Detroit Exposure Aerosol Research Study (DEARS)

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Personal Exposure Research -
Issue

- Individuals experience adverse health effects from PM in the air they breathe (personal exposure)
- EPA regulations to protect human health are based on ambient monitoring data
- Epidemiological studies that show adverse health effects to PM use ambient monitoring data as an estimate of personal exposure
Personal Exposure – Key Questions

- What are the relationships between PM concentrations measured at ambient sites and indoor, outdoor, personal exposure?
- Can PM measurements at central sites adequately represent exposures to ambient PM?
- Do the relationships differ for toxic components of PM? For PM from sources?
Personal Exposure – Key Questions

- Can models be used to improve estimates of exposure from ambient site measurements?
- Can models be used to better understand the relationships between PM sources, ambient air concentrations, and personal exposure?
• Where have we been?
  – NRC 1: Understanding the relationship for PM mass, short-term exposures

• Where are we going?
  – NRC 2: PM for toxic components
  – PM from sources
  – Spatial Variability
  – Chronic exposures
  – Integrating information from source to health effects
Findings from Previous Studies

• For fine PM and sulfates correlations between ambient sites and indoor air or personal exposure is relatively good
  – For community-based epi studies, the ambient monitor should be adequate exposure surrogate

• Attenuation factor ranges from <0.2 to 1.0
  – Strength of the health impact may be underestimated

• Use of personal exposure data in health studies shows greater health impacts
Findings from Previous Studies

- Attenuation factor varies by city and season
  - A single nationwide standard may provide a different level of protection for different populations
- Housing type and ventilation are key factors for attenuation.
- Poor correlations for several species; ultrafine, nitrates, EC, organics
  - Epi studies using ambient monitors may not be able to show health effects
- Criteria gases correlate with fine PM at ambient site but not at person
  - Criteria gases are surrogates not confounders of exposure in epi studies
What’s Next?

• In 10 years, EPA’s regulations will dramatically reduce fine particle sulfate
• These species are well-behaved; exposure and health effects can be reasonably predicted from ambient monitoring data
• What about the species that are left in the air and all of the species measured at Supersites?? Research is needed to
  – Describe the relationship between ambient levels and exposure
  – Determine if epidemiological studies can be used to evaluate health impacts (can ambient monitoring data with or without modeling be used as surrogates)
  – Improve exposure and risk assessments
DEARS- GOAL

• Describe/model the relationship between concentrations at a central site and residential/personal concentrations for
  – PM constituents,
  – PM characteristics
  – PM from specific sources (mobile and point)
  – Air toxics
Emphasis placed on understanding impact of:

– Local sources (mobile and point) on outdoor residential concentrations,

– Housing type and house operation on indoor concentrations

– Locations and activities on personal exposure
Why Detroit?

- Currently in non-attainment for PM$_{2.5}$
- Projected non-attainment status after sulfur reductions in 2010
- Large number of industrial point sources
- Heavy mobile source impact including diesel
- Should be spatial distribution of concentrations
- Summer and winter seasons
- Speciation Trends Network site and National Air Toxics Network Site
- State and local interest
- Existing community partnerships
Field Monitoring Design

- 3 to 4 year study starting in Summer 2004
- Collect data in 120 homes for 5 days in winter and 5 days in summer (1200 sampling days)
- Concurrent monitoring at
  - Central site
  - Residential – outdoors and indoors
  - Person
- Survey data
  - Residential characteristics, participant characteristics, time/activity, source usage.
Study Design

Physical/chemical factors that impact spatial variability and outdoor/ indoor concentrations

– residential location relative to sources and central site monitor
– composition and strength of source emissions
– meteorology
– regional concentrations
– air exchange rates
– housing characteristics/HVAC operations
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Personal</th>
<th>Indoor</th>
<th>Outdoor</th>
<th>Ambient</th>
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<tbody>
<tr>
<td><strong>PM$_{2.5}$</strong> (mass, elements)</td>
<td>x</td>
<td>x</td>
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<td>x</td>
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<tr>
<td><strong>PM$_{\text{coarse}}$</strong> (mass, elements)</td>
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<td>x</td>
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<td>EC/OC (PM$_{2.5}$)</td>
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<tr>
<td>EC (PM$_{2.5}$)</td>
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<td>Nitrate</td>
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<td>Gases</td>
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<td>x</td>
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<td>Carbonyls</td>
<td>x</td>
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<td>Air Exchange</td>
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Monitoring locations- 7 selected based on proximity to sources
Source Apportionment

- Conducted at central site, indoors, and outdoors
- Detailed analysis for source markers
  - elements, EC/OC, sulfate, nitrate, carbonyls (e.g. acrolein), VOCs (e.g., 1,3 butadiene), Hopanes, alkanes, PAHs, and levoglucosan
- Source apportionment using the latest approaches (e.g., multilinear engine, positive matrix factorization) that incorporate exposure, human activity and environmental survey information
Modeling

- **Spatial analysis**
  - Spatial variability in concentrations
  - Relationship between residential and source location
  - Combine monitoring data with air quality model output to improve spatial analysis

- **Air quality modeling**
  - Urban-scale modeling of key sources: impact on residential monitoring locations
  - Regional-scale modeling for transport into airshed

- **Exposure modeling**
  - Links concentrations with population and the activities that impact exposures
  - Predict population exposures due to time spent in residential locations, work/school locations, vehicles
Detroit Study – Other Elements

- Mobile Source Characterization
- Toxicity Studies of PM from major sources
- Detroit Asthma Study
- EPRI Health Study
- Field evaluation of PM_{coarse} sampler
- Evaluation of biogenic markers for PM
- Intensive ambient sit monitoring
Progress to Date-September 2004

- Formal OMB, IRB and EPA approval of DEARS
- Development of community and collaborative support
- Initiation of DEARS field monitoring
- Completion of first season of DEARS field measurements
Summary

• A well-characterized air shed
• Extensive exposure data, including source apportionment
• Modeling to describe exposure variability
• We are looking for more partners to model data and conduct health studies
• COME ON DOWN