Long Term Metal PM$_{2.5}$ Exposures Decrease Cardiac Acceleration and Deceleration Capacities

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Boilermakers and PM$_{2.5}$ Exposures

- Boilermakers build, maintain and repair boilers often located in power plants
- Boilermakers are exposed to PM$_{2.5}$ during welding
  - Base metal of Fe, Mn, Si, Cr, Ni
- Welders have increased risk of ischemic heart disease mortality and non-fatal myocardial infarction

Heart Rate Variability (HRV)

- One proposed biological mechanisms for PM$_{2.5}$ related cardiovascular events includes altered cardiac autonomic response, which is measured by HRV

- HRV is the analysis of the variation in heart periods
- Low HRV is a predictor of poor cardiovascular outcomes

New indices in CV Research

- Acceleration Capacity: Variability in RR intervals before and after increase in a heart rate
- Deceleration Capacity: Variability in RR intervals before and after slowing in a heart rate
Numerous studies report consistent associations between PM$_{2.5}$ air pollution exposures and HRV.

Fewer studies have investigated the association between occupational PM$_{2.5}$ exposures and HRV:
- No effect among vehicle maintenance workers
- Positive association among patrol troopers
- Negative association with 4-hr workday PM$_{2.5}$ and short duration HRV among welders

Previous Research

- Short term and intermediate cardiac autonomic health effects of PM$_{2.5}$ using HRV (Cavallari, Eisen et al. 2007, Cavallari, Eisen et al. 2008, Vallejo, Ruiz et al. 2006, Cavallari, Fang et al. 2010)

- Short term effects of PM$_{2.5}$ using on DC (Baeur, Kantelhardt et al. 2006, Guzik, Piskorski et al. 2012)
Data collection scheme

<table>
<thead>
<tr>
<th>Outcome measurements</th>
<th>Baseline AM (Pre-shift: 0 hr)</th>
<th>Afternoon (Post-shift: 6 hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC and DC</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Exposure measurement</td>
<td>Real-time PM$_{2.5}$ (DustTrak)</td>
<td>X</td>
</tr>
</tbody>
</table>

- Demographic, occupational, smoking, medical history from questionnaire
- Information on days since last welded

Table 3-3: Linear regression coefficients (b1) of main effect of Cumulative Exposure Index (mg/m$^2$-years) on acceleration capacity (msec) and deceleration capacity(msec).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Acceleration Capacity[AC]</th>
<th>Deceleration Capacity[DC]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Models</td>
<td>Beta(95% C.I.)</td>
<td>Beta(95% C.I.)</td>
</tr>
<tr>
<td>Model 1</td>
<td>0.65(-0.05, 1.25)</td>
<td>-0.56(-1.10, 0.02)</td>
</tr>
<tr>
<td>Model 2</td>
<td>1.23(0.23, 2.69)</td>
<td>-1.07(-2.06, 0.08)</td>
</tr>
<tr>
<td>Model 3</td>
<td>1.26(0.17, 2.69)</td>
<td>-1.09(-2.06, 0.12)</td>
</tr>
<tr>
<td>Model 4</td>
<td>1.31(0.14, 2.75)</td>
<td>-1.15(-2.09, 0.20)</td>
</tr>
</tbody>
</table>

- Bold values indicate significant correlations (p<0.05)
- Model 1: AC or DC = b0 + b1*CEI + e
- Model 2: AC or DC = b0 + b1*CEI + b2*Age + e
- Model 3: AC or DC = b0 + b1*CEI + b2*Age + b3*TOD + e
- Model 4: AC or DC = b0 + b1*CEI + b2*Age + b3*TOD + b4*LWD + e

Long Term Metal Particulate Exposures Decrease Cardiac Acceleration Capacity In Welders

Discussion

- The longer the work PM$_{2.5}$ exposure, the lower the AC and DC at follow up
- Increasing age is a strong predictor of declines in AC and DC at follow up
  - There is a potential for cardiac autonomic effects even among the young and healthy

Strengths

- Tease out long term effects from short term effects
- Reduced misclassification of outcome variable
- Detailed work history data

Limitations

- Potential misclassification of Chronic exposure index
- We could not adjust for baseline AC and DC prior to recruitment
Summary/Implications

- Long term PM$_{2.5}$ exposure decreases AC and may also decrease DC.

- Welding fume exposures adversely affects cardiovascular health

- Until the toxic component(s) of PM are identified and eliminated, exposure to occupational PM should be minimized

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Questions

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