PM$_{2.5}$ Air Pollution

Clearing the air

Robert D. Brook, MD
Director, ASH Comprehensive Hypertension Center
Professor of Cardiovascular Medicine
University of Michigan
“The overall evidence is consistent with a causal relationship between PM$_{2.5}$ exposure and CV morbidity and mortality.”
1950s

10 μg/m³ ↓ PM₂.₅ = ↑ life expectancy 7 months
(15% of total ↑ life expectancy)

2000s

**Annual PM₂.₅ Levels**

<table>
<thead>
<tr>
<th>Year</th>
<th>Mean (SD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1980</td>
<td>20.6 ± 4.4 μg/m³</td>
</tr>
<tr>
<td>2000</td>
<td>14.1 ± 2.9 μg/m³</td>
</tr>
<tr>
<td>2007*</td>
<td>11.6 ± 2.8 μg/m³</td>
</tr>
<tr>
<td>2015</td>
<td>8.8 ± 2.2 μg/m³</td>
</tr>
</tbody>
</table>

**Figure 4.** Changes in Life Expectancy for the 1980s–1990s, Plotted against Reductions in PM₂.₅ Concentrations for 1980–2000.

*Epidemiology 2013; 24: 23*
Even Very Low PM$_{2.5}$ Levels Increase Cardiovascular Mortality

$6.3 \pm 2.5 \mu g/m^3$

Canadian Community Health Survey Cohort (n=299,500)

7.6 ± 2.7 year follow-up

CVD: HR 1.19 (95% CI 1.07-1.31) per 10 µg/m$^3$

4.5 µg/m$^3$
King Edward I (1272)
“Malleus Scotorum”

“Whosoever shall be found guilty of burning coal shall suffer the loss of his head”
“From Good Intentions to Proven Interventions: Effectiveness of Actions to Reduce the Health Impacts of Air Pollution”

- March 2009 international, multidisciplinary workshop in Vancouver, Canada
- Identified two strategies to address and mitigate air-pollution related health impacts:
  - Reduce individual baseline risk of CV disease
  - Incorporate air pollution-related health impacts into land-use decisions

“Personal-level interventions have the potential to reduce air pollution exposures”

Understanding Air Pollution and Cardiovascular Diseases: Is It Preventable?  
Masako Morishita¹, Kathryn C. Thompson¹, and Robert D. Brook²

- Air Filtration
- Wearing Face Masks
- Car Filters and Particle Traps
- Closing Windows and Air Conditioning
- Behavioral Changes
- Modified Cook Stoves

“Personalize” Your Air Space

HEPA Filters  
*(indoor protection)*  
48 hour: 57% ↓ in PM$_{2.5}$  
(96.2 to 41.3 μg/m$^3$)

“N-95” Facemask  
*(outdoor protection)*  
48 hour: 97% ↓ in PM$_{2.5}$

↓  Blood pressure  
↓  MCP-1, IL-1, MPO, CD40L

↓  2-hr walking blood pressure  
↓  ECG ischemia (CAD pts)

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J Am Coll Cardiol 2015; 65: 2279-87.

Part Fibr Toxicol 2009; 6

No Evidence for “Simple” Facemasks

--Not an ideal long term solution--
RECOMMENDATIONS FOR HEALTH CARE PROVIDERS
AHA Scientific Statement
Particulate Matter Air Pollution and Cardiovascular Disease

• Evidence-based appropriate treatment of the traditional CV risk factors should be emphasized - may lessen susceptibility

  – Patients without CAD may not be at increased risk of short-term exposure\(^1\)
  – Patients with a normal BMI are at less risk of long-term PM exposures\(^2\)
  – Statins\(^3\), low BMI\(^3\), B vitamins\(^4\), fish oil\(^5\) may abrogate PM-induced HRV changes

RECOMMENDATIONS FOR HEALTH CARE PROVIDERS

AHA Scientific Statement

Particulate Matter Air Pollution and Cardiovascular Disease

- Based upon the forecasted Air Quality Index, prudent recommendations for reducing exposure and limiting activity should be provided based upon the patient’s level of risk

http://airnow.gov/    http://weather.com

- Reduce or eliminate non-mandatory travel and/or commutes
- Reduce outdoor activities in polluted areas or times (rush hour)
- Stay indoor or exercise inside using air conditioning/filters
- Consider closing car windows, using recycled filtered cabin air
- Advocate for Air Quality Standards (AHA, ATS, ALA)
- Educate/guide patients - Air Quality Index (AQI)

<table>
<thead>
<tr>
<th>PM$_{2.5}$</th>
<th>&lt;12 µg/m$^3$</th>
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<tbody>
<tr>
<td><strong>Unhealthy for Sensitive Groups (101-150)</strong></td>
<td>Sensitive groups include people with heart or lung disease, older adults, children and teenagers.</td>
</tr>
<tr>
<td><strong>Sensitive groups:</strong> Reduce prolonged or heavy exertion. It’s OK to be active outside, but take more breaks and do less intense activities. Watch for symptoms such as coughing or shortness of breath.</td>
<td></td>
</tr>
<tr>
<td><strong>People with asthma</strong> should follow their asthma action plans and keep quick relief medicine handy.</td>
<td></td>
</tr>
<tr>
<td><strong>If you have heart disease:</strong> Symptoms such as palpitations, shortness of breath, or unusual fatigue may indicate a serious problem. If you have any of these, contact your health care provider.</td>
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<table>
<thead>
<tr>
<th>PM$_{2.5}$</th>
<th>&gt;150 µg/m$^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Very Unhealthy (201-300)</strong></td>
<td>Everyone</td>
</tr>
<tr>
<td>Sensitive groups: Avoid all physical activity outdoors. Move activities indoors or reschedule to a time when air quality is better.</td>
<td></td>
</tr>
<tr>
<td><strong>Everyone else:</strong> Avoid prolonged or heavy exertion. Consider moving activities indoors or rescheduling to a time when air quality is better.</td>
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<table>
<thead>
<tr>
<th>PM$_{2.5}$</th>
<th>&gt;250 µg/m$^3$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hazardous (301-500)</strong></td>
<td>Everyone</td>
</tr>
<tr>
<td>Sensitive groups: Remain indoors and keep activity levels low. Follow tips for keeping particle levels low indoors.</td>
<td></td>
</tr>
<tr>
<td><strong>Everyone:</strong> Avoid all physical activity outdoors.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Air Quality Index</th>
<th>Who Needs to be Concerned?</th>
<th>What Should I Do?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good (0-50)</td>
<td>It's a great day to be active outside.</td>
<td></td>
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</table>
Can Air Pollution Negate the Health Benefits of Cycling and Walking?

WHO 99th percentile PM$_{2.5}$
Background 95 µg/m$^3$

Break-even point = 100 mins

Tipping point = 30 mins

Tipping point: beyond this, additional PA will not lead to higher health benefits

Break-even point: beyond this, additional PA will cause adverse health effects

BALANCING (MAYBE) COMPETING “PRECAUTIONARY PRINCIPLES” OF ACTION ON PM
The messaging is critically important (what/when/how and whom to inform?)
? Un-intended harms (unwanted behavioral Δ) vs. value of un-tested intervention(s)
RECOMMENDATIONS FOR HEALTH CARE PROVIDERS

AHA Scientific Statement

Particulate Matter Air Pollution and Cardiovascular Disease

• All patients with CV disease should be educated about the CV risks posed by air pollution.

• Consideration should also be given for educating patients without CV disease but who are at high risk

  – Advice from media alerts and health professional to change outdoor behavior and activities\(^1\)

  – Community educators can increase patient knowledge of the adverse health effects related PM\(^2\)

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Cardiology Patients Unaware of PM Risks

Did you know PM affects the heart?

- Yes: 43%
- No: 57%

Doctor ever discussed risks of PM related to heart health?

- Yes: 92%
- No: 8%

n = 500

RECOMMENDATIONS FOR HEALTH CARE PROVIDERS
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Particulate Matter Air Pollution and Cardiovascular Disease

NO FORMAL RECOMMENDATIONS
For or against PERSONAL-LEVEL PROTECTION ACTIONS
(home/car filtration, air conditioning, facemasks)

While a few studies shows favorable changes in surrogate health outcomes\(^1\)\(^-\)\(^3\); too many factors remain unknown:
- Comparative effectiveness of interventions
- Who/when to intervene
- Overall risk/benefit ratio, costs, and value
- Public health impact is not established

Important Future Directions/Research

Individual-Behavioral Changes
- Lower underlying CV risk
- Change activity patterns
- Facemasks
- Home and car air filters

Individual-Exposure Reduction
- Clinician education
- EMR-based alerts
- Access to care
- Optimal messaging

Health Care Provider & System
- Outreach
- Education
- Built environment
- Healthy food access
- Exercise facilities

Community-level
- Outreach
- Education
- Built environment
- Healthy food access
- Exercise facilities

Societal-level
- Air quality
- Emissions
- Roadways
- Climate Δ