Air pollution and cardiovascular disease

Antonella Zanobetti
Harvard T.H. Chan School of Public Health
Introduction

- Air pollution has been consistently associated with both acute and chronic adverse health:
  - Cardiovascular mortality & morbidity
  - Respiratory mortality & morbidity
  - Cerebrovascular events
  - Lung cancer
  - Neurodegeneration (e.g. Parkinson's & Alzheimer's)

- Ambient particulate pollution and traffic have been linked to:
  - myocardial infarction
  - cardiac death risk
  - sudden deaths, arrhythmias

- People with diabetes have twice the risk of PM-associated heart disease compared to those without diabetes.
- Elderly
- Subjects with previous hospitalizations
Potential Mechanisms

• A number of potential pathways have been proposed to explain the associations between short-term and long-term exposure to particulate air pollution and cardiovascular health, including:
  – increased oxidative stress
  – systemic inflammation
  – changes in autonomic function
  – autonomic dysfunction
  – cerebrovascular dysfunction

• The specific underlying biological pathways are poorly understood and the identification of these mechanistic pathways warrants further study.
Study the physiologic mechanisms by which ambient air pollution mediates adverse cardiovascular effects

- Panel/longitudinal studies:
  - Cardiac Rehabilitation Program of the Brigham and Woman Hospital
    - heart rate variability, blood pressure, T-wave alternans
  - Diabetic subjects from Joslin diabetes Center
    - Baseline brachial artery diameter (vascular function)
- VA Normative Aging Studies
  - Arrhythmias
Cardiac Rehabilitation Program

**Population:** 66 39- to 86 year old Boston residents
  – total of 641 visits between 1999 and 2001

**Protocol:**
- Treadmill, bicycle exercise, or weight training.
- Baseline questionnaires on patients characteristics.
- Height, weight, and blood pressure were measured

- Post-hospitalization had repeated visits every 3 months with Holter monitoring for 24 hours.
  - Visit 1: directly post MI (2 to 4 weeks after hospital discharge).
  - Visits 2-4: every 3 months
Data

• **Diary data**
• From questionnaire we determined the location and we classified each subject as:
  – Home, not home, at home only part of the previous 2 hours
  – In traffic in the previous 2 hours defined as: riding a car, bus, subway or train.

• **Exposure assessment**
• Ambient monitor by the Harvard School of Public Health:
  • Hourly Ambient PM$_{2.5}$
  • Hourly Ambient Black Carbon
Ambient pollution and blood pressure in cardiac rehabilitation patients

- Particulate pollution may lead to increased resting BP
- May partially explain the association of pollution with increased risk of acute cardiac events.
- The longer cumulative particle effects (48 to 120 hours), suggest that the mechanism of action of pollution on blood pressure may involve systemic inflammation and subsequent endothelial dysfunction, rather than more immediate effects of autonomic dysfunction.


Percent increase in resting blood pressure for an increase (10th to 90th percentile) in average PM$_{2.5}$ for the previous 48, 72, 96, and 120 hours

Percent change in DBP, SBP and MAP

Averaging time for PM$_{2.5}$
Reduction in Heart Rate Variability with traffic and air pollution in coronary artery disease patients

Following hospitalization for coronary artery disease, both particulate pollution, and being in traffic, a marker of stress and pollution, were associated with decreased HRV.

<table>
<thead>
<tr>
<th>Exposure</th>
<th>r-MSSD Percent change</th>
<th>95% CI</th>
<th>HF Percent change</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-hr mean ambient PM$_{2.5}$</td>
<td>-2.0</td>
<td>(-3.3, -0.6)</td>
<td>-5.2</td>
<td>(-9.2, -1.1)</td>
</tr>
<tr>
<td>In traffic, past 2 hr</td>
<td>-15.2</td>
<td>(-24.8, -4.4)</td>
<td>-39.2</td>
<td>(-58.0, -12.0)</td>
</tr>
<tr>
<td>In traffic, part of the past 2 hr</td>
<td>-2.8</td>
<td>(-5.4, -0.2)</td>
<td>-4.8</td>
<td>(-12.4, 3.4)</td>
</tr>
</tbody>
</table>

T-wave alternans (TWA), air pollution and traffic in high-risk subjects

- Cardiac electrical instability proposed as potential mechanism for pollution-related adverse cardiac outcomes, particularly malignant arrhythmias

- T-wave alternans (TWA)

- Marker of cardiac electrical instability and predictor of increased risk of ventricular arrhythmias and fibrillation

- Measured as differences in the amplitude between adjacent T waves, within each 30 minutes period

We investigated associations of
- BC, PM$_{2.5}$, being in traffic
with risk of increase in TWA in subjects post-hospitalization

Percent change in maximum TWA for 10 mg/m$^3$ a increase in ambient and indoor PM$_{2.5}$ and 1 mg/m$^3$ increase in BC (n=48 subjects, 5,830 half-hour observations)

We found significant associations between TWA-MAX and ambient PM$_{2.5}$ and BC, indoor pollution and being in traffic

<table>
<thead>
<tr>
<th></th>
<th>PM$_{2.5}$</th>
<th>BC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>95% C.I.</td>
</tr>
<tr>
<td><strong>Ambient central site pollution</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean 2 hrs</td>
<td>1.7</td>
<td>(0.7-2.7)</td>
</tr>
<tr>
<td>Traffic</td>
<td>6.0</td>
<td>(3.3-8.7)</td>
</tr>
<tr>
<td><strong>Indoor pollution at home</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean 2 hrs</td>
<td>1.5</td>
<td>(0.6-2.4)</td>
</tr>
</tbody>
</table>
Brachial Artery Responses to Ambient Pollution, Temperature, and Humidity in People with Type 2 Diabetes: A Repeated-Measures Study

64 Diabetic subjects from Joslin diabetes Center, Boston 49- to 85-year-old

Up to 5 Visits every 2 weeks Total 280 repeated measures

Increases in air pollution narrow brachial artery diameter

Zanobetti A, et al. EHP; 2014;122(3):242-8
Associations between arrhythmia episodes and temporally and spatially resolved black carbon and particulate matter in elderly patients

- VA Normative Aging Study (NAS)
- Arrhythmia episodes measured as ventricular ectopy (VE):
  - having bigeminy, trigeminy or couplets episodes.
- We examined 1,448 observations of men free from known chronic medical conditions who had either one (n = 701), two (n = 451), three (n = 217), or four (n=79) ECG measurements.

**BC spatiotemporal land-use regression model**

**Daily PM$_{2.5}$ predictions using satellite derived aerosol optical depth (AOD)**
Odds ratios and 95% confidence intervals (CI) of the association between ventricular arrhythmia episodes and air pollution

We found a significant association between arrhythmias and increased levels of residence-specific estimates BC and PM$_{2.5}$ in the general population.

<table>
<thead>
<tr>
<th></th>
<th>VE</th>
<th>%</th>
<th>95%CI</th>
<th>IQR</th>
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</thead>
<tbody>
<tr>
<td><strong>BC</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Same Day</td>
<td>1.32</td>
<td>1.06</td>
<td>1.64</td>
<td>0.39</td>
</tr>
<tr>
<td>2 days average</td>
<td>1.42</td>
<td>1.12</td>
<td>1.79</td>
<td>0.35</td>
</tr>
<tr>
<td>3 days average</td>
<td>1.46</td>
<td>1.15</td>
<td>1.84</td>
<td>0.30</td>
</tr>
<tr>
<td><strong>PM$_{2.5}$</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Same Day</td>
<td>1.22</td>
<td>1.02</td>
<td>1.46</td>
<td>6.89</td>
</tr>
<tr>
<td>2 days average</td>
<td>1.22</td>
<td>1.00</td>
<td>1.49</td>
<td>6.21</td>
</tr>
<tr>
<td>4 days average</td>
<td>1.35</td>
<td>1.10</td>
<td>1.66</td>
<td>5.63</td>
</tr>
</tbody>
</table>

• Higher associations compared to previously published studies.

• “...The overall evidence is consistent with a causal relationship between PM$_{2.5}$ exposure and cardiovascular morbidity and mortality.”

• “Finally, PM$_{2.5}$ exposure is deemed a modifiable factor that contributes to cardiovascular morbidity and mortality.”
THANK YOU!