Air Pollution and Cardiopulmonary Effects in an International Travel Study

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Introduction – PM exposure and health effects
- PM is associated with a range of health effects – designated as a carcinogen by IARC
  - Respiratory and cardiac morbidity and mortality
  - Pulmonary inflammation and injury
  - Increase in respiratory symptoms and hospital admissions
  - Travelers may be exposed to various air pollutants (gases and particles) when abroad
  - Traveling abroad to cities with high PM provides a ‘test scenario’ with rapidly changing PM concentrations as well as PM composition
- According to Chris Sanford - Travel Medicine has traditionally focused on infectious diseases, diarrhea, and accidents
- Or can air pollution exposures contribute to travelers’ illness and death, especially in vulnerable populations?

Introduction – Hypothesis and Specific Aims
- Main hypothesis: Exposure to high levels of inhaled PM adversely impacts the cardiopulmonary system when individuals travel abroad

Introduction – Hypothesis and Specific Aims
Does traveling to cities with high pollution levels significantly impact cardiopulmonary health and quality of life?

Health effects of traveling to polluted cities abroad
U.S. travel statistics – 38 million outbound travelers

International travel statistics – expected to reach 1.8 billion travelers in 2030
Methods – Study design

• Enrolled a total of 34 volunteers who were traveling abroad from NYC/NJ

• Inclusion criteria for the study
   21 or older
   Non-smoking adults

• Inclusion/exclusion criteria for analyses
  ✓ Provide baseline and abroad data for at least 5 days at each location

Methods – Data collection (5-7 days morning and evening)

Pre-travel NY/NJ
(Baseline)

Abroad city

Post-travel NY/NJ

Methods – calibration and quality control

• Low cost PM sensors (Airbeam) were pre-calibrated using concentrated ambient particles

• Koko Pro spirometers were tested against a more advanced PFT unit

• Omron wrist BP monitor

• Polar heart rate sensor
  ✓ Marco Altini’s HRV Data Logger App for iPhone
Results

Exposure categorization – by city or by pollution level?

- Some cities are polluted only during particular seasons
- Therefore, exposure-based categorization and PM levels were used to study dose-response

<table>
<thead>
<tr>
<th>1. PM concentration</th>
<th>2. PM Level</th>
<th>3. Region</th>
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</thead>
<tbody>
<tr>
<td>Change per 10 μg/m³</td>
<td>Low (0 – 35 μg/m³)</td>
<td>Pre-travel NY</td>
</tr>
<tr>
<td></td>
<td>Medium (36 – 100 μg/m³)</td>
<td>Europe</td>
</tr>
<tr>
<td></td>
<td>High (&gt; 100 μg/m³)</td>
<td>South Asia, East Asia (Africa)</td>
</tr>
</tbody>
</table>

Results - Lung function decrements (FEV1) are associated with pollution level/category

Main effects plots of fitted means for evening FEV1 for Low (0 to 35 μg/m³), Medium (36 – 100 μg/m³), and High (> 100 μg/m³) cities.

Results – Increase in respiratory symptoms

By pollution category – dose response?

Respiratory symptom score averages - based on Low, Medium, and High pollution categories.
Results – Cardiac Effects

- Increased PM exposure negatively impacted HRV
- 10 µg/m³ of outdoor (evening) PM was associated with a reduction of 0.6 ms of SDNN (Standard Deviation of Normal-Normal intervals)
- Reduced HRV signifies that a change in the balance between the sympathetic and parasympathetic nervous systems can occur when travelling to polluted cities
- Increased PM exposure was positively correlated with average heart beat (10 µg/m³ → 0.2 beats/min of evening HR)
- Systolic and Diastolic BP didn’t show any statistically significant correlations with measured air pollution concentrations

Results – Other factors influencing changes

FEV₁ % change by pollution category and region

Slopes of lung function change varied by region – Composition differences may influence toxicity and therefore effect
Results
Comparison with other studies and impact on susceptible groups

- Under same conditions susceptible populations may have a higher effect.

Conclusions

- Evidence validates the hypothesis that exposure to higher levels of PM during travel abroad is associated with adverse cardiopulmonary health outcomes.
- Travel to cities with significantly higher PM pollution than NY (home city) can result in dose-related reductions in lung function and HRV, increases in BP, and increases in respiratory symptoms.
- Travel to cities in South and East Asia resulted in larger changes. However, city or region alone is not a good predictor of health impacts.
- Staying indoors in polluted cities may not be protective.

Conclusions

- Changes were seen in healthy young adults – susceptible groups may have higher impact?
- Were the observed changes really an adverse effect of air pollution?
  - ATS/ERS guidelines on adverse effect: Loss of lung function in combination with respiratory symptoms is considered adverse.
- Should travel medicine doctors advise their patients about air pollution?
  - Recommendations:
    - Avoid travel during some seasons
    - Pre-emptive medication
    - Use suitable masks (in consultation with physician)
- Should physicians and others be politically active for regulatory control to reduce air pollution?

Publications

Media releases and news articles
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Questions?
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Discussion
Factors influencing health-exposure relationships
• Study population characteristics – healthy, young adults
• College students -> may have avoided outdoors on polluted days
• Not required to follow any procedures other than measurements
• Particulate matter composition differences in regions/cities
• Biomass vs. fossil fuel
• For similar PM concentrations, gradient was different
• More robust in East Asia
• Some evidence from limited filter samples collected
• Individual variability in respiratory symptom incidence/intensity
• Time segment and activity patterns -> More active in morning hours

Conclusions
• Morning PM exposures (indoor and outdoor) were more correlated with evening lung function decrement
  • FEV1 was a more sensitive measure of pulmonary function changes than PEF
  • Evening cardiac health endpoints were more correlated with evening PM exposures
• Factors other than PM concentration, such as PM composition, temperature, and other air pollutants (e.g., ozone, NOx) can influence and/or modify the observed adverse effects