Short-Term Effects of Particulate Air Pollution Exposure on Incidence and Severity of Pneumonia

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Background

• Pneumonia = lung infection, usually by bacteria or viruses
• Common and serious illness
  • In USA in 2010: 1.1 million hospitalizations, 52,000 deaths

http://www.cdc.gov/nchs/FASTATS/pneumonia.htm
Pneumonia and air pollution

• Exposure to outdoor air pollution causes pulmonary inflammation and likely impairs host defenses and increases risk for infection
• Short term exposure to ambient air pollution is associated with increased hospital admissions for pneumonia
• Little is known about the impact of air pollution on ED visits for pneumonia, pneumonia severity, or mortality

Hypothesis

• We hypothesized that short-term increased levels of outdoor air pollutants would be associated with increased incidence and severity of pneumonia.
Case ascertainment

• We identified 4758 cases of pneumonia presenting to seven Wasatch Front IHC EDs during the periods of Dec 2009- Nov 2010, and Dec 2011- Nov 2012.

• Cases were defined by:
  • diagnosis of pneumonia (ICD-9 coding) and
  • confirmed by physician review of chest imaging reports.
Exposure estimation

- Estimated daily exposure to PM2.5
  - Based on residential location
  - Inverse distance weighting of available monitoring data

- Created running averages for various lag periods
  - 3 and 7 day running averages
  - 0, 1, 3, 7 day lags
Outcomes of interest

• ED visits for pneumonia
• Hospital admission for pneumonia
• ICU admission within 72 hours
• 2007 IDSA-ATS severe community-acquired pneumonia (CAP) criteria (≥3 = severe CAP)
  • Respiratory rate ≥30
  • PaO2/FiO2 ≤ 250
  • Multilobar infiltrates
  • Blood urea nitrogen ≥20 mg/dL
• 30 and 90 day mortality
  • Confusion
  • Leukopenia
  • Thrombocytopenia
  • Hypothermia
  • Hypotension
Case crossover study

• Time stratified case crossover study design: Uses pneumonia cases as their own control by comparing exposure at time of event to exposure at randomly selected date either 21 days before or after event

• Outcomes:
  • ED visits for pneumonia
  • hospital admission for pneumonia
Case-control study

• Population: individuals seen at an ED with pneumonia
• Cases: those that developed severe pneumonia
• Controls: those that did not develop severe pneumonia
• Measures of severity (outcomes):
  • ICU admission within 72 hours
  • IDSA-ATS severe community-acquired pneumonia score ≥ 3
  • 30- and 90- day mortality
Analysis

- Assessed running averages of 3 and 7 days for several lag periods.
- Conditional (case-crossover) and unconditional (case-control) logistic regression.
- Stratified analysis by age (age <65 and age ≥65 years) and season of high respiratory disease (December - April).
Results

- Strongest association seen with average PM2.5 for seven days preceding ED visit. (7-day running average, zero lag)
Results

• Among adults ≥65 years old, 10 μg/m³ increase in 7 day average PM2.5 was associated with:
  • 30% increase in odds of ED pneumonia diagnosis
  • 29% increase in hospital admission for pneumonia

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Age</th>
<th>n</th>
<th>Odds Ratio</th>
<th>95% CI</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ED visit for PNA</td>
<td>&lt; 65</td>
<td>2110</td>
<td>1.14</td>
<td>0.96 – 1.34</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>≥ 65</td>
<td>1458</td>
<td><strong>1.30</strong></td>
<td>1.07 – 1.57</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Hospital admission for PNA</td>
<td>&lt; 65</td>
<td>962</td>
<td>1.02</td>
<td>0.80 - 1.32</td>
<td>0.85</td>
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<tr>
<td></td>
<td>≥ 65</td>
<td>1180</td>
<td><strong>1.29</strong></td>
<td>1.05 - 1.59</td>
<td>0.02</td>
</tr>
</tbody>
</table>
Results

• Among adults ≥65 years old with pneumonia, a 10 μg/m³ increase in 7 day average PM2.5 was associated with:
  • 89% increase in odds of ICU admission
  • 37% increase in severe CAP score ≥ 3.

<table>
<thead>
<tr>
<th>Outcome</th>
<th>Age</th>
<th>n</th>
<th>Odds Ratio</th>
<th>95% CI</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICU admission within 72 h</td>
<td>&lt; 65</td>
<td>414</td>
<td>0.98</td>
<td>0.67 - 1.44</td>
<td>0.91</td>
</tr>
<tr>
<td></td>
<td>≥ 65</td>
<td>520</td>
<td><strong>1.89</strong></td>
<td><strong>1.31 - 2.73</strong></td>
<td><strong>&lt;0.01</strong></td>
</tr>
<tr>
<td>ATS severe CAP score ≥ 3</td>
<td>&lt; 65</td>
<td>448</td>
<td>1.00</td>
<td>0.68 - 1.46</td>
<td>0.99</td>
</tr>
<tr>
<td></td>
<td>≥ 65</td>
<td>584</td>
<td><strong>1.37</strong></td>
<td><strong>1.01 - 1.87</strong></td>
<td><strong>0.04</strong></td>
</tr>
</tbody>
</table>
Results

• Increased pneumonia cases and severity of pneumonia was seen primarily during the months December – April
• Ambient PM2.5 levels were not associated with 30 or 90-day mortality.
Conclusions

• In older adults (≥65 yo), short-term particulate air pollution exposure on the Wasatch Front is associated with increased risk of ED visits and hospitalization for pneumonia.

• Among those with pneumonia, increased PM2.5 exposure is associated with increased severity of pneumonia.

• We speculate that pollution-induced inflammation impairs defense against infection and leads to increased severity of illness.

• Older adults may be more susceptible to these effects.
Next steps

• Evaluate effects of other pollutants: ozone, NO2
• Incorporate additional variables into analysis including effects of temperature, hospital, socioeconomic status
• Further explore association with mortality and eCURB as predictor of mortality
• Evaluate other respiratory diseases
References

Impact of the Electronic Support Tool on Pneumonia Outcomes

• Implemented at 4 Hospitals in 2011

• Measured rates of hospital admission, death, readmissions for patients with pneumonia before and after implementation

3 "Usual Care" hospitals did not undergo implementation – paper guidelines available