

Air Pollution and Health in Asia Current Status & Emerging Issues The PAPA Studies

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CSE Conference on Health and Environment
March 2006



The Health Effects of Air Pollution In Asia

- Health Effects Institute
- Health burden of air pollution in Asia in a global context
- Sources
- Key pollutants and health effects
- Health benefits of interventions
- Sensitive populations: The poor
- Enabling science to move forward

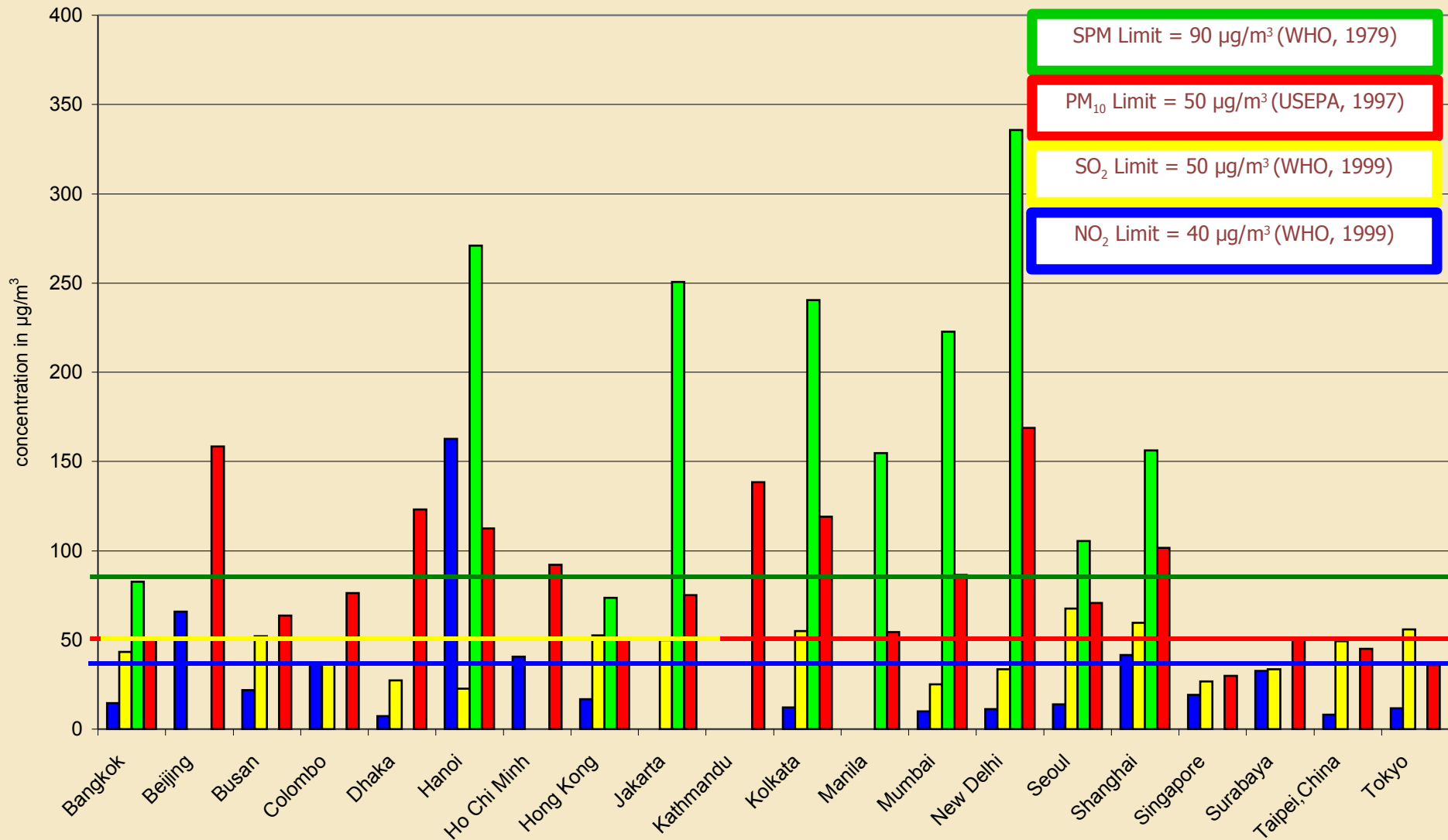


The Health Effects Institute

- Founded in 1980 to provide impartial, high-quality science on health effects of air pollution
- Joint and balanced core funding from
 - Government (U.S. EPA)
 - Industry (28 worldwide auto)
 - *Many partners: CAI-Asia, WHO, ADB, CARB, Oil, Chemical industry, foundations, others*
- Independent Board and Expert Science Committees oversee and review all research
- High level international experts (India, China US, EU)
- Over 250 studies, scientific reviews, reanalysis
 - Relevant to regulation
 - North & South America, Europe, Asia
 - CO, particulate matter,, ozone, NO2, diesel exhaust, benzene, butadiene, manganese, MTBE, others



The Problem: Air Pollution in Asia: High Levels in Many Cities (2000-2003)



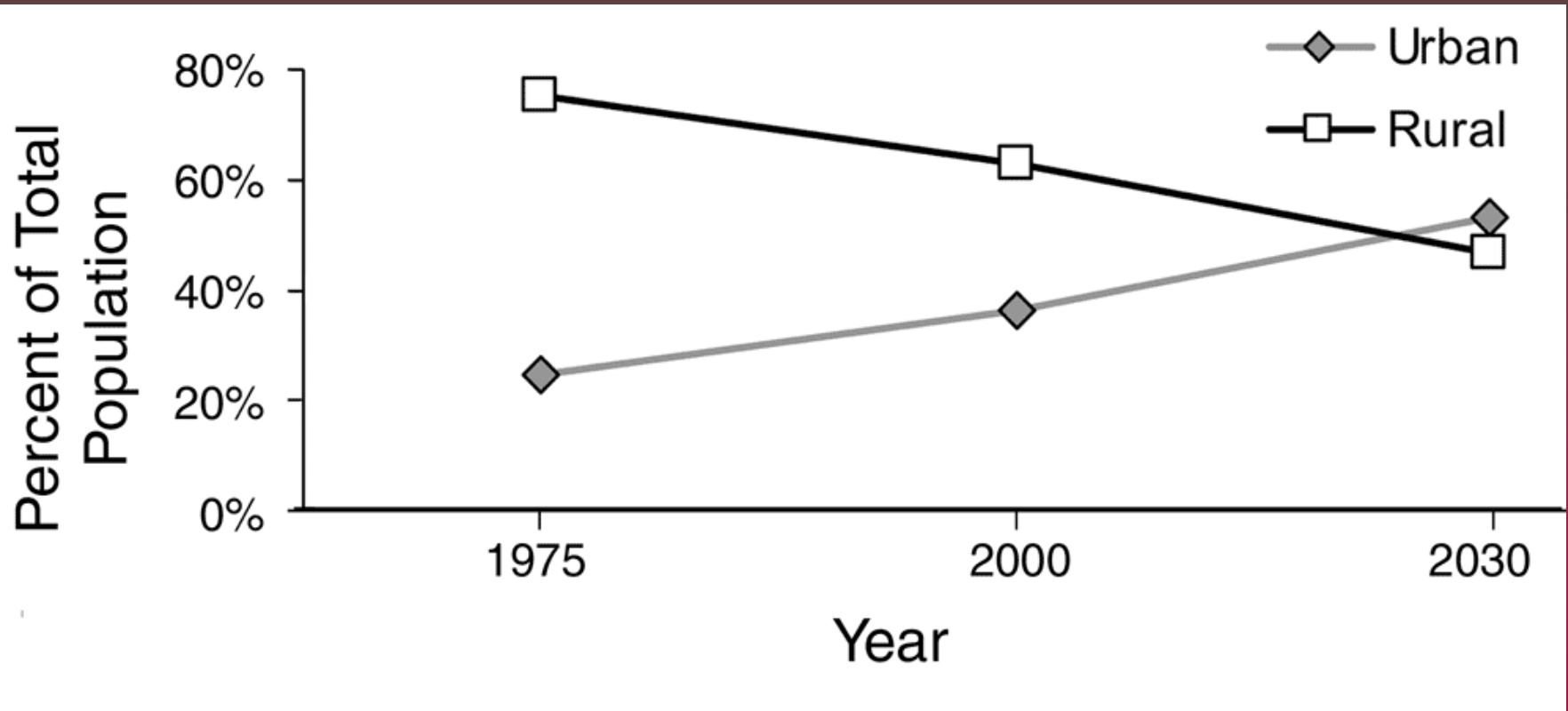
Science base for understanding health effects from key pollutants strengthening

- In 7 years of science since last US PM standard:
 - Relationship of ambient monitors to personal exposure better understood
 - Major long-term studies rigorously reanalyzed, extended
 - Pope American Cancer Society Study\Harvard Six Cities
 - Major multi-city short-term study in Europe (APHEA)
 - Science establishing plausible biological pathways
 - Though modest weakening in some studies of acute effects
- Based on detailed assessment of science
 - USEPA Proposed tightening of PM Standard
 - WHO releases stringent air quality guidelines for PM, Ozone
 - Europe and California revising their standards



An Increasingly Urban Population

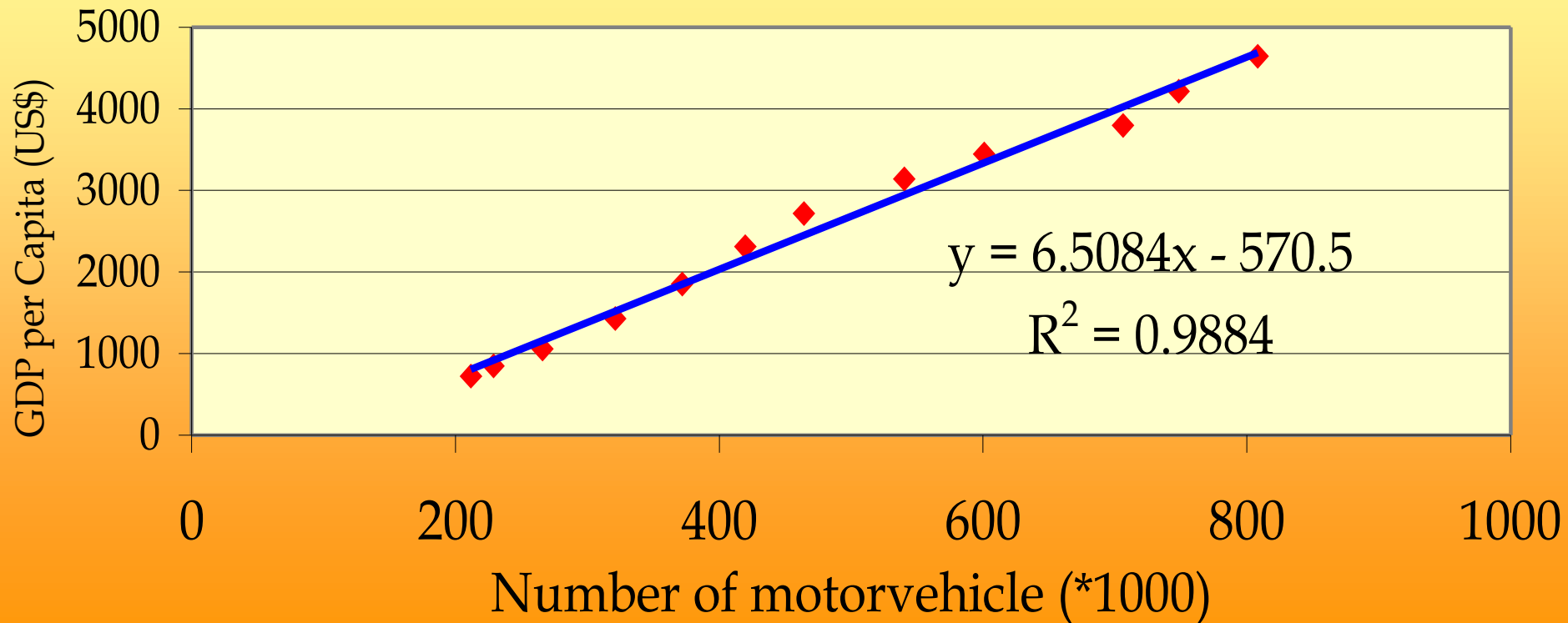
(data from UN/UN Centre for Human Settlements 1995-2002)



Rapid Growth in Income and Vehicles: Shanghai

(source: Tsinghua University)

Relatiivity between GDP and Number of Motor Vehicle in Shanghai



WHO Global Burden of Disease (GBD)

Excess Deaths from Selected Environmental Factors

Environmental Risks	Global Estimate	Asian Estimate (S ,SE Asia + W Pacific)	Asia as a percent of Global
Unsafe Water	1,730,000	730,000	42%
Urban Outdoor Air	799,000	487,000	65%
Indoor Air	1,619,000	1,025,000	63%
Lead	234,000	88,000	37%

Particular Challenge: Many Sources of Air Pollution in Asia

- Combustion
 - Agricultural burning
 - Brick Kilns
 - Vehicles
 - Trash burning
 - Factories
 - Power generation
 - Cooking in slums
 - Other area sources
- Non-Combustion
 - Agricultural cultivation
 - Street sweeping
 - Windblown sand
 - Unpaved roads
 - Paved roads (asbestos, rubber etc)
 - Construction

Health Effects

- Different Pollutants have Different Effects
 - Carbon Monoxide - circulatory system, heart
 - Ozone - respiratory system, lung
 - Lead - nervous system, brain
 - PM - lung, potential effects on heart
 - Diesel Exhaust - PM contributor, respiratory, cancer
 - Sulfur Dioxide – impaired respiratory function, PM Contributor
 - Nitrogen Dioxide – lung irritant. ozone contributor
 - Air Toxics – cancer, reproductive, neurotoxic
 - ***There are potential effects of the mixture***
- Carbon Dioxide and Carbon Particles - climate change



Health Effects

- Some Populations more sensitive than others
 - Children
 - Elderly
 - People with heart and lung disease
- Asthma is growing
 - **150 million asthmatics worldwide**
 - **Increasing in most countries (2% to 5% per year)**
 - **Asthmatics much more sensitive to air pollution**
- Differential effects on those living in poverty an emerging concern



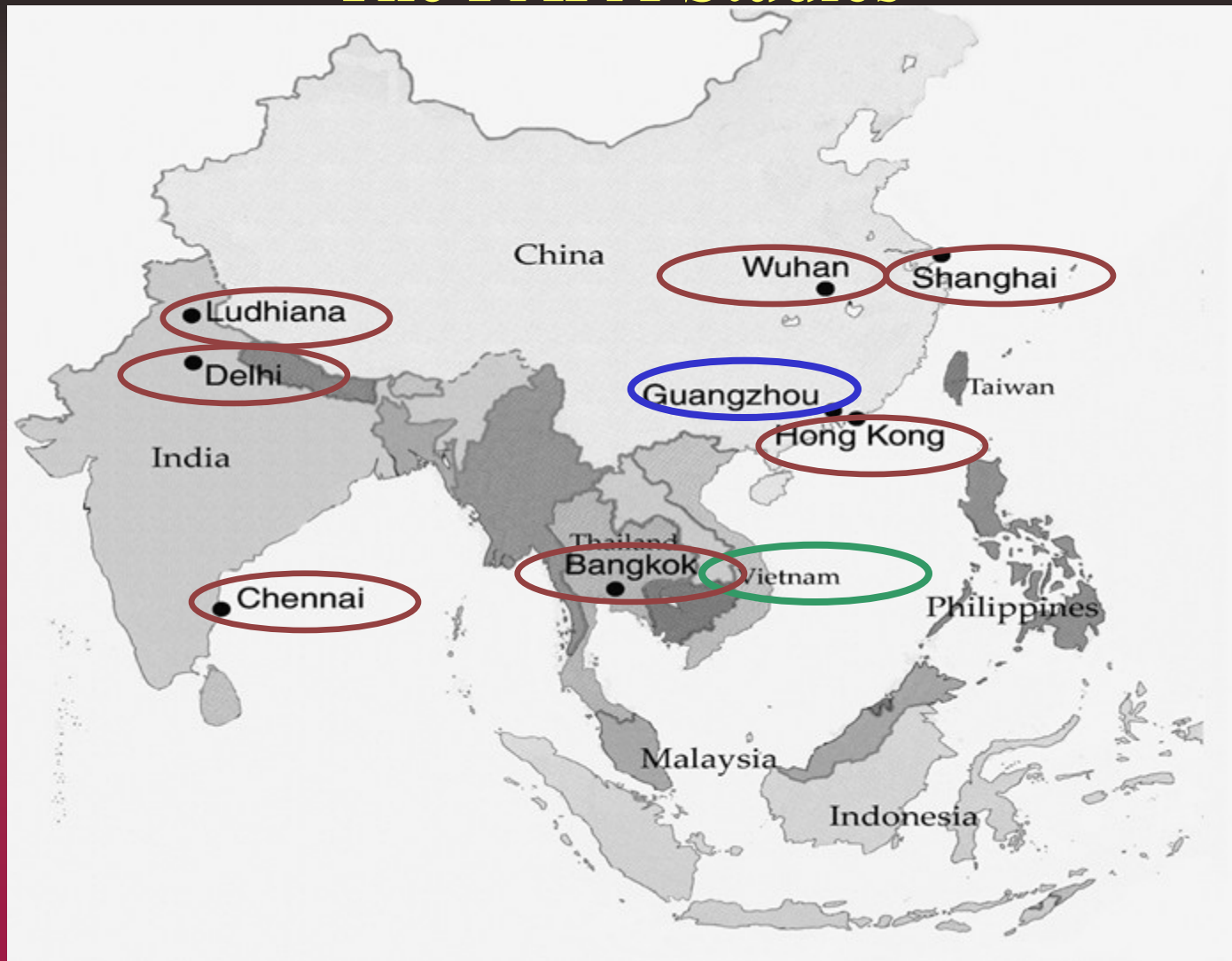


Air Pollution Health Effects Science

- An extensive Western Literature
- Active and increasing Asian science literature recently documented by “PAPA”
- The HEI Public Health and Air Pollution in Asia (PAPA) Program
 - A Project of the Clean Air Initiative for Asian Cities (CAI-Asia)
- Including ongoing studies in Hong Kong, Shanghai, Wuhan and Bangkok
- New! *Studies beginning in India (Chennai, Delhi, Luciana)*



The PAPA Studies



PAPA Literature Review: *Health Effects of Outdoor Air Pollution in Developing Countries of Asia*



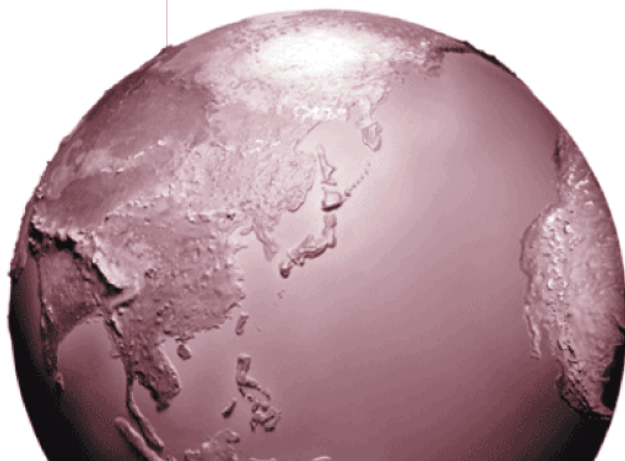
SPECIAL REPORT 15

**HEALTH
EFFECTS
INSTITUTE**

April 2004

**Health Effects of Outdoor Air
Pollution in Developing Countries
of Asia: A Literature Review**

HEI International Scientific Oversight Committee
of HEI Public Health and Air Pollution in Asia Program
(a program of the Clean Air Initiative for Asian Cities)



- **Systematic identification of 140 peer-reviewed Asian studies 1980-2003 (over 60 from China)**
- **Special focus on studies of daily changes in air pollution and health**
- **Conduct first ever Asian meta analysis” 28 “time series” studies evaluated in depth effects in Asia and to assess relative to West**
- **Identify knowledge gaps to guide future research**
- *Now being updated with many recent studies, made web accessible,*



NEW: PAPA Compendium of Asian Science on Health Effects of Air Pollution

- 2003 PAPA Literature Review extended to include 2003-2005 and additional early studies
- Refined search methods show strong growth in Asian science base ***double*** number of Asian studies (130-260)
- Indian studies increase from 15-21
- HEI web-based comprehensive summary, summary statistics and study citation *available as new resource for policy makers*
April 2006



NEW! Studies of Air Pollution and Health in Asia 1980–2005



Sample Web Page: Literature Review Table



Health Effects of Outdoor Air Pollution in Asia: A Literature Review

Table 2. China Studies[†]

Citation	Design	Study Location	Study Period	Study Sample	Exposure	Health Outcome	Summary of Published Findings
Environmental Health Monitoring Department of the Nanning Anti-Epidemic Station. 1986. Relationship between air pollution and children's prevalence of carrying <i>Streptococcus hemolyticus</i> alpha, beta on the nasal mucosa [in Chinese]. <i>Zhonghua Yu Fang Yi Xue Za Zhi</i> 20:157-159.	Cross section	Nanning	1982-1983	Children aged 8-11yr	SPM, SO ₂ , NO _x	Children's prevalence of carrying <i>Streptococcus hemolyticus</i> alpha, beta on nasal mucosa	The rate of carrying streptococcus hemolyticus on the nasal mucosa among children in heavy polluted area with higher SO ₂ , NO ₂ , SPM levels was higher than that in control area.
Chang G, Pan X, Xie X, Gao Y. 2003. Time-series analysis on the relationship between air pollution and daily mortality in Beijing [in Chinese]. <i>Wei Sheng Yan Jiu</i> 32:565-568. *	Time series	Beijing	1998-2000	Residents in 8 districts	TSP, PM ₁₀ , SO ₂ , NO _x , CO	Daily cause-specific mortality (RespD, CVD, CBVD, CHD, COPD)	Airborne levels of CO, SO ₂ , NO _x , and PM ₁₀ each correlated significantly with mortality, especially from RespD, CVD, CBVD, CHD, and COPD. TSP levels were associated with RespD.
Dai H, Song W, Gao X, L Chen. 2004. Study on relationship between ambient PM10, PM2.5 pollution and daily mortality in a district in Shanghai [in Chinese]. <i>Wei Sheng Yan Jiu</i> 33:293-297.	Time series	Shanghai	2002-2003	1.24 million residents in a district of Shanghai	PM ₁₀ , PM _{2.5}	Daily mortality for all-cause, cardiovascular, and respiratory causes	Each increase of 10 µg/m ³ in PM ₁₀ and PM _{2.5} was associated with 0.53% and 0.85% increase of daily mortality, respectively.

* Entries in bold type were included in the 2004 meta-analysis.

† Last updated April 2006.



Health Effects



PM Health Effects

- High levels of PM (e.g. $500 \mu\text{/m}^3$) known to cause premature death
 - e.g. London 1952
- Recent studies in North and South America, Europe, Asia, have found association of PM with death at much lower levels
 - no evidence of a “threshold” (safe level)
- Recent progress toward identifying biological mechanisms, though not conclusive

PM: *Linked to Increased Mortality, Morbidity*

- A Number of Epidemiology Studies
- Acute Effects (black smoke)

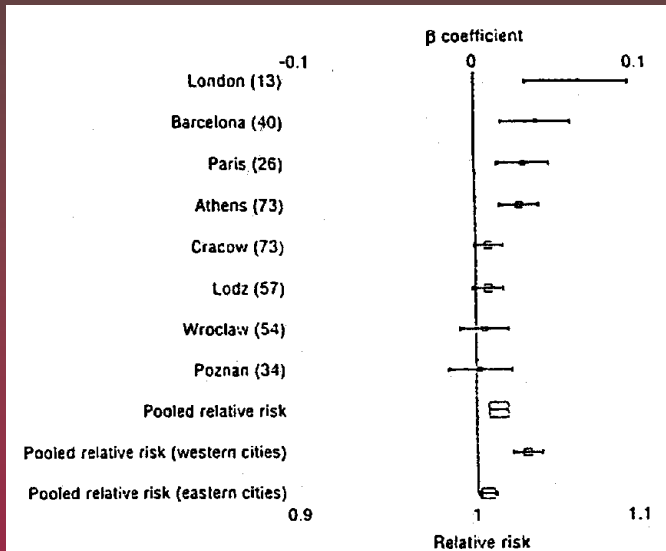
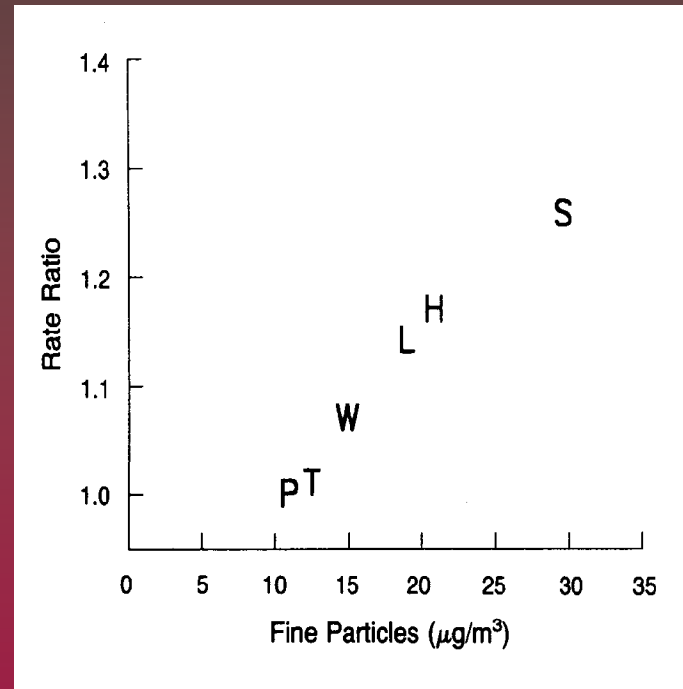


Fig 2 Estimated individual city and pooled relative risks of mortality associated with increase of $50 \mu\text{g}/\text{m}^3$ in black smoke levels. Numbers in parentheses are median value of pollutant, and the size of the point representing each relative risk is inversely proportional to its variance

Long Term Effects PM 2.5



Europe (APHEA)

US (Six Cities)

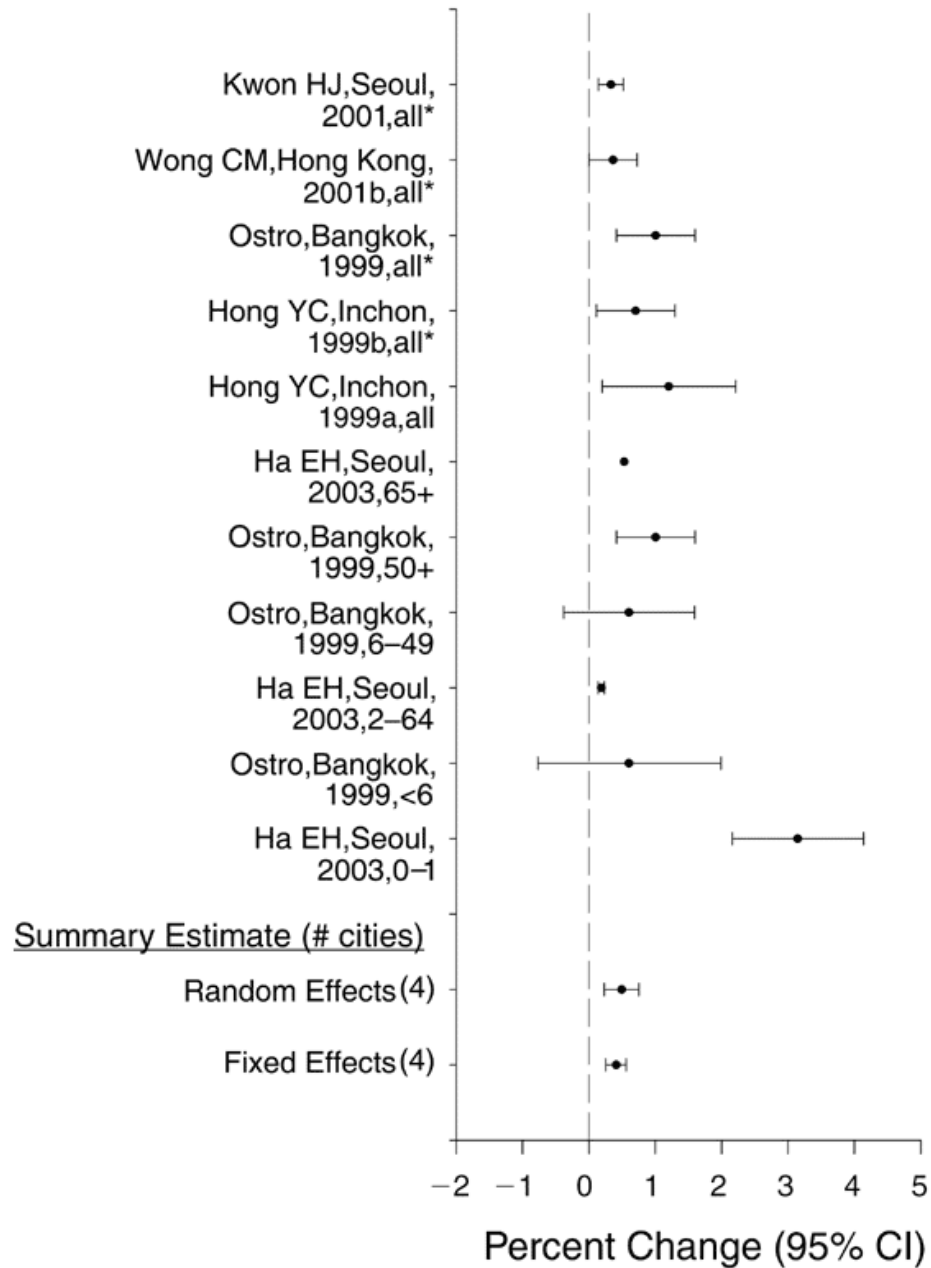


Asia Cities

PAPA Review

Initial Results

Figure 18 PM10 and All Cause Mortality

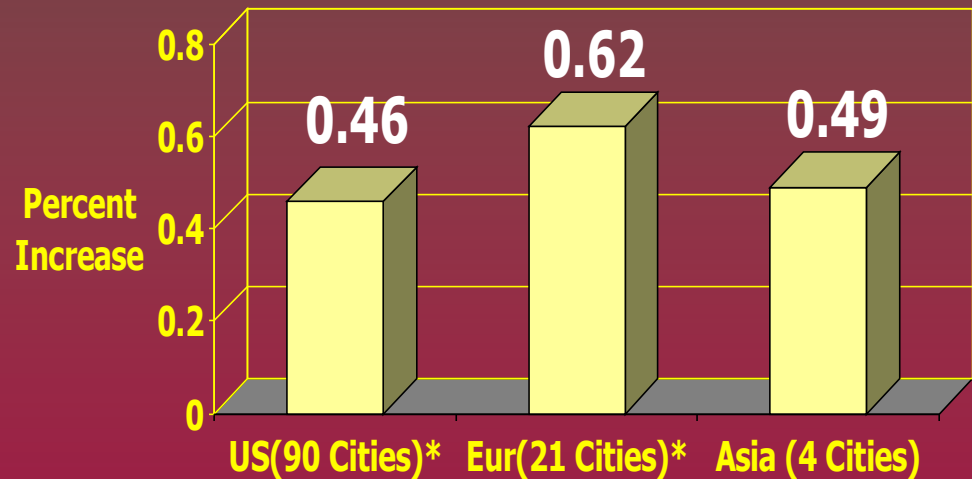


EVIDENCE FROM ASIA:

HEI Meta-Analysis of Asian Studies of Daily Mortality/Hospital Admissions (Public Health and Air Pollution in Asia (PAPA) 2004)

- 28 recent daily time series studies examined in depth
- Studies find effects of air pollution on rate of death, illness
 - ~0.5% increase per 10 $\mu\text{g}/\text{m}^3$ of PM_{10}
 - High levels of air pollution in Asian cities ($>100 \mu\text{g}/\text{m}^3$), imply a substantial public health impact
- *Limitations*
 - Small number of cities
 - Not geographically representative (poorest, most polluted countries under-represented)

Percent Increase in Mortality per 10 micrograms PM_{10}

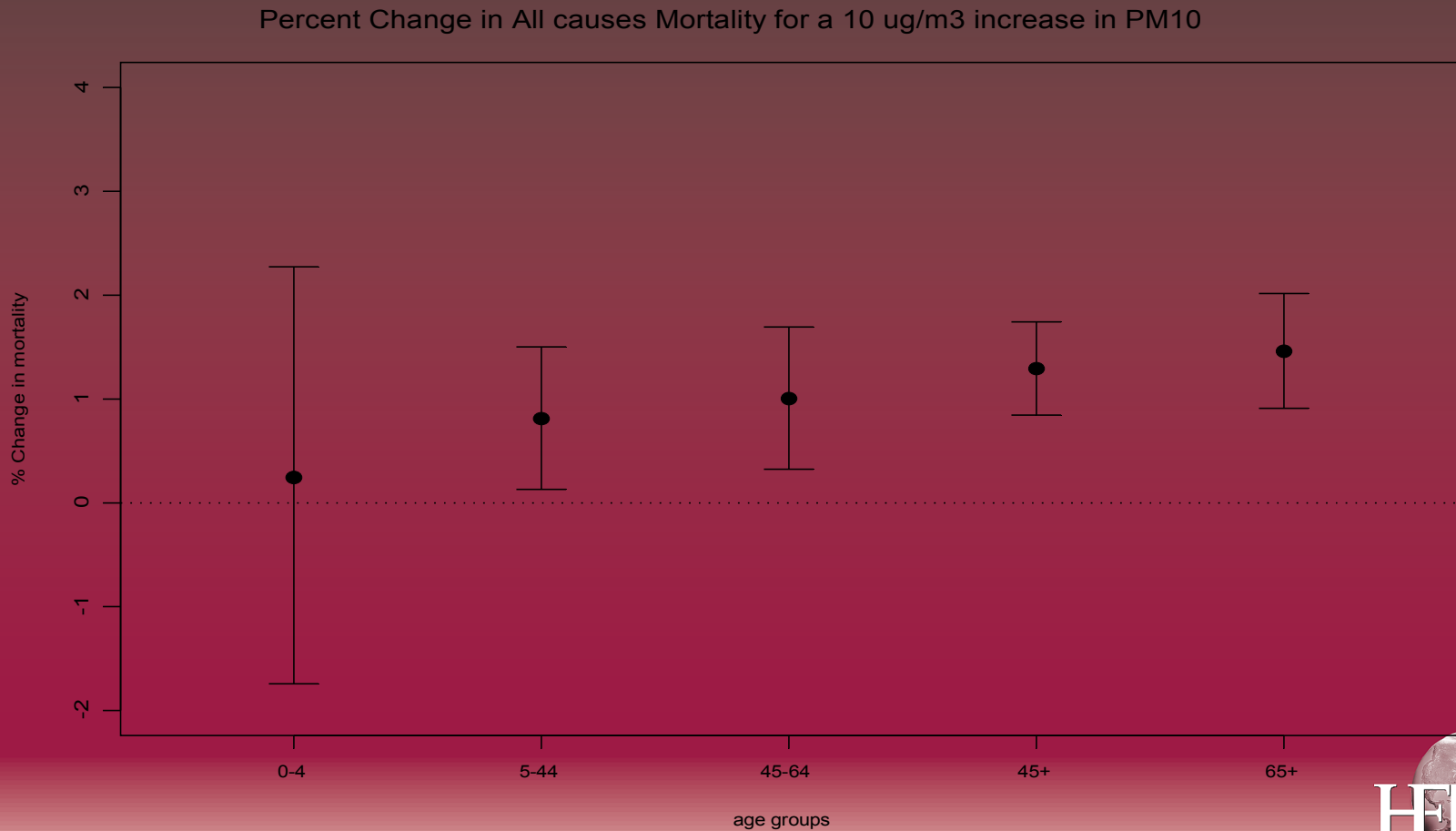


* Estimates Using Pre-GAM Results (without revision)



PAPA Preliminary Results: Bangkok Study

Acute effects across greater age range than Western populations



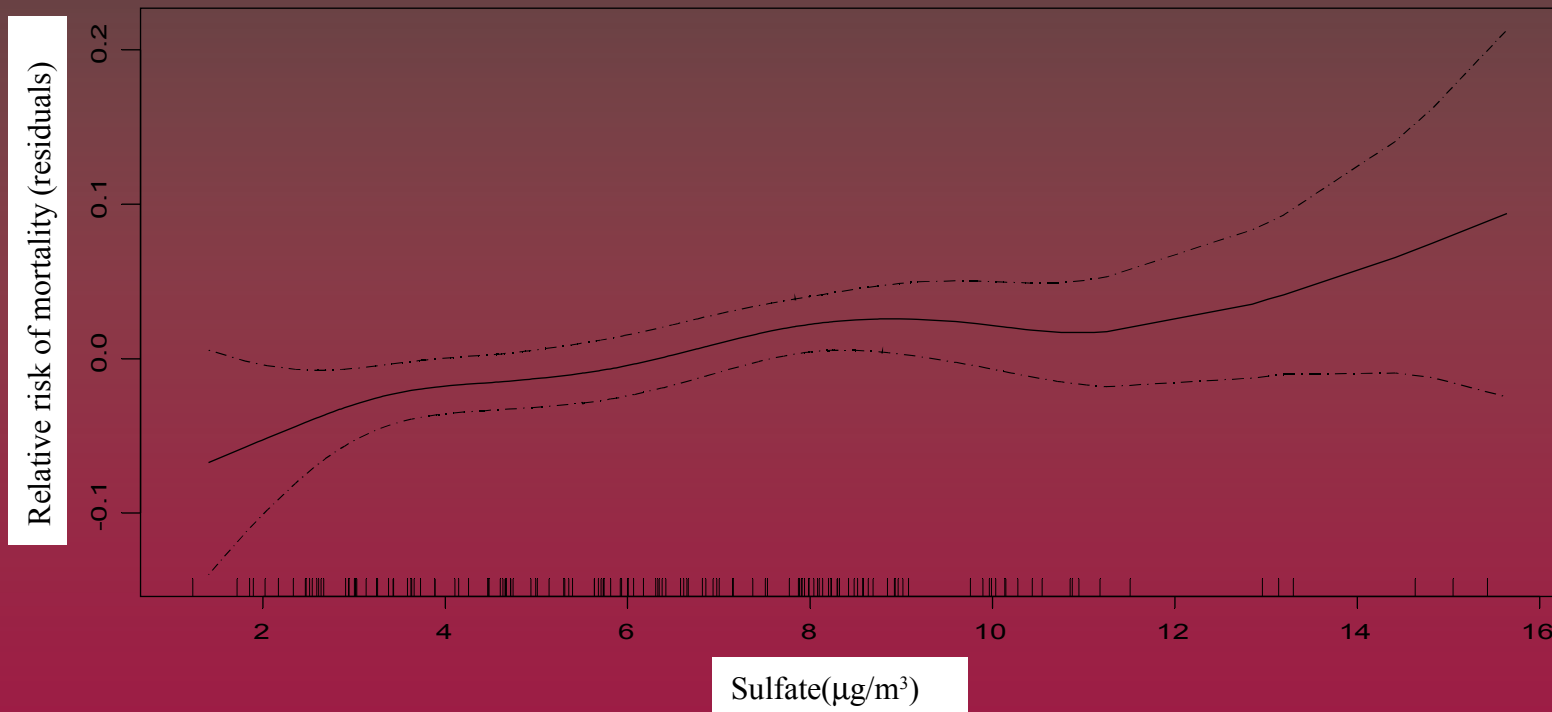
Sulfur Dioxide

- Emitted from fossil fuel combustion
 - especially from coal burning facilities, high sulfur fuels
- Can impair breathing in asthmatic children and adults
- Has been associated, along with PM, with
 - increased aggravation of heart and lung disease
 - premature mortality
- Recent study in Hong Kong (Lancet 2002) has found:
 - substantial reductions in SO₂ emissions can result in measurable improvements in mortality and illness



Effects of Sulfate on Premature Mortality

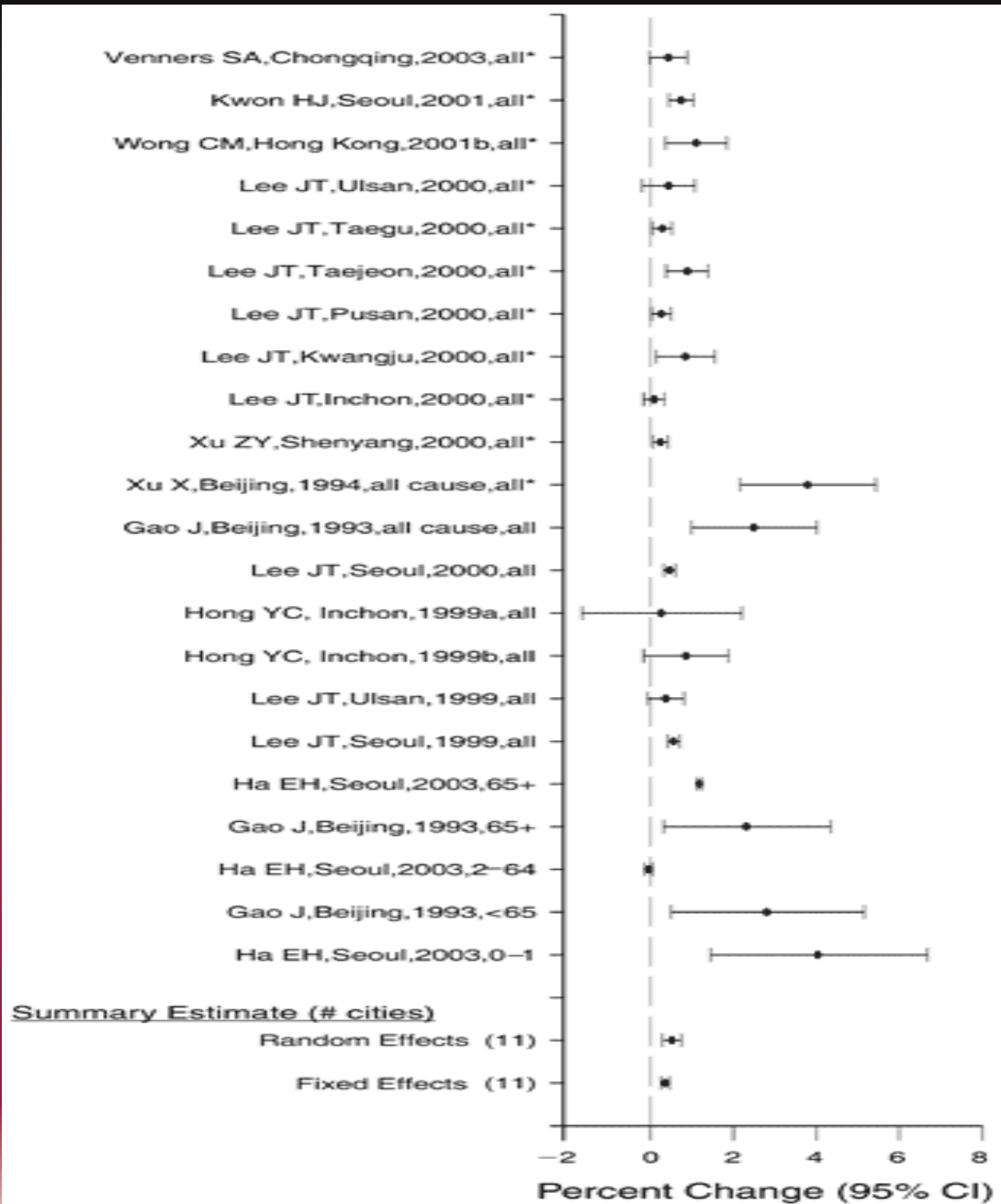
Source: HEI Reanalysis of the American Cancer Society Study (Krewski 2000)



Acute Evidence from Asia

SO₂ and All Cause Mortality

PAPA Review



Diesel Health Effects

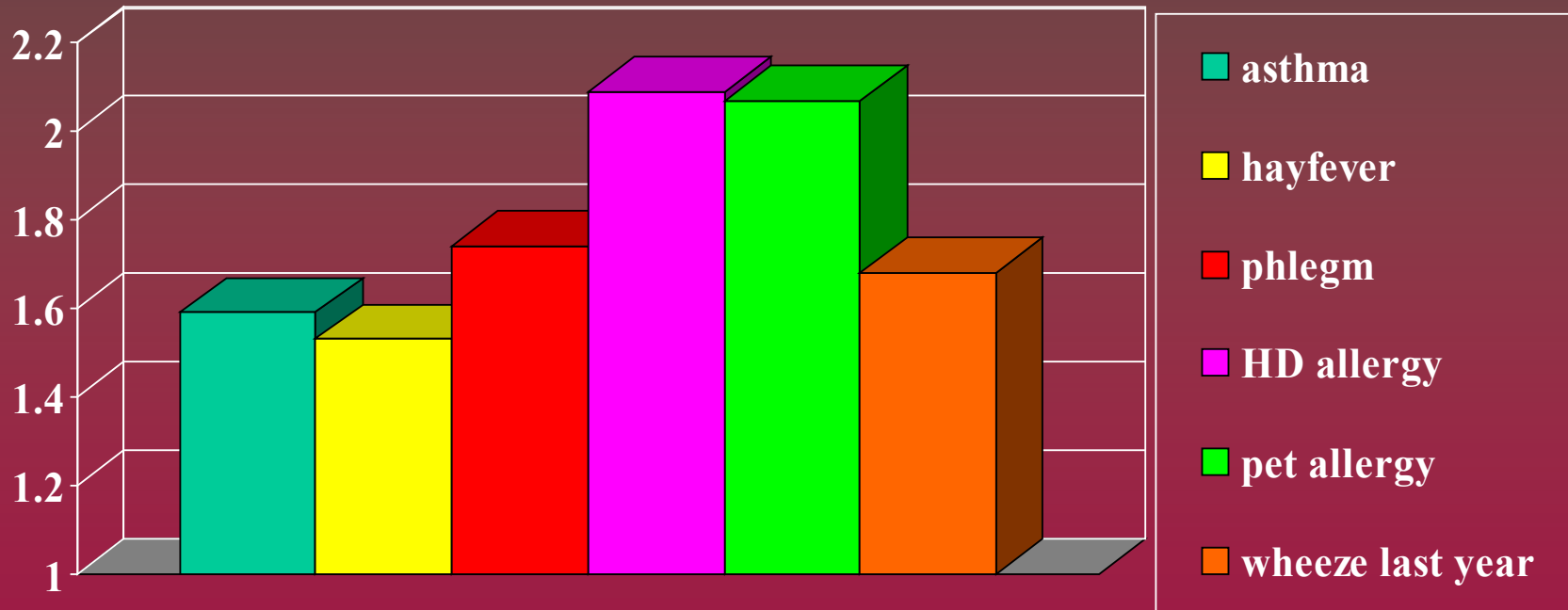
- Diesel Engines have substantial advantages:
 - higher fuel efficiency
 - lower CO and CO₂ emissions
 - Future new & retrofitted engines show outstanding promise for low emissions
- However, some especially older engines , also emit high levels of
 - particulate matter, NO_x, and chemicals attached to the particles (e.g. PAHs)
- Major types of health effects :
 - characteristic PM effects
 - acute effects (e.g. exacerbating asthma)
 - cancer effects (IARC, USEPA, CARB, likely\known Carcinogen)



Diesel Effects on Childhood Illness

(Brunekreef, et al Study in 24 Dutch schools)

Increased Symptoms comparing High Truck Traffic (>10,000) to Low Truck Traffic



Health Benefits of Emission Reductions



In Asia: Hong Kong Fuel Sulfur Reduction

(A.J. Hedley et al Lancet 8\2002)

-July 1999 Hong Kong Environmental Protection Department restricted sulfur content of fuels to .05% (by weight)

-Many fuel sources affected (e.g. industrial, vehicles)

-Near term impact

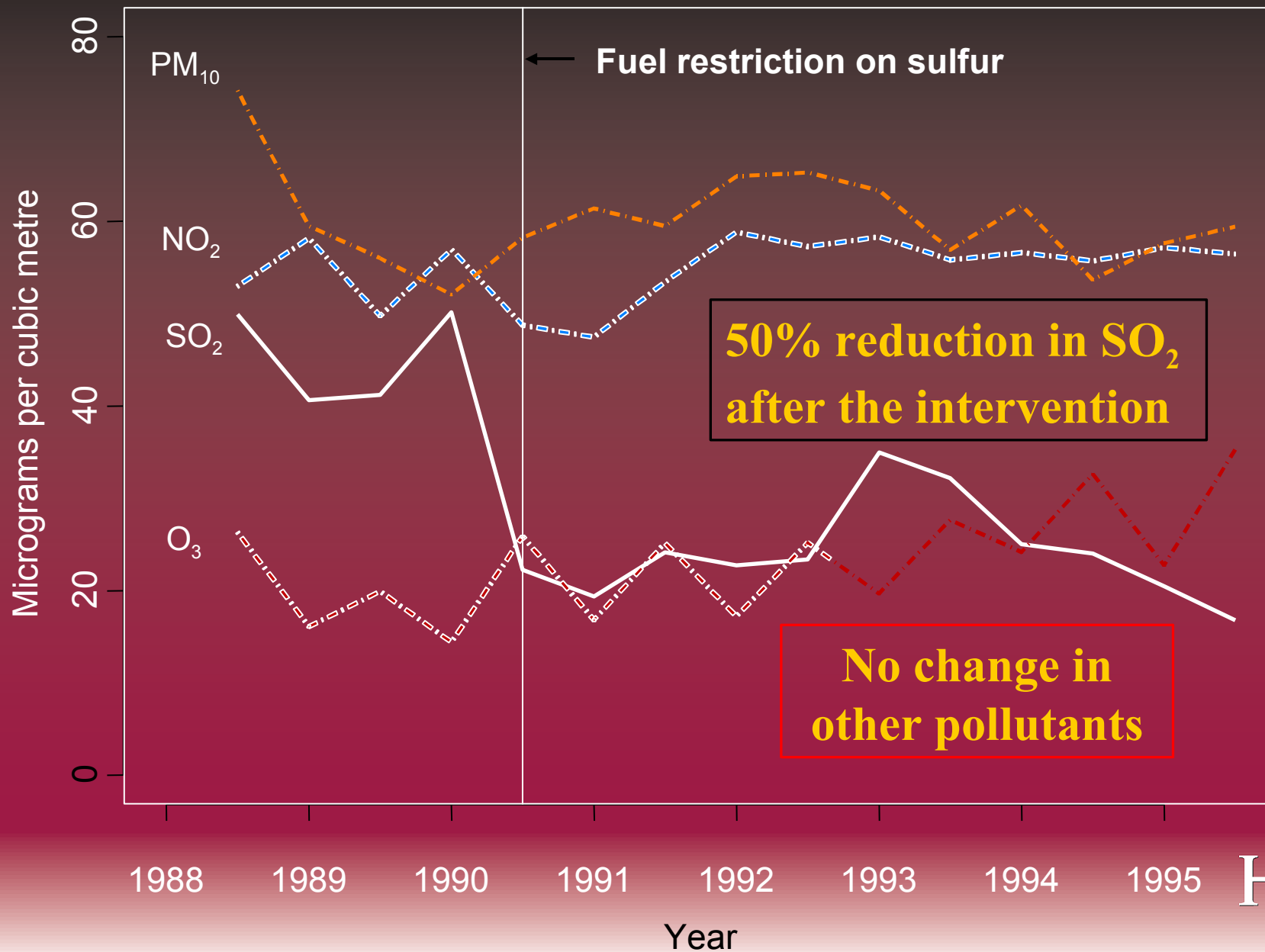
- ambient SO₂ levels

- health

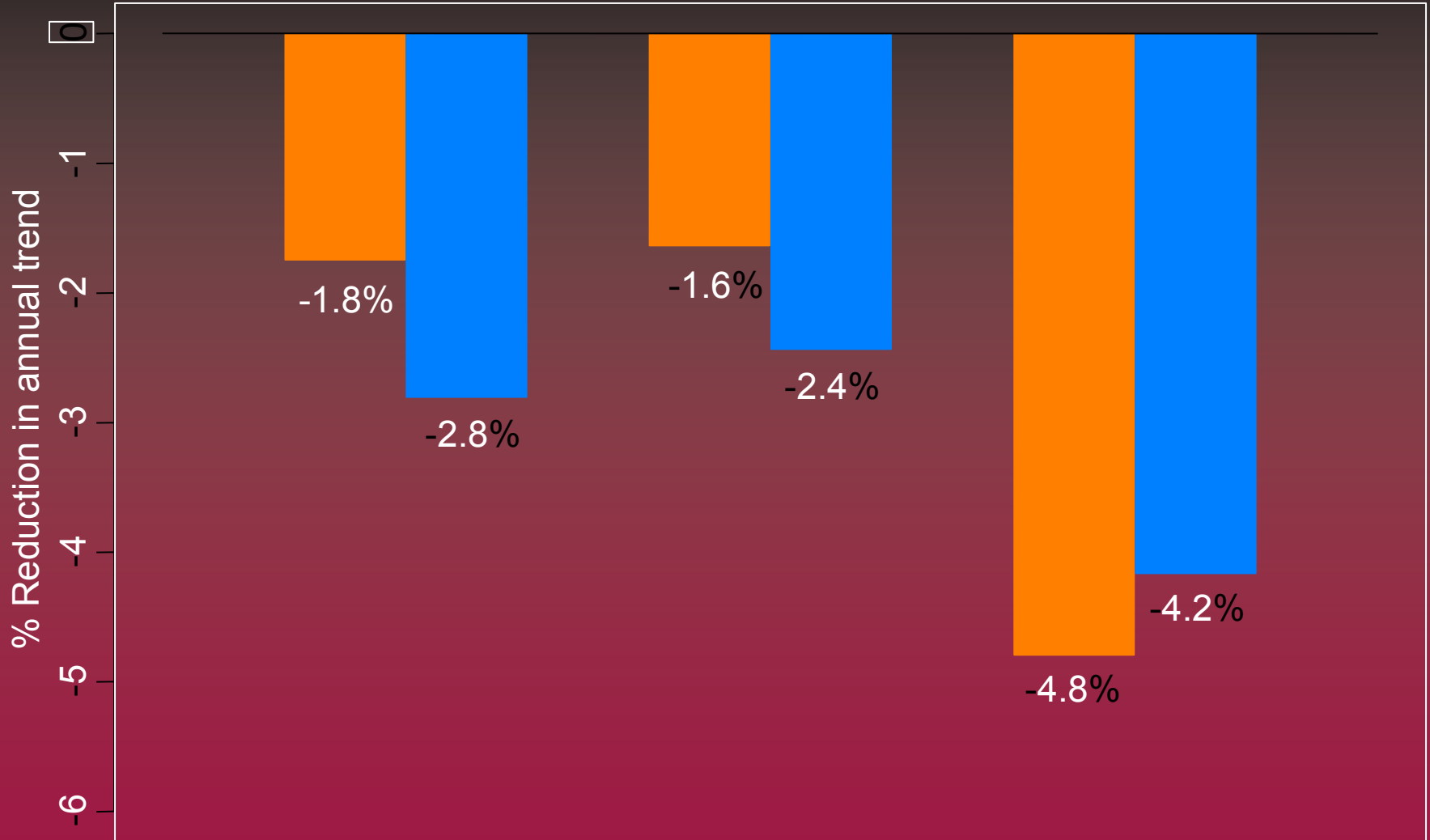
-Adjusted for seasonality, other factors



AIR POLLUTANT CONCENTRATIONS 1988 - 95 IN HONG KONG HALF YEARLY MEAN LEVELS



REDUCTIONS IN DEATHS AFTER SULFUR RESTRICTION



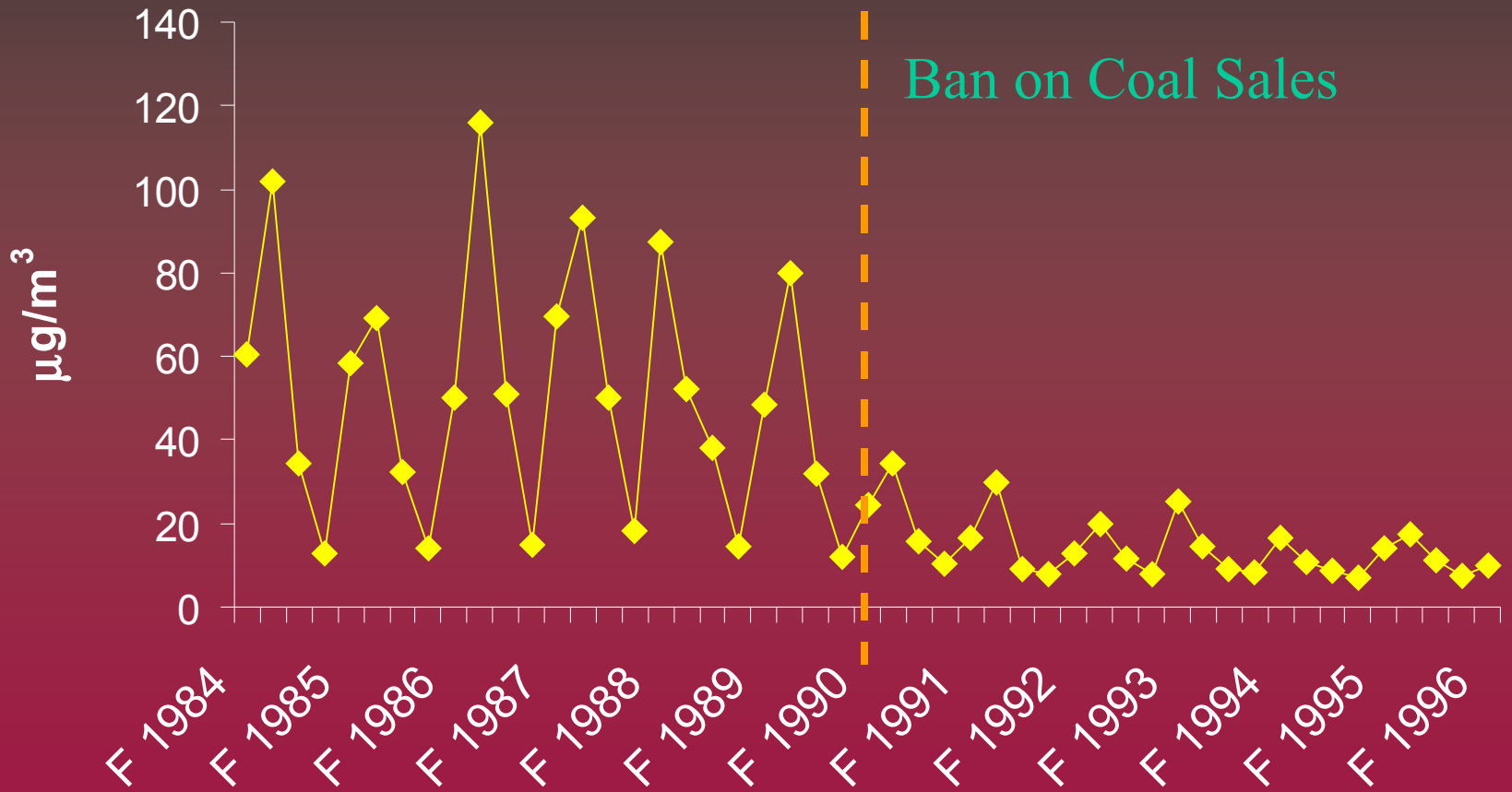
15-64 65+
All causes

15-64 65+
Cardiovascular

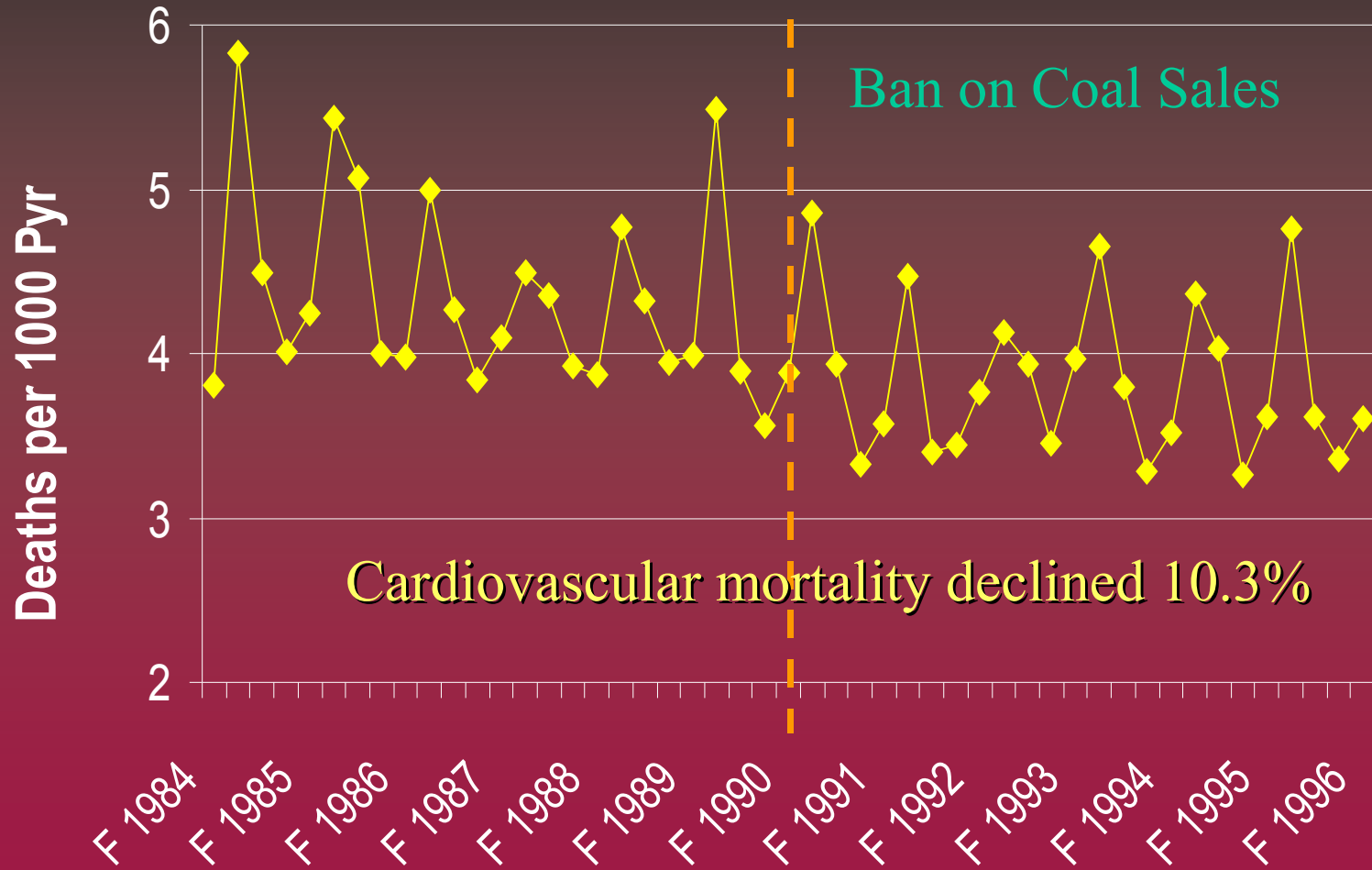
15-64 65+
Respiratory



Dublin Black Smoke



Dublin Cardiovascular



Cardiovascular mortality declined 10.3%

Ban on Coal Sales

A Special Challenge for PAPA:

Air pollution, poverty, and health

- Some evidence (mostly from US, Europe) that the poor face worse effects from air pollution
- In Asia the poor and high high levels of air pollution combine in densely populated urban settings
 - Potential for significant public health impacts
- New PAPA study underway in Ho Chi Minh City, Vietnam
 - Support from Asian Development Bank, DFID, Vietnam Government
- Study design exportable to India, other areas

Key questions:

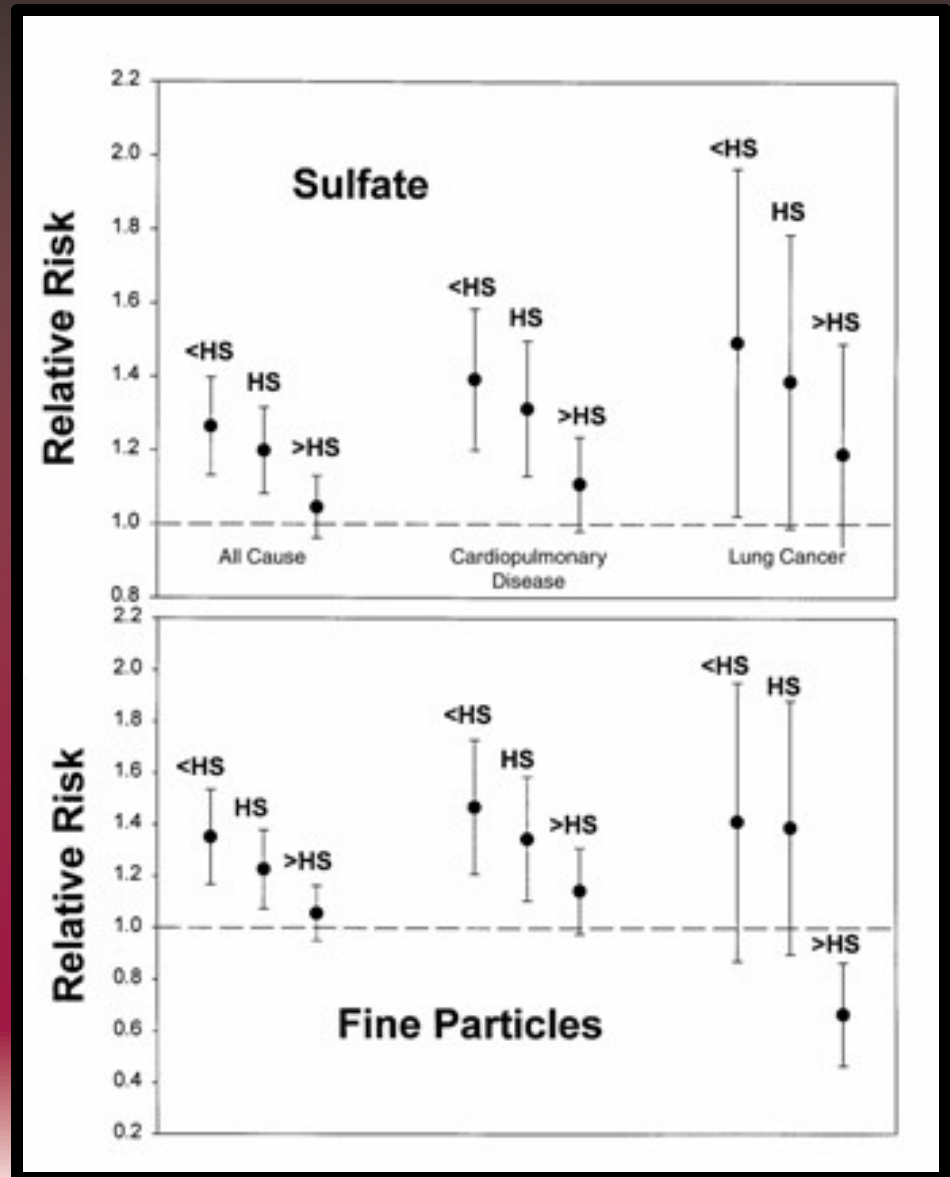
Are the poor more exposed to air pollution?

Do the poor suffer worse effects from air pollution?



Higher Risks Among the Less Educated

- Evidence from HEI Reanalysis of US studies
- Risk goes up with lower education in ACS and Six-Cities studies
- Few similar studies elsewhere in the world, clear need to move forward



Why the poor may suffer more health effects from air pollution

- Higher exposures

- Living close to traffic
- Roadside occupations
- Small and medium scale industries
- Use of solid fuels for cooking



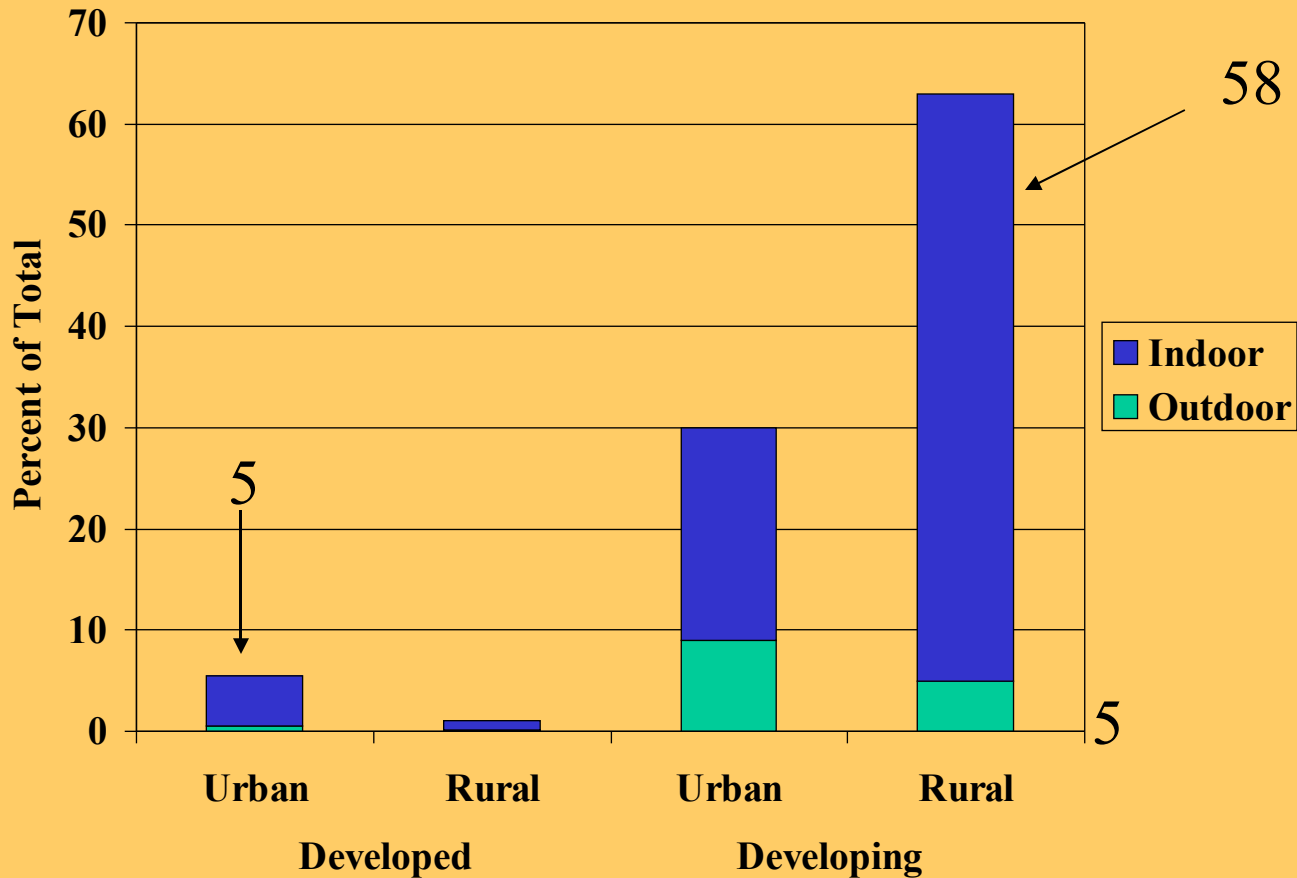
- More susceptible

- Poor nutrition / immunosuppression
- Higher incidence of 'diseases of poverty'
- Lack of timely access to health care



Where are the exposures?

Example: Global Particulate Exposures



Conclusions

- Air pollution in Asia exists at high levels
- WHO GBD finds high mortality impact in Asia
- There are a variety of health effects, including those caused by emissions from vehicles, factories, power plants, biomass combustion
- Key effects include:
 - Effects on mortality from particulate matter, SO₂ emissions
 - Effects on existing respiratory disease (e.g. asthma)
 - Respiratory effects, cancer from diesel emissions
- With a few exceptions, science on health effects of key pollutants (i.e. PM) tending to strengthen since last reviews
- WHO, EPA, others recently moved to establish more stringent standards & guidelines for PM, Ozone



Conclusions

- PAPA documents expanding science base across Asia
- Health effects observed in initial PAPA analysis illustrates similar effects in Asian, Western populations
- Additional analysis needed to understand key differences in effects resulting from
 - Pollution mixes
 - Population characteristics
 - Air pollution impact on diseases not observed in West (i.e. TB)
 - Differential effects on poor



Conclusion:

Using Science to Inform Decisions

- Science important to advance knowledge
 - But also needs to build information for better air quality decisions
- Good air pollution science needs:
 - Adequate data
 - Health
 - Air quality

Skilled investigators

-Statistics, toxicology, epidemiology...

Supportive collaborators

-local officials

Skills to translate health science into policy analysis and

- Communicate the results
- Rest of workshop to explore with data users and data providers



Thank You!

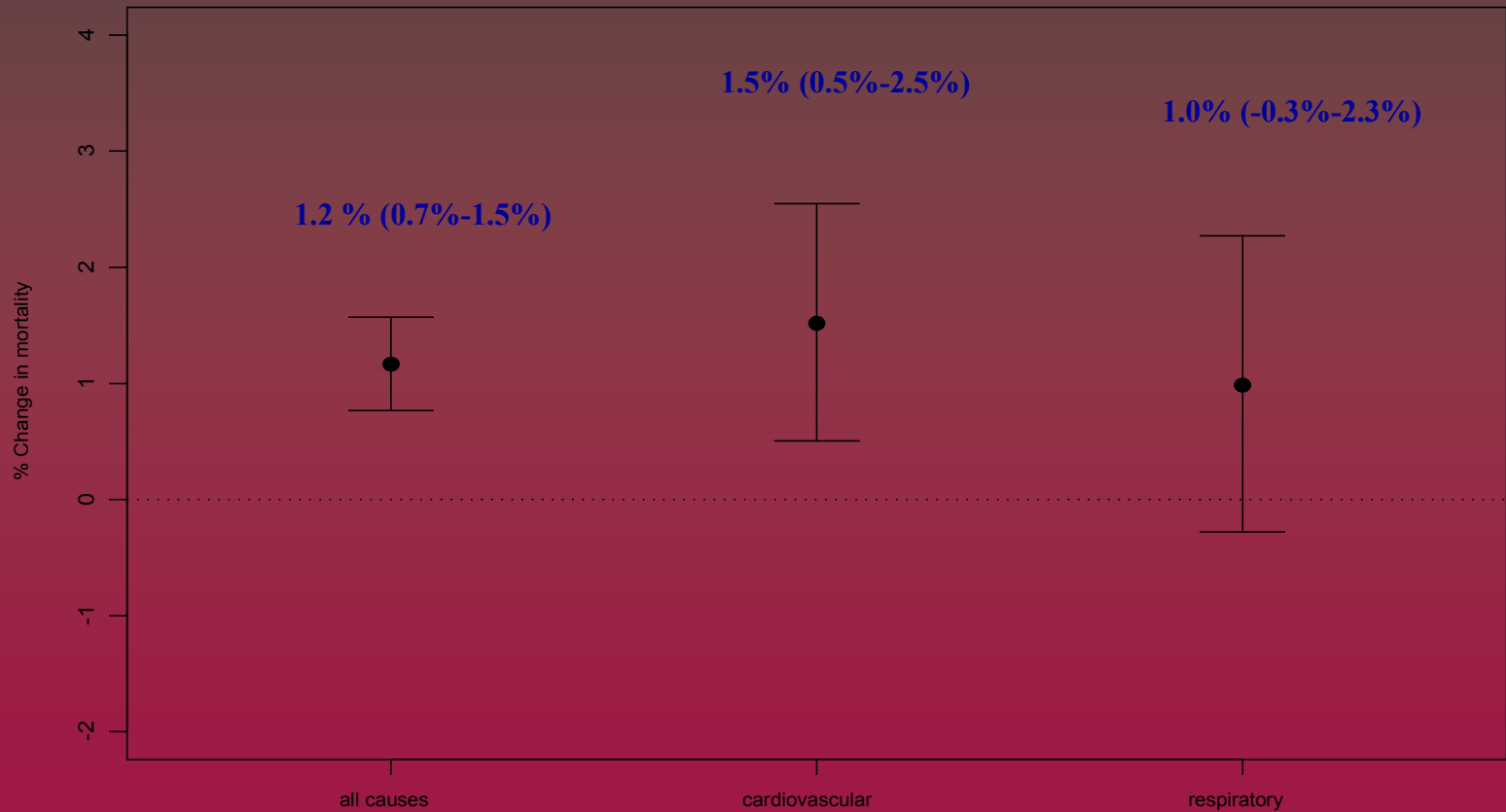
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Percent Change in Mortality for a 10 ug/m3 increase in PM10



Results of Hong Kong Study

Mortality outcomes were significantly related to all the pollutants at the best single lag day (e.g.)

Mortality for all natural causes	lag day	Excess risk % per 10 $\mu\text{g}/\text{m}^3$ (95% CI)
All ages		
NO ₂	1	0.67 (0.38, 0.95)
SO ₂	0	0.59 (0.17, 1.00)
PM ₁₀	0	0.38 (0.14, 0.63)
O ₃	1	0.26 (0.02, 0.51)

Similar but larger effects for older age groups were found



Effect of Air Pollution Control on Death Rates in Dublin

- Concentrations of BS declined 70% , (SO₂ 11.3%)
- Cardiovascular mortality declined 10.3%
- 12-year study duration necessitated correction for other external and risk factors:
 - Weather patterns
 - Influenza epidemics
 - Changes in Hypertension, Cigarette smoking
- HEI funding extension study Ireland - wide

Studying Air Pollution, Poverty, and Health in Ho Chi Minh City (HCMC)

- Initiated at the request of Asian Development Bank (ADB)
- Led by HCMC health and environment experts
 - In last stages of formal approval
- Key challenge is data on:
 - Housing and Health Conditions
 - Air Quality
- Goal: Methods suitable for use in other cities
 - building an evidence base across Asia



Canal-Side Slum Housing

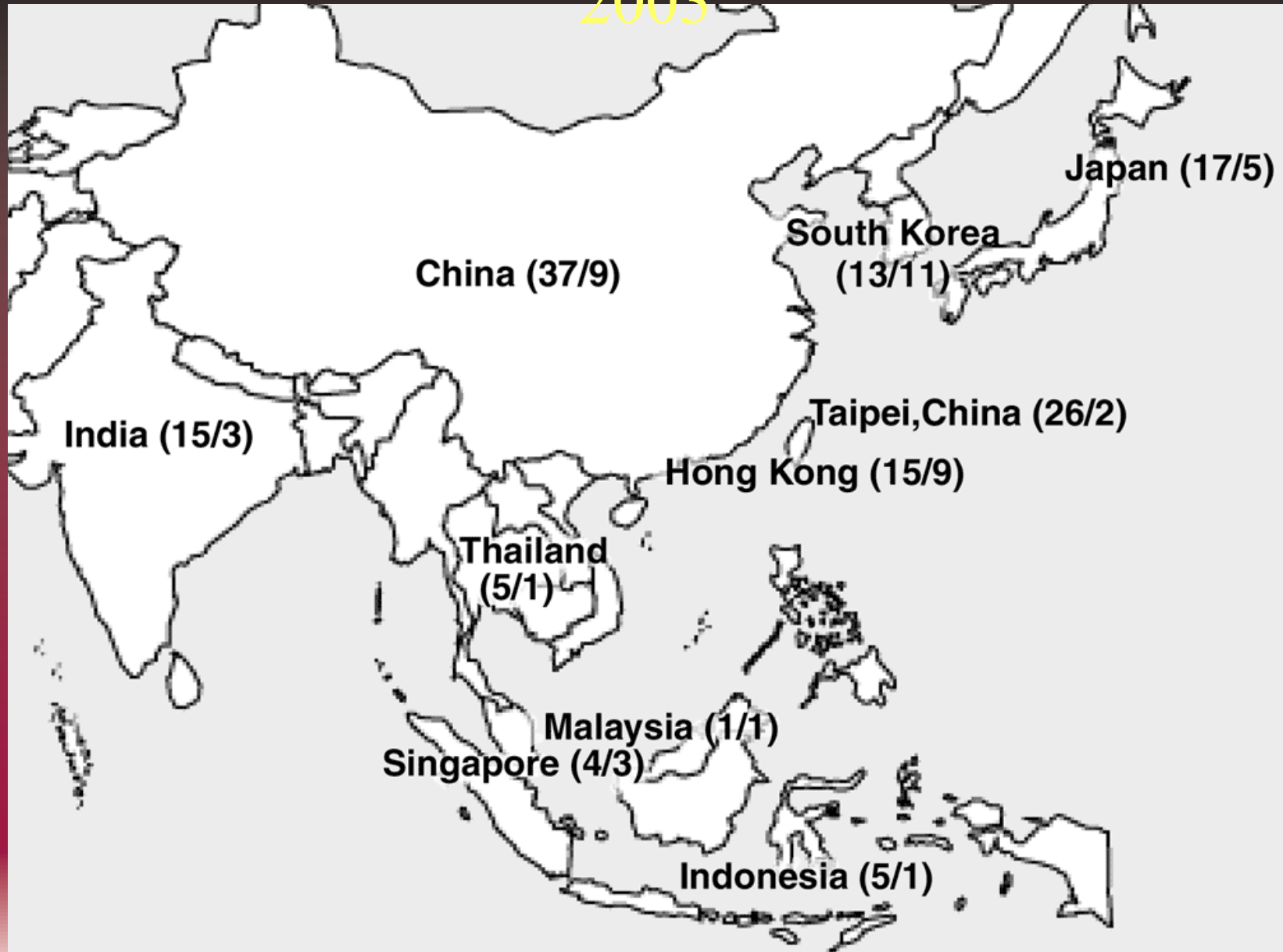


Study Approaches

- Project being developed and conducted by interdisciplinary team of local investigators in HCMC
 - Department of Health, Pediatric Hospitals, HEPA, DOLISA
 - Technical assistance (training, workshops) by international consultants as needed
- Study Component 1
 - Assess childhood respiratory health admissions, air pollution, and poverty status
- Study Component 2
 - Neighborhood measurement and survey to assess exposure and attitudes in relation to poverty



Studies of Air Pollution and Health in Asia 1980–2003



In Europe: Effect of Air Pollution Control on Death Rates in Dublin; Intervention Study (Clancy et al 2002)

- Impacts on mortality of banning the marketing, sale and distribution of coal in Dublin
 - Ban began Sept 1, 1990 – clear effect date
- Study compared
 - levels of BS, SO₂ & mortality indices
 - 72 mos. pre ban vs. 72 mos. post ban
- *HEI currently funding Ireland – wide analysis*

