Personal Exposure to Particles and Gaseous Pollutants

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Indoor Exposure Assessment Section
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Today’s Presentation

Background
- Personal exposure, personal monitoring
- Physical properties and health effects of ultrafine particles (UFP)

Recent personal monitoring study (CARB)

Summary
- Lessons learned
- Future directions
Background
How is Exposure Defined?

Exposure not the same as concentration

Concentration – mass per unit volume

Exposure – Concentration x time (duration of exposure)

“the contact of a chemical, physical, or biological agent with the outer boundary of an organism” (Berglund et al. 2002)

Dose – Exposure x dosimetry factor

Amount of pollutant that enters body
Ambient vs Personal Monitoring

Ambient monitoring

- Does not accurately estimate personal exposure
- Ambient monitors - not in “breathing zone” of subject
- Incomplete time/activity
  - Exposures do not stop at the entrance to home or work
- Early studies (e.g. PTEAM) – $PM_{10}$ exposures 1.5x higher than determined by ambient

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Map showing areas of interest.
Personal monitoring
- Worn by participant
- Near real-time, short term exposure
- High spatial and temporal resolution

UFP – Greater spatial and temporal variability than larger particles

UFP – Physical Properties and Health Effects

UFP exposure and health effects not at well understood as larger particles

<0.10 µm in size

Human hair 50-70µm

Negligible mass

Quantified by particle # conc or surface area

Proximity to source can greatly affect UFP exposure

Pilot Study
Personal Exposure Pilot Study

Exposures to UFP, CO, NO$_2$, PM$_{2.5}$

Study Aims

- Determine pollutant concentrations for different microenvironments and activities
- Estimate relative contributions of pollutants from indoor and outdoor microenvironments to personal exposure
- Determine feasibility of larger exposure study in the future
  - Evaluate sampling backpack and UFP monitor (usability for future studies)
Study Design

15 participants (12 CARB staff and 3 children)

Backpack with Instruments: DiSCmini (UFP), TSI AM520* (PM$_{2.5}$), CairClip (NO$_2$), Langan T15n (CO), Qstarz GPS

*Only 3 participants
Study Design (con’t.)

Baseline survey

Daily activity diary/GPS

Backpacks carried for two 48h periods (later reduced to 24)
  One weekday and one weekend day (Sacramento area)

30 exposure profiles collected
  (626 hours of data - 87% completeness)

Exit survey

Six microenvironments defined (plus activities)
  1. Indoors at home (cooking, smoking, candle or incense burning)
  2. Outdoors Near Home (gardening)
  3. In Transit (driving, bus, train, biking, walking, etc.)
  4. At Work
  5. Outdoors Away Home
  6. Indoors Away from Home (restaurant, etc.)
Key Results
## Concentration of UFP and PM$_{2.5}$ in Each Microenvironment

<table>
<thead>
<tr>
<th>Concentration by Microenvironment</th>
<th>% Time</th>
<th>Mean</th>
<th>SD</th>
<th>5%</th>
<th>Med</th>
<th>95%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UFP Concentrations (Part. #/cc)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indoors at Home</td>
<td>59</td>
<td>10620</td>
<td>45538</td>
<td>575</td>
<td>3072</td>
<td>30489</td>
</tr>
<tr>
<td>Outdoors near Home</td>
<td>2</td>
<td>19107</td>
<td>17574</td>
<td>1415</td>
<td>13650</td>
<td>55278</td>
</tr>
<tr>
<td>In Transit</td>
<td>9</td>
<td>14674</td>
<td>60115</td>
<td>1247</td>
<td>7878</td>
<td>35105</td>
</tr>
<tr>
<td>At Work</td>
<td>16</td>
<td>5412</td>
<td>18277</td>
<td>582</td>
<td>2243</td>
<td>18147</td>
</tr>
<tr>
<td>Outdoors away from Home</td>
<td>3</td>
<td>11435</td>
<td>11640</td>
<td>526</td>
<td>9807</td>
<td>30902</td>
</tr>
<tr>
<td>Indoor away from Home</td>
<td>11</td>
<td>21489</td>
<td>58489</td>
<td>1045</td>
<td>4686</td>
<td>95191</td>
</tr>
<tr>
<td><em><em>PM$_{2.5}$ Concentrations (µg/m$^3$)</em> n=3</em>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indoors at Home</td>
<td>60</td>
<td>15</td>
<td>15</td>
<td>7</td>
<td>11</td>
<td>24</td>
</tr>
<tr>
<td>Outdoors near Home</td>
<td>1.5</td>
<td>16</td>
<td>2</td>
<td>13</td>
<td>16</td>
<td>18</td>
</tr>
<tr>
<td>In Transit</td>
<td>10</td>
<td>23</td>
<td>26</td>
<td>4</td>
<td>18</td>
<td>40</td>
</tr>
<tr>
<td>At Work</td>
<td>21</td>
<td>5</td>
<td>8</td>
<td>2</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>Outdoors away from Home</td>
<td>2.5</td>
<td>21</td>
<td>3</td>
<td>17</td>
<td>21</td>
<td>24</td>
</tr>
<tr>
<td>Indoor away from Home</td>
<td>5</td>
<td>37</td>
<td>95</td>
<td>5</td>
<td>21</td>
<td>39</td>
</tr>
</tbody>
</table>

* 24h NAAQS – 35µg/m$^3$
## Concentrations of CO in Each Microenvironment and NO$_2$ Indoors

<table>
<thead>
<tr>
<th>Concentration by Microenvironment</th>
<th>% Time</th>
<th>Mean</th>
<th>SD</th>
<th>5%</th>
<th>Med</th>
<th>95%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CO Concentrations (ppm)</strong>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indoors at Home</td>
<td>59</td>
<td>0.48</td>
<td>0.68</td>
<td>0.03</td>
<td>0.23</td>
<td>1.53</td>
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<tr>
<td>Outdoors near Home</td>
<td>2</td>
<td>0.44</td>
<td>0.48</td>
<td>0.01</td>
<td>0.16</td>
<td>1.23</td>
</tr>
<tr>
<td>In Transit</td>
<td>9</td>
<td>0.69</td>
<td>1.11</td>
<td>0.04</td>
<td>0.43</td>
<td>2.08</td>
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<tr>
<td>At Work</td>
<td>16</td>
<td>0.36</td>
<td>0.51</td>
<td>0.01</td>
<td>0.18</td>
<td>0.98</td>
</tr>
<tr>
<td>Outdoors away from Home</td>
<td>3</td>
<td>0.48</td>
<td>0.71</td>
<td>0.00</td>
<td>0.24</td>
<td>1.88</td>
</tr>
<tr>
<td>Indoor away from Home</td>
<td>11</td>
<td>1.00</td>
<td>1.52</td>
<td>0.07</td>
<td>0.36</td>
<td>4.85</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>NO$_2$ Concentration (ppb) indoor only</strong>**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indoors at Home</td>
</tr>
<tr>
<td>Indoor away from Home</td>
</tr>
</tbody>
</table>

*CA 8hr CO std – 9.0 ppm

**CAAQS Annual NO$_2$ – 30 ppb
UFP Concentrations by Activity

Transit and Outdoor

Indoor

Particle #/CC

* (P<0.05)

Mean particle count

Biking  Bus  Driving  Train(RT)  Motorcycle  Walking  Gardening  Indoor Baseline  Cooking (self)  Cooking (other)  Cooking Gas  Cooking Elec
Estimated Microenvironmental Contributions to Total UFP Exposure (24h)

- Indoors at home: 37%
- Indoors away from home: 15%
- At Work: 7%
- In Transit: 11%
- Outdoors Near Home: 3%
- Outside away from home: 2%

Indoor total = 84%
**PM$_{2.5}$ Concentrations by Activity**

* *n=3 participants for total of 6 profiles (0 cooking w/electricity)*
Estimated Microenvironmental Contributions to Total PM$_{2.5}$ Exposure (24 h)

Indoors at home: 53%
Indoors Cooking: 14%
In Transit: 15%
At Work: 7%
Outdoors Near Home: 2%
Outside away from home: 3%
Indoors away from home: 6%

Indoor total = 80%
NO$_2$ Concentration by Cooking Activity

![Chart showing NO$_2$ concentration by cooking activity]

- **Indoor Baseline**
- **Cooking (self)**
- **Cooking (other)**
- **Cooking Gas**
- **Cooking Elec**

**CAAQS 30ppb (annual)**
Summary
Conclusions

Pilot Study

> 80 percent of individual’s UFP and PM$_{2.5}$ exposure occurs within indoor microenvironments

Insight into peak concentrations

- Cooking and traffic sources
- Help minimize peak exposures

PM concentration and exposure in buses/vehicles/light rail relatively low

Indoor CO and NO$_2$ exposures - elevated for cooking activity but generally low

Backpack and DiSCmini worked well for personal UFP measurements
Limitations and Future Directions

**Limitations and lessons learned**

- Small sample size
  - CARB staff not representative of California population
  - One person in extreme environment can skew results
- Longer data collection time and/or equipment responsibilities decreased compliance
- Incorrect recall or incomplete activity diary
  - GPS useful tool for confirming some activities

**Future directions**

- Personal exposures within EJ communities
- Full scale personal exposure study
Thank You