Air pollution and its reproductive effects on human beings in China

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Outline

• Background

• Ambient air pollution and reproductive health in China – epidemiologic evidence

• Future research needs
“Pollution in China” – by LU Guang
In terms of health, air pollution is most significant among various environmental risks in China.

Cost of environmental pollution in China in 2003

<table>
<thead>
<tr>
<th></th>
<th>Air pollution</th>
<th>Water pollution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease burden</td>
<td>400,000 premature deaths</td>
<td>52,000 cancer deaths</td>
</tr>
<tr>
<td>Health economic loss</td>
<td>519.9 Billion</td>
<td>9.5 Billion</td>
</tr>
<tr>
<td>Other economic loss</td>
<td>36.7 Billion</td>
<td>158.0 Billion</td>
</tr>
</tbody>
</table>

Source: World Bank, *Cost of Pollution in China*
Satellite Global PM$_{2.5}$ concentrations

Population-weighed PM$_{2.5}$ levels in China: 55 $\mu$g/m$^3$ (annual average)
Ratio of PM$_{2.5}$ concentrations: 2005/1990

Brauer et al, EST, 2012
Estimated ozone concentrations (2005, ppb)

Brauer et al, EST, 2012
Heavy fog in China
January, 2013
Heavy fog in China
January, 2013
PM$_{2.5}$ levels during the fog
Global Burden of Disease (2010)

Lim et al, Lancet, 2012
Top 20 risk factors for mortality

Lim et al, Lancet, 2012
PM$_{2.5}$ and ALRI

Mean PAF—ALRI—2010—Mortality

GBD, 2012
PM$_{2.5}$ and COPD

Mean PAF—Chronic obstructive pulmonary disease—2010—Mortality

GBD, 2012
PM$_{2.5}$ and CHD

Mean PAF—Ischemic heart disease—2010—Mortality

39%

GBD, 2012
PM$_{2.5}$ and stroke

Mean PAF - Hemorrhagic and other non-ischemic stroke - 2010 - Mortality

GBD, 2012
PM$_{2.5}$ and lung cancer

Mean PAF—Trachea, bronchus and lung cancers—2010—Mortality

20% smoking 40%

GBD, 2012
Air pollution research in China

1. PM$_{2.5}$ emissions from light-duty gasoline vehicles in Beijing, China.
   PMID: 24810839 [PubMed - as supplied by publisher]
   Related citations

2. Biodegradation of C5-C 8 fatty acids and production of aroma volatiles by Myroides sp. ZB35 isolated from activated sludge.
   Xiao Z, Zhu X, Xi L, Hou X, Fang L, Lu JR.
   PMID: 24810320 [PubMed - in process]
   Related citations
A summary of air pollution epidemiologic studies in China

• **Short-term exposure studies**
  – Time-series/case crossover studies
    • Single-city analysis: Beijing, Hong Kong, Shanghai, Shenyang, Taiyuan, Wuhan, etc.
    • Multi-city analysis: PAPA, CAPES
  – Panel study: Beijing

• **Long-term exposure study**
  – Cross-sectional study: several
  – Cohort study: CNHS-Air

• **Intervention study**
  – Beijing Olympics
  – Hong Kong
China Air Pollution and Health Effects Study

A new multi-city time-series study in China

Supported by China Ministry of Environmental Protection

Health and Exposure Data

- **Health outcomes**
  - Total and cause-specific mortality (for every city)
  - Hospital visits (Shanghai)

- **Air pollution**
  - PM$_{10}$, SO$_2$, NO$_2$ (for every city)
  - PM$_{2.5}$ (Beijing, Shanghai, Shenyang, Xi’an, Guangzhou)
  - PM$_{2.5}$ components (Xi’an)
  - PM$_{10-2.5}$ (Beijing, Shanghai, Shenyang)
  - BC (Shanghai)
  - O$_3$ (Shanghai, Suzhou)
  - CO (Shanghai, Anshan, Taiyuan)
  - Visibility (Shanghai)
CAPES study: what will it contribute to policy making in China?

- Robustness of time-series study risk estimates
- New evidence of the national C-R function
- Comparison of risk estimates gained from China and developed countries
- Regional/city variability in results: source apportionment
- Does threshold exist
Effects of PM$_{10}$ in the CAPES cities

- Total mortality
- Cardiovascular mortality
- Respiratory mortality

Chen et al, AJE, 2012
Regional pattern of PM$_{10}$ health impact

CAPES
Possible reasons of regional pattern

- SO2
- PM
- NOx
- O3

90% (CAPES)
Regional pattern: a potential role of indoor exposure to outdoor PM$_{10}$

\[ \text{PM}_{10} = \left( \frac{\text{tout} \cdot \Delta \text{CPM}_{10} \cdot \text{out} + \text{tin} \cdot \Delta \text{CPM}_{10} \cdot \text{in}}{24 \text{hour} \cdot \Delta \text{CPM}_{10} \cdot \text{out}} \right) \]

$R^2 = 0.55$

Zhou et al., AE, 2013
Establishment of Exposure-response Functions of Air Particulate Matter and Adverse Health Outcomes in China and Worldwide

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Possible reasons for the smaller effects in Chinese cities

Pope et al, Circulation, 2009
Most Chinese studies focus on the cardiorespiratory system, and few examine the reproductive outcomes.
Mechanisms of effect following PM exposure: oxidative stress

Particulate Matter Exposure

- Placental Disruption
- Endothelial Dysfunction

Respiratory Symptoms:
- Morbidity
- Asthma
- Pulmonary dysfunction
- Inflammation

Impact:
- Preterm Birth
- IUGR
- LBW
- Infant Mortality

Cardiovascular Effects:
- Autonomic imbalance
- Hypercoagulability
- Arrhythmia
Air Pollution and Low Birth Weight in Beijing (Wang et al, EHP, 1997)

- **Design**: a cohort of all pregnant women in four areas in Beijing between 1989-1991, 74,671 first-parity live births with gestational age 37-44 weeks

- **Outcome**: preterm birth, low birth weight

- **Statistical methods**: Multiple linear regression and logistic regression, adjusting for gestational age, residency, year of birth, maternal age, and infant gender.

- **Results**: Significant associations of SO2 and TSP during the 3\textsuperscript{rd} trimester and low birth weight
Petrochemical exposure with spontaneous abortion in Beijing (Xu et al, OEM, 1998)

- **Design**: a retrospective epidemiological study, 2853 (93%) of the women in a large petrochemical complex in Beijing
- **Outcome**: spontaneous abortion during the first pregnancies
- **Statistical methods**: Multiple logistic regressions
- **Results**: significant increase of spontaneous abortion for women working in all of the production plants with frequent exposure to petrochemicals (8.8%; range of 5.8%–9.8%), compared with those working in nonchemical plants (2.2%; range of 0.0%–7.1%).
Air pollution and preterm birth in Shanghai (Jiang et al, BES, 2007)

- **Design**: Birth Registry-based time-series study
- **Outcome**: preterm birth
- **Statistical methods**: Poisson regression with generalized additive model
- **Results**: significant effect of outdoor air pollution only with 8-week exposure before preterm births; not find any significant acute effect of outdoor air pollution on preterm birth in the week before birth.
Air pollution and preterm birth in Guangzhou (Zhao et al, Environ Health, 2011)

- **Design**: Birth Registry-based time-series study
- **Outcome**: preterm birth
- **Statistical methods**: Poisson regression with generalized additive model
- **Results**: significant acute effect (lag 3-4 days) of outdoor air pollution on preterm birth.
<table>
<thead>
<tr>
<th>Field</th>
<th>Description</th>
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<tbody>
<tr>
<td>Name of infants</td>
<td>婴儿姓名</td>
</tr>
<tr>
<td>Gender of infants</td>
<td>性别</td>
</tr>
<tr>
<td>Date of birth</td>
<td>出生日期</td>
</tr>
<tr>
<td>Birth weight</td>
<td>出生体重</td>
</tr>
<tr>
<td>Apgar score</td>
<td>胎儿评分</td>
</tr>
<tr>
<td>Educational level of mothers</td>
<td>教育程度 1. 研究生 2. 大学本科 3. 大学专科及专科学校 4. 中专及中技 5. 普工学校 6. 高中 7. 初中及以下</td>
</tr>
<tr>
<td>Occupation of mothers</td>
<td>职业</td>
</tr>
<tr>
<td>Educational level of fathers</td>
<td>教育程度 1. 研究生 2. 大学本科 3. 大学专科及专科学校 4. 中专及中技 5. 普工学校 6. 高中 7. 初中及以下</td>
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<tr>
<td>Occupation of fathers</td>
<td>职业</td>
</tr>
<tr>
<td>G/P</td>
<td>分娩方式 1. 自然产 2. 难产 3. 新产 4. 胎吸 5. 钳产 6. 新破头</td>
</tr>
<tr>
<td>Delivery style</td>
<td>分娩方式 1. 自然产 2. 难产 3. 新产 4. 胎吸 5. 钳产 6. 新破头</td>
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<tr>
<td>Gestational age</td>
<td>妊娠周数</td>
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<td>Birth defect (Y/N)</td>
<td>出生缺陷</td>
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Time-series approach omits seasonally-varying exposures and birth outcomes, and thus might be inappropriate in studying the association between air pollution and birth outcomes

Darrow et al, 2009, Epidemiology
Future research needs

- Birth cohort study and air pollution
- PM components and birth outcomes
- Additional data collection for Birth Registry: smoking (A/P), drinking
- Other birth outcomes: birth defects
- **Research opportunity in China**: huge population, high pollution levels, establishment of PM2.5 monitoring network and Birth Registry in the country
Thank you!

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