Evidence to drive decisions: Building an Air Quality Management System

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Building an Air Quality Management System

- Significant air pollution challenge
- Multiple sources
- But, many cost-effective solutions available
- What are the elements of comprehensive air quality management system?
India: Many Cities Substantially Exceed WHO and Indian Air Quality Guidelines

2008 Annual Mean PM$_{10}$ Levels In Indian Cities*

- WHO Guideline: 20 µg/m$^3$
- India Standard: 60µg/m$^3$

Source: WHO 2011
Many Sources of PM in India
Asia PM 2.5 Source Apportionment: Vehicles ~20% - 35%

Source: Chowdhury, HEI
Seasonality of Sources in India

Vehicles ~20% – 30% of total PM2.5 (depending on city and season)

- Fossil fuel and biomass combustion dominates:
  - Fossil Fuel
    - Del: 25-33%
    - Kol: 37-53%
    - Mum: 21-35%
  - Biomass
    - Del: 7-19%
    - Kol: 13-18%
    - Mum: 7-20%

- Dust dominates during Spring and Summer
  - Long range transport and dust from local construction

- Biomass and coal are high in winter
  - Heating
  - Poor mixing and atmospheric inversion

Road Dust an additional 10% – 30%

Source: Adapted from Chowdhury et al. (2007).
The Basics of Air Quality Management
(U.S. National Academy of Sciences Report)

Assessing Status
Measuring Progress
-AQ Monitoring
-Health Effects

Setting Standards and Objectives
-Ambient AQ Standards
-Critical Ecosystem Loads

Designing and Implementing Control Strategies
-Identifying key sources
-Controlling Emissions
-Anticipating Growth

Air Quality Management in the United States
http://books.nap.edu/catalog/10728.html
## India has already set PM and Ozone Ambient Air Quality Standards (in \( \mu g/m^3 \))

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>WHO AQG (Interim Targets)</th>
<th>US EPA</th>
<th>EU*</th>
<th>China GB3095-1996</th>
<th>China Newly Revised** (adopted by 2016)</th>
<th>India (Revised 2009)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM10 Annual</td>
<td>20 (70-50-30)</td>
<td>---</td>
<td>40</td>
<td>100</td>
<td>70</td>
<td>60</td>
</tr>
<tr>
<td>PM10 Daily</td>
<td>50 (150-100-75)</td>
<td>150</td>
<td>50</td>
<td>150</td>
<td>150</td>
<td>100</td>
</tr>
<tr>
<td>PM2.5 Annual</td>
<td>10 (35-25-15)</td>
<td>12</td>
<td>25</td>
<td>na</td>
<td>35</td>
<td>40</td>
</tr>
<tr>
<td>PM2.5 Daily</td>
<td>25 (75-50-37.5)</td>
<td>35</td>
<td>---</td>
<td>na</td>
<td>75</td>
<td>60</td>
</tr>
<tr>
<td>Ozone 8-hour</td>
<td>100</td>
<td>~150 (75 ppb)~120-140* (60-70ppb)</td>
<td>100***</td>
<td>na (1 hr. avg. of 200)</td>
<td>160</td>
<td>100</td>
</tr>
</tbody>
</table>

* Evaluation Underway

***target value, not limit value
The Basics of Air Quality Management
(U.S. NAS 2004)

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Many Sources of PM in India.

...require comprehensive strategy
Mobile Sources: Cars, Trucks, Buses, Three-Wheelers

Elements of a Comprehensive Vehicle Pollution Control Strategy

- Clean Vehicle Technology
- Appropriate Maintenance
- Transportation & Land Use Planning
- Clean Fuels

Source: Michael Walsh
The Traffic Impact Area in Delhi:
HEI Analysis: 55% of the Population within 500 meters of a Freeway; 50 meters of a Major Road
Technology Now Exists To Dramatically Clean Up New Vehicles

- India has made progress
  - Bharat Stage 4/3
- But much cleaner, more cost-effective technologies now available (Euro 5, 6)
- *Low sulfur fuel is critical*

Source: Michael Walsh
**Stationary Sources:**
**e.g. Electric Power, Brick Kilns**

- Substantial contributors to exposure
- Cost-effective technologies and cleaner fuels available
- Requires:
  - Clear Rules (level playing field)
  - Staff to inspect, enforce
Sources: Household Cooking

- Substantial contributor to both indoor and outdoor exposure
- Contributes to both health effects and short-lived climate change forcing (black carbon)
- Improved technology and fuels available
  - Requires resources and education
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Action can have Results:
When Hong Kong Fuel Sulfur (and SO₂) Went Down in 1990, Health Improved

[Graph showing air pollutant concentrations 1988-95 in Hong Kong half yearly mean levels.]

- Fuel restriction on sulphur

- PM₁₀, NO₂, SO₂, O₃

- 50% reduction in SO₂ after the intervention

- No change in other pollutants

[Bar chart showing reductions in deaths after sulphur restriction:
- All causes: -1.8% (15-64), -2.8% (65+);
- Cardiovascular: -1.6% (15-64), -2.4% (65+);
- Respiratory: -4.6% (15-64), -4.8% (65+).]
Action can have Results
When action was taken during Beijing Olympics, air pollution went down...

(PM$_{2.5}$ Monitoring)

Instruments for PM$_{2.5}$: R&P and TEOM1400
Source: Hao, 2008
...and heart health improved

- HEI-funded study with PKU and Rutgers University tested air and heart health
- Before, during, and after Olympics
- New report (2012): when air pollution improved measures of heart inflammation and health improved

**JAMA Journal of the American Medical Association**

**Association Between Changes in Air Pollution Levels During the Beijing Olympics and Biomarkers of Inflammation and Thrombosis in Healthy Young Adults**

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Yueshan Wang, PhD
Ping Zhu, MD
Pamela Ohnemus-Strickland, PhD
Miu Hu, PhD
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Tong Zhu, PhD
Junfeng Jin, Zhang, PhD

**Context** Air pollution is a risk factor for cardiovascular diseases (CVD), but the underlying biological mechanisms are not well understood.

**Objective** To determine whether markers related to CVD pathophysiological pathways (biomarkers for systemic inflammation and thrombosis, heart rate, and blood pressure) are sensitive to changes in air pollution.

**Design, Setting, and Participants** Using a quasi-experimental opportunity offered by greatly restricted air pollution emissions during the Beijing Olympics, we measured pollutants daily and the outcomes listed below in 128 healthy young adults before, during, and after the 2008 Olympics (June 2–October 30). We used linear mixed-effects models to estimate the improvement in outcome levels during the Olympics and the anticipated reversal of outcome levels after pollution controls ended to determine whether changes in outcome levels were associated with changes in pollutant concentrations.

**Main Outcome Measures** C-reactive protein (CRP), fibrinogen, von Willebrand factor, soluble CD40 ligand (sCD40L), soluble P-selectin (sCD62P) concentrations; white blood cell count (WBC); heart rate; and blood pressure.

**Results** Concentrations of particulate and gaseous pollutants decreased substantially (~15% to ~60%) from the pre-Olympic period to the during-Olympic period. Using a median test conducted at the 0.05 level, we observed statistically significant improvements in sCD62P levels by ~34.0% (95% CI, ~38.4% to ~29.2%, P < .001) from a pre-Olympic mean of 6.29 ng/mL to a during-Olympic mean of 4.16 ng/mL and von Willebrand factor by ~13.1% (95% CI, ~18.6% to ~7.5%, P < .001) from 106.4% to 92.6%. After adjustments for multiple comparisons, changes in the other outcomes were not statistically significant. In the post-Olympic period when pollutant concentrations increased, most outcomes approximated pre-Olympic levels, but only sCD62P and systolic blood pressure were significantly worsened from the during-Olympic period. The fraction of above-detection-limit values for CRP (percentile = 0.3 μg/L) was reduced from 55% in the pre-Olympic period to 46% in the during-Olympic period and reduced further to 36% in the post-Olympic period. Interruption range increases in pollutant concentrations were consistently associated with statistically significant increases in fibrinogen, von Willebrand factor, heart rate, sCD62P, and sCD40L concentrations.

**Conclusions** Changes in air pollution levels during the Beijing Olympics were associated with acute changes in biomarkers of inflammation and thrombosis and measures of cardiovascular physiology in healthy young persons. These findings are of uncertain clinical significance.

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www.jama.com
Although progress can be made…

- …sustained progress requires broader knowledge and communication of public health impact
  - Air pollution improved during the Beijing Olympics, but rose again shortly after
  - And in Delhi, air pollution dropped after the CNG conversions – but has now risen to much higher levels…
- Continued setting of standards, implementation, and enforcement all require support
- The new GBD can help further support and inform action
Thank You

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