Air pollution and its reproductive effects on human beings in China

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International Symposium on Developmental Toxicity

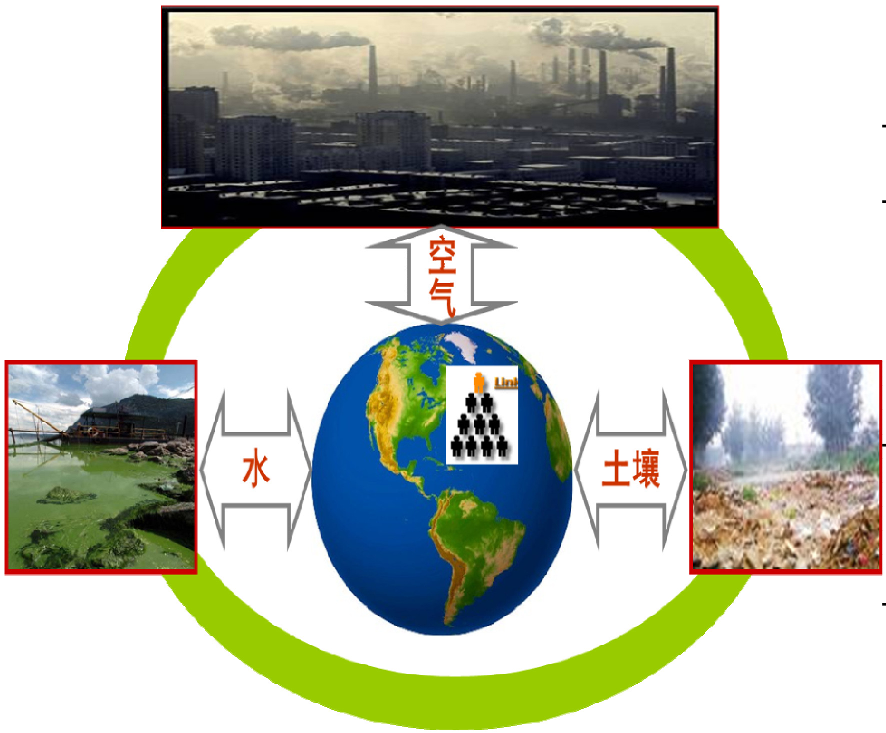
May 14, 2014

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

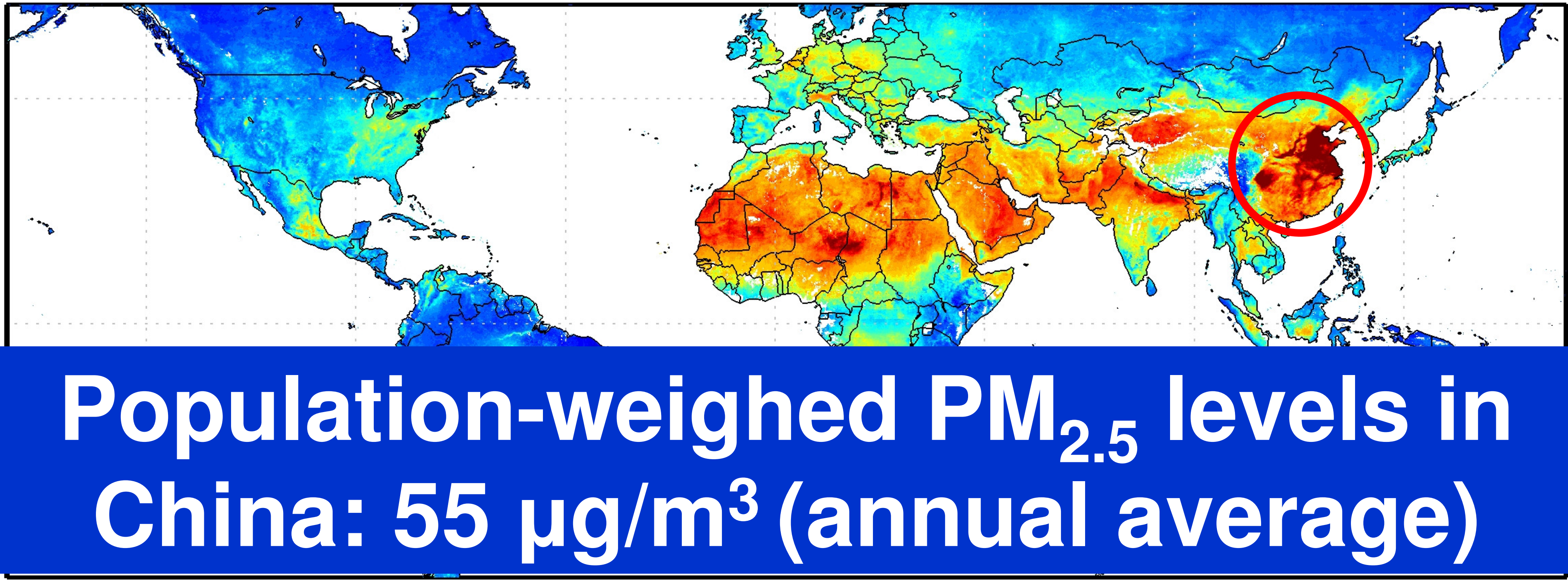


Cost of environmental pollution in China in 2003

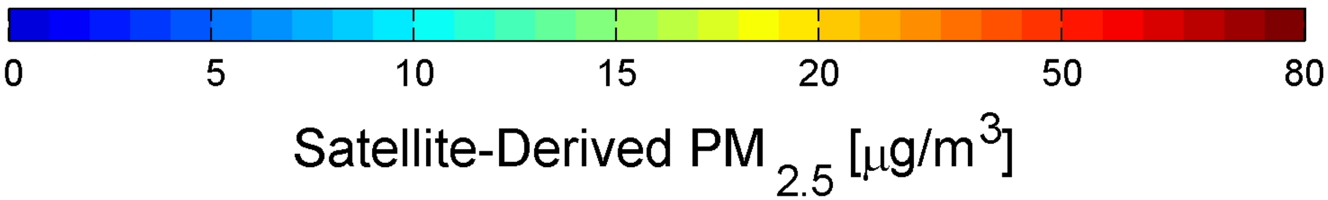
	Air pollution	Water pollution
Disease burden	**400,000 premature deaths**	52,000 cancer deaths
Health economic loss	**519,9 Billion □**	9.5 Billion □
Other economic loss	36,7 Billion □	158,0 Billion □

Source: World Bank, *Cost of Pollution in China*

Satellite Global $PM_{2.5}$ concentrations

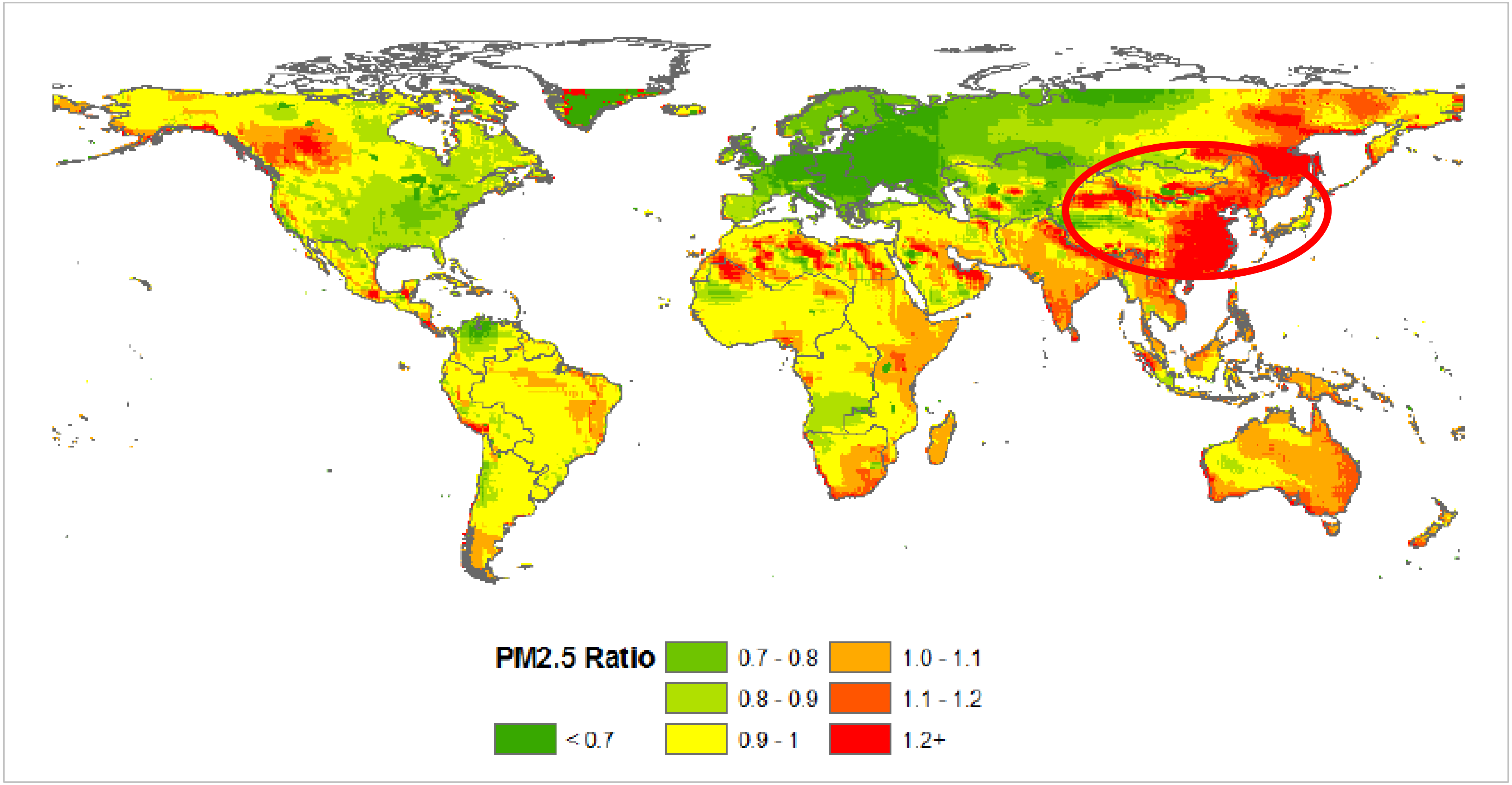


Population-weighed $PM_{2.5}$ levels in China: 55 μg/m^3 (annual average)



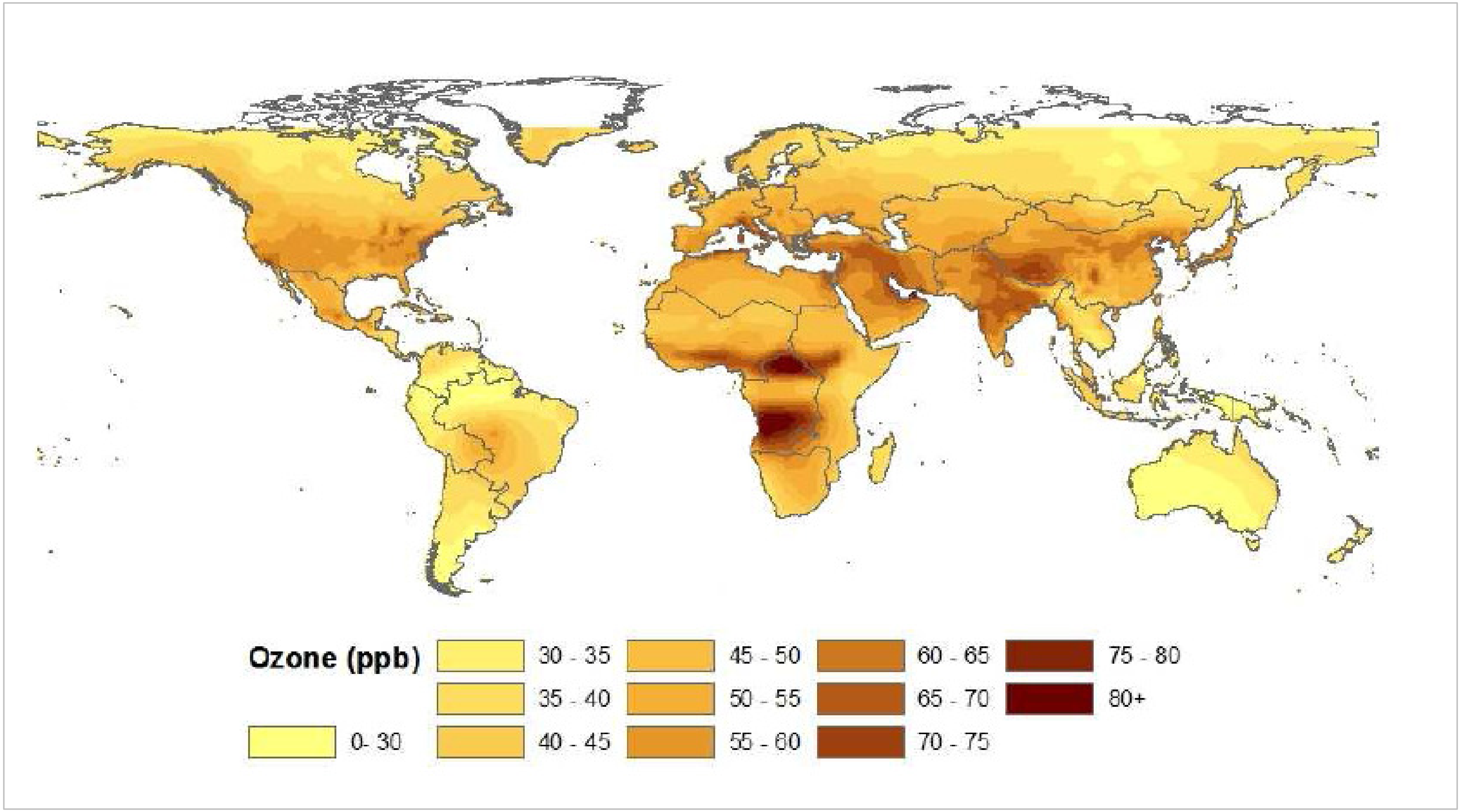
EHP, 2010

Ratio of $PM_{2.5}$ concentrations: 2005/1990



Brauer et al, EST, 2012

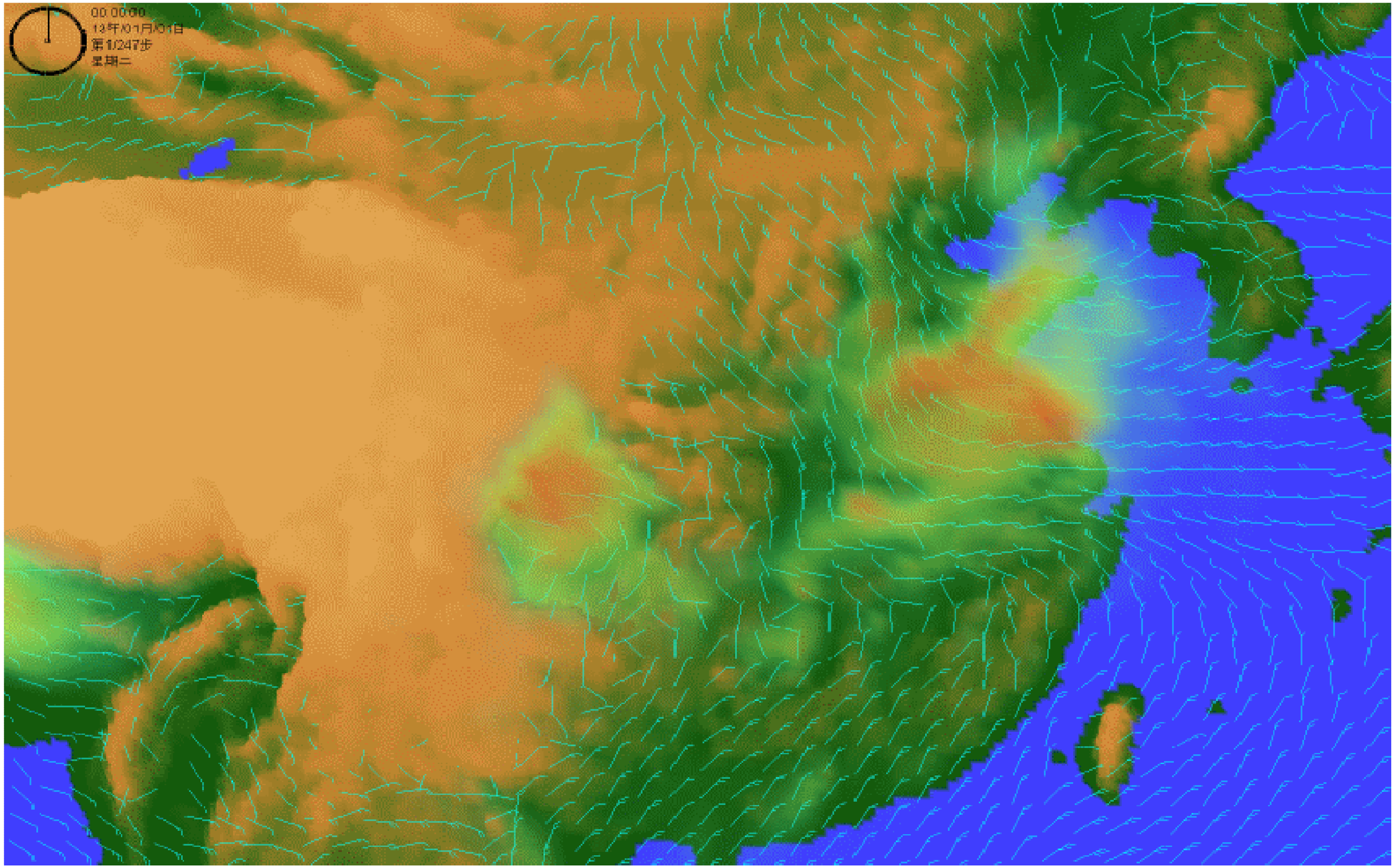
Estimated ozone concentrations (2005, ppb)



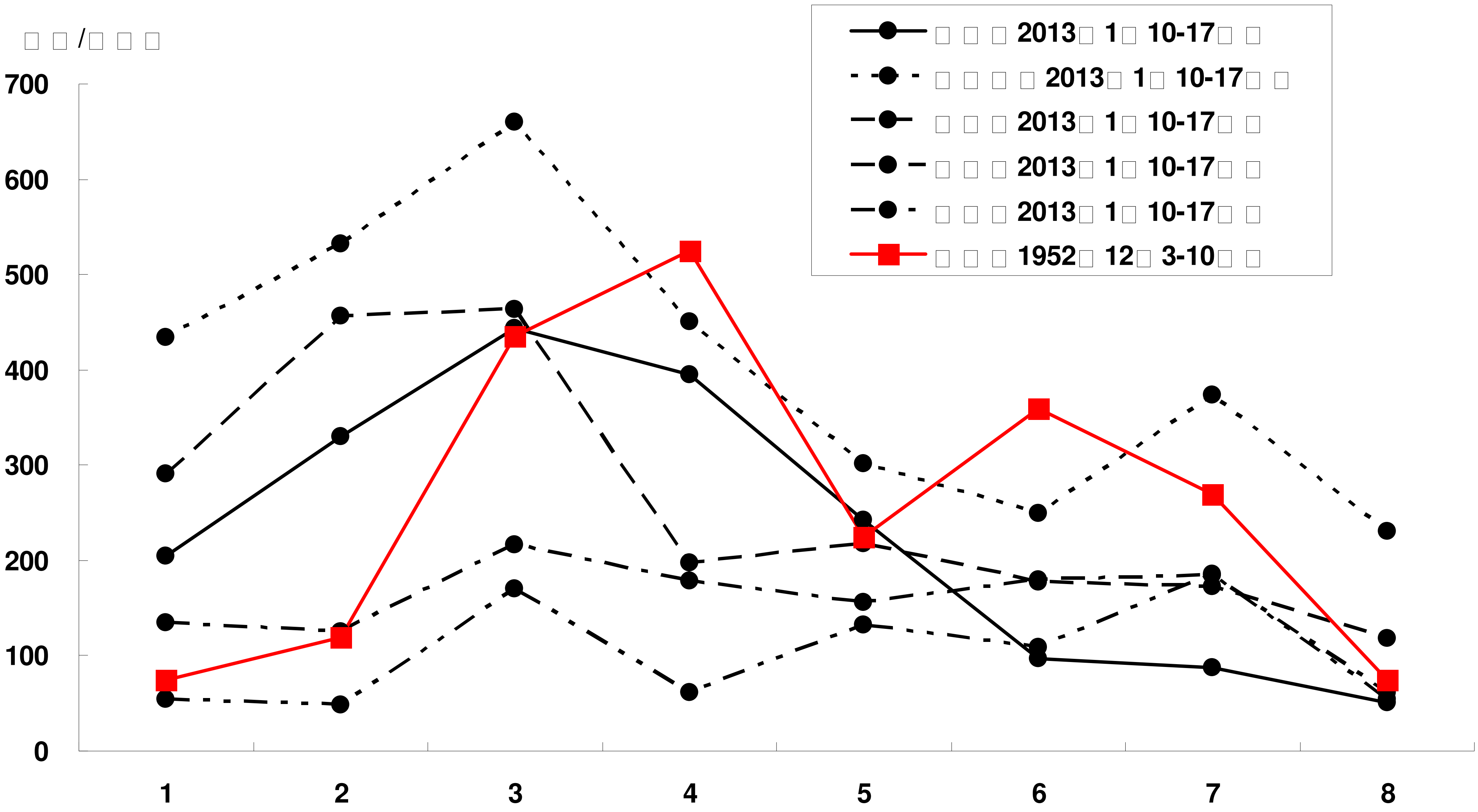
Brauer et al, EST, 2012

Heavy fog in China
January, 2013

Heavy fog in China January, 2013



$PM_{2.5}$ levels during the fog



Global Burden of Disease (2010)

Articles

A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010

Summary

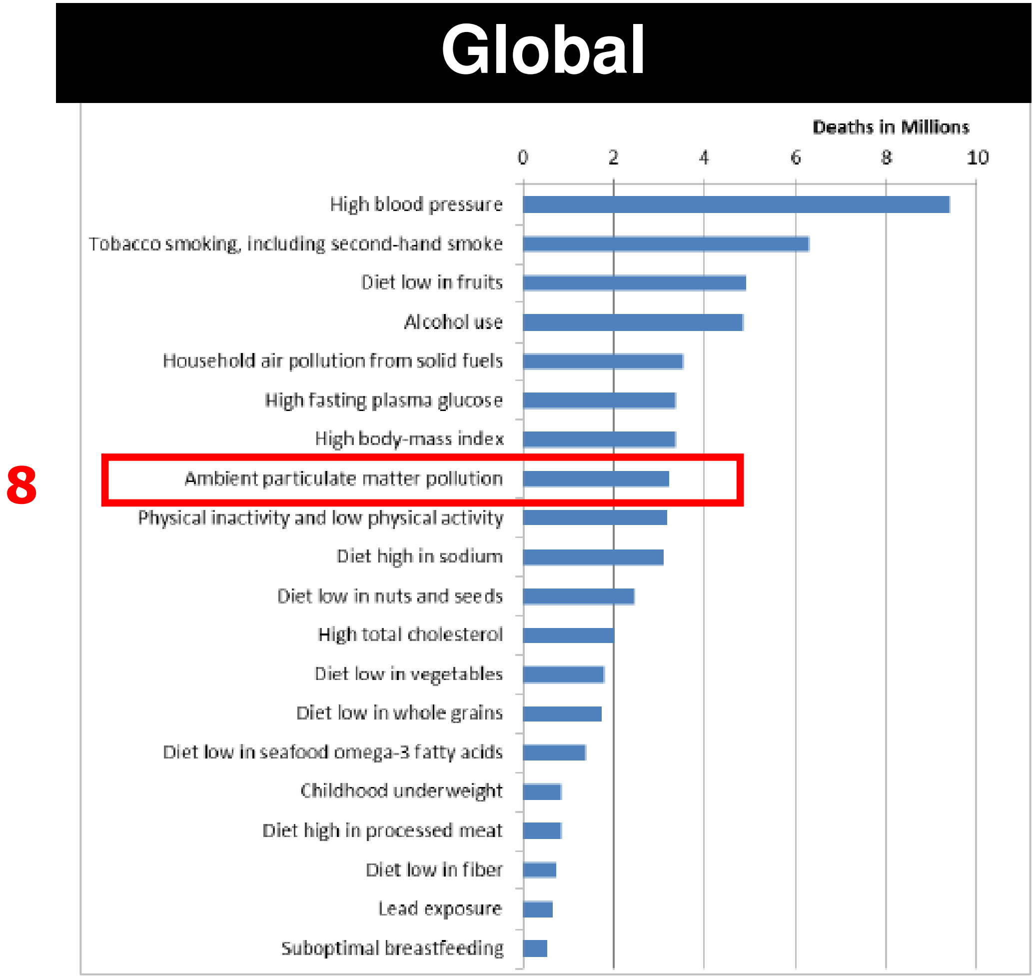
Background Quantification of the disease burden caused by different risks informs prevention by providing an account of health loss different to that provided by a disease-by-disease analysis. No complete revision of global disease burden caused by risk factors has been done since a comparative risk assessment in 2000, and no previous analysis has assessed changes in burden attributable to risk factors over time.

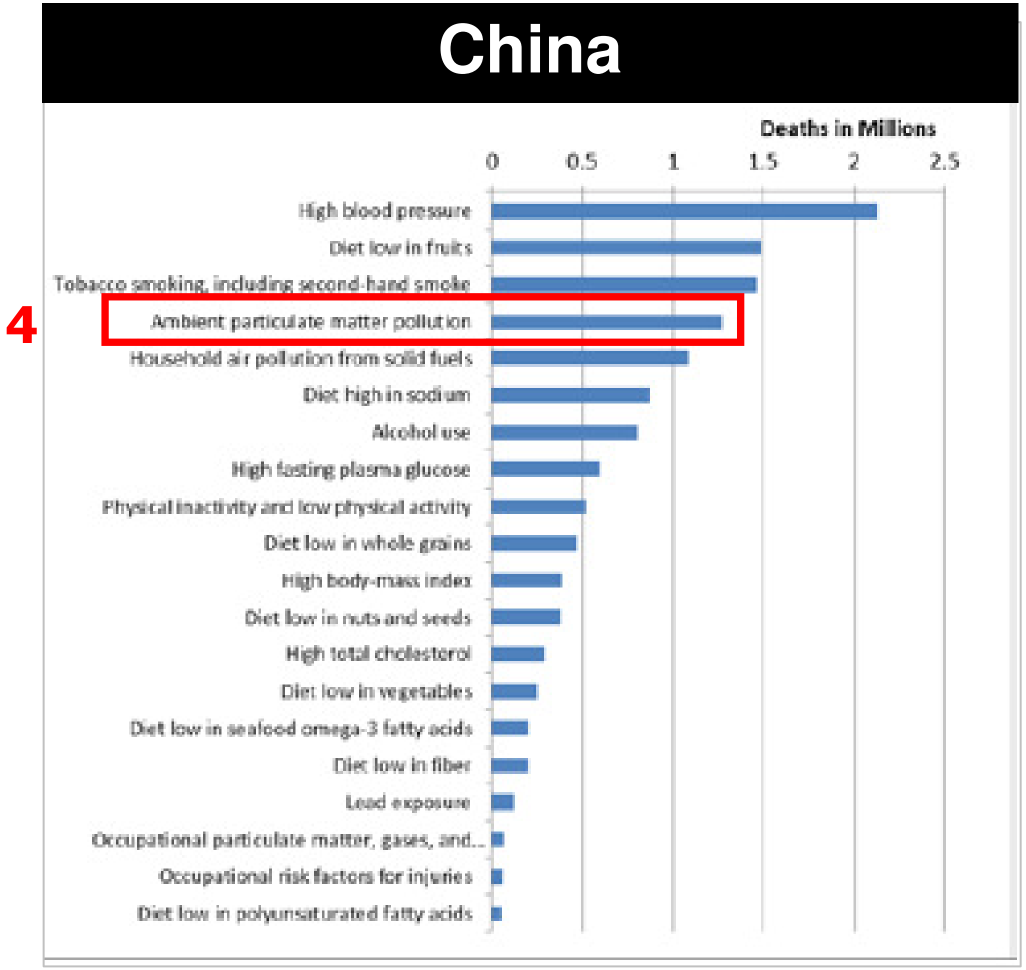
Methods We estimated deaths and disability-adjusted life years (DALYs; sum of years lived with disability [YLD] and years of life lost [YLL]) attributable to the independent effects of 67 risk factors and clusters of risk factors for 21 regions in 1990 and 2010. We estimated exposure distributions for each year, region, sex, and age group, and relative risks per unit of exposure by systematically reviewing and synthesising published and unpublished data. We used these estimates, together with estimates of cause-specific deaths and DALYs from the Global Burden of Disease Study 2010, to calculate the burden attributable to each risk factor exposure compared with the theoretical-minimum-risk exposure. We incorporated uncertainty in disease burden, relative risks, and exposures into our estimates of attributable burden.

Findings In 2010, the three leading risk factors for global disease burden were high blood pressure (7·0% [95% uncertainty interval 6·2–7·7] of global DALYs), tobacco smoking including second-hand smoke (6·3% [5·5–7·0]), and alcohol use (5·5% [5·0–5·9]). In 1990, the leading risks were childhood underweight (7·9% [6·8–9·4]), household air pollution from solid fuels (HAP; 7·0% [5·6–8·3]), and tobacco smoking including second-hand smoke (6·1% [5·4–6·8]). Dietary risk factors and physical inactivity collectively accounted for 10·0% (95% UI 9·2–10·8) of global DALYs in 2010, with the most prominent dietary risks being diets low in fruits and those high in sodium. Several risks that primarily affect childhood communicable diseases, including unimproved water and sanitation and childhood micronutrient deficiencies, fell in rank between 1990 and 2010, with unimproved water

Lim et al, Lancet, 2012

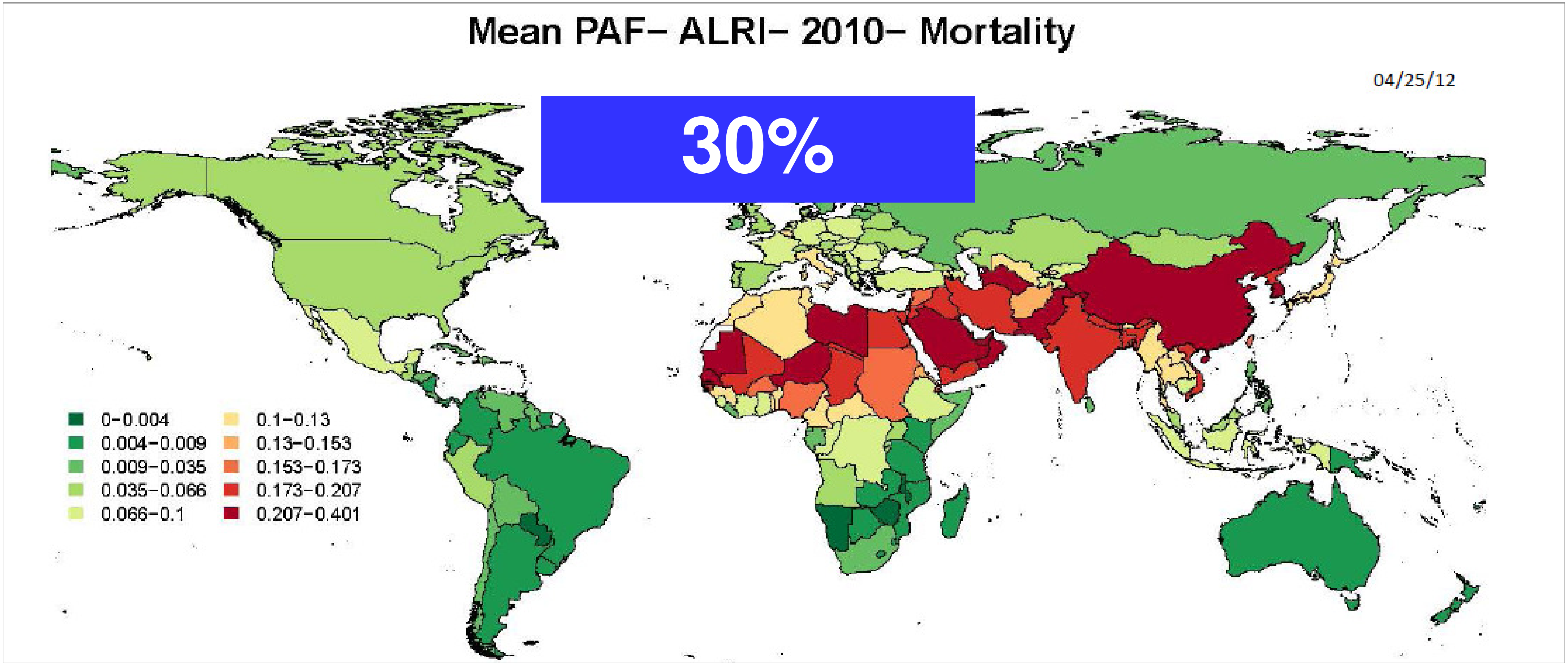
Top 20 risk factors for mortality





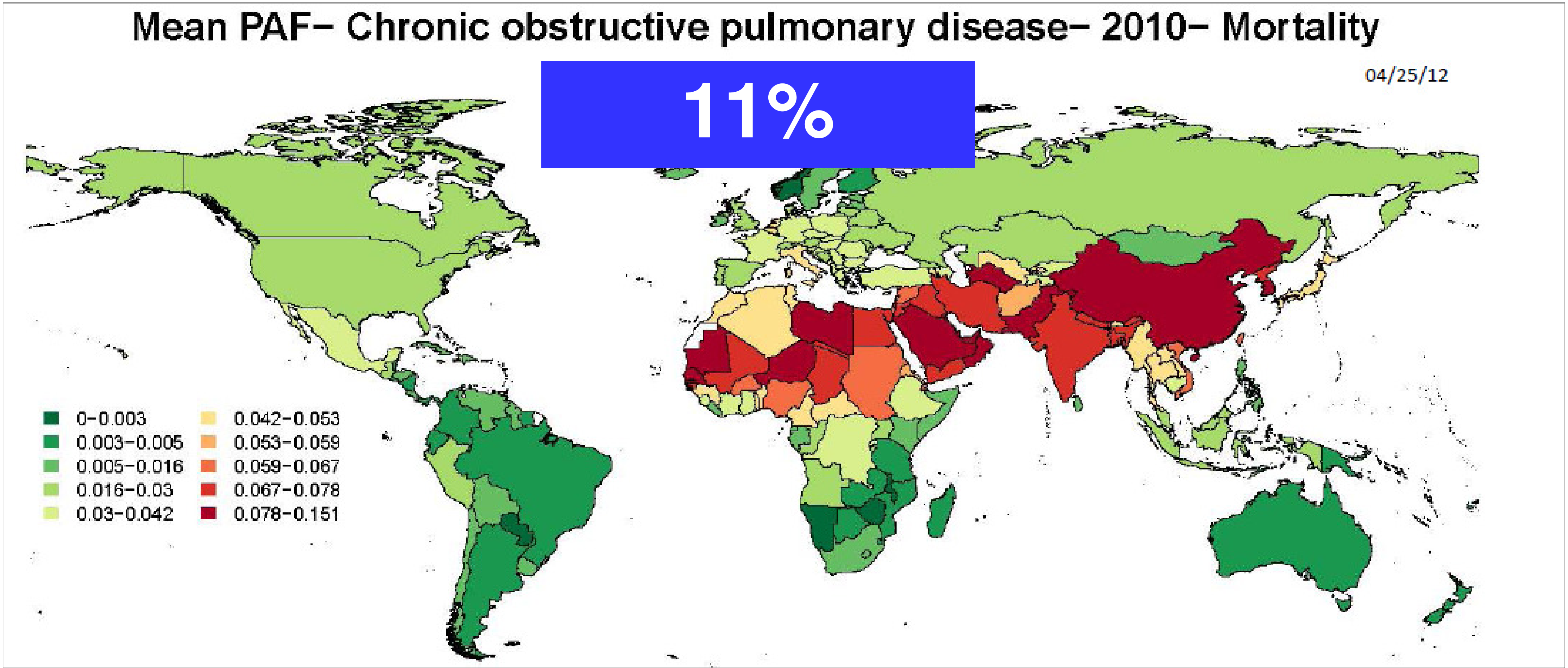
Lim et al, Lancet, 2012

$PM_{2.5}$ and ALRI



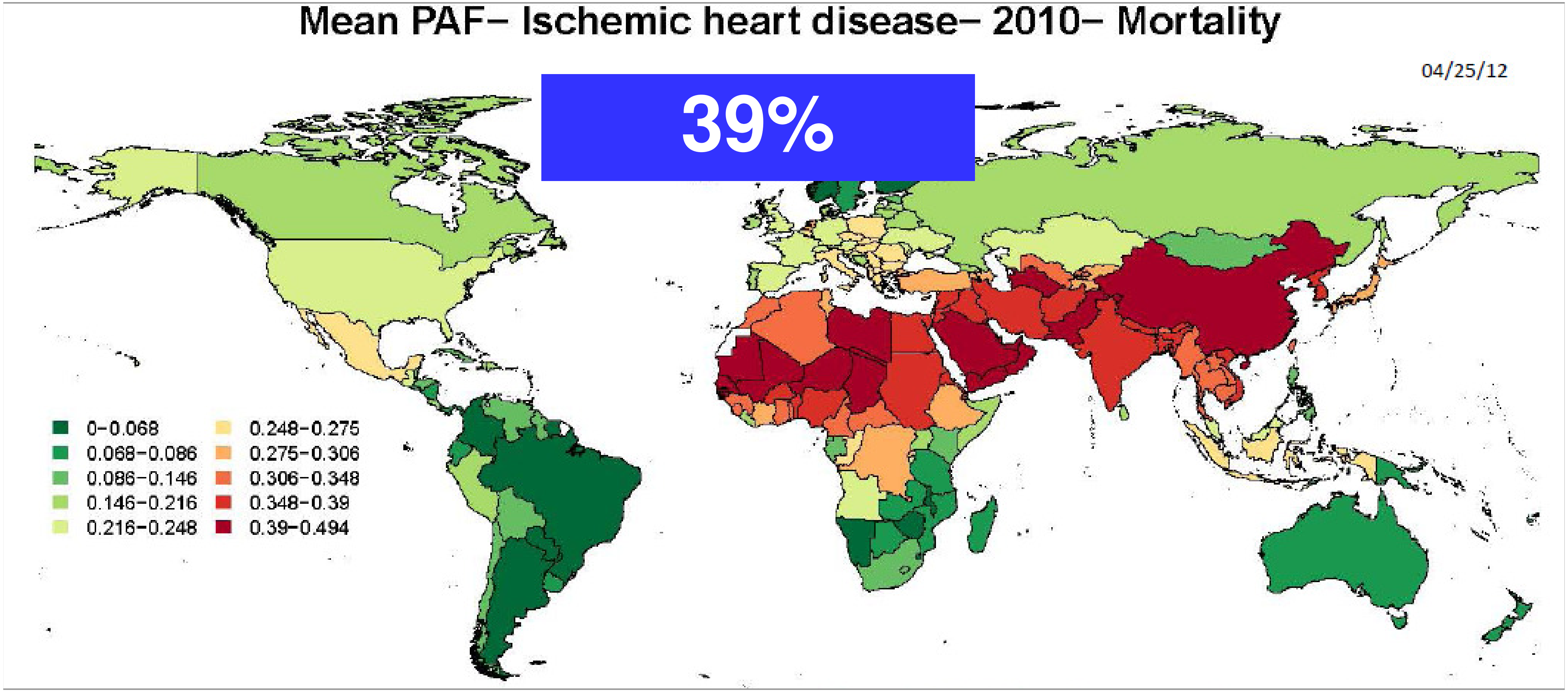
GBD, 2012

$PM_{2.5}$ and COPD



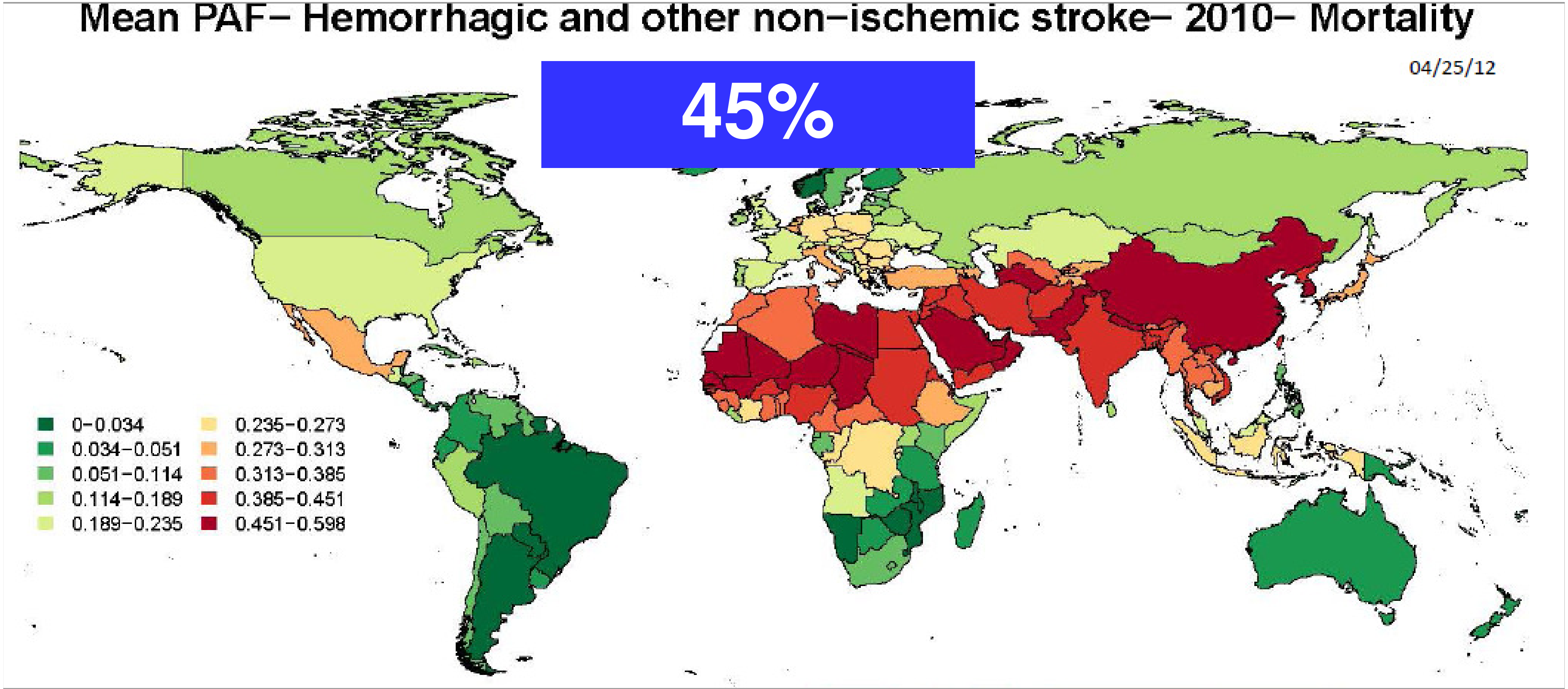
GBD, 2012

$PM_{2.5}$ and CHD



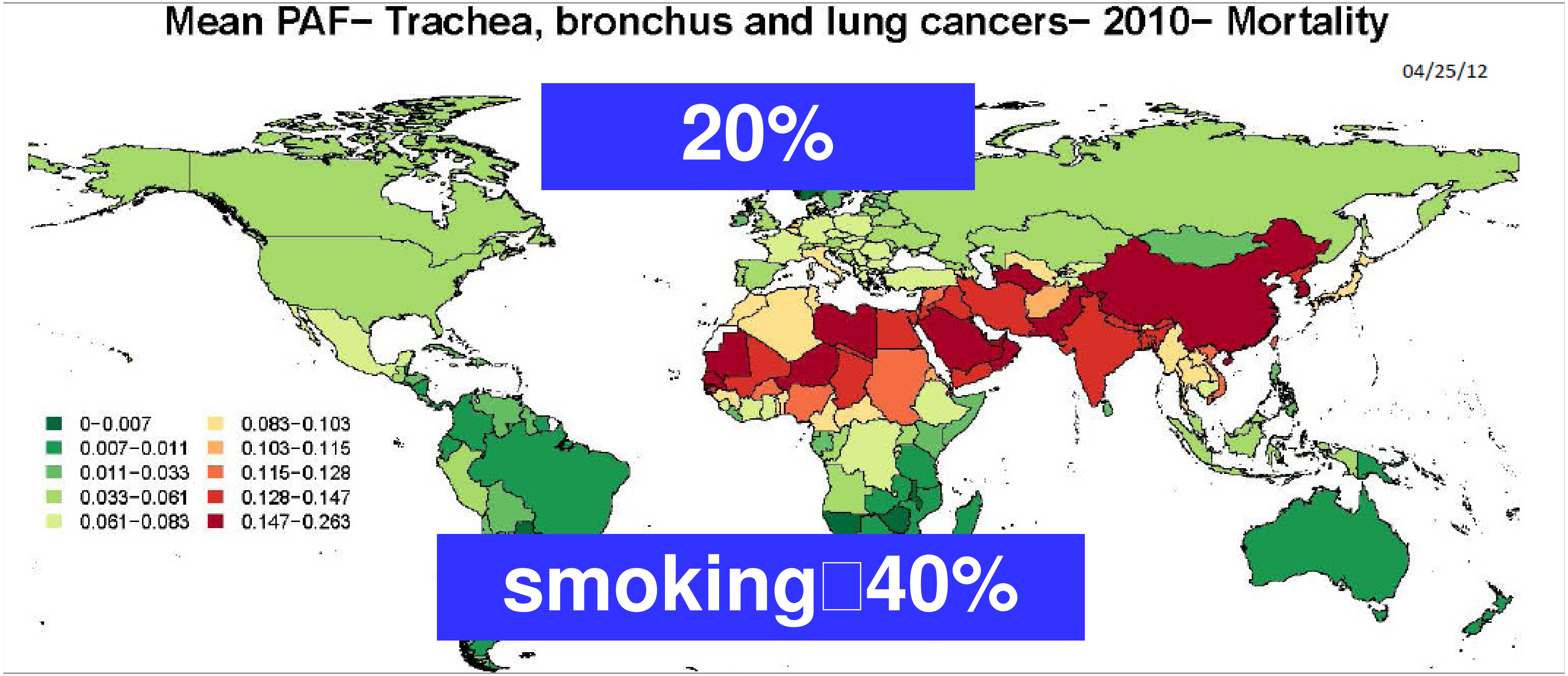
GBD, 2012

$PM_{2.5}$ and stroke



GBD, 2012

$PM_{2.5}$ and lung cancer



GBD, 2012

Air pollution research in China

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

CAPES

CAPES

- ***C***hina ***A***ir ***P***ollution and Health ***E***ffects ***S***tudy

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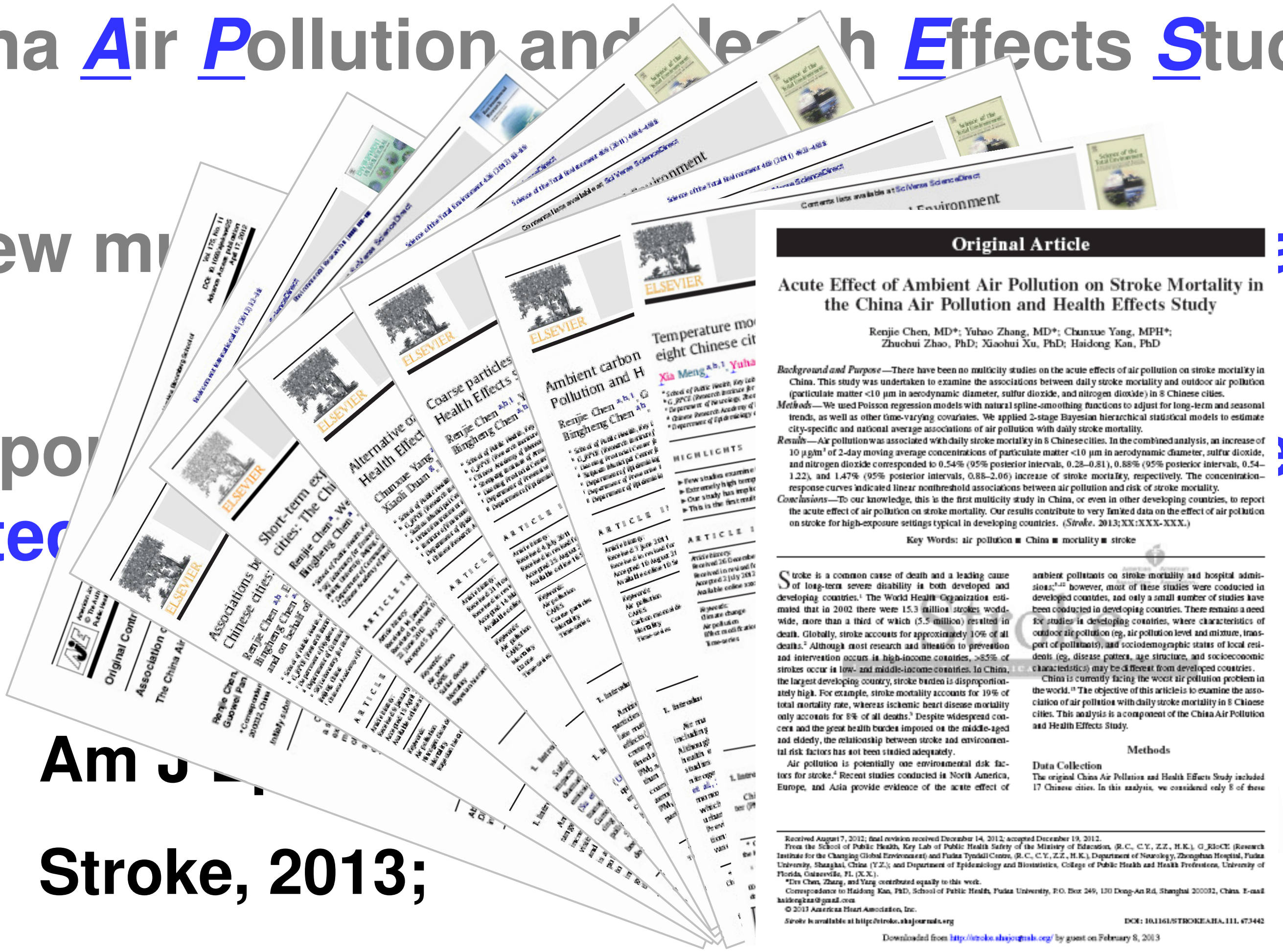

Original Article

Acute Effect of Ambient Air Pollution on Stroke Mortality in the China Air Pollution and Health Effects Study

Renjie Chen, MD*; Yuhao Zhang, MD*; Chunxue Yang, MPH*; Zhuohui Zhao, PhD; Xiaohui Xu, PhD; Haidong Kan, PhD

Background and Purpose—There have been no multicity studies on the acute effects of air pollution on stroke mortality in China. This study was undertaken to examine the associations between daily stroke mortality and outdoor air pollution (particulate matter <10 μm in aerodynamic diameter, sulfur dioxide, and nitrogen dioxide) in 8 Chinese cities.

Methods—We used Poisson regression models with natural spline-smoothing functions to adjust for long-term and seasonal trends, as well as other time-varying covariates. We applied 2-stage Bayesian hierarchical statistical models to estimate city-specific and national average associations of air pollution with daily stroke mortality.

Results—Air pollution was associated with daily stroke mortality in 8 Chinese cities. In the combined analysis, an increase of 10 $\mu g/m^3$ of 2-day moving average concentrations of particulate matter <10 μm in aerodynamic diameter, sulfur dioxide, and nitrogen dioxide corresponded to 0.54% (95% posterior intervals, 0.28–0.81), 0.88% (95% posterior intervals, 0.54–1.22), and 1.47% (95% posterior intervals, 0.88–2.06) increase of stroke mortality, respectively. The concentration–response curves indicated linear nonthreshold associations between air pollution and risk of stroke mortality.

Conclusions—To our knowledge, this is the first multicity study in China, or even in other developing countries, to report the acute effect of air pollution on stroke mortality. Our results contribute to very limited data on the effect of air pollution on stroke for high-exposure settings typical in developing countries. (*Stroke*. 2013;XX:XXX-XXX.)

Key Words: air pollution ■ China ■ mortality ■ stroke

Stroke is a common cause of death and a leading cause of long-term severe disability in both developed and developing countries.[1] The World Health Organization estimated that in 2002 there were 15.3 million strokes worldwide, more than a third of which (5.5 million) resulted in death. Globally, stroke accounts for approximately 10% of all deaths.[2] Although most research and attention to prevention and intervention occurs in high-income countries, >85% of strokes occur in low- and middle-income countries. In China, the largest developing country, stroke burden is disproportionately high. For example, stroke mortality accounts for 19% of total mortality rate, whereas ischemic heart disease mortality only accounts for 8% of all deaths.[3] Despite widespread concern and the great health burden imposed on the middle-aged and elderly, the relationship between stroke and environmental risk factors has not been studied adequately.

Air pollution is potentially one environmental risk factors for stroke.[4] Recent studies conducted in North America, Europe, and Asia provide evidence of the acute effect of ambient pollutants on stroke mortality and hospital admissions;[5-12] however, most of these studies were conducted in developed countries, and only a small number of studies have been conducted in developing countries. There remains a need for studies in developing countries, where characteristics of outdoor air pollution (eg, air pollution level and mixture, transport of pollutants), and sociodemographic status of local residents (eg, disease pattern, age structure, and socioeconomic characteristics) may be different from developed countries.

China is currently facing the worst air pollution problem in the world.[13] The objective of this article is to examine the association of air pollution with daily stroke mortality in 8 Chinese cities. This analysis is a component of the China Air Pollution and Health Effects Study.

Methods

Data Collection

The original China Air Pollution and Health Effects Study included 17 Chinese cities. In this analysis, we considered only 8 of these

Received August 7, 2012; final revision received December 14, 2012; accepted December 19, 2012.
From the School of Public Health, Key Lab of Public Health Safety of the Ministry of Education, (R.C., C.Y., Z.Z., H.K.), G_RIoCE (Research Institute for the Changing Global Environment) and Fudan Tyndall Centre, (R.C., C.Y., Z.Z., H.K.), Department of Neurology, Zhongshan Hospital, Fudan University, Shanghai, China (Y.Z.); and Department of Epidemiology and Biostatistics, College of Public Health and Health Professions, University of Florida, Gainesville, FL (X.X.).
*Drs Chen, Zhang, and Yang contributed equally to this work.
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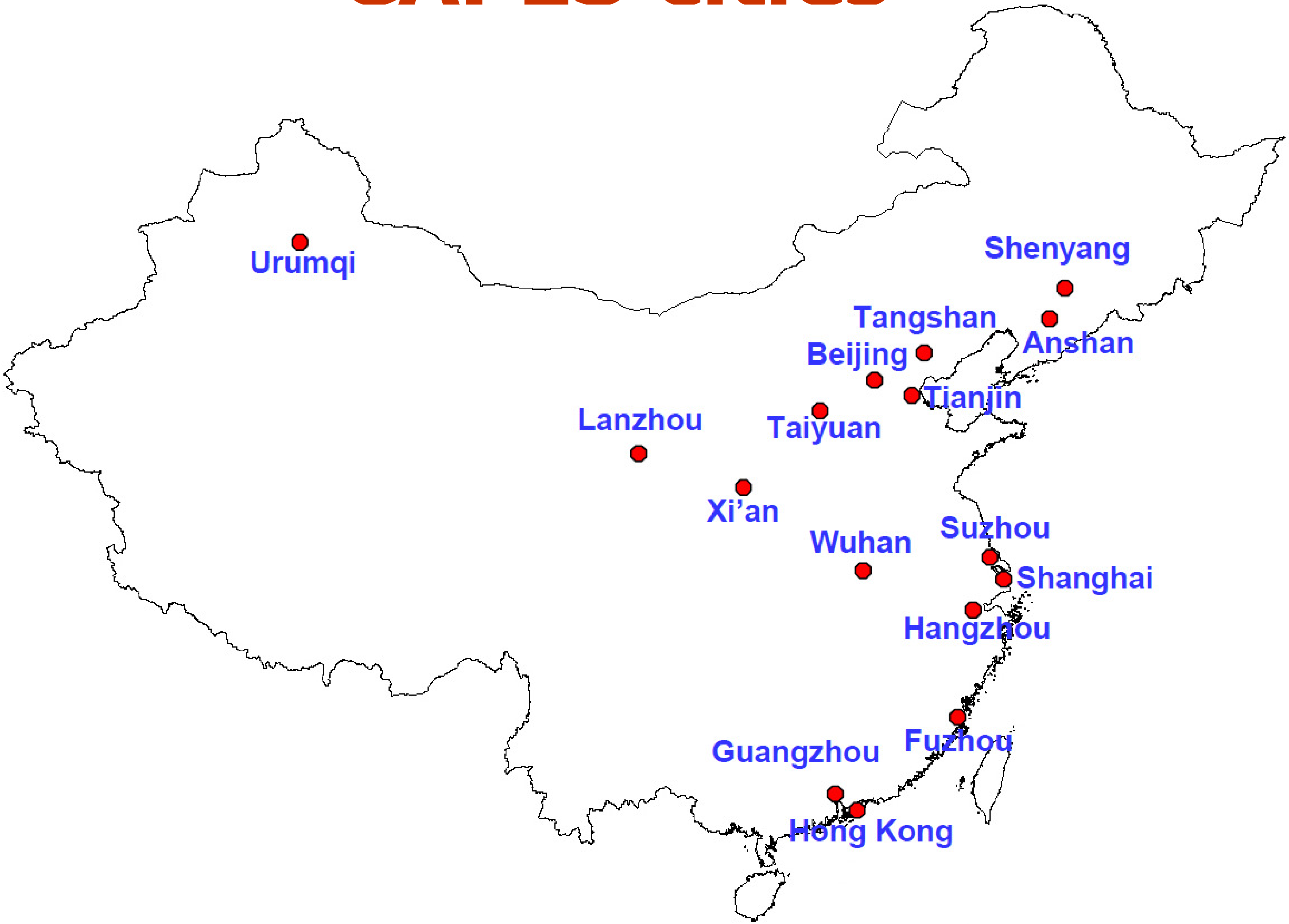
Stroke is available at http://stroke.ahajournals.org
DOI: 10.1161/STROKEAHA.111.673442

Am J E…

Stroke, 2013;

CAPES cities



CAPES

Health and Exposure Data

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

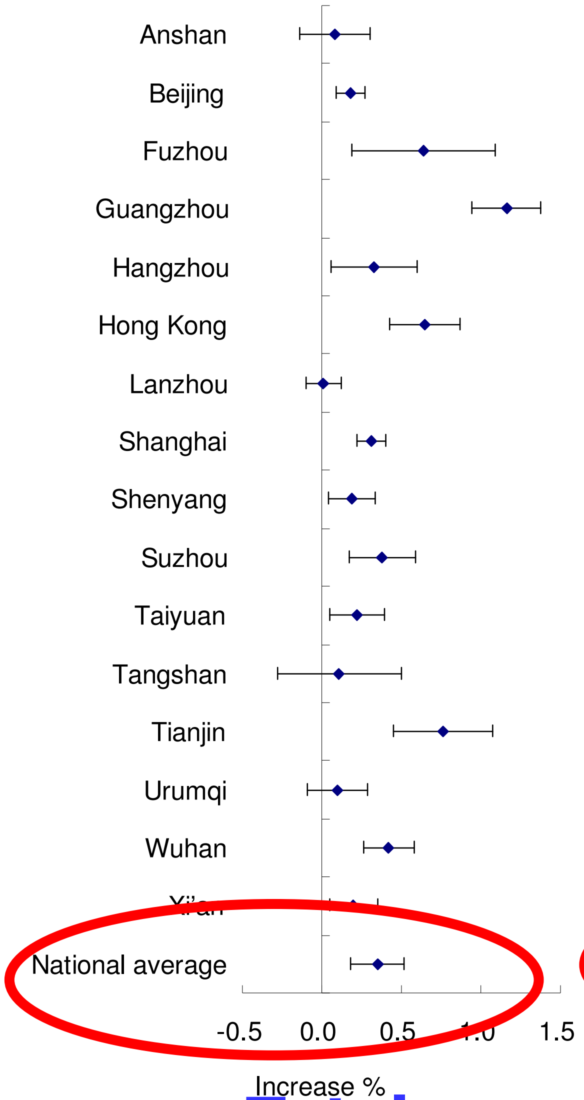
- **Air pollution**
  - PM_{10}, SO_2, NO_2 (for every city)
  - $PM_{2.5}$ (Beijing, Shanghai, Shenyang, Xi'an, Guangzhou)
  - $PM_{2.5}$ components (Xi'an)
  - $PM_{10-2.5}$ (Beijing, Shanghai, Shenyang)
  - BC (Shanghai)
  - O_3 (Shanghai, Suzhou)
  - CO (Shanghai, Anshan, Taiyuan)
  - Visibility (Shanghai)

CAPES study: what will it contribute to policy making in China?

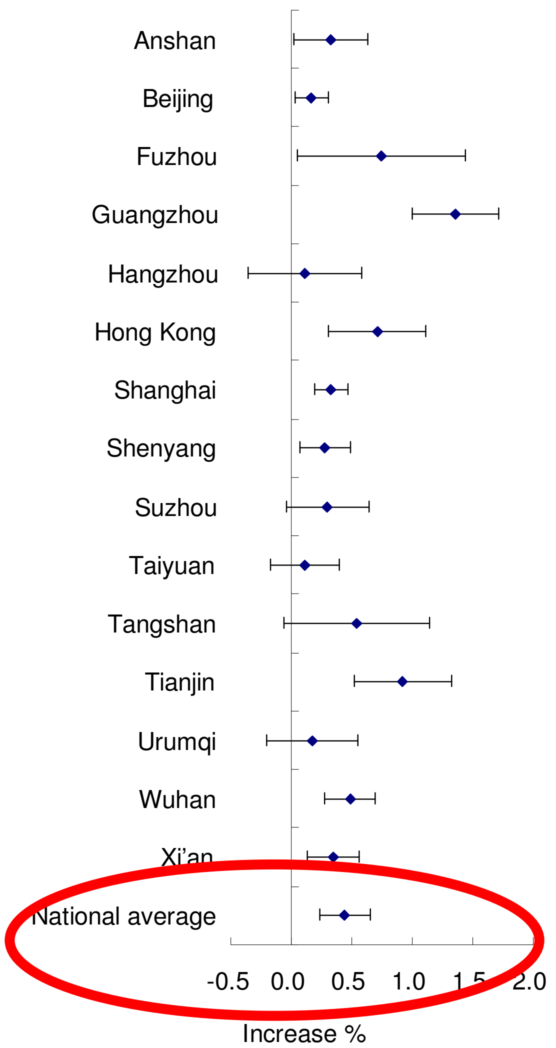
- Robustness of time-series study risk estimates
- New evidence of the national C-R function
- Comparison of risk estimates gained from China and developed countries
- Regional/city variability in results: source apportionment
- Does threshold exist

CAPES

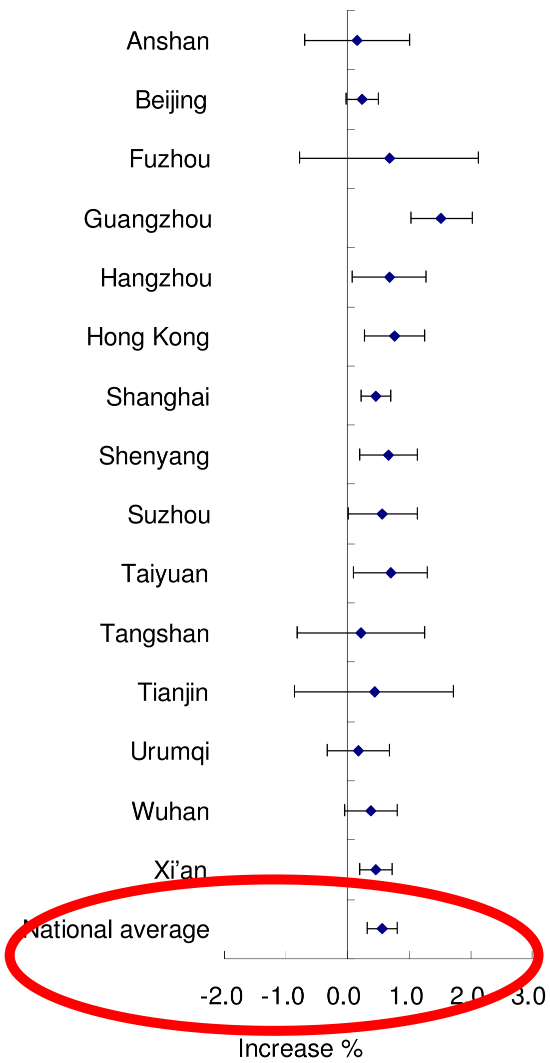
Effects of PM_{10} in the CAPES cities



Total mortality



Cardiovascular mortality

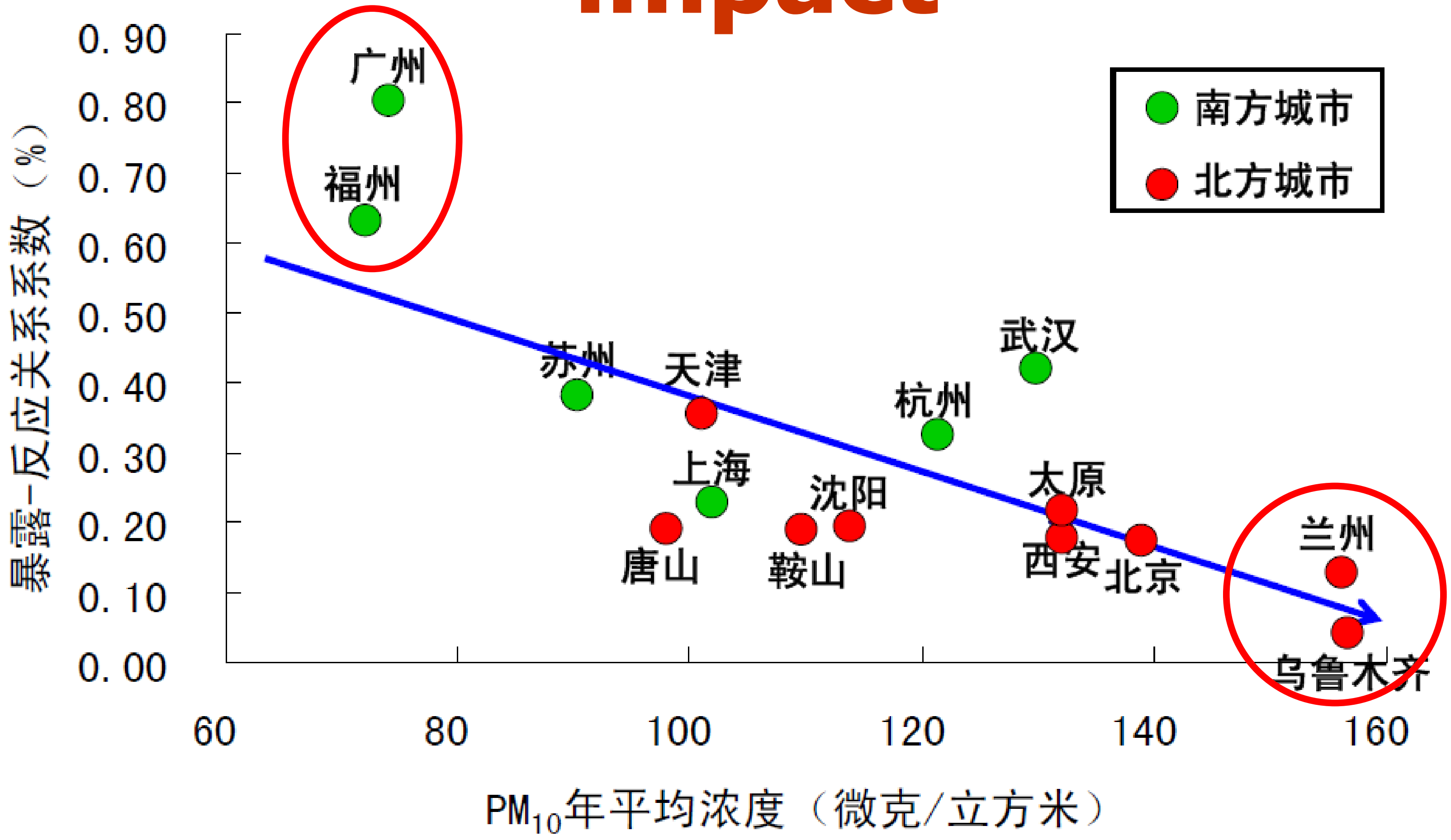


Respiratory mortality

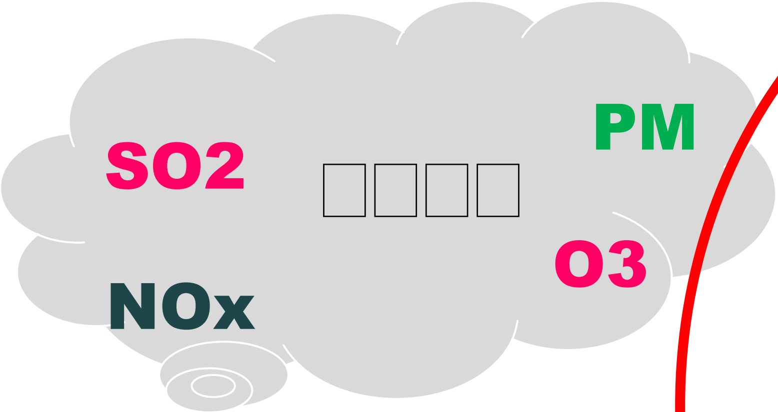
Chen et al, *AJE*, 2012

CAPES

Regional pattern of PM_{10} health impact



Possible reasons of regional pattern



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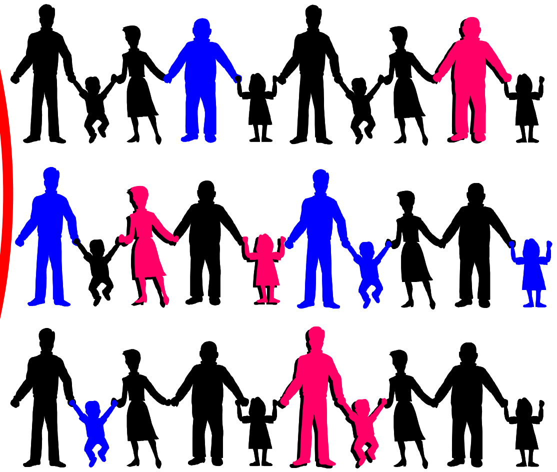
(□□90%□□□□□)



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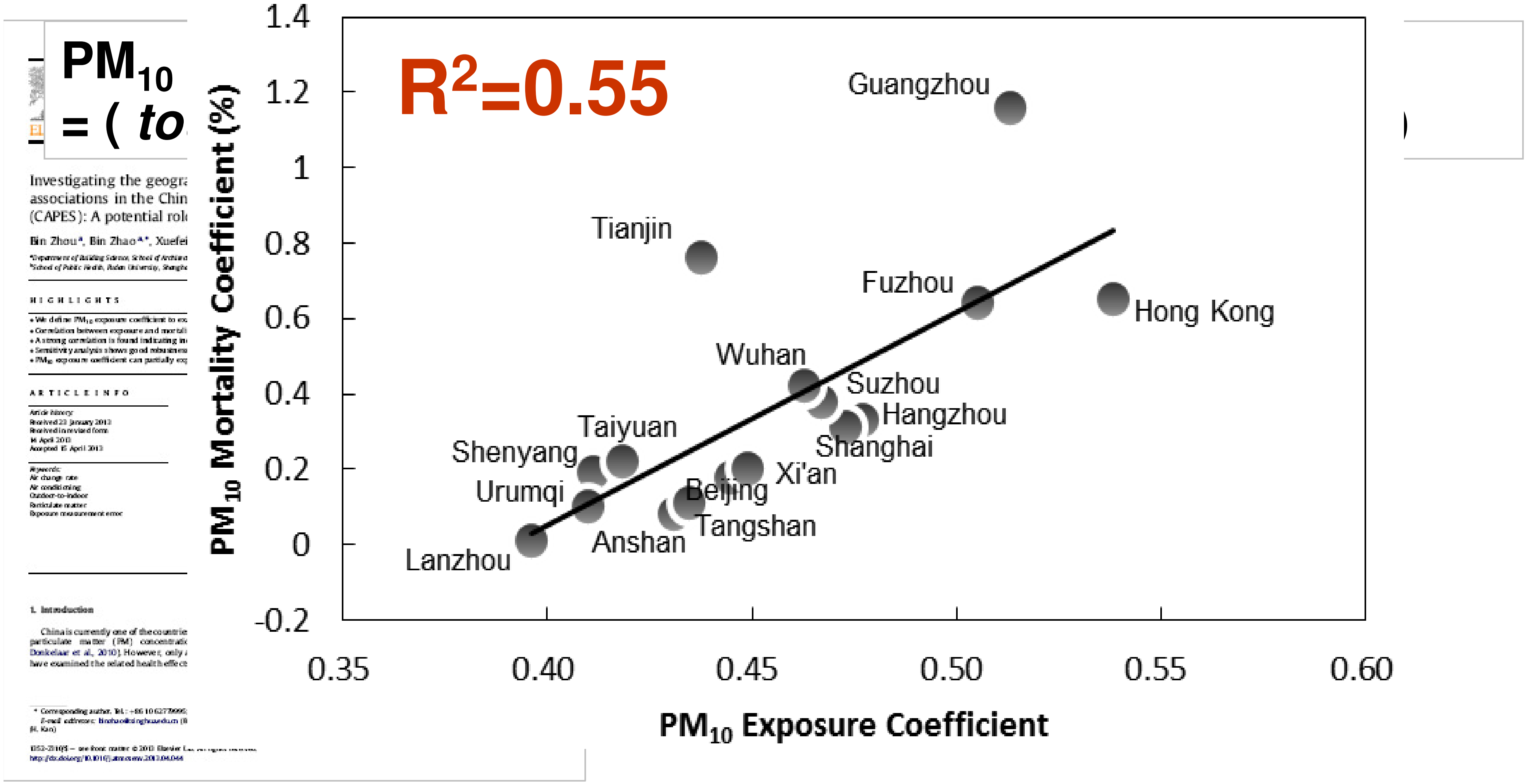
Regional pattern: a potential role of indoor exposure to outdoor PM_{10}



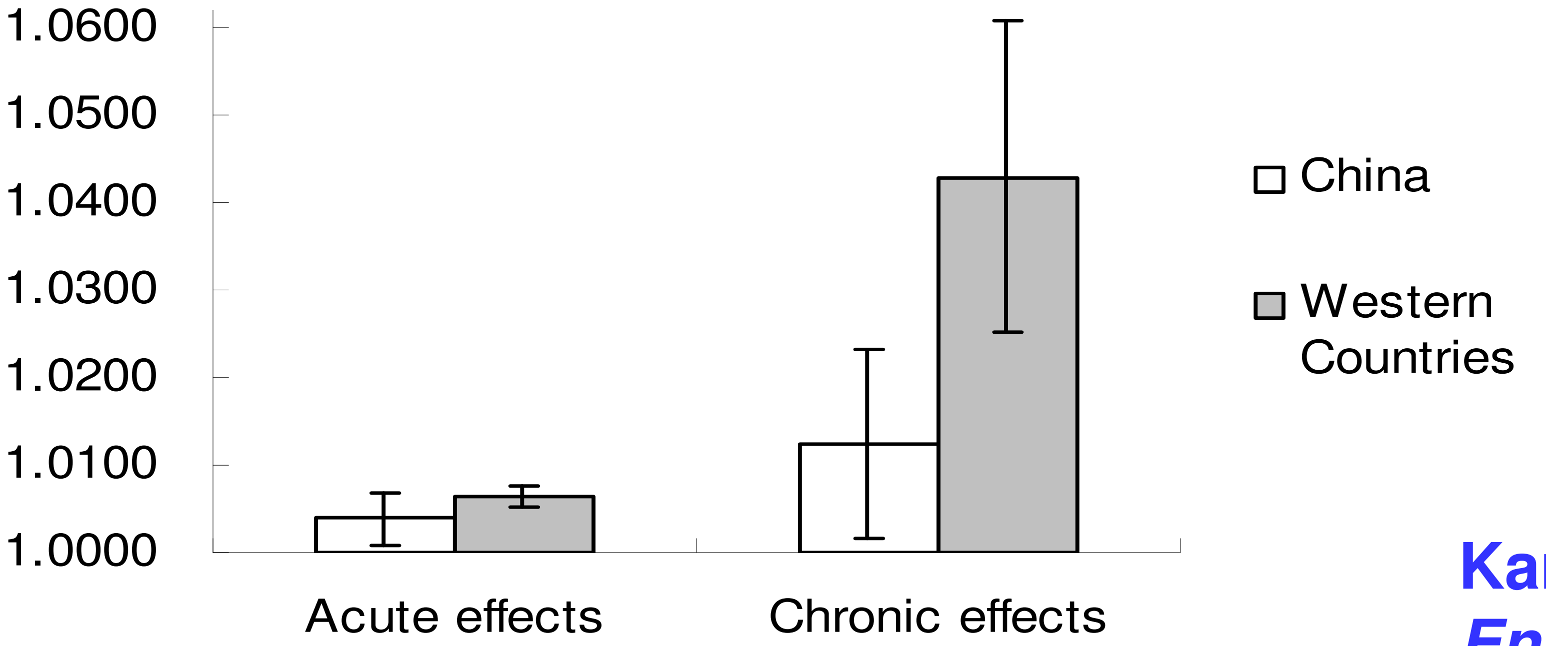
Zhou et al, AE, 2013

BIOMEDICAL AND ENVIRONMENTAL SCIENCES **18**, 159-163 (2005)

Establishment of Exposure-response Functions of Air Particulate Matter and Adverse Health Outcomes in China and Worldwide[1]

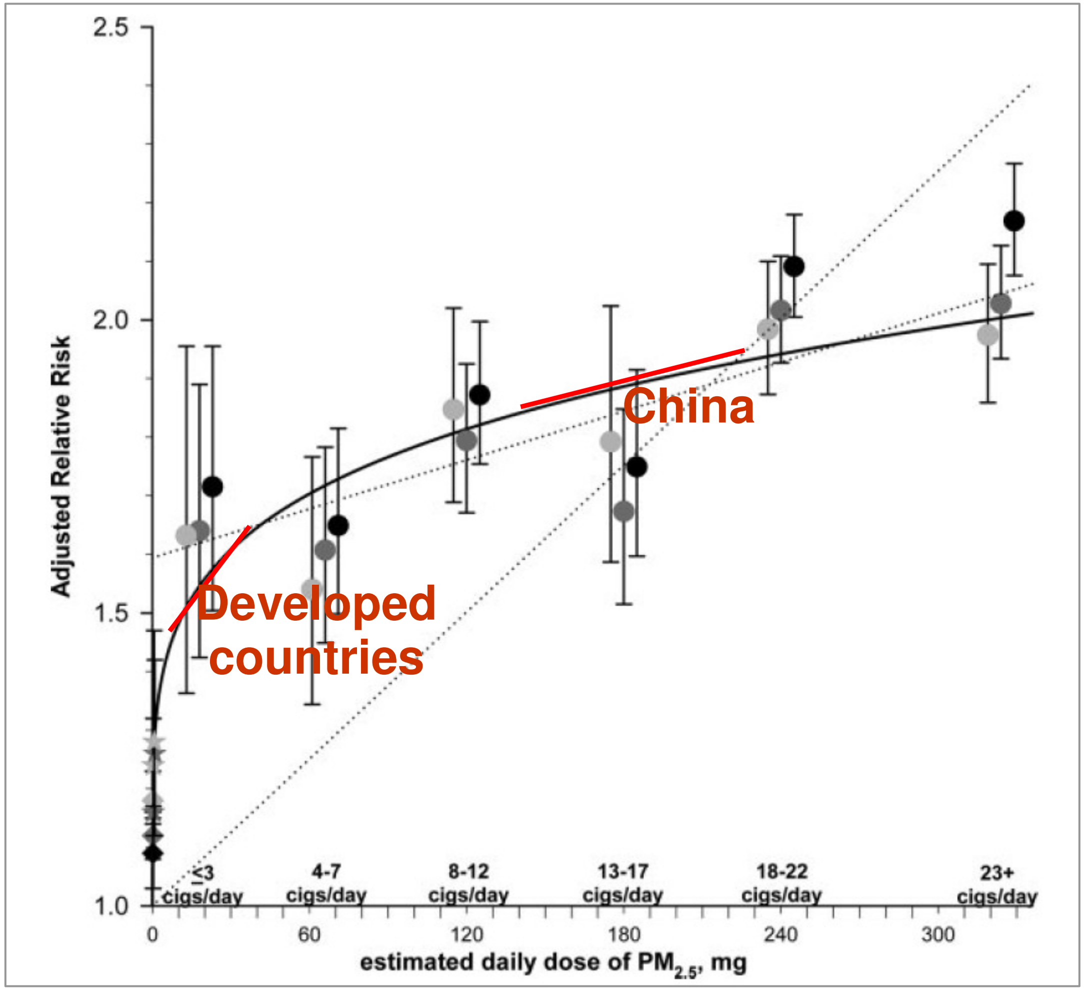
HAI-DONG KAN[*,2], BING-HENG CHEN[*], CHANG-HONG CHEN[#], BING-YAN WANG[#], AND QING-YAN FU[†]

[*]*Department of Environmental Health, School of Public Health, Fudan University, Shanghai 200032, China;* [#]*Shanghai Academy of Environmental Science, Shanghai 200233, China;* [†]*Shanghai Environmental Monitoring Center, Shanghai 200030, China*



Kan et al, *Biomed Environ Sci*, 2005

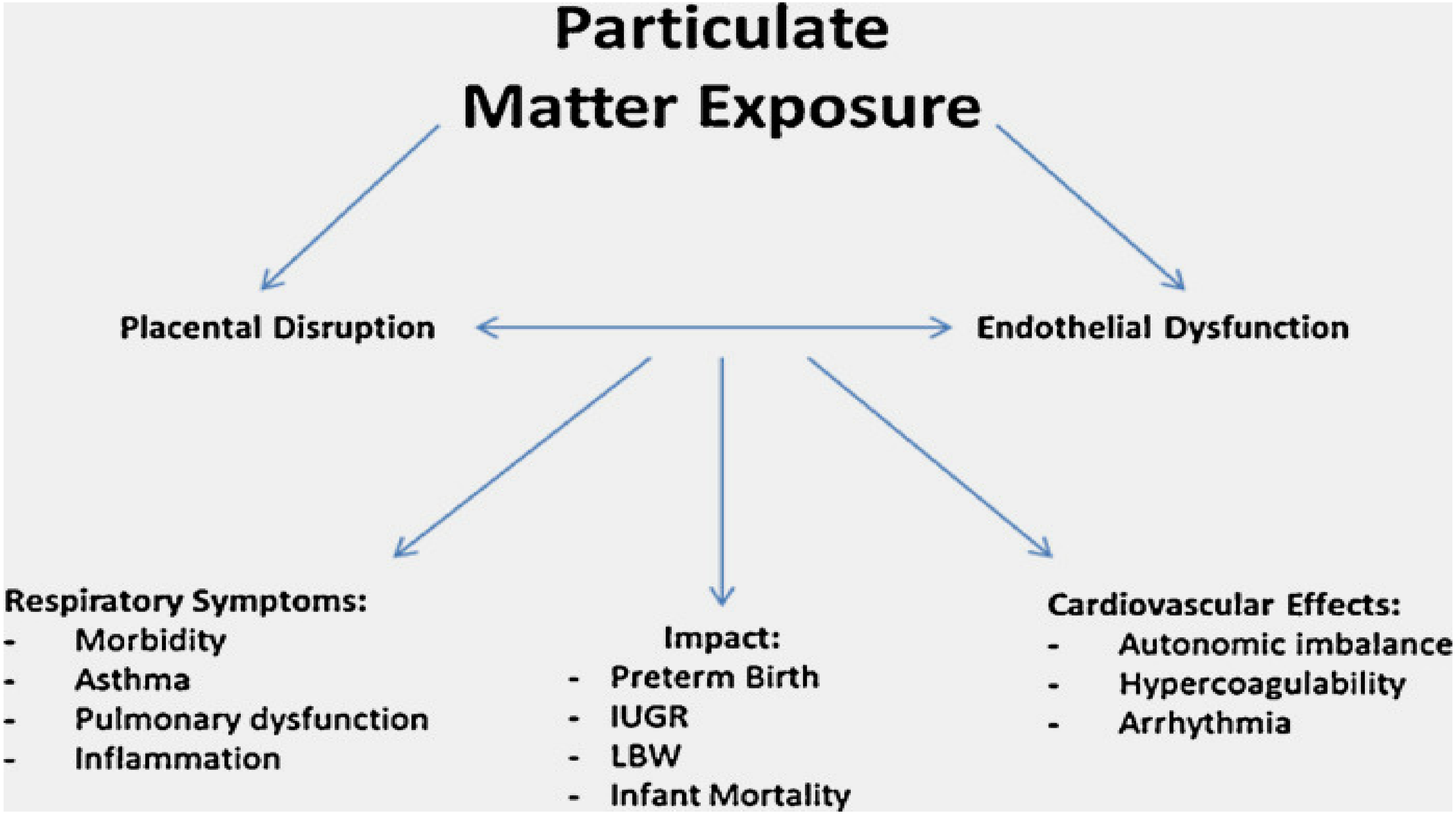
Possible reasons for the smaller effects in Chinese cities



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



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 3rd trimester and low birth weight

Petrochemical exposure with spontaneous abortion in Beijing (Xu et al, OEM, 1998)

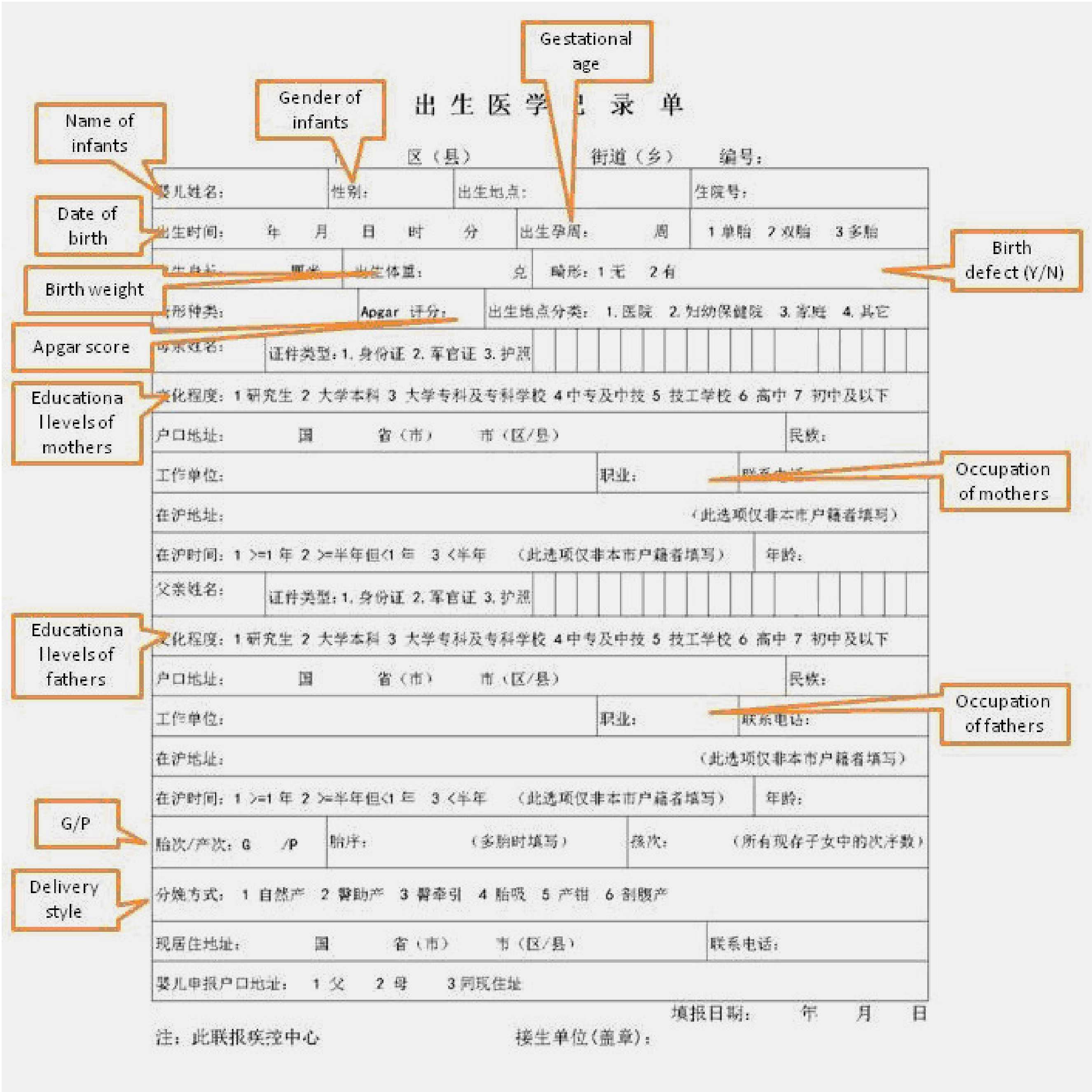
- **Design**: a retrospective epidemiological study, 2853 (93%) of the women in a large petrochemical complex in Beijing
- **Outcome**: spontaneous abortion during the first pregnancies
- **Statistical methods**: Multiple logistic regressions
- **Results**: significant increase of spontaneous abortion 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-sereis 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.



出生医学记录单

区（县）　街道（乡）　编号：

婴儿姓名：　性别：　出生地点：　住院号：

出生时间：　年　月　日　时　分　出生孕周：　周　1 单胎　2 双胎　3 多胎

出生身长：　厘米　出生体重：　克　畸形：1 无　2 有

畸形种类：　Apgar 评分：　出生地点分类：　1. 医院　2. 妇幼保健院　3. 家庭　4. 其它

母亲姓名：　证件类型：1. 身份证　2. 军官证　3. 护照

文化程度：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 技工学校　6 高中　7 初中及以下

户口地址：　国　省（市）　市（区/县）　民族：

工作单位：　职业：

在沪地址：　（此选项仅非本市户籍者填写）

在沪时间：1 >=1 年　2 >=半年但<1 年　3 <半年　（此选项仅非本市户籍者填写）　年龄：

父亲姓名：　证件类型：1. 身份证　2. 军官证　3. 护照

文化程度：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 技工学校　6 高中　7 初中及以下

户口地址：　国　省（市）　市（区/县）　民族：

工作单位：　职业：　联系电话：

在沪地址：　（此选项仅非本市户籍者填写）

在沪时间：1 >=1 年　2 >=半年但<1 年　3 <半年　（此选项仅非本市户籍者填写）　年龄：

胎次/产次：G　/P　胎序：　（多胎时填写）　孩次：　（所有现存子女中的次序数）

分娩方式：　1 自然产　2 臀助产　3 臀牵引　4 胎吸　5 产钳　6 剖腹产

现居住地址：　国　省（市）　市（区/县）　联系电话：

婴儿申报户口地址：　1 父　2 母　3 同现住址

填报日期：　年　月　日

注：此联报疾控中心　　接生单位（盖章）：

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 !

Q ?