
- 90% of settled particles >10 μ m diameter
- 11,000 tons of particles < 2.5 μ m diameter

Characteristics of settled WTC dust

- Alkaline (pH9-11)
- Particulate matter
 - Calcium sulfate (gypsum)
 - Calcium carbonate
 - Crystalline silica
- Construction materials
 - Cement
 - Concrete
 - Wallboard
- Fibers
 - Fibrous glass
 - Gypsum fibers
 - Chrysotile asbestos



concrete

glass fiber

Banauch et al. Curr. Opinion Pulm Med 2005, 11:160-168
USGS Environmental Studies of WTC

asbestos

Chemical constituents of WTC dusts

- Combustion of jet fuel
- Organic pollutants
 - Polycyclic aromatic hydrocarbons
- Combustion products of plastics, metals, woods, insulation, fluorescent lights, computer and video monitors
- Hydrocarbons
 - Napthalene
 - Polychlorinated biphenyls (PCBs)
 - Dioxins
 - Benzene
- Heavy metals
 - Mercury
 - Lead

Exposure assessment for community members

- Complicated by variety of exposure possibilities
- Variable amount of time in area (there on 9/11, evacuated or not, returned episodically to clean)
- No studies done immediately after event to assess exposure
- Recall

Acute exposures - Dust cloud(s)

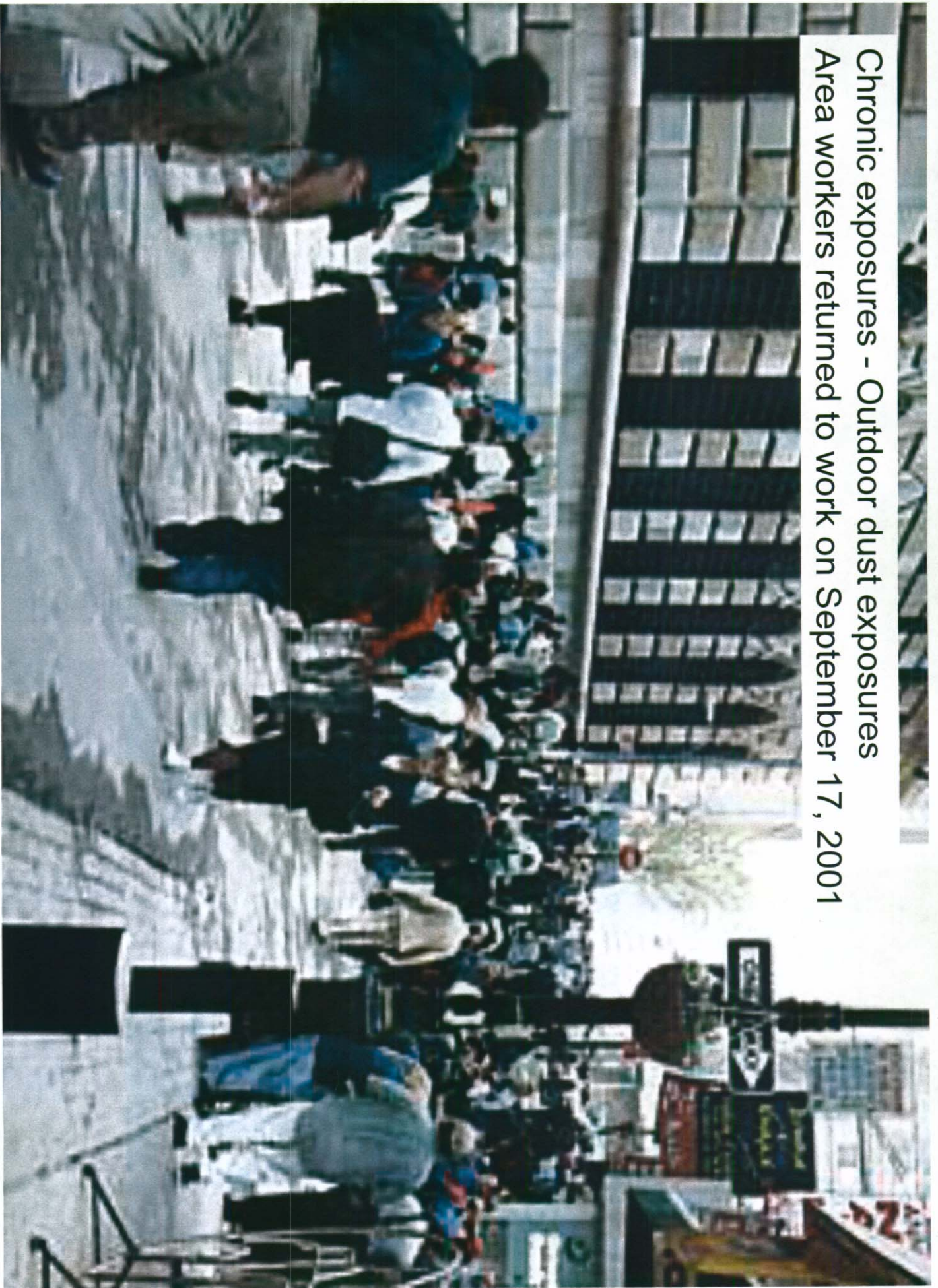


Debris before buildings collapsed

Multiple dust clouds

Extensive dust in afternoon after buildings collapsed

Chronic exposures - Outdoor dust exposures
Area workers returned to work on September 17, 2001



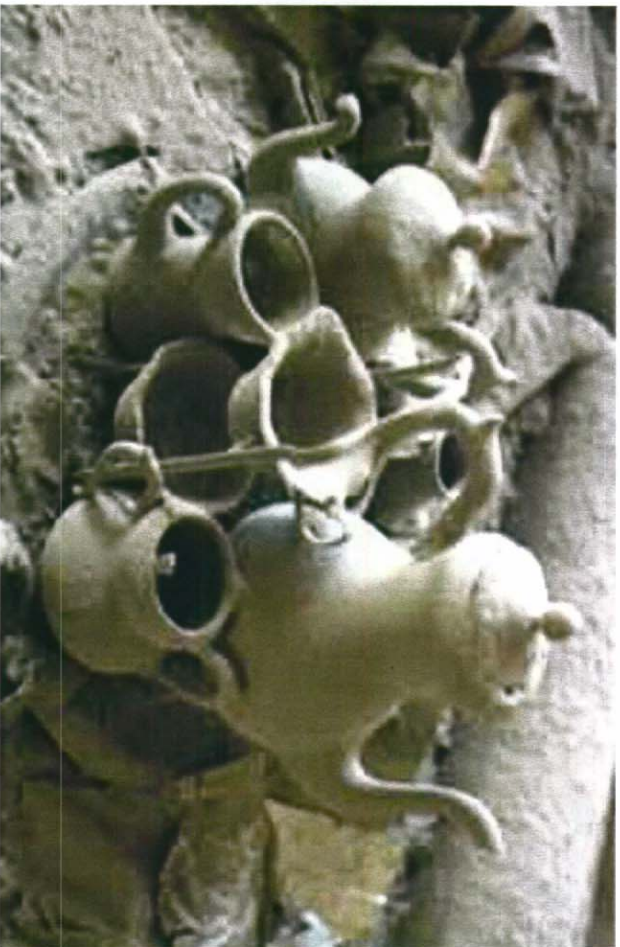
Chronic exposures - Indoor dust exposures



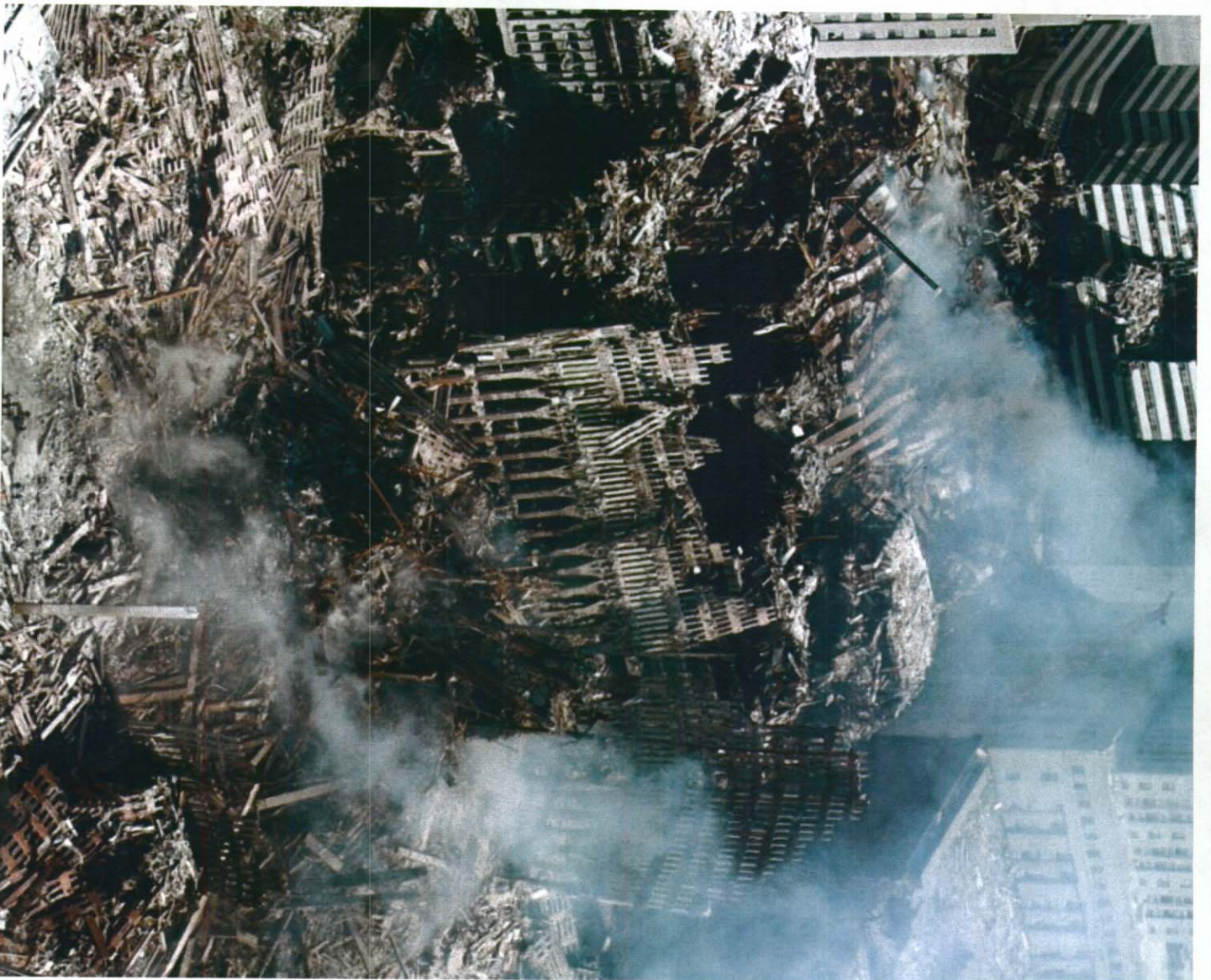
- Dust settled inside buildings/ventilation systems
- Dust resuspended from incompletely cleaned ventilation systems



Indoor dust exposures



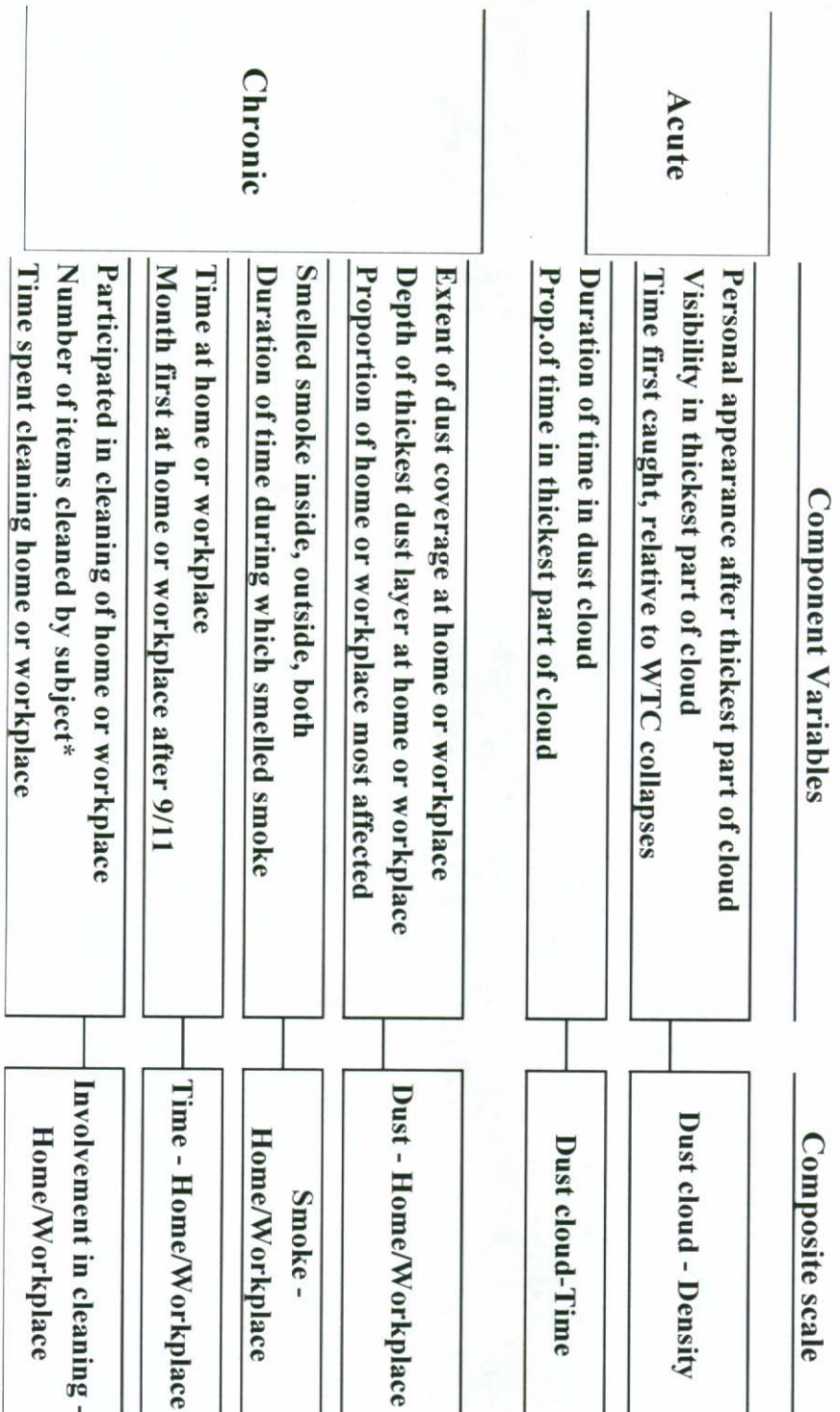
- Few residents evacuated
- Chemical composition similar to outdoor



Gases and fumes

- Fires burned through December 2001

Structure of composite exposure scales generated by principal components analysis of DOHMH WTC Registry study



Maslou *et al.* Chronic and acute exposures to the WTC disaster and lower respiratory symptoms” area residents and workers, Am J Pub Health in press 2011

Disease assessment in the community

- October 11, 2001 – Pace University Community Forum
- Academic-community coalitions
 - FDNY
 - Organized labor/Occupational clinics/Local politicians
 - WTC Workers Medical Screening/Monitoring/Treatment program
- Community

WTC Residents Respiratory Health Study



- Collaborative effort of NYU, New York State Department of Health and local community
- Funded by CDC and NIH(NIEHS)
- Cross-sectional study of control and exposed population designed, implemented and completed 16 months after 9/11/01
- Responses analyzed from 2,812 individuals

Persistent^b new-onset respiratory symptoms in “previously normal” residents

| | Exposed (n=2410) | Control (n=271) | Crude Incidence ratio (95% CI)* |
|------------------------------|---------------------|--------------------|------------------------------------|
| Cough without cold,% | 16.0 | 4.0 | 3.99 (2.15-7.38)* |
| Daytime SOB, % | 10.6 | 3.6 | 2.94 (1.53-5.66)* |
| Wheeze, % | 10.5 | 1.6 | 6.50 (2.44-17.33)* |
| AM chest tightness, % | 8.4 | 1.6 | 5.21 (1.95-13.91)* |
| SOB after exercise, % | 7.4 | 1.7 | 4.45 (1.66-11.91)* |
| Night-time SOB, % | 6.2 | 0.8 | 7.64 (1.90-30.70)* |
| Any of the above symptoms, % | 26.4 | 7.5 | 3.53 (2.28-5.47)* |

^bSymptom frequency ≥ 2 days per week in the past 4 weeks.

* Effect still statistically significant after adjusting for age, gender, education, smoking and race.

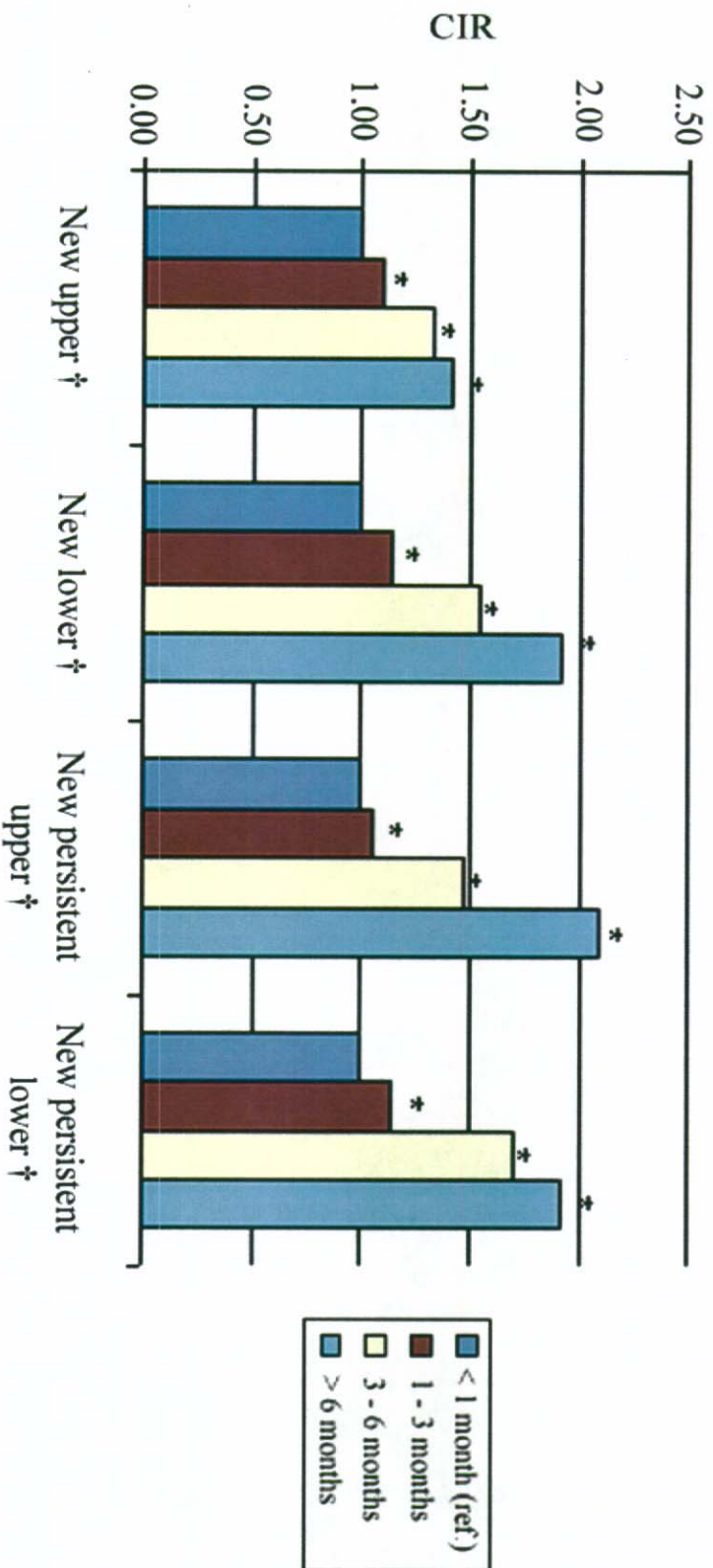
Increase in medical consultation and asthma medicine use in previously normal residents^a

| | Exposed (n=2410) | Control (n=271) | Crude IR (95% CI)* |
|---|---------------------|--------------------|-----------------------|
| Unplanned Medical Visits (in the past 12 months) | 13.7% | 7.8% | 1.77 (1.16-2.70)* |
| Fast Relief Med Use (in the past 4 weeks) | 8.0% | 3.3% | 2.41 (1.25-4.65)* |
| Controller Med Use (in the past 4 weeks) | 8.6% | 3.7% | 2.33 (1.25-4.34)* |

^a No diagnosis of asthma, chronic obstructive pulmonary disease, chronic bronchitis, or other lung disease before 9/11/2001.

* Effect still statistically significant after adjusting for age, gender, education, and race.

New onset symptoms associated with persistence of dust or odors in home



NYC DOHMH WTC Health Registry

- Studies increased respiratory symptoms in subsequent DOHMH WTC Registry studies in individuals surveyed between 2003 – 2004

WTC Environmental Health Center

- Bellevue Hospital/NYULMC
 - 2002 community collaborative pilot program for treatment of residents/area workers in the Bellevue Hospital Asthma clinic
- WTC Environmental Health Center
 - 2005 American Red Cross Liberty Disaster Relief Fund
 - 2006 funding from City of New York
 - 2008 first Federal funding (CDC-NIOSH)

WTC Environmental Health Center

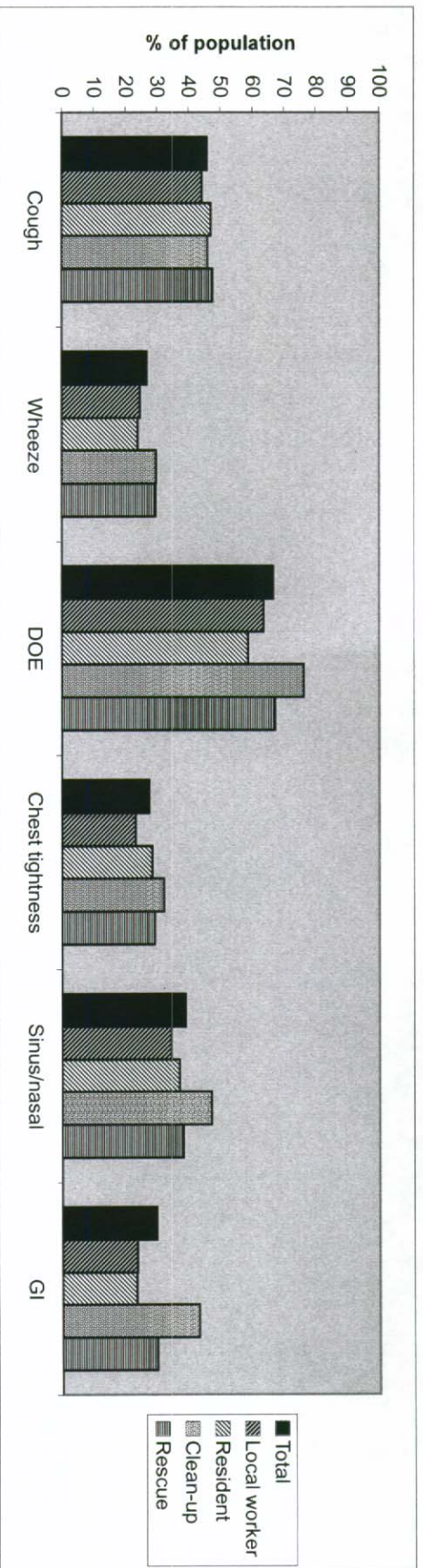
- Treatment program for individuals with presumed WTC-related illness
 - Had to have potential exposure (geographic boundaries)
 - Had to have symptom (initially physical, subsequently mental health or physical)
- Target populations: Non-rescue workers
 - residents
 - local workers
 - students
 - clean-up workers
- Multidisciplinary treatment program (medical, mental health, social services)
- Nearly 6,000 individuals enrolled between September 2005 to September 2011 for treatment

Characteristics of WTC EHC population enrolled 9/2005 – 5/2008 (N = 1898)

| Characteristic | Total |
|------------------|-----------|
| Gender, N (%) | |
| Male | 1005 (53) |
| Female | 893 (47) |
| Age, mean±SD | 48 ± 12 |
| Race, N (%) | |
| White | 867 (46) |
| Black | 318 (17) |
| Asian | 217 (11) |
| Ethnicity, N (%) | |
| Hispanic | 792 (42) |
| Dust cloud | 740 (40) |

Disease assessment – disease characteristics (symptoms)

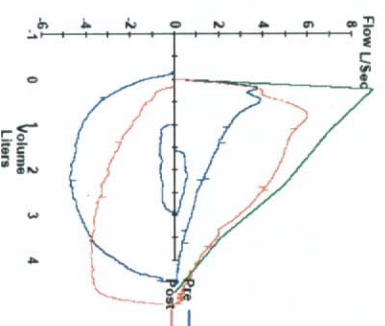
New onset persistent symptoms in previously normal WTC EHC populations (N = 1898)



Reibman *et al.* Characteristics of a residential and working community with diverse exposure to WTC dust, gas and fumes J Occup Env Med 2009

CASE MR

- 37 year old resident of Lower Manhattan (Beekman Street)
- Previously healthy (training for marathon), no history of childhood asthma/lifelong nonsmoker
- Not in dust cloud
- Stayed in apartment and cleaned dust-covered apartment
- Onset of shortness of breath and wheezing 6 months later
- Presented to WTC EHC in 2006 with persistent upper airway symptoms (nasal congestion, post nasal drip) and daily lower airway symptoms (shortness of breath, wheezing)
- Treated aggressively for asthma
- Continues to need therapy to control symptoms



Patterns of spirometry in WTC EHC patients with < 5 p-y tobacco use (N = 1109)

| Spirometry pattern | Total N=1109 |
|--|-----------------|
| Normal | 790 (71) |
| Obstructed ¹ , N (%) | 67 (6) |
| Low FVC ² , N (%) | 224 (20) |
| Obstructed and low FVC ³ , N (%) | 28 (3) |

How can we explain respiratory symptoms in population with normal lung function

- Hyperresponsiveness?
- Spirometry unable to detect small airway damage?
- Other reasons – cardiac, mental health?

Disease assessment – disease marker

Spirometry in firefighters before and after 9/11

6-month exam
% predicted (L)

| | |
|-----------------------|-----------|
| FVC | 90 (4.63) |
| FEV ₁ | 90 (3.88) |
| FEV ₁ /FVC | 0.78 |

Spirometry in firefighters before and after 9/11

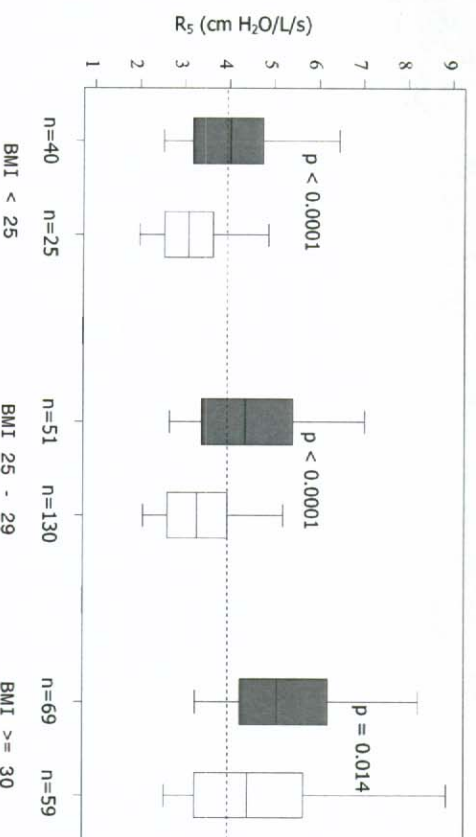
| | Pre-WTC % predicted (L) | 1-month exam % predicted (L) | 6-month exam % predicted (L) |
|-----------------------|----------------------------|---------------------------------|---------------------------------|
| FVC | 99 (4.94) | 94 (4.70) | 90 (4.63) |
| FEV ₁ | 103 (4.22) | 96 (3.97) | 90 (3.88) |
| FEV ₁ /FVC | 0.86 | 0.79 | 0.78 |

- 6 year assessment: FDNY lost 360 - 390 ml/year of FEV₁ (normal loss of 31 ml each year)

World Trade Center Health Impacts on FDNY Rescue Workers: A 6 Year Assessment 9/01 - 9/07 Fire Department, City of NY 2007

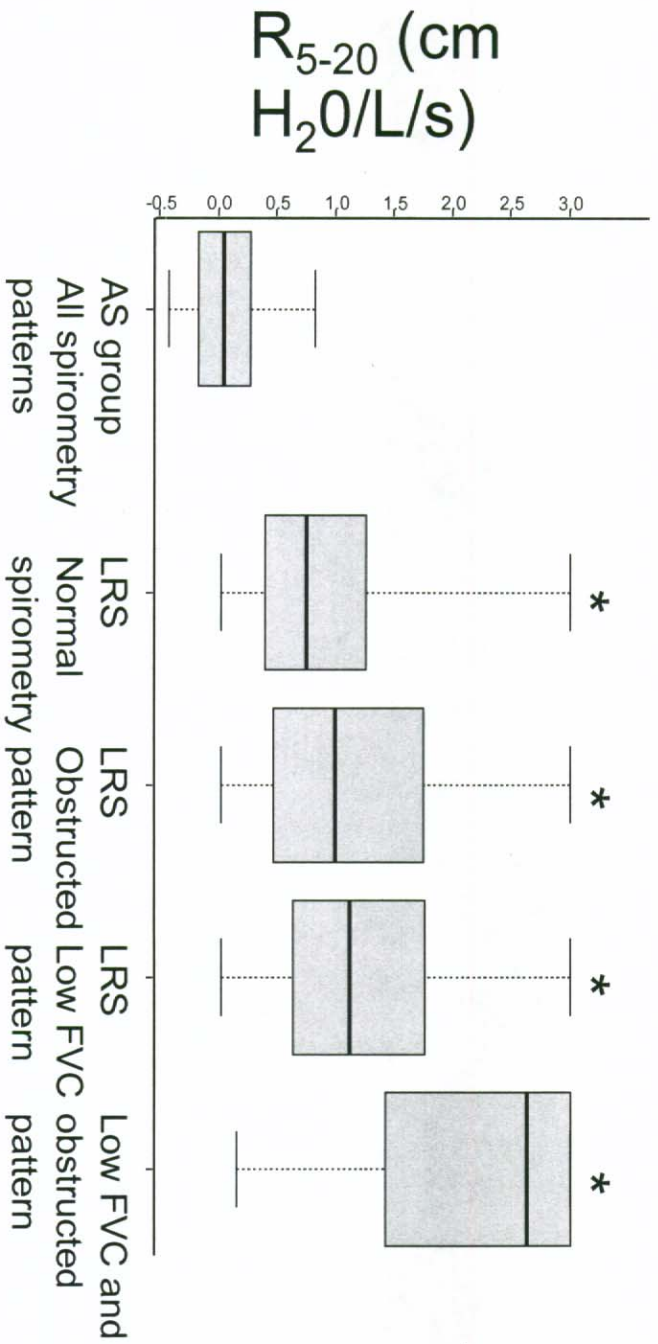
Impulse oscillometry as a non-invasive way to assess lung function, including distal airways

- IOS measures pressure waves applied externally to respiratory symptom at different oscillating frequencies
- Small studies of WTC patients suggested abnormalities in IOS (Oppenheimer et al. Chest 2007)
- Case-control study of DOHMH WTC Registry area residents and workers - elevated IOS measurements (R_5 , R_{5-20}) associated with symptoms even in those with normal spirometry



Friedman *et al.* Case-control study of lung function in World Trade Center Health Registry area residents and workers *Amer J Resp Crit Care Med* 2011

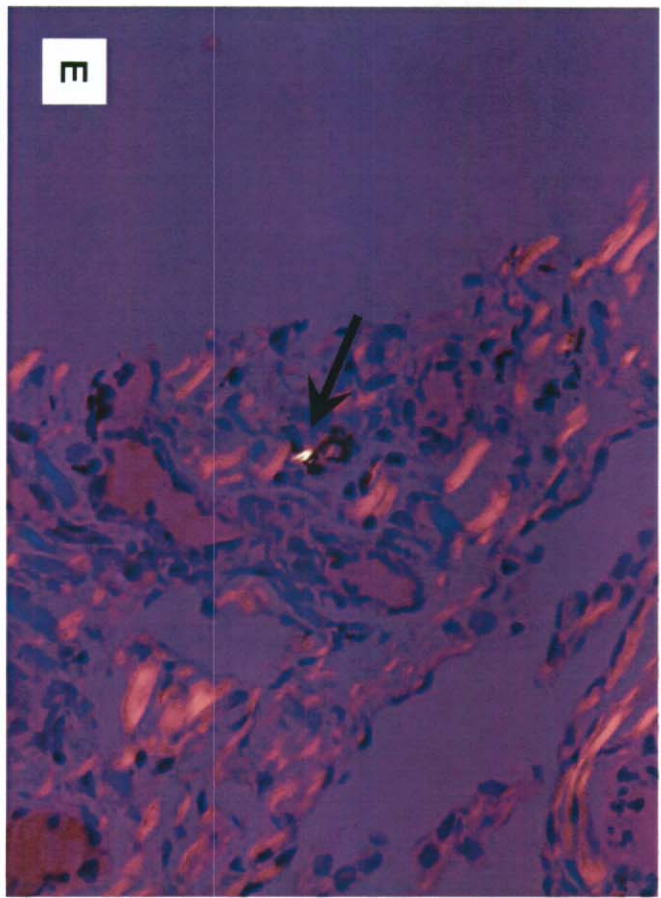
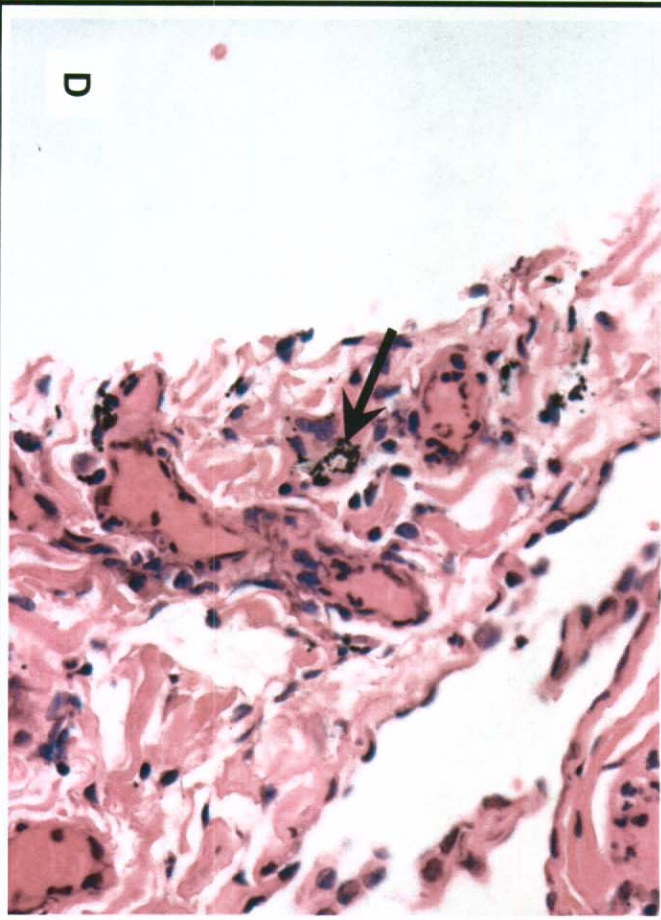
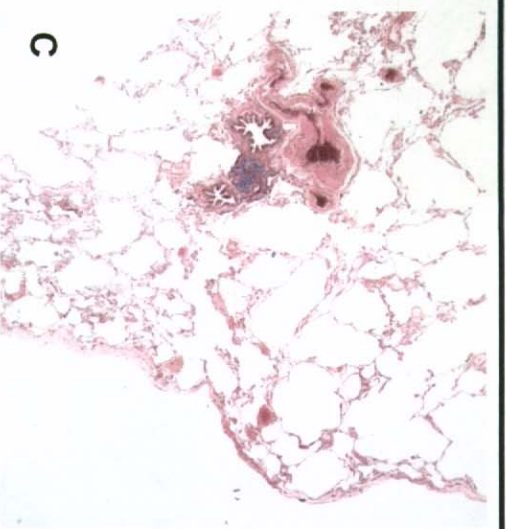
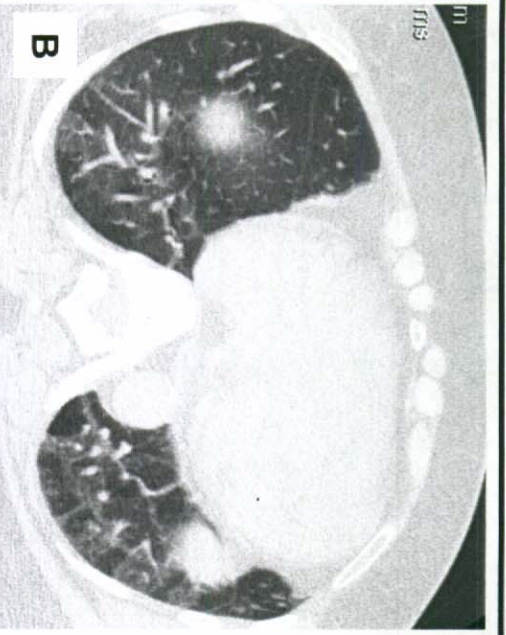
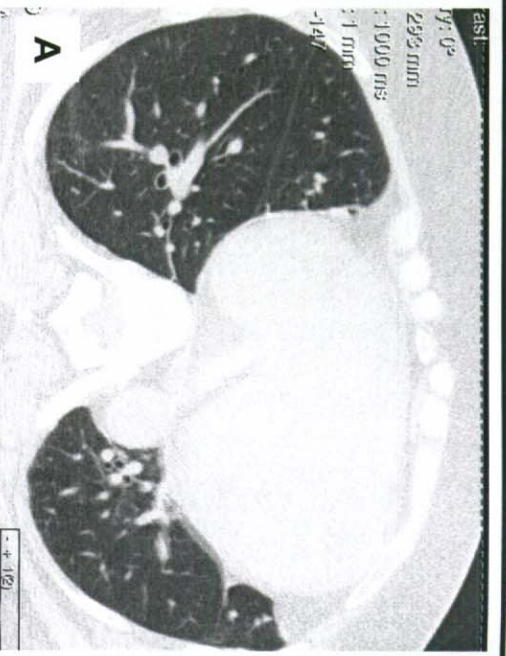
IOS (R5-20) was increased in WTC EHC patients compared to in asymptomatic control group



IOS increased with severity of symptom (wheeze)

Pathologic findings in WTC EHC patients

- Case series of patients (N = 12) who underwent VATS (video assisted thoracoscopic surgery) for clinical indications
- Pathologic findings
 - patchy interstitial fibrosis
 - bronchiolitis and small airways abnormalities
 - emphysematous changes in all
 - intracellular birefringent particles under polarizing light microscopy

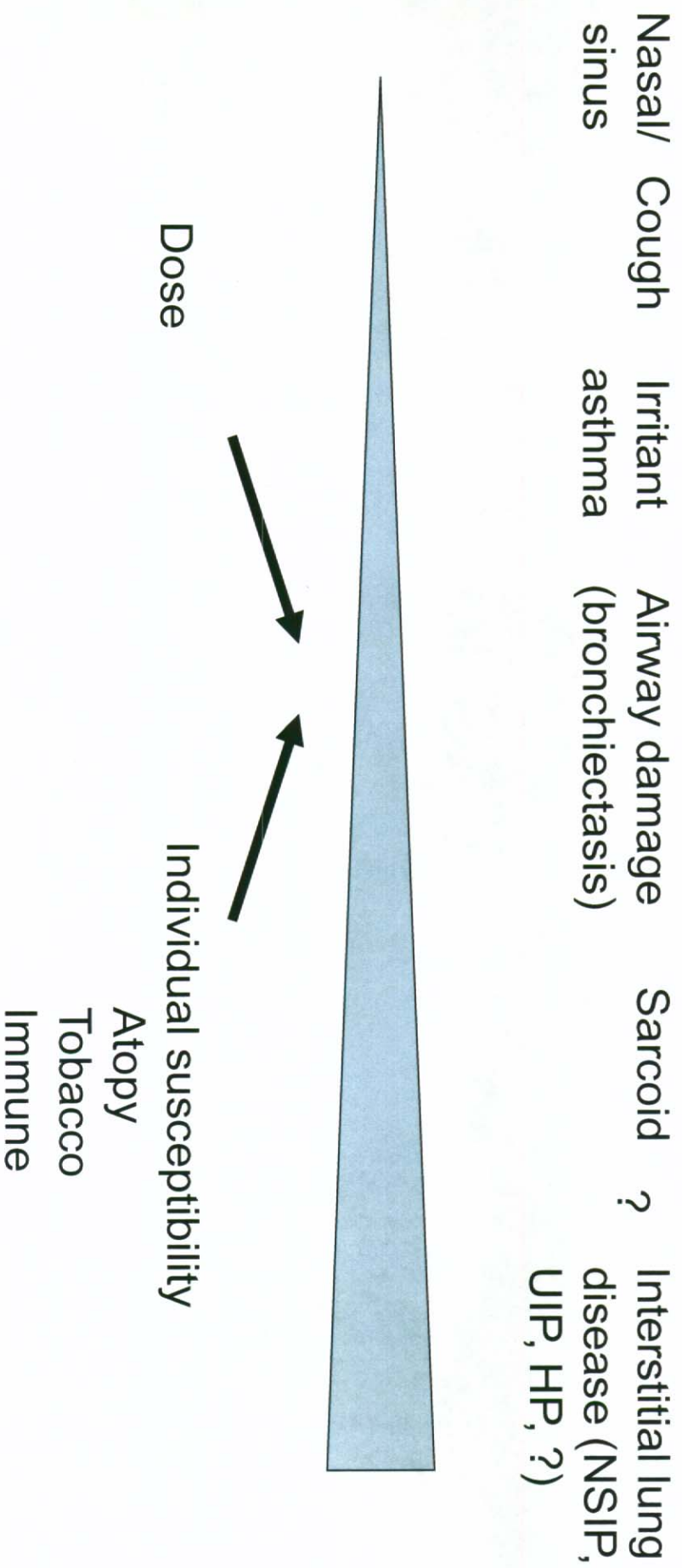


Particle analysis of lung biopsy specimens

- Scanning electron microscopy with energy dispersive x-ray spectroscopy (SEM-EDS) performed on 5 samples
- Silica
- Aluminum silicate
- Titanium
- Talc
- Metals – steel, copper, chromium,



Disease heterogeneity in response to environmental exposure



Lung function over time in community members enrolled in WTC EHC (linear annual change ml/year)

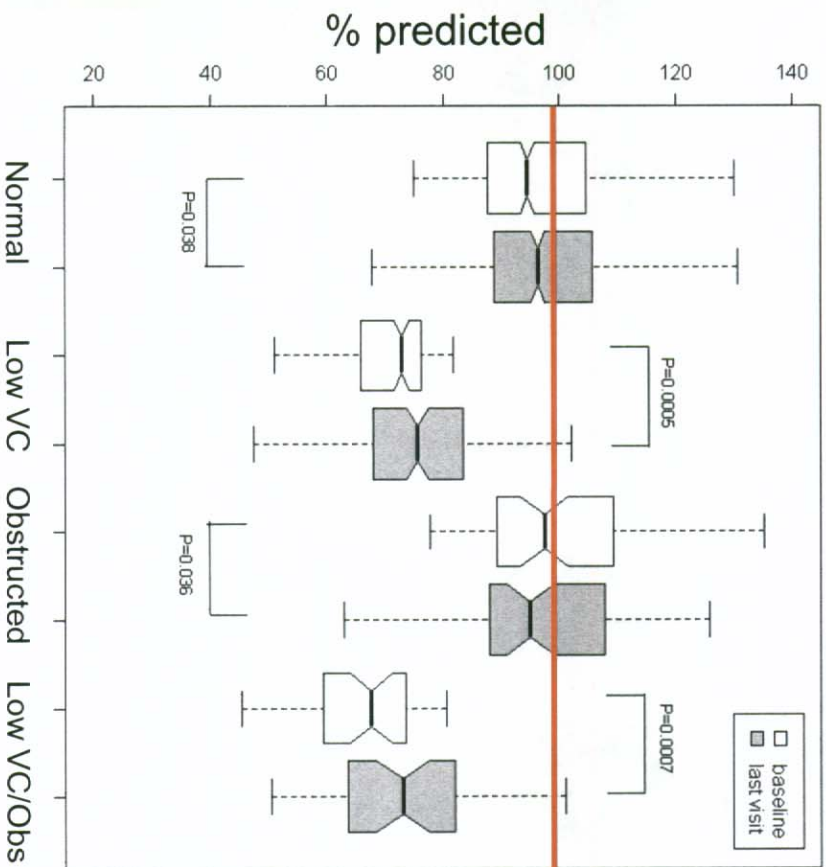
| | FVC | | | | FEV ₁ | | | |
|---------------------------|---------------------|----|-----------|---------|---------------------|----|----------|---------|
| | Estimate ml/year | SE | 95% CI | p-value | Estimate ml/year | SE | 95% CI | p-value |
| Total | 54 | 7 | (41,67) | <0.0001 | 30 | 5 | (19,40) | <0.0001 |
| Spirometry pattern | | | | | | | | |
| Normal | 43 | 8 | (28,58) | <0.0001 | 15 | 6 | (3,27) | 0.02 |
| Low FVC | 84 | 13 | (58,110) | <0.0001 | 37 | 9 | (18,56) | 0.0001 |
| Obstructed | -47 | 33 | (-115,20) | 0.163 | 46 | 22 | (2,91) | 0.04 |
| Low FVC/Obstru cted | 115 | 38 | (37,193) | 0.005 | 111 | 36 | (39,183) | 0.003 |

Linear mixed effects model adjusted for age, BMI, gender, race/ethnicity, dust-cloud exposure, smoking status, and WTC exposure category
Liu et al. manuscript submitted

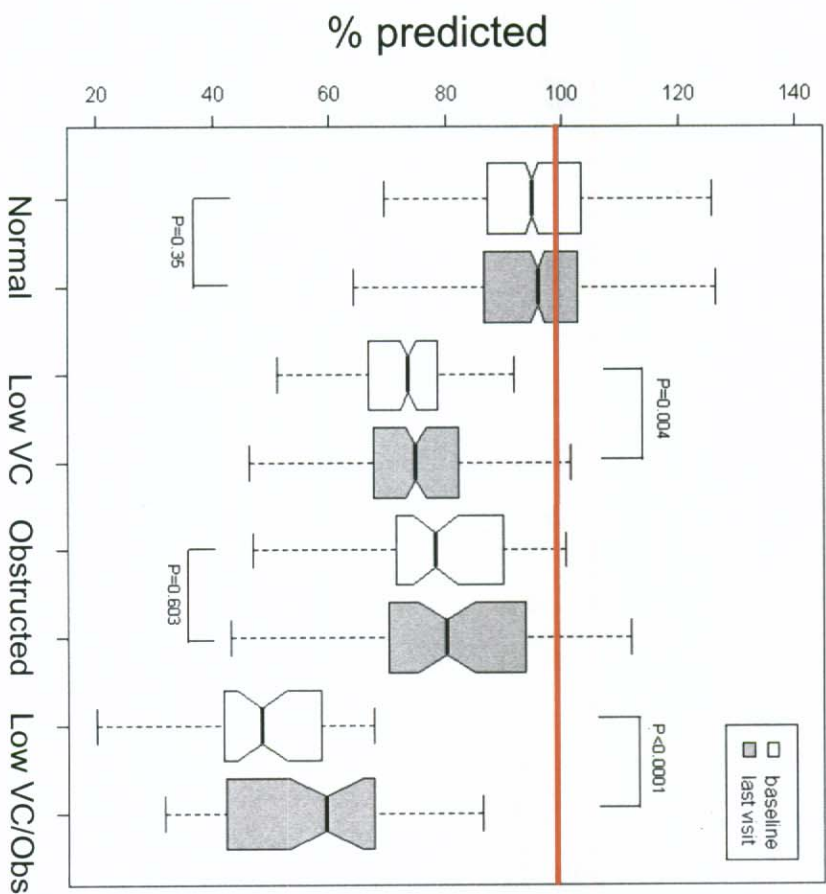
Spirometry in patients in the WTC EHC improved, but did not return to normal if baseline pattern was abnormal

(baseline (white) last visit (grey))

FVC



FEV₁



P-values calculated using Wilcoxon signed rank test for paired data
Liu et al. manuscript submitted

Lung function over time in community members enrolled in WTC EHC by target category (linear annual change ml/year)

| | FVC | | | | FEV ₁ | | | |
|------------------------------|------------------|----|----------|---------|------------------|----|----------|---------|
| | Estimate ml/year | SE | 95% CI | p-value | Estimate ml/year | SE | 95% CI | p-value |
| Total population | 54 | 7 | (41,67) | <0.0001 | 30 | 5 | (19,40) | <0.0001 |
| WTC exposure category | | | | | | | | |
| Resident | 53 | 18 | (18,88) | 0.003 | 26 | 13 | (0,51) | 0.05 |
| Local worker | 20 | 11 | (-2,41) | 0.075 | 7 | 9 | (-10,24) | 0.40 |
| Resc/recov | 69 | 10 | (50,88) | <0.0001 | 39 | 8 | (22,55) | <0.0001 |
| Clean-up | 114 | 29 | (56,173) | 0.0002 | 61 | 18 | (26,96) | 0.001 |

Linear mixed effects model adjusted for age, BMI, gender, race/ethnicity, dust-cloud exposure, smoking status
Liu et al. manuscript submitted

Risk for probable PTSD in Patients of the WTC EHC enrolled with physical symptoms 4-7 years after 9/11 (n = 1825)

| | N | (%) ¹ | % PTSD sx within each category | Adjusted OR ³ (95% CI) |
|-----------------------|------|------------------|--------------------------------------|--------------------------------------|
| Age | | | | |
| <25 | 30 | (1.6) | 33.3 | 1 |
| 25-44 | 612 | (33.5) | 41.5 | 0.91 (0.26-3.19) |
| 45-64 | 1023 | (56.1) | 45.0 | 1.11 (0.32-3.85) |
| 65+ | 160 | (8.8) | 28.8 | 0.68 (0.18-2.52) |
| Gender | | | | |
| Male | 954 | (52.3) | 40.4 | 1 |
| Female | 871 | (47.7) | 44.2 | 1.37 (1.00-1.87) |
| Race/Ethnicity | | | | |
| NH White | 577 | (31.6) | 35.9 | 1 |
| NH Black | 310 | (17.0) | 34.2 | 0.6 (0.38-0.92) |
| Hispanic | 725 | (39.7) | 51.3 | 1.23 (0.83-1.83) |
| Asian | 174 | (9.5) | 37.9 | 0.53 (0.26-1.08) |
| Income | | | | |
| < 15K/year | 775 | (42.5) | 53.8 | 2.97 (2.06-4.28) |
| >15 – 30K/year | 327 | (17.9) | 43.4 | 1.90 (1.24-2.91) |
| >30K/year | 684 | (37.5) | 28.4 | 1 |

Probable PTSD in Patients of the WTC EHC enrolled with physical symptoms 4-7 years after 9/11 (n = 1825)

| Exposure Category | N | (%) ¹ | % PTSD sx within each category | Adjusted OR ³ (95% CI) |
|----------------------|------|------------------|--------------------------------|-----------------------------------|
| Local worker | 782 | (42.9) | 38.2 | 1 |
| Clean-up worker | 440 | (24.1) | 54.8 | 0.74 (0.42-1.3) |
| Resident | 364 | (20.0) | 37.6 | 0.81 (0.53-1.23) |
| Rescue/recovery | 184 | (10.1) | 41.3 | 1.45 (0.86-2.45) |
| Other | 55 | (3.0) | 30.9 | 0.71 (0.32-1.58) |
| Dust cloud | | | | |
| No | 981 | (54.7) | 38.1 | 1 |
| Yes | 813 | (45.3) | 46.7 | 2.12 (1.54-2.93) |
| Respiratory symptoms | | | | |
| Upper and lower | 423 | (26.8) | 56.7 | 2.81 (1.8-4.38) |
| Lower only | 659 | (41.7) | 41.3 | 1.45 (0.96-2.19) |
| Upper only | 155 | (7.7) | 38.8 | 1.71 (0.94-3.1) |
| Neither | 378 | (23.9) | 25.4 | 1 |
| Dyspnea score | | | | |
| >3 | 245 | (20.5) | 58.8 | 2.39 (1.64-3.49) |
| ≤3 | 949 | (79.5) | 31.4 | 1 |
| Spirometry category | | | | |
| Normal | 1054 | (69.5) | 41.2 | 1 |
| Abnormal | 462 | (30.5) | 42.6 | 0.87 (0.62-1.22) |

Preliminary data on children ≤ 18 on 9/11 Demographic characteristics (n = 87*)

| Characteristic | |
|---------------------|-----------|
| Sex, % | |
| Female | 55.0 |
| Male | 45.0 |
| Age on 9/11 (range) | 11 (0-18) |
| Race/Ethnicity, % | |
| White | 53.2 |
| Black | 13.1 |
| Hispanic | 23.9 |
| Asian | 9.8 |

Children included if ≤ 18 on 9/11 (n = 156) and had complete data set (n = 87)

Trasande and Fiorino et al. manuscript in preparation

Exposure characteristics of children in the WTC

EHC

| Exposure characteristics | |
|---|------|
| Caught in dust cloud, % | 38.5 |
| Heavy volume of dust in clothing, hair, % | 22.5 |
| Dust in home, % | 36.7 |
| Heavy dust in home, % | 18.6 |
| School in Southern Manhattan, % | 61.4 |

Presence in dust cloud and risk for abnormal lung function in children

New asthma diagnosis in 22.6%, mean latency of 3.2 years

| | OR | P value |
|-----------------------------|-----|---------|
| FEV ₁ < LLN | 2.5 | ns |
| FVC < LLN | 3.9 | ns |
| FEV ₁ /FVC < LLN | 5.6 | 0.02 |
| FEF 25-75 < LLN | 3.3 | 0.09 |
| Obstructive pattern | 8.8 | 0.009 |

LLN = lower limit of normal
Data adjusted for BMI category

Unanswered questions in the “survivor” population

- Medical questions
 - Cancer risk
 - Lung disease – long term progression, types, how to treat
 - Connective tissue disorders
 - Neurologic sequela – headaches, neuropathy
 - Vulnerable populations
- Mental health
 - who is at risk for persistent PTSD
 - long term outcomes
 - treatment of PTSD in civilian populations and associated with complex mental health and physical co-morbid conditions and socioeconomic issues
- risk for cognitive defects with intractable PTSD

Unanswered questions in the “survivor” population

- Children
 - Medical
 - What are their lung risks
 - Are there developmental/endocrinologic risks
 - Mental health

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Community

organizations
Beyond Ground Zero
Network
9/11 Environmental
Action
Battery Park Residents
Coalition
Independence Plaza
Tenants Org
Southbridge Tenants Org

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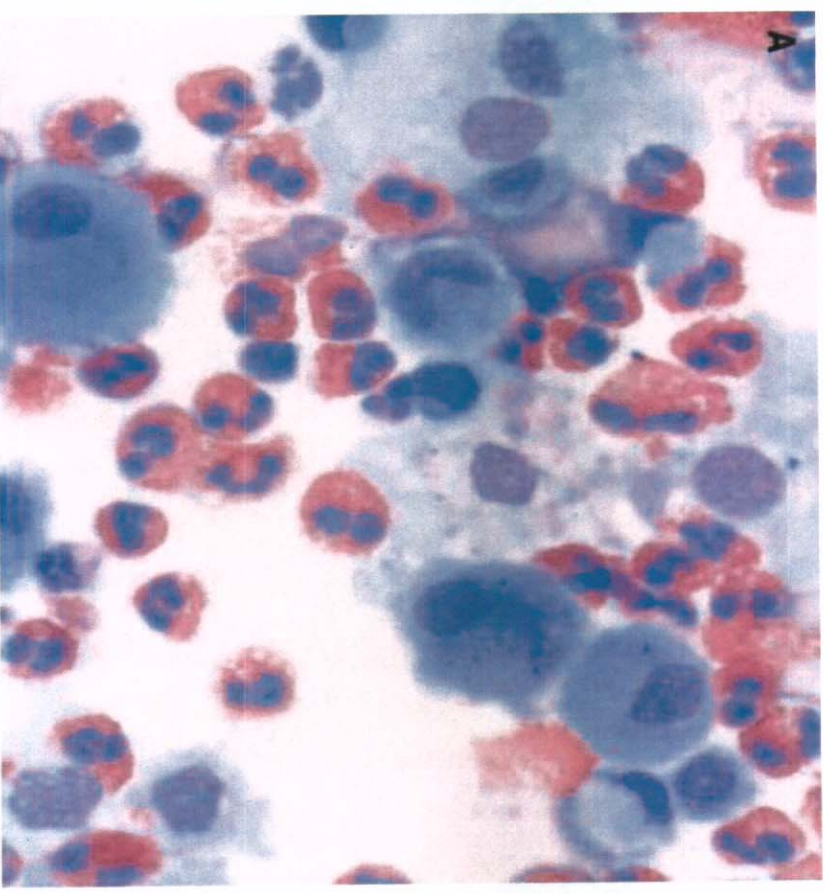
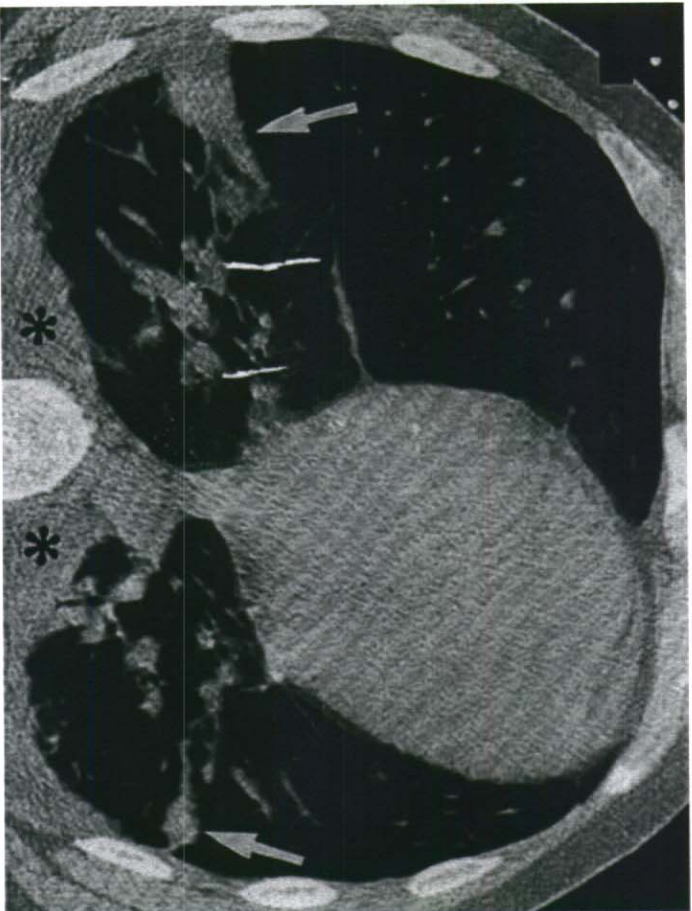
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Early onset disease: Acute eosinophilic pneumonia in a firefighter



Mineralogic analysis of bronchoalveolar lavage from firefighter



(A) Amosite asbestos fiber (uncoated)



(B) Fly ash particle



(C) Degraded fibrous glass.