

Air pollution epidemiology in China: Progress and research needs

Haidong Kan

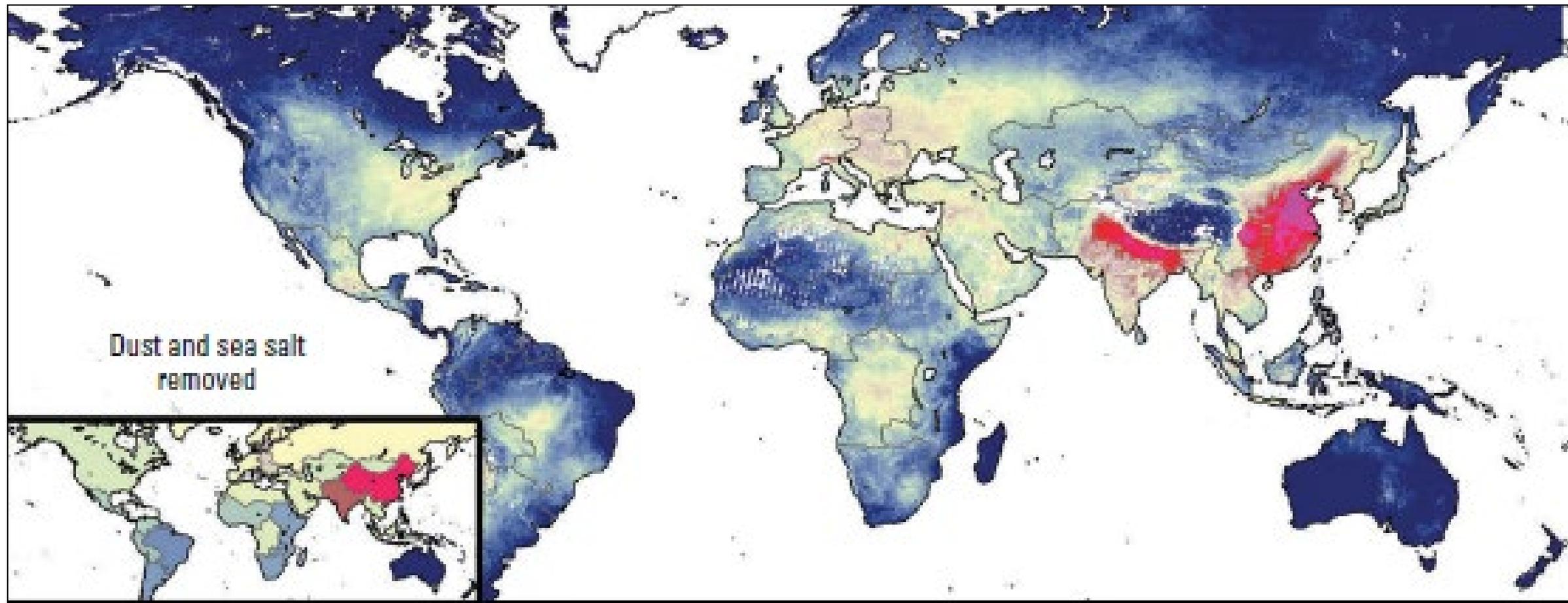
Fudan University, Shanghai, China

**HEI Annual Conference
Seattle, May 6, 2019**

Outline

- **Overview of air pollution epidemiology in China**
- **Factors contributing to China's progress**
- **Lessons and research needs**

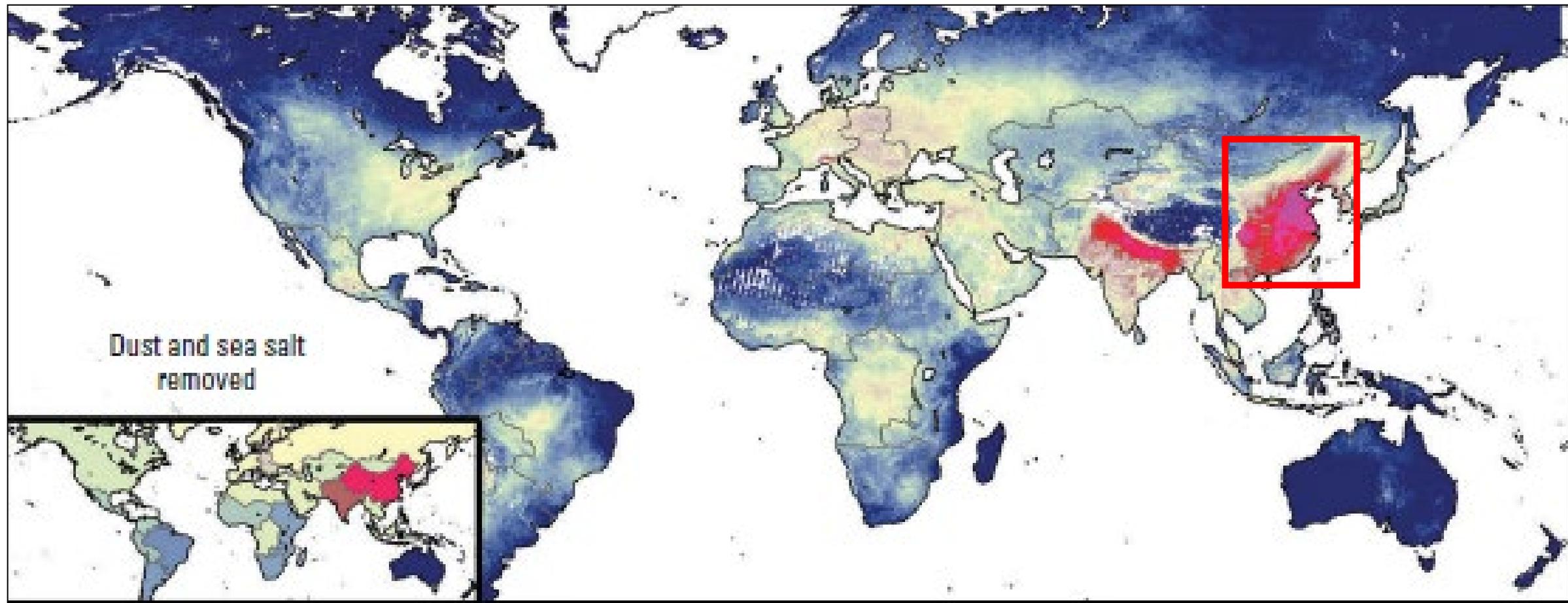
Dust- and sea salt-free PM_{2.5} concentrations



Donkelaar et al, *EHP*, 2015

PM_{2.5} = particulate matter < 2.5 μm in aerodynamic diameter

Dust- and sea salt-free PM_{2.5} concentrations



Donkelaar et al, *EHP*, 2015

PM_{2.5} = particulate matter < 2.5 μm in aerodynamic diameter

China Air Pollution Prevention and Control Action Plan (2013-)

1.Reducing emissions

2. Rein in energy intensive and highly polluting industries

3. Vigorously promote clean production, promote public transport

4. To speed up the adjustment of energy structure, increase the supply of clean energy



5. Strengthen energy conservation and environmental protection index constraints

6. Carry out new mechanism of incentive and constraint and energy conservation and emissions reduction

7. Prompting industrial transformation and upgrading by law and standard

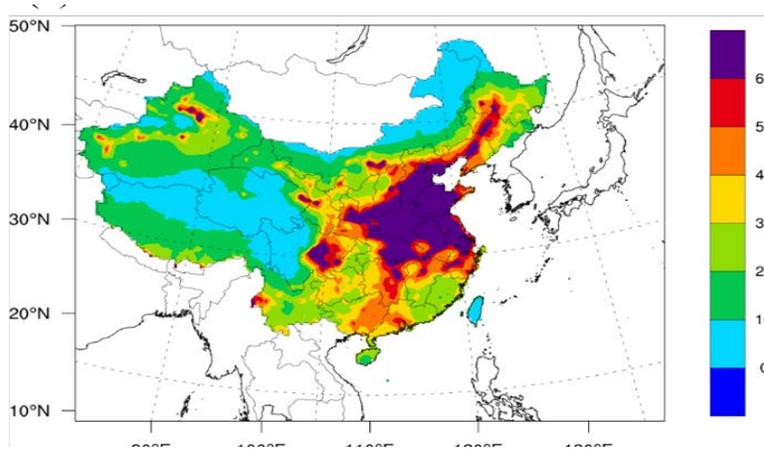
8. Prompting industrial transformation and upgrading by law and standard

9. Bring heavy pollution weather into the local government emergency management

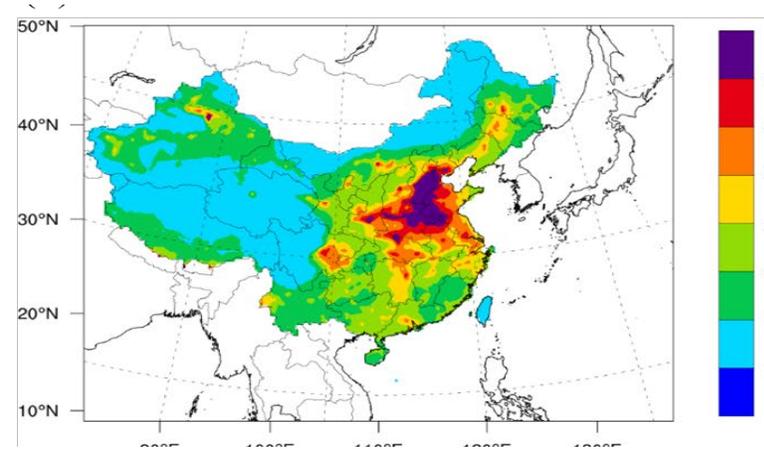
10.The local government overall responsibility for local air quality

PM_{2.5} concentration changes in China (2013-2017)

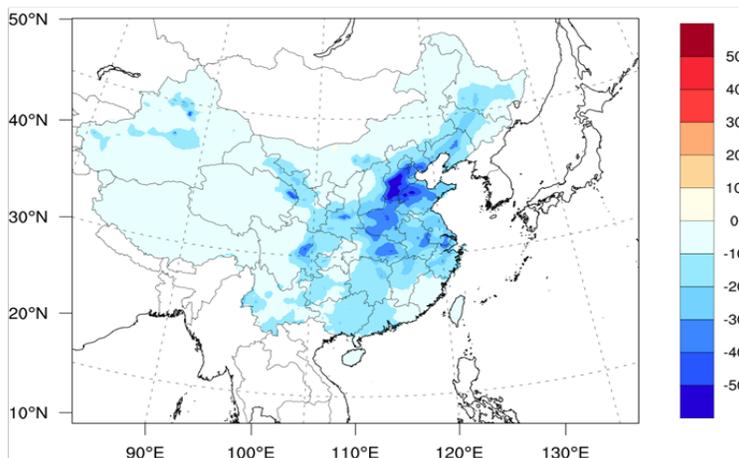
Annual PM_{2.5} concentration in 2013



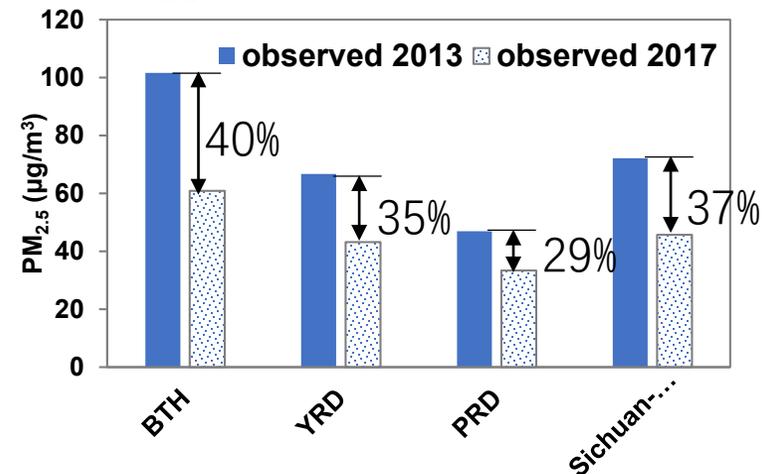
Annual PM_{2.5} concentration in 2017



Distribution of PM_{2.5} changes



PM_{2.5} reductions in key regions



BTH = Beijing-Tianjin-Hebei
 YRD = Yangtze River Delta
 PRD = Pearl River Delta
 PM_{2.5} = particulate matter < 2.5 µm in aerodynamic diameter

Courtesy of Shuxiao Wang, Tsinghua University

Air pollution and health is a hot research topic in China

The screenshot shows the PubMed search results for the query "air pollution and China". The search bar at the top contains the text "air pollution and China" and a "Search" button. Below the search bar, there are options for "Format: Summary", "Sort by: Most Recent", and "Per page: 20". The search results are displayed in a list format, with the top three results highlighted as "Best matches for air pollution and China":

- [Air Pollution and Mortality in China.](#)
Lin H et al. Adv Exp Med Biol. (2017)
- [Air Pollution Prevention and Control Policy in China.](#)
Huang C et al. Adv Exp Med Biol. (2017)
- [Air Pollution, Disease Burden, and Health Economic Loss in China.](#)
Niu Y et al. Adv Exp Med Biol. (2017)

Below the search results, there is a "Search results" section showing "Items: 1 to 20 of 8603". The number "8603" is circled in red. To the right of the search results, there is a "Results by year" bar chart showing the number of papers published each year from 2016 to 2018. A red arrow points to the bar for 2018, which is the highest. Below the bar chart, there is a "Download CSV" link. At the bottom of the page, there is a "PMC Images search for air pollution and China" link.

China

2018: 1,311 papers
2017: 1,054 papers
2016: 978 papers

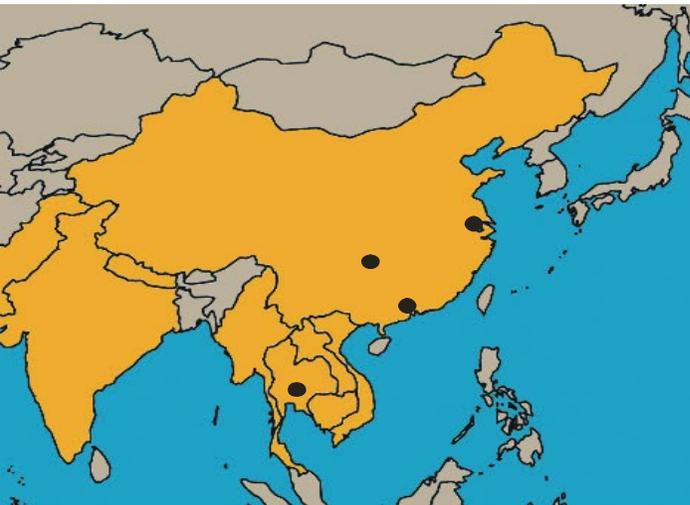
Global

2018: 3,776 papers
2017: 3,673 papers
2016: 3,693 papers

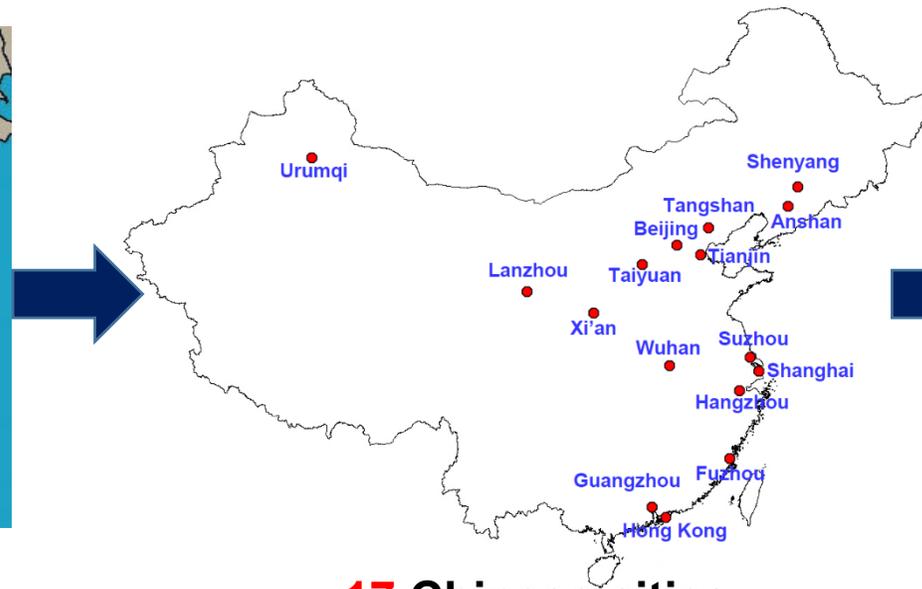
A summary of air pollution epidemiology in China

- **Short-term exposure (time-series/case crossover) studies**
 - **Single-city analysis: Beijing, Hong Kong, Shanghai, etc.**
 - **Multi-city analysis: Public Health and Air Pollution in Asia (3 Chinese cities), 17 cities, 272 cities**
- **Long-term exposure (cohort) study**
 - **China National Hypertension Survey (TSP)**
 - **Chinese Men's cohort (PM_{2.5})**
 - **Chinese Healthy Longevity Cohort (CLHLS) (PM_{2.5})**
- **Intervention study**
 - **Population level: Beijing Olympics; Nanjing Young Olympics**
 - **Individual level: air purifier, mask, dietary supplementation**

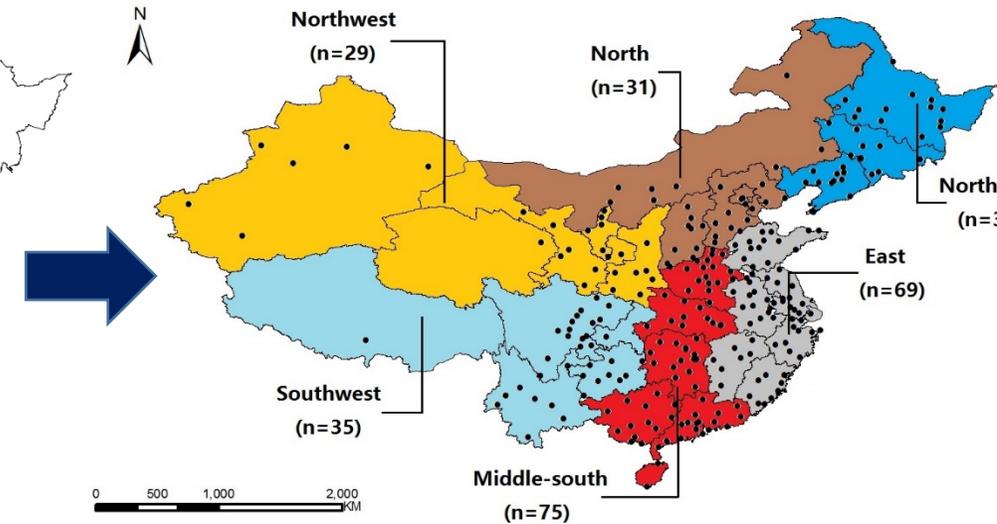
Short-term exposure studies



PAPA (3 Chinese cities)



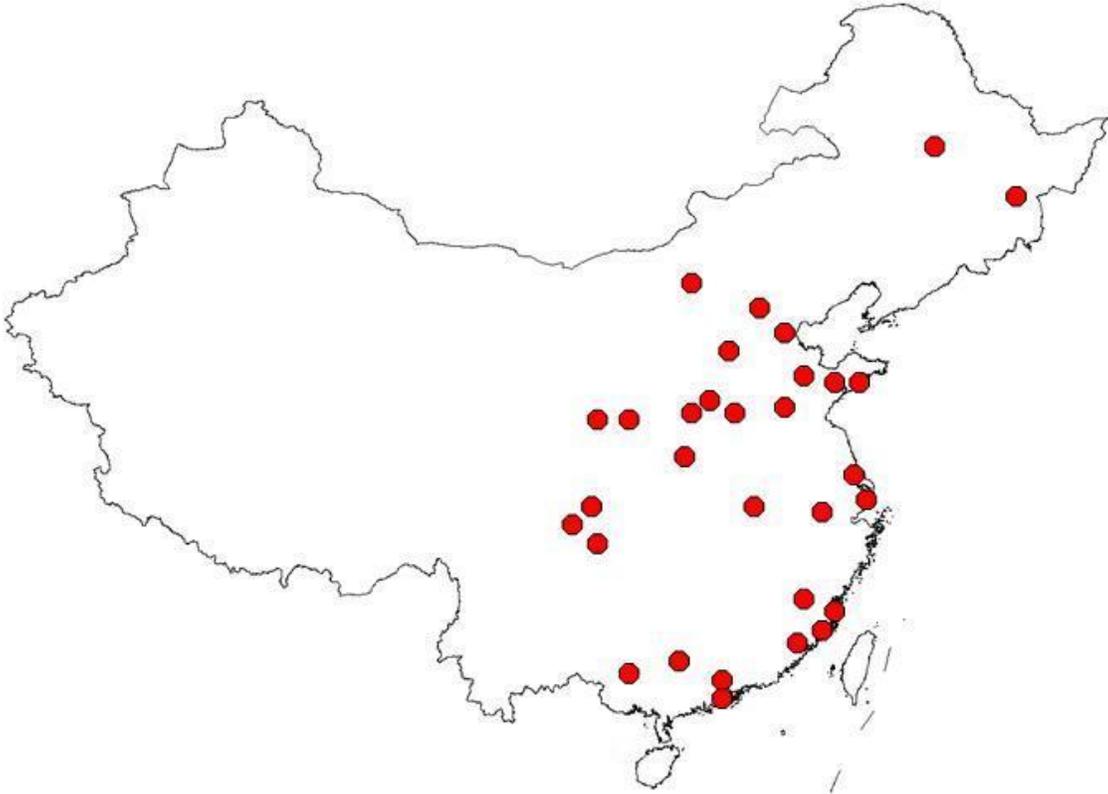
17 Chinese cities



272 Chinese cities

- Particulate Matter (PM) Coefficients **LOWER** than in Europe and North America
- **Stronger** associations in cities with **lower PM_{2.5}** levels or **higher temperatures**, as well as in subpopulations with **elder age** or **less education**

Long-term exposure studies - China National Hypertension Survey



- Each $10 \mu\text{g}/\text{m}^3$ increase in **TSP** was associated with increased risk of death *:
 - 0.2% for total mortality (p=0.222)
 - **0.8% for cardiovascular mortality (p=0.003)**
 - 0.4% for respiratory mortality (p=0.448)
 - 1.0% for lung cancer mortality (p=0.095)

Cao et al, 2011

Long-term exposure studies - Chinese Men's Study

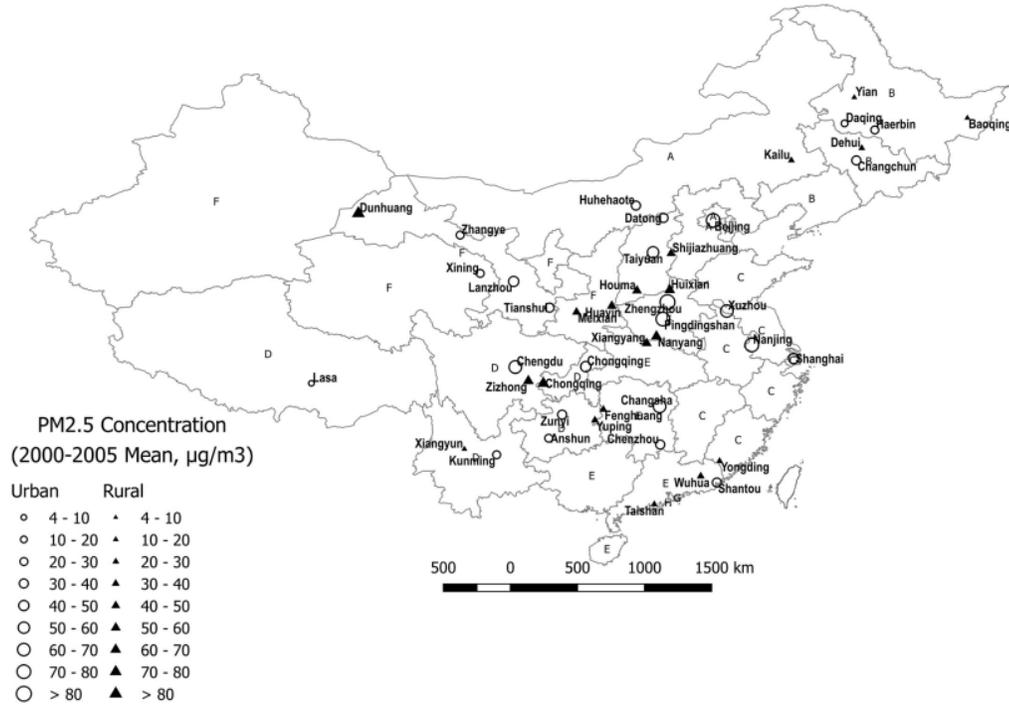
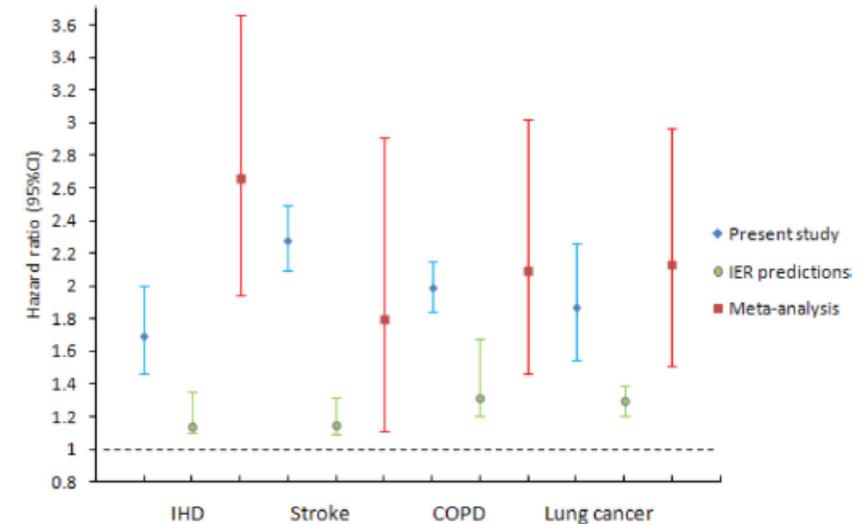
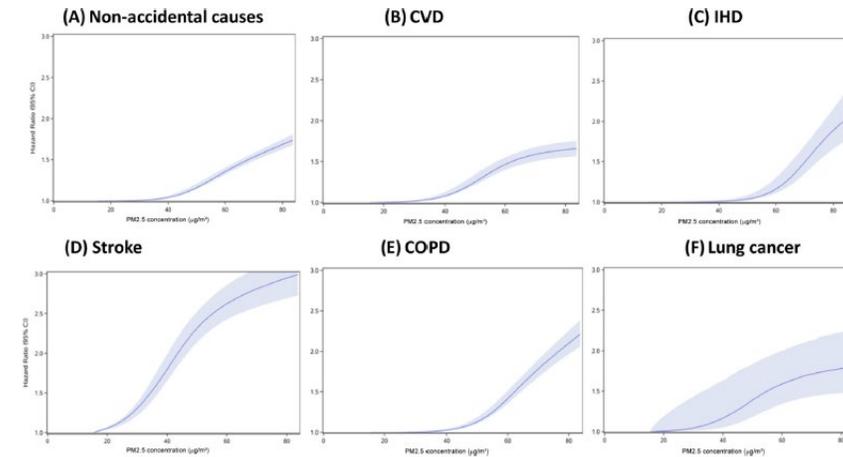


Figure 1. Mean concentrations (2000–2005 mean) of $\text{PM}_{2.5}$ in the 45 urban and rural DSP sites in the cohort. A: North; B: Northeast; C: East; D: Southwest; E: South Central; F: Northwest; G: Hong Kong Special Administrative Region; H: Macao Special Administrative Region. The software used to create the figure is QGIS (version 2.18; QGIS Community, open source).



Yin et al, 2018

Long-term exposure studies - Chinese Healthy Longevity Cohort (CLHLS)

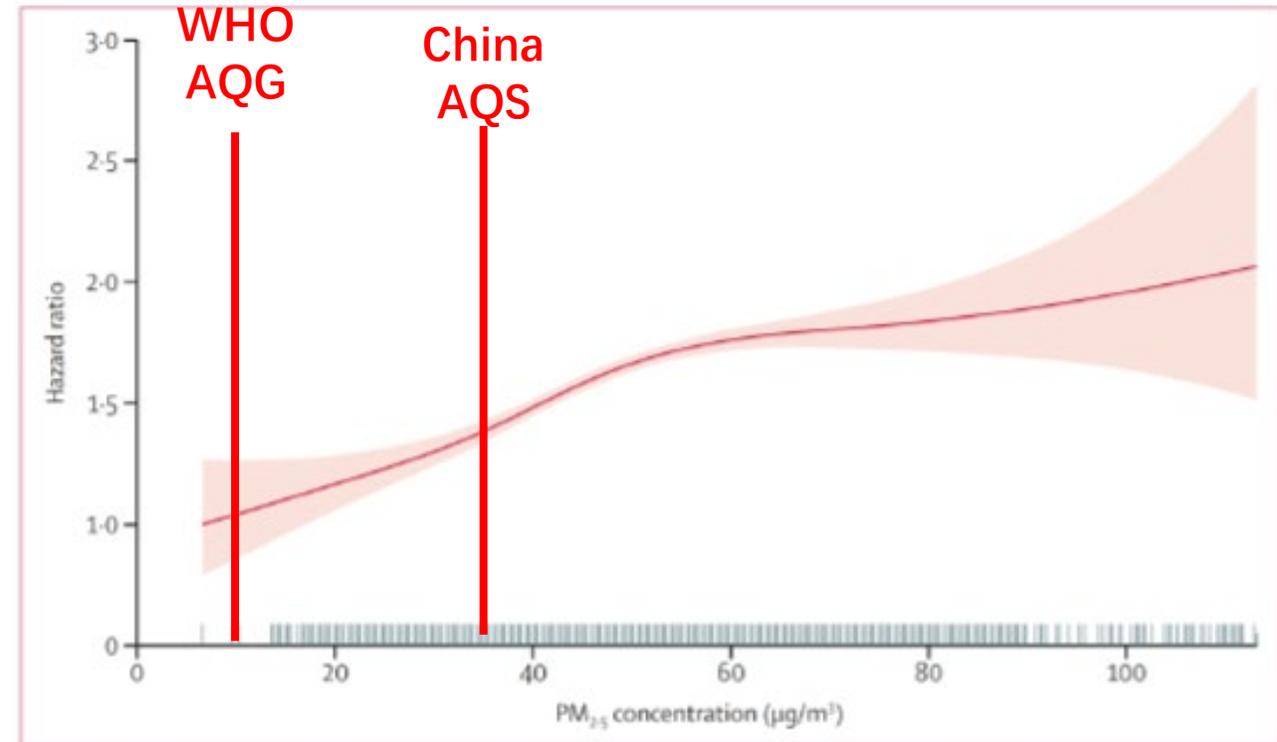
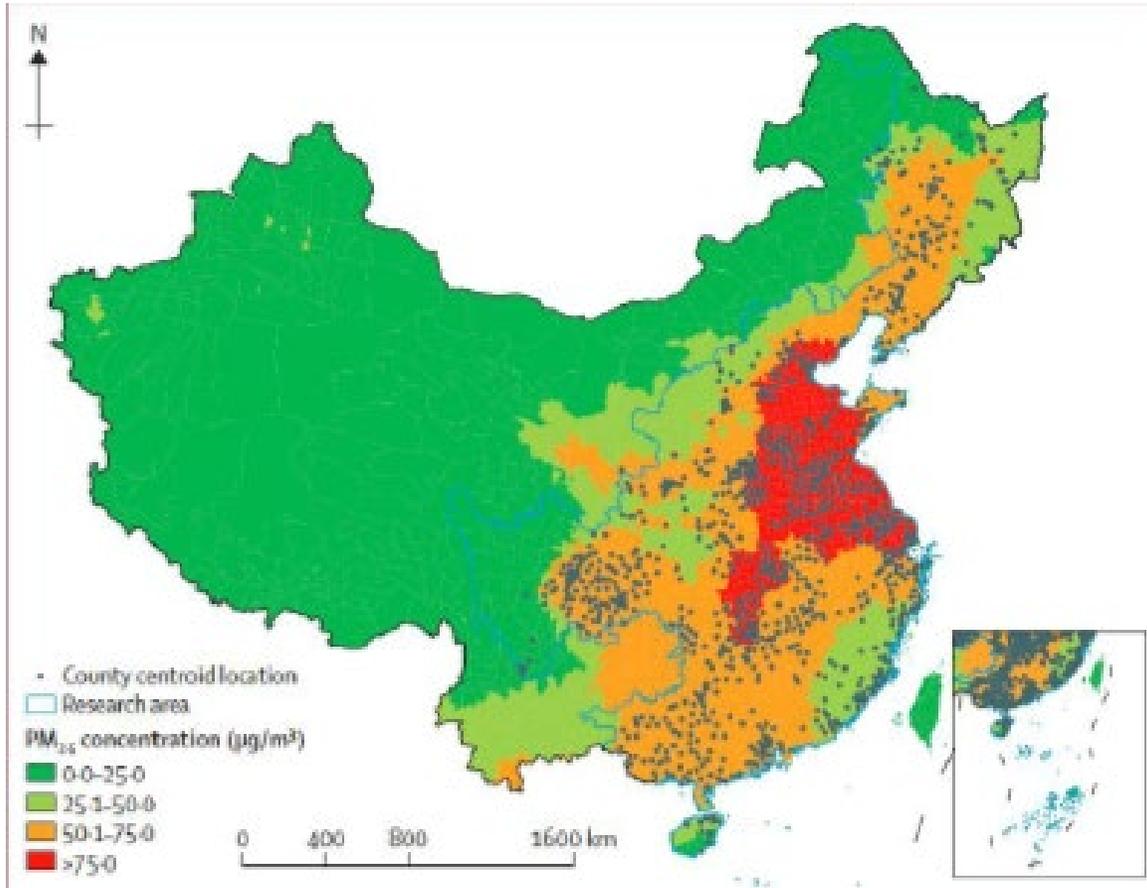
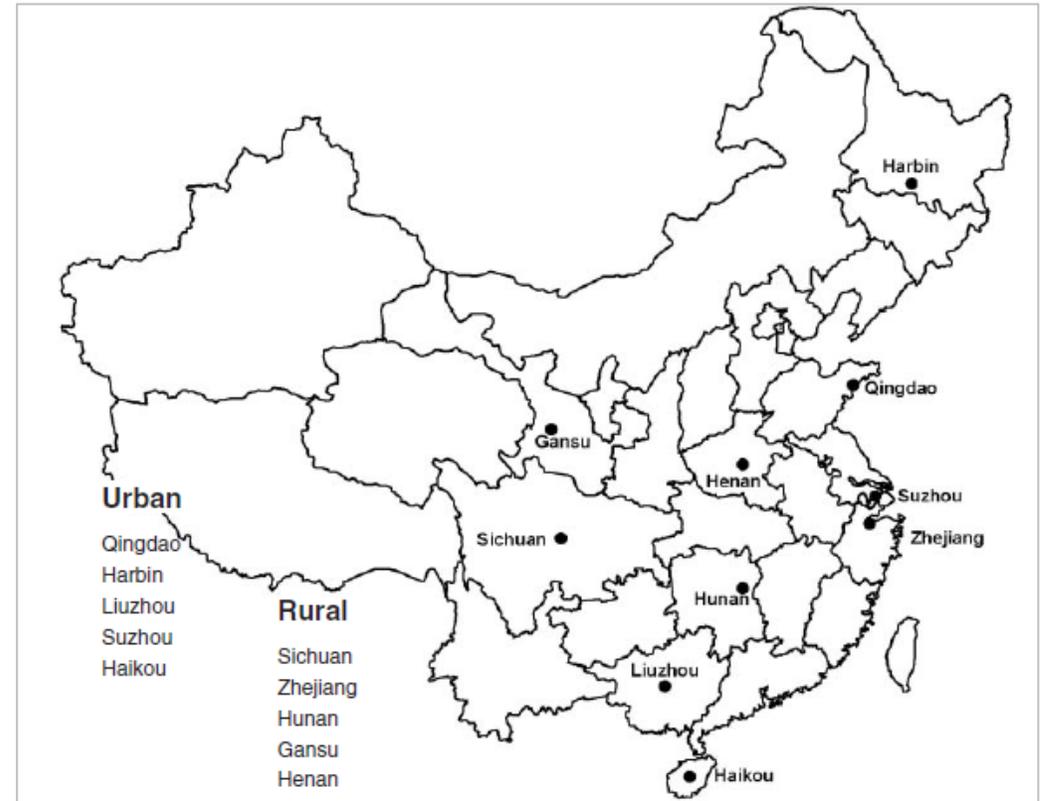


Figure 2: Curve association between all-cause mortality and a 10 µg/m³ increase in 3-year average PM_{2.5} concentration
Shading indicates 95% CIs. The reference PM_{2.5} concentration was 6.7 µg/m³ (curve results from model 10).

Long-term exposure studies - China Kadoorie Biobank

- **Half a million** participants
- **10 sites**: 5 urban, 5 rural
- **High data quality, experienced investigators** (Zhengmin Chen, Richard Peto)
- **Publications**: JAMA 2017, NEJM 2016, Lancet 2015, BMJ 2015



Chen et al, 2005

More air pollution cohorts in China are coming soon!

	Sample size & locations	Outcomes
Long-term Effects of Air Pollution in China (China-LEAP)	127 thousands (ChinaMUCA, InterASIA, CIMIC); 21 cities	Mortality, morbidity, biomarkers
China Health and Retirement Longitudinal Study (CHARLS)	17 thousands; 28 provinces, 150 counties	Mortality, morbidity, biomarkers
Subclinical outcomes of polluted air in China (SCOPE-China)	8 thousands; 28 cities	Biomarkers
33 Chinese Communities Study	40 thousands; 4 cities, 33 communities	Mortality, morbidity
SAGE-China, PURE-China		



providing information for global exposure-response function at the **HIGH end**

Intervention studies

Population level

- Beijing Olympics
- Nanjing Young Olympics

Individual level

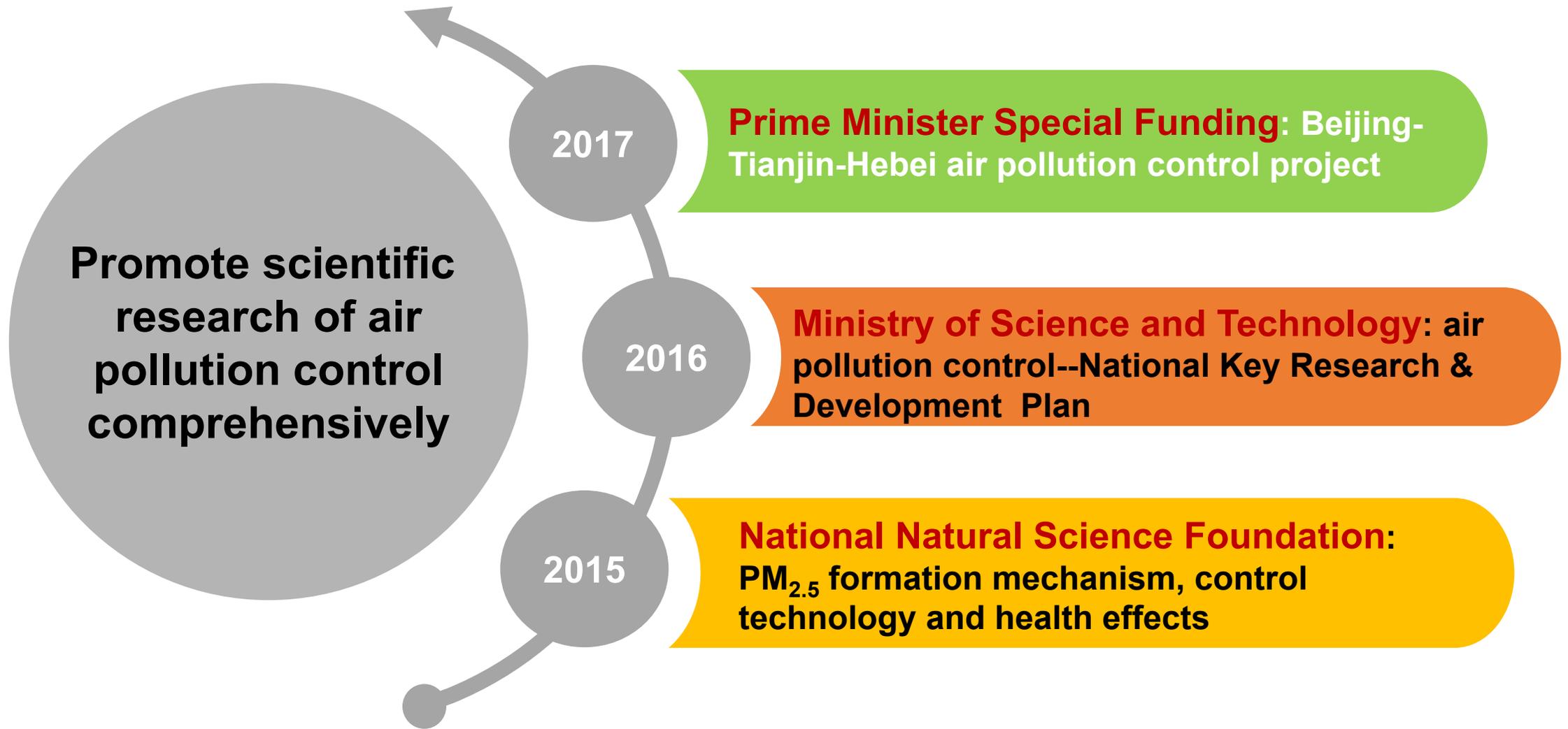
- Air purifiers (in **Beijing**, **60%** at home, **40%** at work)
- Masks (**30%**)
- Dietary supplementation (**30%**)

Factors contributing to China's progress

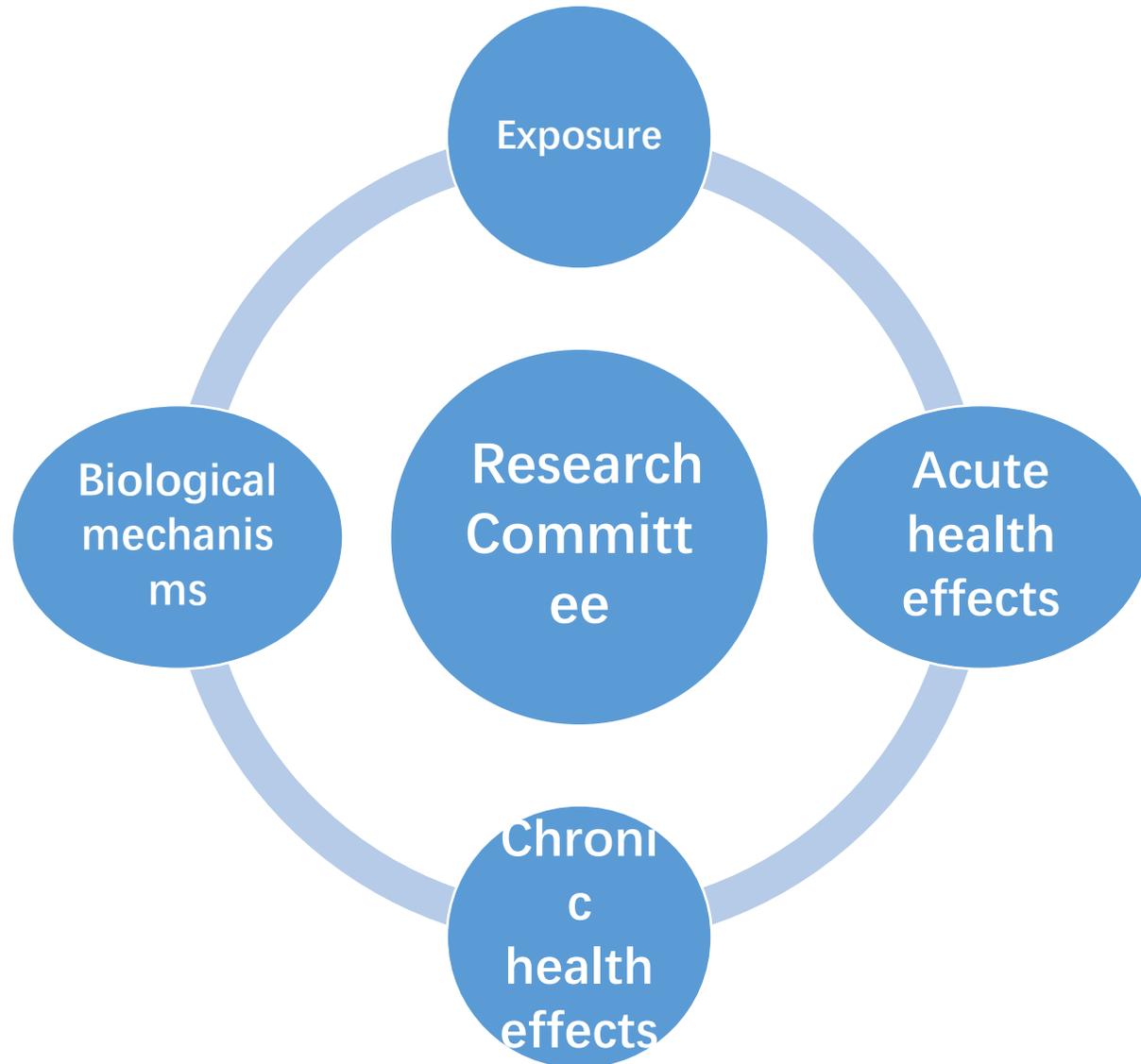
- **Government funding**
- **Increasing exposure and health data**
- **Education system**

Government funding

- National Development Research Program

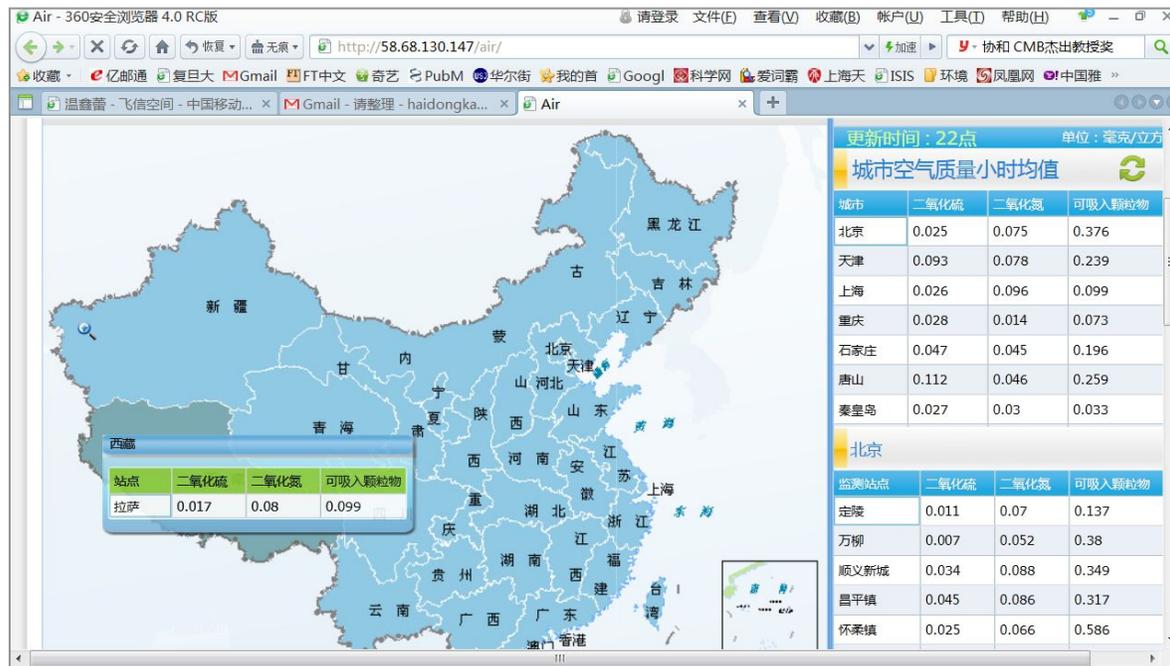


Ministry of Science and Technology (MOST) air pollution control program



**MOST Air Pollution Program
Research Committee**

Exposure data - National air quality monitoring network since 2013



National PM Components Monitoring Network

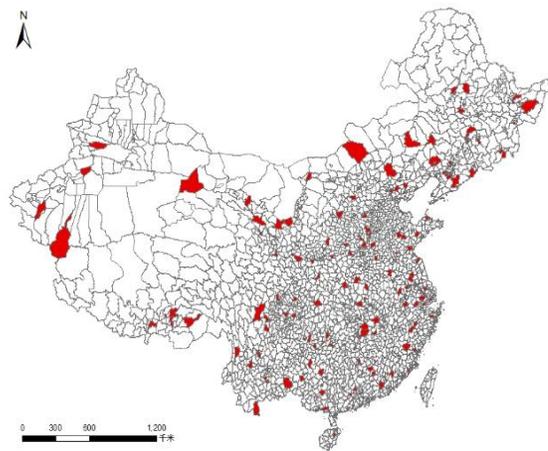
- Initiated in 2016
- 93 Chinese cities included in 2019
- PM components
 - OC, EC
 - Elements: V, Fe, Ni, Zn, et al
 - Soluble ions: sulfate, nitrate, ammonium, et al

- 338 cities, 1,436 stations (2016)
- 6 criteria pollutants (PM_{2.5}/PM₁₀/O₃/SO₂/NO₂/CO)
- Largest one in developing countries

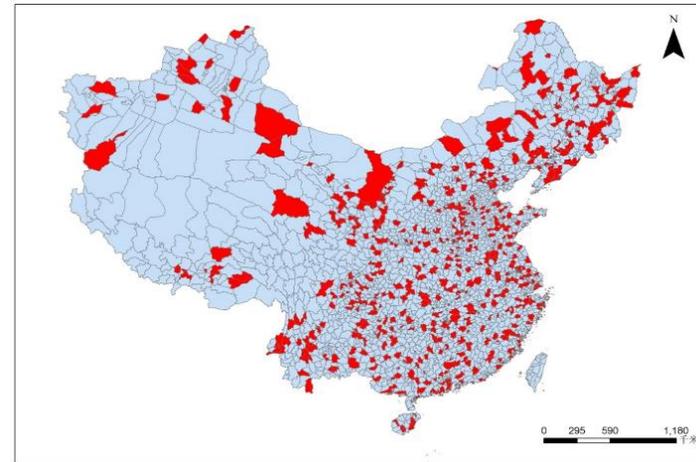
PM = particulate matter
PM_{2.5} = particulate matter < 2.5 μm in aerodynamic diameter
PM₁₀ = particulate matter < 10 μm in aerodynamic diameter
O₃ = ozone; SO₂ = sulfur dioxide
NO₂ = nitrogen dioxide; CO = carbon monoxide
OC = organic carbon; EC = elemental carbon

Health data – Disease Surveillance Points (DSP) system in China

- DSPs are nationally representative and cover about 23% of China's total population;
- A DSP was either a district in an urban area or a county in a rural area;
- Web based death reporting; 7.2 million death cases reported in 2017.



Geographic distribution of
DSPs in 1990



Geographic distribution of
DSPs in 2013

Courtesy of Peng Yin, China CDC

Health Data - National Cohort Consortium under the Chinese Precision Medicine Program

- **2016:** China Kadoorie Biobank (national model cohort, 0.5M), Beijing-Tianjin-Hebei (0.1M), and Central China (0.1M)
- **2017:** Eastern China (0.1M), Southern China (0.1M), Northeast China (0.1M), Northwest China (0.1M), and Southwest China (0.1M)
- **Total:** 1.2M

Education system

- In 2018, 94 Schools of Public Health in China
 - 12,700 undergraduate student; 2,500 master students; 400 PhD students
 - Most schools have Department of Environmental Health
- CDC system
 - 4-level system: National, Province-level, City-level, and District-level
 - Department of Environmental health

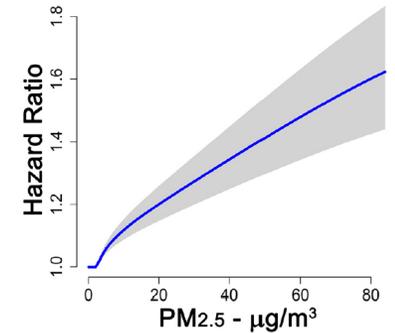
Implications of Chinese studies

China

- To provide local evidence for air quality management
- China Air Quality Stations (AQS)

Globally

- Global exposure-mortality model (GEMM)
- WHO Air Quality Guidelines (AQG)



**Burnett et al,
2018**

Limitations of Chinese studies

- Most in cities
- Most on particulate matter, few on ozone and nitrogen dioxide (NO₂)
- 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 modeling
 - Omics technology (e.g. exposome)

Thank you !

kanh@fudan.edu.cn