Association of particulate air pollution with heart rate variability in Beijing taxi drivers

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Motor Vehicles in Beijing

- The increasing trend of motor vehicles in Beijing from 1949-2009
Study Subjects

- Inclusion criteria:
  - nonsmoking;
  - healthy;
  - body mass index (BMI) \( \leq 30 \);
  - normal blood pressure, normal resting ECG and normal blood test results;
  - daytime taxicab driving hours;
  - employment as a taxi driver for at least 1 year
Study Protocol

- Panel study design:
  - Continuous personal exposure to PM$_{2.5}$ and ambulatory ECG monitoring
  - Conducted on each subject during a 12-hr work shift (09:00-21:00)
  - In 3 time periods: before, during, and after the Beijing 2008 Olympic Games, respectively
    - Only on weekdays (from Monday to Friday)
Personal Exposure Monitoring

- $\text{PM}_{2.5}$:
  - Real-time concentrations
  - Mass concentrations
- Other exposure variables:
  - $\text{CO}/\text{NO}_2/\text{NO}$
  - Temperature/relative humidity
HRV Measurements

- Holter recorder:
  - Each subject wore the Holter recorder for 12 hr
    - 09:00-21:00

- Data processing:
  - HRV indices were calculated in standard 5-min segments throughout the entire recording
  - SDNN, LF power, HF power
Statistical Analysis

- Raw HRV indices comparison:
  - One-way analysis of variance (ANOVA)
- Model fits:
  - Mixed-effects models: overall & subject-specific
  - Loess smoother: dose-response relationship
  - SAS software (version 9.1)
Mixed-Effects Models

- **Fixed effects:**
  - Real-time PM$_{2.5}$ moving average (5 min to 4 hr)
  - Adjusted for: age, time of day, log$_{10}$-HR, temperature & relative humidity

- **Random effects:**
  - Subject, day of the year
    - Accounting for autocorrelation of repeated measurements within-subject and within-day
Characteristics on Subjects

- **Subjects:**
  - $n=11$, 6 were females
  - Mean age: 35.5 years
    - Range: 27-41 years
  - Employment as a taxi driver: 6.0±3.4 years
  - BMI: 26.1±3.5
  - Normal: BP, resting ECG, blood lipids
## Exposure Results

**Table 1. Daily averages of exposure variables inside the taxicab**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Period</th>
<th>Percentiles</th>
<th>IQR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before</td>
<td>During</td>
<td>After</td>
</tr>
<tr>
<td>PM$_{2.5}$ real-time (µg/m$^3$)</td>
<td>95.4±58.6</td>
<td><strong>39.5±25.2</strong></td>
<td>64.0±80.3</td>
</tr>
<tr>
<td>PM$_{2.5}$ mass (µg/m$^3$)</td>
<td>105.5±44.1</td>
<td><strong>45.2±27.0</strong></td>
<td>80.4±72.5</td>
</tr>
<tr>
<td>CO (ppm)</td>
<td>3.6±1.4</td>
<td>2.8±1.0</td>
<td>2.7±0.7</td>
</tr>
<tr>
<td>NO$_2$ (ppb)</td>
<td>36.4±12.3</td>
<td>30.3±12.2</td>
<td>37.1±17.0</td>
</tr>
<tr>
<td>NO (ppb)</td>
<td>176.1±84.8</td>
<td>156.0±77.2</td>
<td>268.0±55.5</td>
</tr>
<tr>
<td>Temp (°C)</td>
<td>30.0±4.4</td>
<td>28.8±2.0</td>
<td>25.0±2.2</td>
</tr>
<tr>
<td>RH (%)</td>
<td>38.8±9.5</td>
<td>41.7±6.6</td>
<td>24.8±5.8</td>
</tr>
</tbody>
</table>
## Distribution of HRV

**Table 2. Distribution of 5-min HRV indices by time period**

<table>
<thead>
<tr>
<th>Variable/Period</th>
<th>n</th>
<th>25%</th>
<th>50%</th>
<th>75%</th>
<th>95%</th>
</tr>
</thead>
<tbody>
<tr>
<td>5-min SDNN (msec)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before</td>
<td>1320</td>
<td>34</td>
<td>44</td>
<td>54</td>
<td>78</td>
</tr>
<tr>
<td>During</td>
<td>1366</td>
<td>39</td>
<td>49</td>
<td>58</td>
<td>76</td>
</tr>
<tr>
<td>After</td>
<td>1309</td>
<td>35</td>
<td>44</td>
<td>54</td>
<td>72</td>
</tr>
<tr>
<td>5-min LF power (msec²)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before</td>
<td>1298</td>
<td>304.7</td>
<td>507.6</td>
<td>830.8</td>
<td>1506.2</td>
</tr>
<tr>
<td>During</td>
<td>1360</td>
<td>353.5</td>
<td>606.2</td>
<td>888.6</td>
<td>1526.2</td>
</tr>
<tr>
<td>After</td>
<td>1287</td>
<td>310.6</td>
<td>500.1</td>
<td>803.1</td>
<td>1509.5</td>
</tr>
<tr>
<td>5-min HF power (msec²)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Before</td>
<td>1298</td>
<td>52.1</td>
<td>97.9</td>
<td>185.1</td>
<td>375.6</td>
</tr>
<tr>
<td>During</td>
<td>1360</td>
<td>81.9</td>
<td>139.0</td>
<td>222.8</td>
<td>420.3</td>
</tr>
<tr>
<td>After</td>
<td>1287</td>
<td>60.9</td>
<td>126.4</td>
<td>228.7</td>
<td>425.6</td>
</tr>
</tbody>
</table>
Percent Changes in HRV

Figure 1. Percent changes (95% CIs) in 5-min HRV indices associated with an IQR (69.5 μg/m³) increase of the PM$_{2.5}$ for moving averages from 5 min to 4 hr.
Figure 2. Subject-specific effect estimates for 5-min HRV indices associated with an IQR (69.5 μg/m³) increase in the 30-min PM$_{2.5}$ moving average.
Conclusions

- Raw HRV indices comparison:
  - Low PM$_{2.5}$ exposure period (during the Olympic Games) was associated with relatively high HRV
  - Higher PM$_{2.5}$ exposures (before and after the Olympic Games) were associated with relatively low HRV

- Model fits:
  - Marked changes in PM air pollution may lead to cardiac autonomic imbalance in young healthy individuals
    - Indicated by declines in several 5-min HRV indices

- Subject-specific effect estimates:
  - Several subjects had positive response in HRV under PM exposure
  - Factors affecting heterogeneity of responses to PM exposure need further study
Thank you for your attention!