Air pollution and human health in China

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Air pollution has been a long-lasted problem in China

Donkelaar et al, *EHP*, 2015
China Blue Sky Protection Campaign (2018-2020)

PM$_{2.5}$

Zhang et al, *Innovation*, 2022

Ozone

Meng et al, *Environ Pollut*, 2022
Air pollution remains a major public health challenge

"In 2019, 1.42 million and 90 thousands Chinese people died from PM$_{2.5}$ and O$_3$ pollution respectively"

—— Global Burden of Disease Study 2019

<table>
<thead>
<tr>
<th>Top 10 causes of death in the world in 2019</th>
<th>Top 10 causes of death in China in 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of deaths (ten thousands)</td>
<td>Number of deaths (ten thousands)</td>
</tr>
<tr>
<td>High blood pressure</td>
<td>Smoking</td>
</tr>
<tr>
<td>Smoking</td>
<td>High blood pressure</td>
</tr>
<tr>
<td>Dietary risks</td>
<td>High blood pressure</td>
</tr>
<tr>
<td>Air pollution</td>
<td>Dietary risks</td>
</tr>
<tr>
<td>High blood sugar</td>
<td>Air pollution</td>
</tr>
<tr>
<td>High BMI</td>
<td>High blood sugar</td>
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<tr>
<td>High LDL</td>
<td>High LDL</td>
</tr>
<tr>
<td>Impairments of kidney functions</td>
<td>High BMI</td>
</tr>
<tr>
<td>Malnutrition</td>
<td>Inappropriate temperature</td>
</tr>
<tr>
<td>Drinking</td>
<td>Impairments of kidney functions</td>
</tr>
<tr>
<td></td>
<td>Drinking</td>
</tr>
</tbody>
</table>

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“In 2019, 1.42 million and 90 thousands Chinese people died from PM$_{2.5}$ and O$_3$ pollution respectively”

—— Global Burden of Disease Study 2019
Air pollution and health is a hot research topic

China
2022: 3,773 papers
2015: 905 papers
2010: 337 papers

Global
2022: 8,197 papers
2015: 4,125 papers
2010: 2,781 papers
Selected air pollution epidemiologic studies in China

- **Short-term exposure (time-series/case crossover) studies**
  - Single-city analysis: Beijing, Hong Kong, Shanghai, etc.
  - Multi-city analysis: PAPA (3 Chinese cities), CAPES, 272 cities

- **Long-term exposure (cohort) study**
  - China PAR (Prediction for ASCVD Risk in China)
  - CKB (China Kadoorie Biobank)

- **Intervention study**
  - Population level: Beijing Olympics
  - Individual level: air purifier, mask, dietary supplementation
Short-term exposure studies

• PM Coefficients **LOWER** than in Europe and North America

Wong et al, *EHP*, 2008  
Chen et al, *AJE*, 2012  
Chen et al, *AJRCCM*, 2017
PAPA (Public Health and Air Pollution in Asia)

http://www.healtheffects.org/international.htm

Wong et al, EHP, 2008
PAPA: network and capacity building not only in China, but also in other Asian counties
Long-term exposure: CKB-Air cohort

Liu et al, EST, 2022; Sun et al, Gastroenterology, 2023; Sun et al, Lancet Planet Health, 2023
Intervention study: Beijing Olympics (2008)

Typical air pollution in Beijing

Good air quality during the Beijing Olympics
### The Beijing HEART Study

**Health Effects of Air Pollution Reduction Trial**

#### HEART Study Schedule

<table>
<thead>
<tr>
<th>Pre-Olympics</th>
<th>During-Olympics</th>
<th>Post-Olympics</th>
</tr>
</thead>
<tbody>
<tr>
<td>V1</td>
<td>V2</td>
<td>V3</td>
</tr>
<tr>
<td>6/10 to 6/23</td>
<td>6/24 to 7/7</td>
<td>6/29</td>
</tr>
<tr>
<td>V4</td>
<td>V5</td>
<td>V6</td>
</tr>
<tr>
<td>8/4 to 8/15</td>
<td>10/6 to 10/17</td>
<td>10/20 to 10/31</td>
</tr>
<tr>
<td>July 20, 2008</td>
<td>September 24, 2008</td>
<td></td>
</tr>
</tbody>
</table>

### Intervention study: Beijing Olympics (2008)

**Rich et al, JAMA, 2012**

#### Table 3. Biomarker Concentrations by Period and Between-Period Change in Participant-Specific Biomarker Concentrations, Adjusted for Temperature and Relative Humidity

<table>
<thead>
<tr>
<th>Biomarker, Units</th>
<th>Before</th>
<th>During</th>
<th>After</th>
<th>Before to During, Mean (95% CI), %</th>
<th>Before to After, Mean (95% CI), %</th>
<th>ε-Value</th>
<th>P Value</th>
<th>Between-Period Percentage Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>sCD63P, ng/mL</td>
<td>6.29 (5.97 to 6.63)</td>
<td>4.16 (3.86 to 4.48)</td>
<td>5.38 (5.10 to 6.06)</td>
<td>-34.0 (-38.4 to -29.2)</td>
<td>&lt;.001</td>
<td>33.7 (17.7 to 51.3)</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>sCD40L, ng/mL</td>
<td>1.86 (1.79 to 1.94)</td>
<td>1.76 (1.66 to 1.86)</td>
<td>1.82 (1.77 to 2.07)</td>
<td>-5.7 (-10.5 to -0.7)</td>
<td>.03</td>
<td>9.1 (-3.7 to 23.5)</td>
<td>.17</td>
<td></td>
</tr>
<tr>
<td>von Willebrand factor, %</td>
<td>106.4 (98.5 to 114.4)</td>
<td>92.6 (82.6 to 102.5)</td>
<td>79.5 (66.9 to 92.1)</td>
<td>-13.1 (-18.6 to -7.5)</td>
<td>&lt;.001</td>
<td>-14.2 (-20.9 to 1.6)</td>
<td>.19</td>
<td></td>
</tr>
<tr>
<td>Heart rate/min</td>
<td>66.5 (65.0 to 68.1)</td>
<td>65.4 (63.8 to 67.0)</td>
<td>66.1 (64.2 to 68.1)</td>
<td>-1.7 (-3.4 to -0.1)</td>
<td>.04</td>
<td>1.1 (-2.5 to 4.9)</td>
<td>.54</td>
<td></td>
</tr>
<tr>
<td>Fibrinogen, mg/dL</td>
<td>250 (242 to 258)</td>
<td>250 (240 to 259)</td>
<td>261 (249 to 273)</td>
<td>0.1 (-2.5 to 2.2)</td>
<td>.90</td>
<td>4.3 (-1.7 to 10.2)</td>
<td>.21</td>
<td></td>
</tr>
<tr>
<td>Blood pressure, mm Hg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systolic</td>
<td>102.5 (99.9 to 105.2)</td>
<td>100.9 (97.4 to 104.4)</td>
<td>110.5 (105.9 to 115.0)</td>
<td>-1.8 (-3.9 to 0.4)</td>
<td>.10</td>
<td>10.7 (2.8 to 18.5)</td>
<td>.01</td>
<td></td>
</tr>
<tr>
<td>Diastolic</td>
<td>60.2 (57.9 to 62.5)</td>
<td>60.1 (57.0 to 63.1)</td>
<td>60.1 (56.2 to 64.0)</td>
<td>-0.3 (-3.0 to 2.5)</td>
<td>.86</td>
<td>0.1 (-9.7 to 9.9)</td>
<td>.99</td>
<td></td>
</tr>
<tr>
<td>White blood cell count, X10^3</td>
<td>5200 (4900 to 5500)</td>
<td>5400 (5100 to 5700)</td>
<td>5210 (4990 to 5530)</td>
<td>2.2 (-2.3 to 6.6)</td>
<td>.34</td>
<td>-3.9 (-11.5 to 3.6)</td>
<td>.44</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: sCD40L, soluble CD40 ligand; soluble P-selectin sCD62P.

*Blood marker was log-transformed. Geometric means and its 95% confidence interval.*

*Significance is established if P value <.003, the individual significance level needed to maintain a family-wise Type I error rate of 0.05.*
**Intervention study: personal intervention**

- **Mask (outdoor)**
- **Air purifier (indoor)**
- **Dietary supplement**

**Beijing Residents:**
- Air purifiers at home: 60%
- Air purifiers at work: 40%
- Wear mask: 30%
- Take anti-haze food: 30%

Implications of Chinese studies

China

• To provide local evidence for air quality management
• China AQS

Globally

• Global exposure-mortality model (GEMM)
• WHO AQG

Burnett et al, 2018
Limitations of Chinese studies

• Most in cities

• Most on PM, few on ozone and NO$_2$

• Few on specific sources, such as traffic

• Be careful of environmental disparities from individual interventions
Future research needs in China

• PM$_{2.5}$ & ozone cohort studies

• Intervention studies:
  • accountability study;
  • Longer intervention period, more outcomes (e.g. morbidity and mortality changes)

• New technologies in air pollution epidemiology
  • Sensors, big data
  • Source apportionment
  • Satellite data, air pollution modelling
  • Omics technology (e.g. exposome)
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