Exhaled nitric oxide in children with asthma:
1) Outdoor- versus indoor-generated PM
2) Short term PM exposure

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Exhaled nitric oxide (eNO) is a ubiquitous molecule in the body and is a non-invasive marker of airway inflammation. eNO is known to be elevated in individuals with asthma, is increased when a subject is having an asthma attack, and is decreased in those individuals using corticosteroid medication. eNO has been compared with other techniques for measuring inflammation (ex. breath condensate, induced sputum).
Subject Characteristics

- 19 subjects: 14 male, 5 female
- Ages 6-13
- Medication use:
  - 10 inhaled corticosteroid (ICS) users
  - 9 ICS nonusers
- FEV1%: 67-100%
Data Collection

**PM\textsubscript{2.5}**
- Local outdoor (HI)
- Local indoor (HI)
- Personal (HPEM)
- Average of 3 central sites: Kent, Lynnwood, and Lake Forest Park (TEOM)

Health Endpoint
- Daily concentration of eNO (ppb)
Estimating Exposure to Ambient and Non-ambient PM
Source-Specific Exposure Model

\[ E_t = E_a + E_{ig} + \text{“personal cloud”} \]

\[ E_a = [y + (1-y)(F_{inf})]C_a \]

\[ E_{ig} = (1-y)(C_{ig}) \]

\[ \alpha = \text{“attenuation factor”} \]

\[ E_t = \text{HPEM or pDR} \]

\[ y = \text{fraction of time spent outdoors} \]

\[ C_a = \text{ambient (outdoor) concentration (HI or neph)} \]

\[ C_{ig} = \text{indoor-generated concentration} = C_i - C_a(F_{inf}) \]

\[ C_i = \text{indoor concentration (HI or neph)} \]
Results

• Associations between various measured PM metrics and exhaled NO
• Associations between estimated concentrations of outdoor- and indoor-generated PM2.5 and eNO
Results ICS nonusers
eNO, ppb (95% CI)

For a 10 ug/m³ increase in PM$_{2.5}$, eNO increase

• Personal: 4.5 (1.02, 7.9)
• Indoor: 4.2 (1.02, 7.4)
• Outdoor: 4.3 (1.4, 7.2)
• Central: 4.2 (1.2, 6.4)
• EIG: -3.3 (-1.1, 7.7)
• EAG: 5.0 (0.3, 9.7)

– No effects were seen in ICS users
Previous findings

- Exhaled NO is a feasible, non-invasive technique for measuring airway inflammation.
- Various measures of PM$_{2.5}$ were associated with a marker of airway inflammation in children with asthma.
- Inhaled corticosteroid use attenuated the association between eNO and PM2.5.
- Other panel studies have reported associations between PM2.5 and eNO. (Adamkiewicz et al, 2004; Jansen et al, 2004)
Short term analysis

- Objectives:
  - To determine the effect of short term PM exposure (hourly lags) on exhaled nitric oxide
Methods

• Polynomial distributed lag model
• Hourly lags of PM up to 48 hours
• Model controlled for temperature, relative humidity, ambient NO concentrations and medication use
Polynomial distributed lag model

\[ E[Y] = B_0 + b_i + B_1(Z_{1 ids} - \overline{Z}_{1 is}) + B_2 med_i + B_3 med_i \ast (Z_{1 ids} - \overline{Z}_{1 is}) \]

\[ + B_4(Z_{2 ids} - \overline{Z}_{2 is}) + B_5 med_i \ast (Z_{2 ids} - \overline{Z}_{2 is}) + B_6(Z_{3 ids} - \overline{Z}_{3 is}) \]

\[ + B_7 med_i \ast (Z_{3 ids} - \overline{Z}_{3 is}) + B_8(Z_{4 ids} - \overline{Z}_{4 is}) + B_9 med_i \ast (Z_{4 ids} - \overline{Z}_{4 is}) \]

\[ + B_{10}(W_{ids} - \overline{W}_{is}) + B_{11}age + B_{12}rh + B_{13}temp \]

where

\[ Z_1 = \sum_{n=1}^{24} PMLag_n, \quad Z_2 = \sum_{n=1}^{24} n \ast PMLag_n, \quad Z_3 = \sum_{n=1}^{24} n^2 \ast PMLag_n \quad \text{and} \quad Z_4 = \sum_{n=1}^{24} n^3 \ast PMLag_n \]

\( W \) is the ambient NO concentration
### Averaged PM effect

<table>
<thead>
<tr>
<th>PM</th>
<th>change in eNO per 10 µg/m3 PM</th>
<th>95% Lower CI</th>
<th>95% Upper CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>lag 1 hour</td>
<td>7.16</td>
<td>3.72</td>
<td>10.59</td>
</tr>
<tr>
<td>lag 4 hour</td>
<td>6.39</td>
<td>2.85</td>
<td>9.93</td>
</tr>
<tr>
<td>lag 8 hour</td>
<td>0.56</td>
<td>-1.07</td>
<td>2.20</td>
</tr>
<tr>
<td>PM 2.5 averaged from 7pm to 4 am</td>
<td>1.61</td>
<td>0.15</td>
<td>3.07</td>
</tr>
<tr>
<td>PM 10 averaged from 7pm to 4 am</td>
<td>2.27</td>
<td>0.78</td>
<td>3.77</td>
</tr>
</tbody>
</table>
effect of lags on eNO

change in eNO (ppm)

lag (hr)
Conclusions

• eNO is associated with PM exposure up to 11 hours prior to eNO measurement
• An association between eNO and PM averaged during high wood smoke hours (7 pm to 4 am) was observed