EANET Workshop on the Relationship between the Atmospheric Environment, Human Health and Ecosystems

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Effects of air pollution on human health

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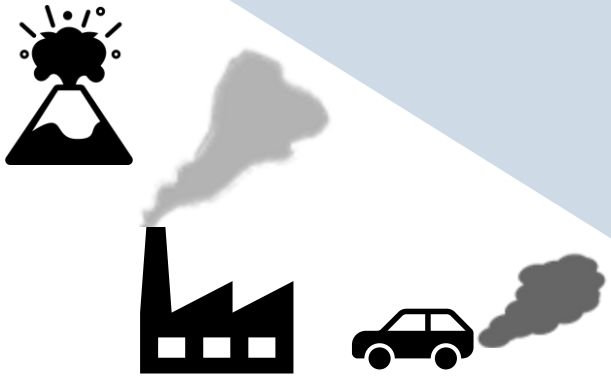
Contents

- Exposure to air pollution and its health effects
- Evaluating health effects of air pollutants by epidemiological approaches
- Global mortality attributable to PM2.5
- Environmental policy and its effect to reduce air pollution related health outcomes

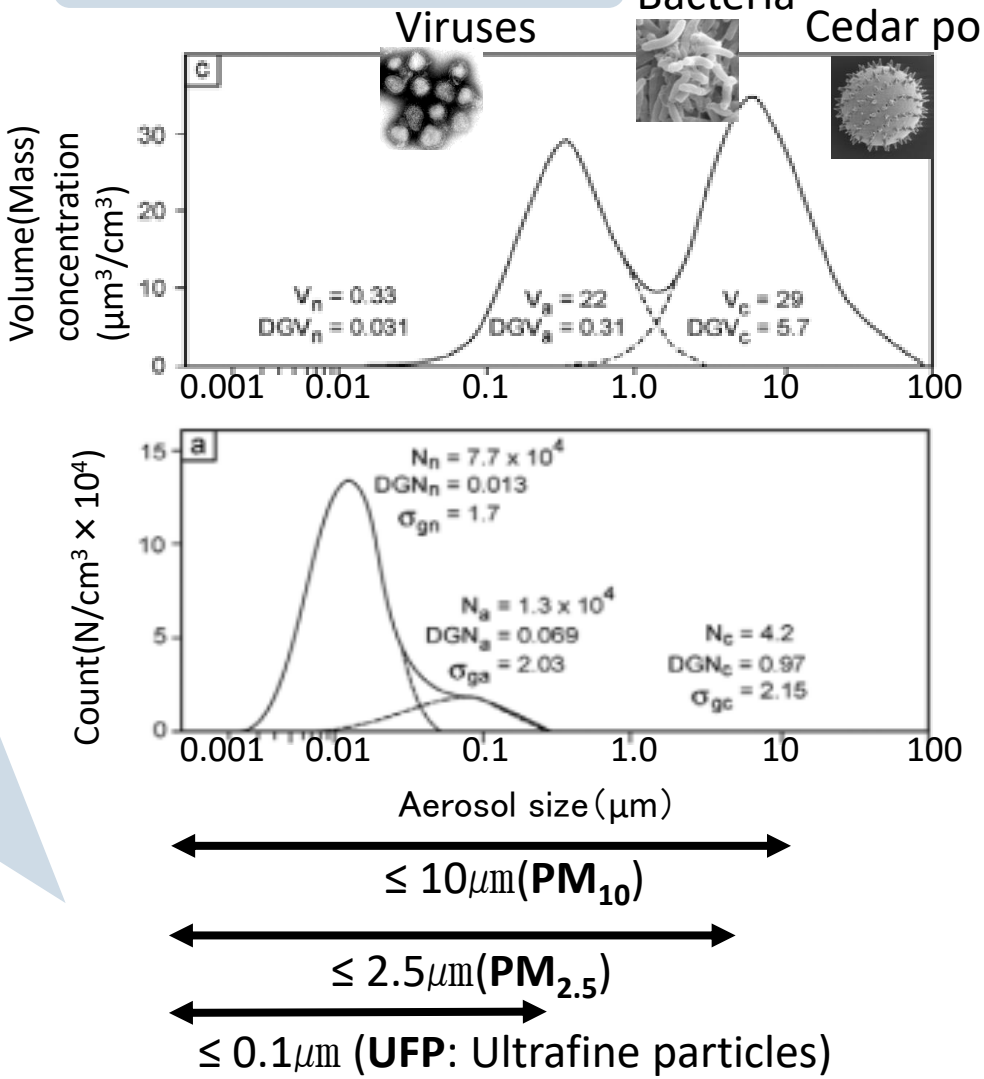
Air pollution affecting human health

Gaseous pollutants

Nitrogen dioxide (NO_2)
Sulphur dioxide (SO_2)
Ground level ozone (O_3)
Carbon monoxide (CO)
Volatile organic compounds (VOCs)

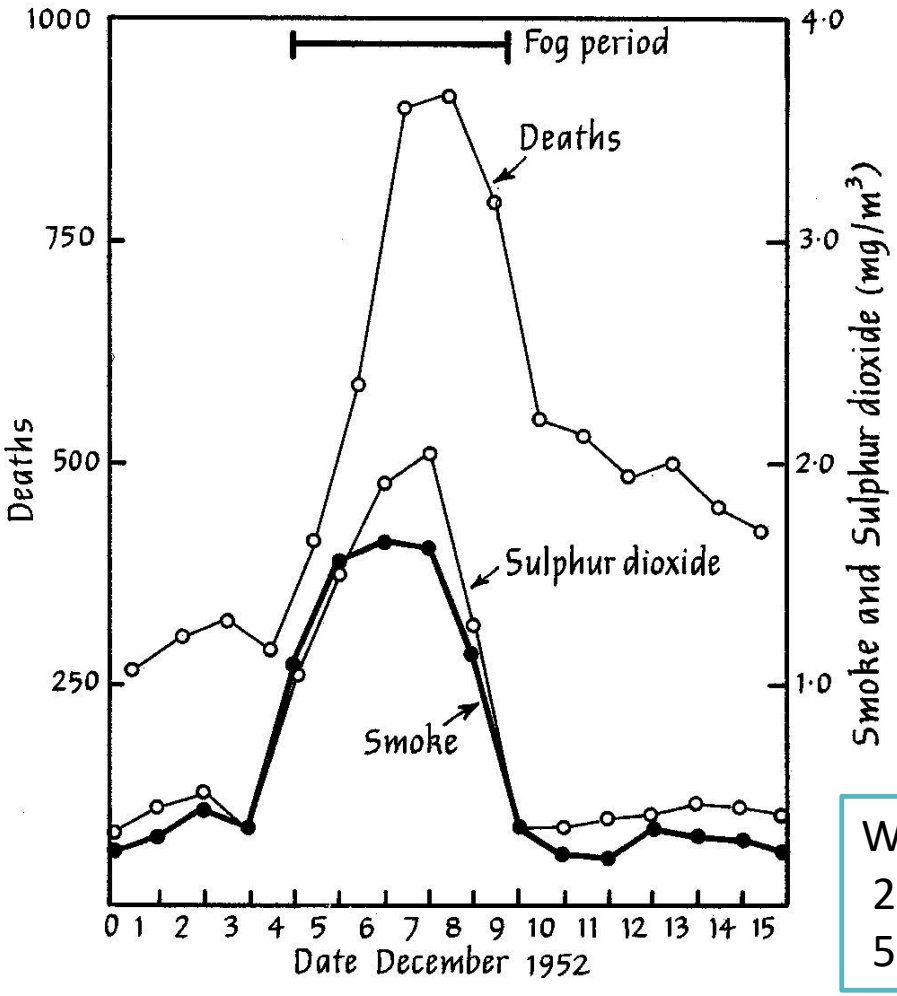


Particulate pollutants



Whitby (1978)

Air pollution episodes indicating the health effects of smoke (particles) and SO2: Great Smog of London, UK in 1952



Wilkins, E. T. (1954) JRSI., 74: 1-21

Encyclopedia Earth

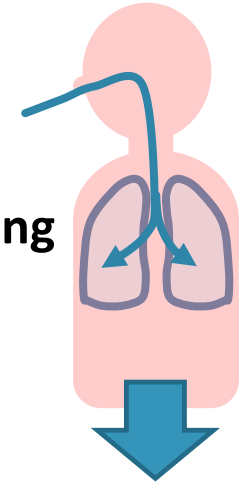
- Exposure to air pollution increased deaths.
- Health effects of air pollution appeared immediately after exposure.
- Health effects of air pollution persisted longer.

WHO guideline for SO_2
20 µg/m^3 (24 hour)
500 µg/m^3(10 min)

Routes of exposure and possible health effects

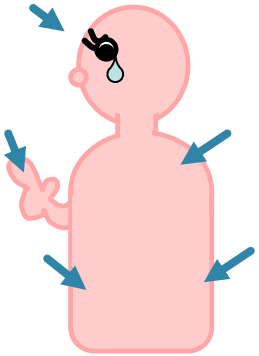
Respiratory Route

Inhalation

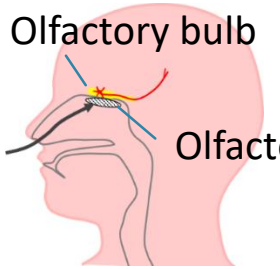


Dermal route

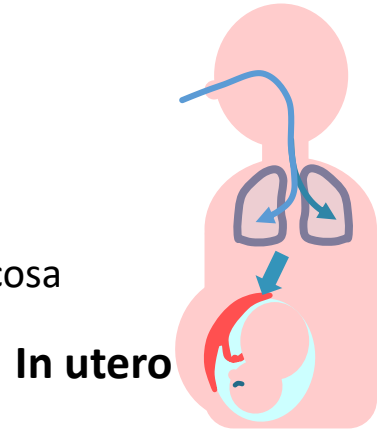
Skin Contact



Nasal route



Transplacenta route



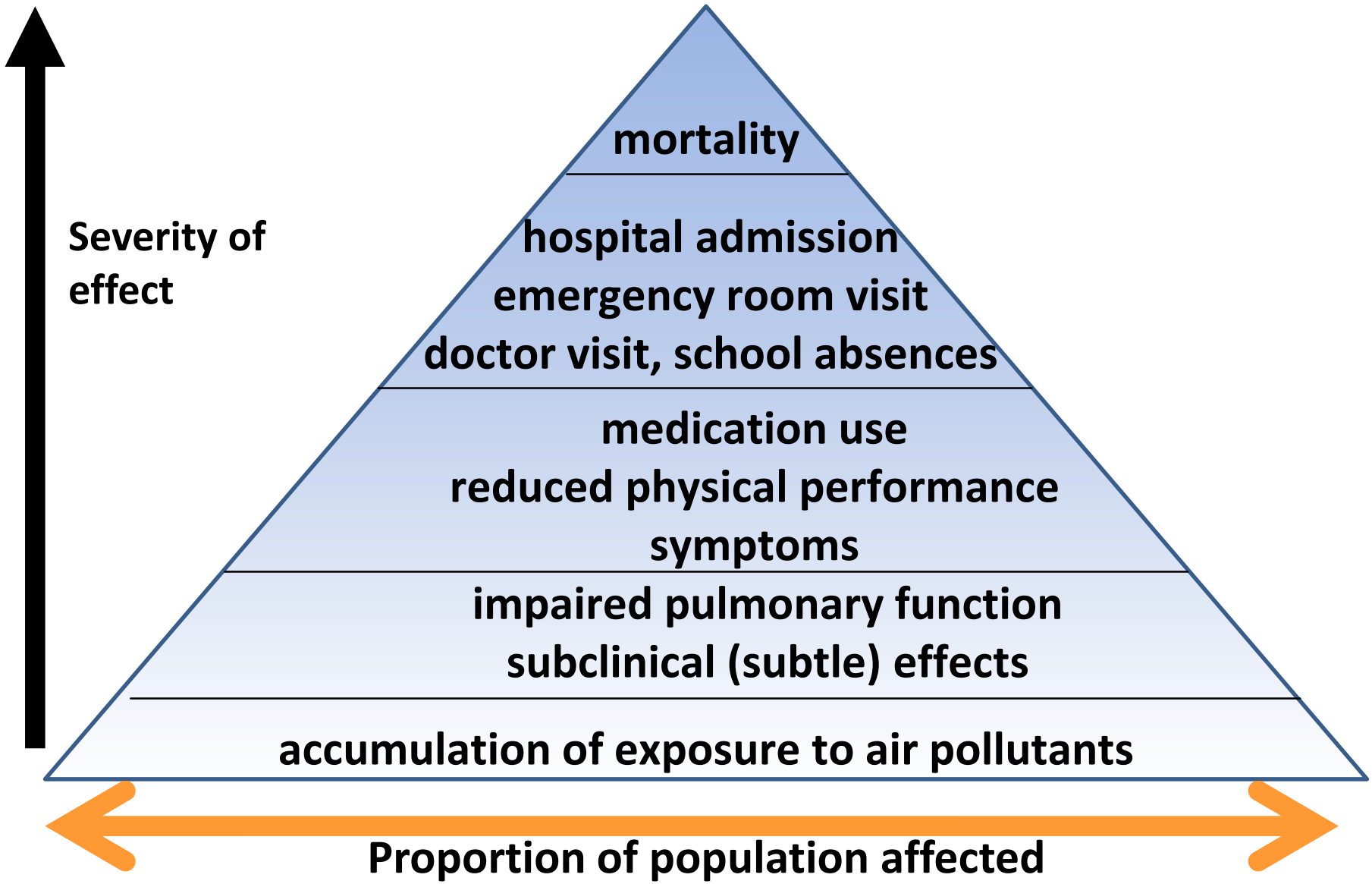
1. Pulmonary oxidative stress and inflammation
2. Affecting autonomic nervous system and cause imbalance
3. Very small particles and constituents may directly translocate into the systemic circulation

Respiratory diseases, Lung cancer
Cardiovascular diseases (Ischemic heart diseases, Stroke)
Cognitive disfunction, Diabetes
Maternal health outcomes (Low birth weights)

Evaluating the health effects of air pollutants

- Toxicological approach (Experimental studies)
  - Use cells, animals, human volunteers
  - Expose the subjects by specific environmental substances under certain conditions
  - Clarify the mechanisms, exposure response relationship
- Epidemiological approach（Observational studies）
  - Clarify the frequency and the distribution of the diseases of interests among the population
  - Assess the association of diseases with various factors

Pyramid of health effects of air pollutants



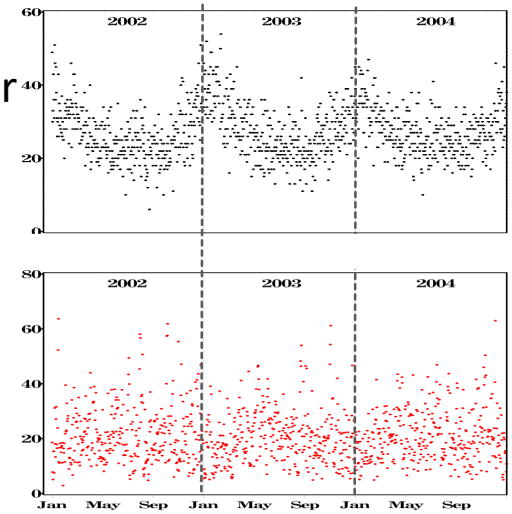
Time duration of exposure

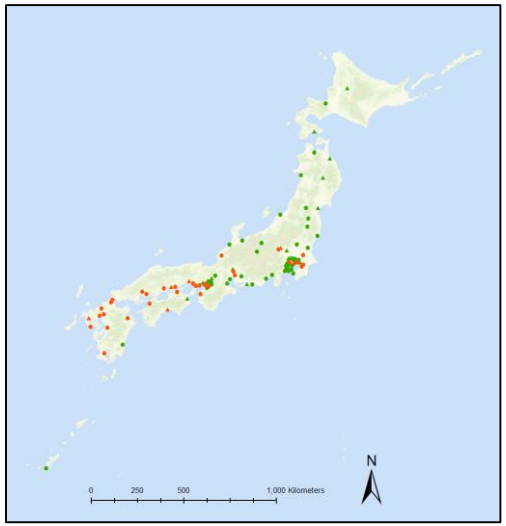
	Short-term exposure effects	Long-term exposure effects
Time from exposure to health outcome	**Hours to days**	**Months to years (Accumulated)**
Health outcome indicator	**Acute onset diseases** Mortality, Hospitalization, Emergency visit, Outpatient visit, Disease onset (AMI, stroke), Worsening of disease (asthma, COPD) **Daily variation in function and symptoms** Blood pressure, symptom diary	**Chronic change (including acute onset diseases)** Mortality Incidence of diseases (Cardiovascular/respiratory diseases, Cancer)
Variation in exposure	**Temporal variation**	**Spatial variation**
Study design, statistical methods	Time-series study Case-crossover design others	Ecological study Cross-sectional study Cohort study, Case-control study
Confounders	**Time-variant factors** (Meteorological factors, calendar time, co-pollutants)	**Time-invariant factors** (Age, sex, risk factors)

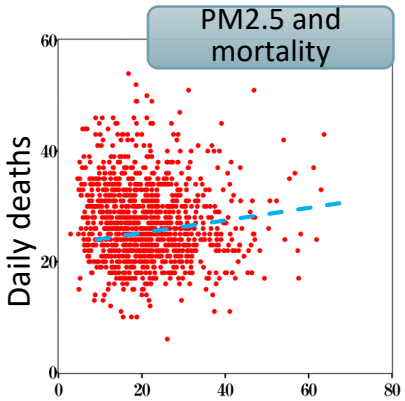
Examining the health effects of short-term exposure to air pollution in Japan

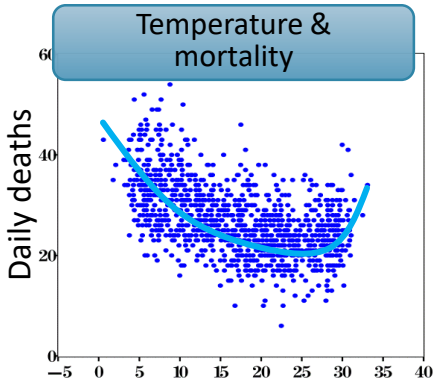
Daily number of deaths

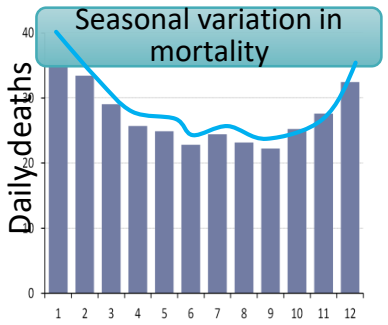
PM2.5

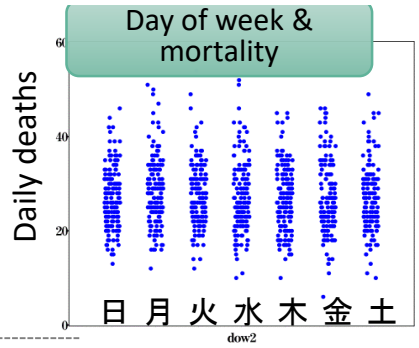


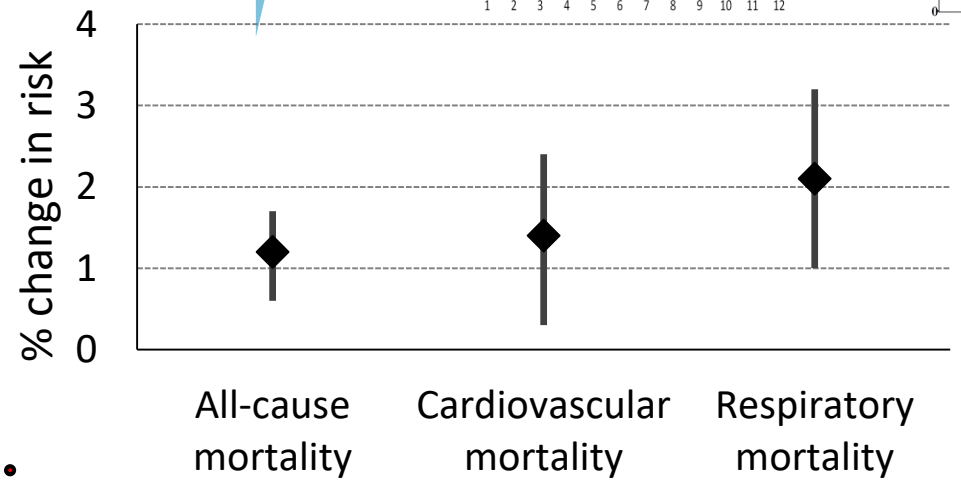










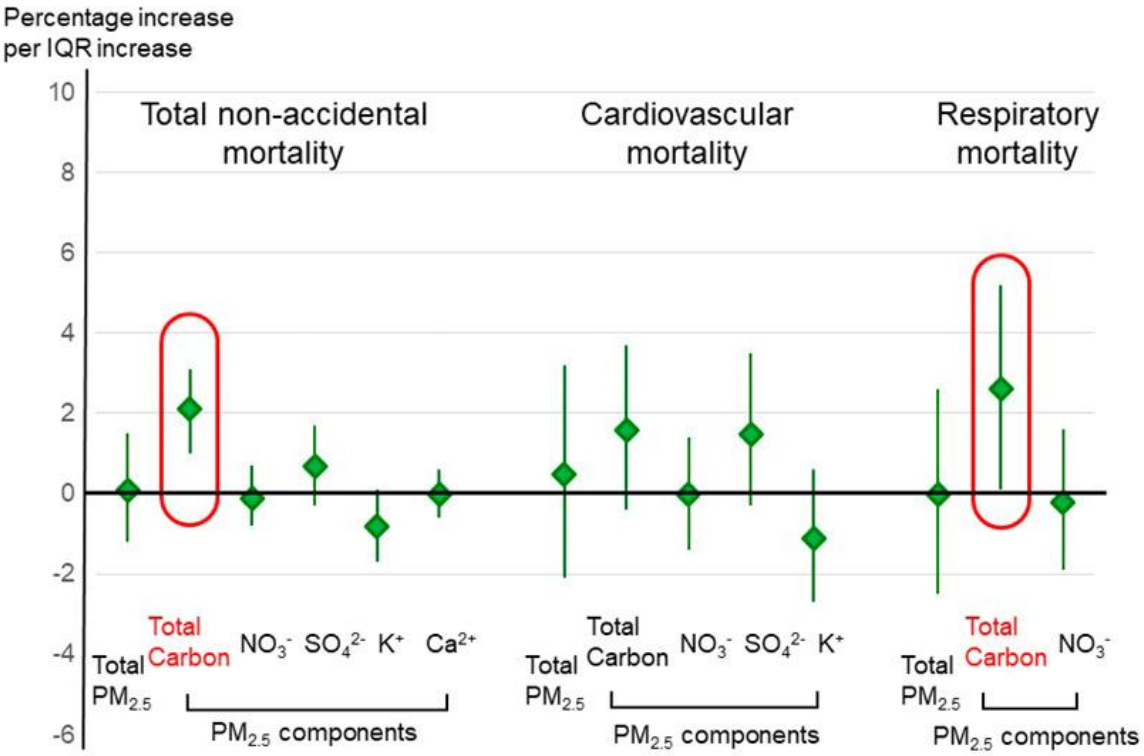


Michikawa, Ueda et al. JE2019)

Health effects of chemical components of PM2.5

- The health effects of PM2.5 may vary by area.
- There is a seasonal variation in the health effects of PM2.5.

In the study of Tokyo, carbon elements may have stronger health effects than others on respiratory mortality.

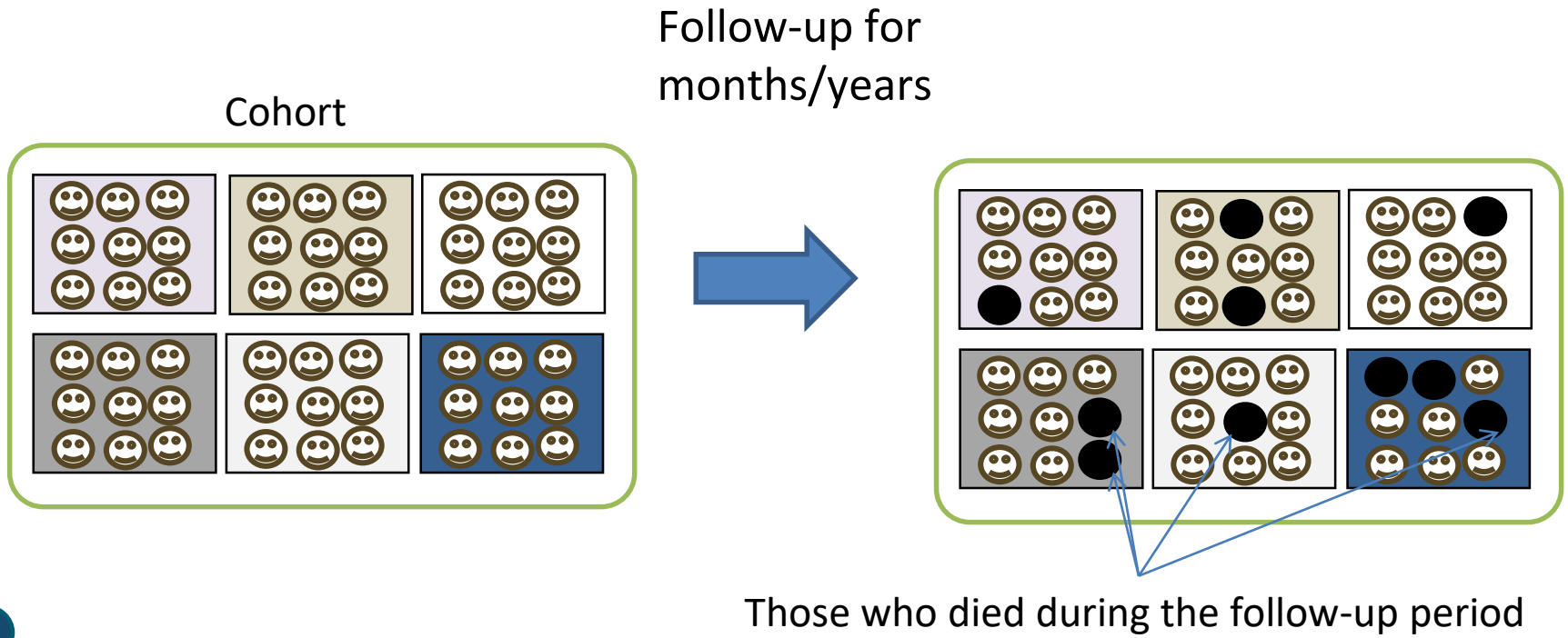


Association between exposure to $PM_{2.5}$ components at lag0-1 and mortality in the multi-component model.

Michikawa et al. STOTEN(2021)

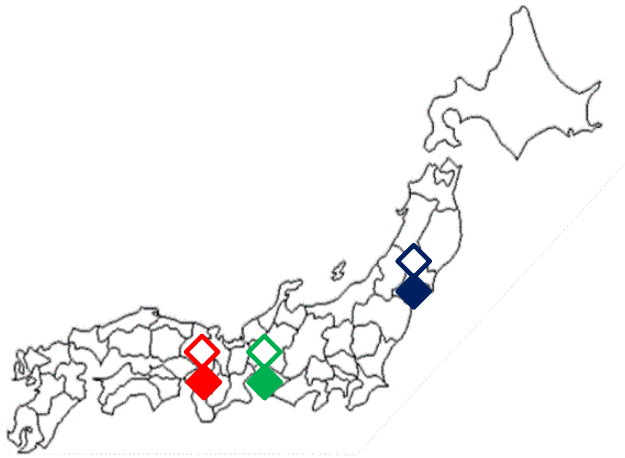
Cohort study to evaluate the health effects of long-term exposure to air pollutants

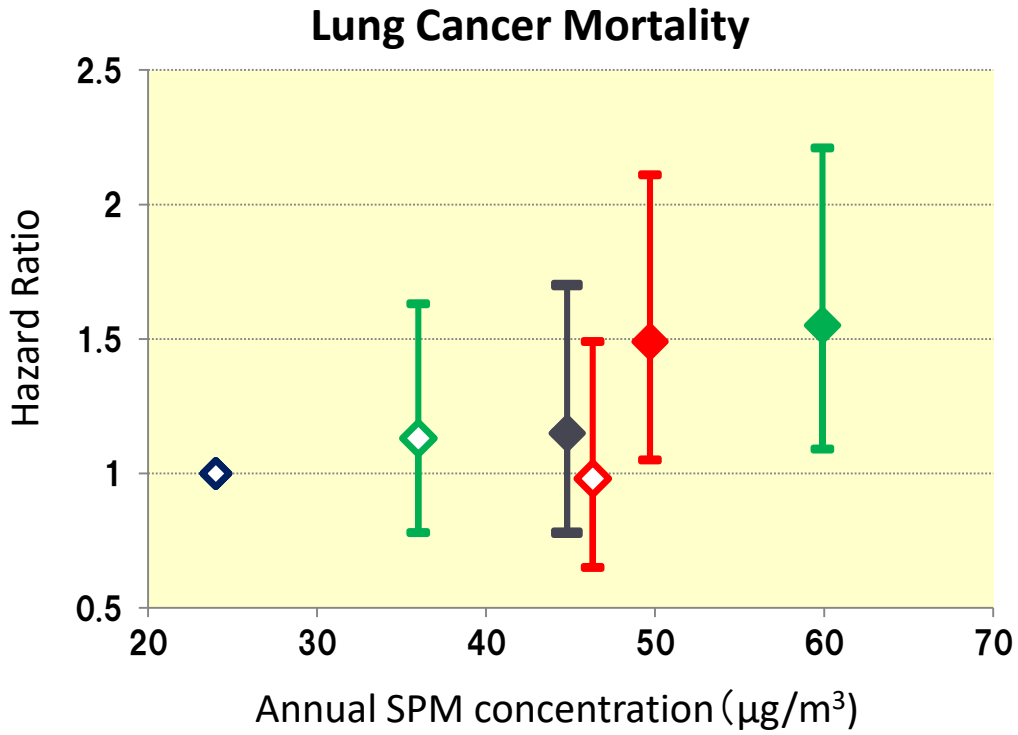
- Cohort members are classified at the level of air pollution exposure
- Compare the mortality (or incidence) among the areas with different levels of air pollutants
- Adjusted for other factors (e.g. age, smoking…) at the individual level in the analysis



Cohort study in Japan: PM exposure and Lung cancer mortality

- Three-Prefecture Cohort Study
  - Areas: 6 cities in 3 prefectures (3 urban cities and 3 rural areas)
  - Subjects: 63,520 participants were followed up for 10 years from 1983
  - Exposure: 10 yrs concentration of SPM (1974-1983)





Katanoda et al. J Epidemiol 2011;21(2):132-143

PM2.5 - Mortality risk function based on the epidemiological studies

Linear function

$$RR = 1 \quad if \quad X \le X_{th}$$

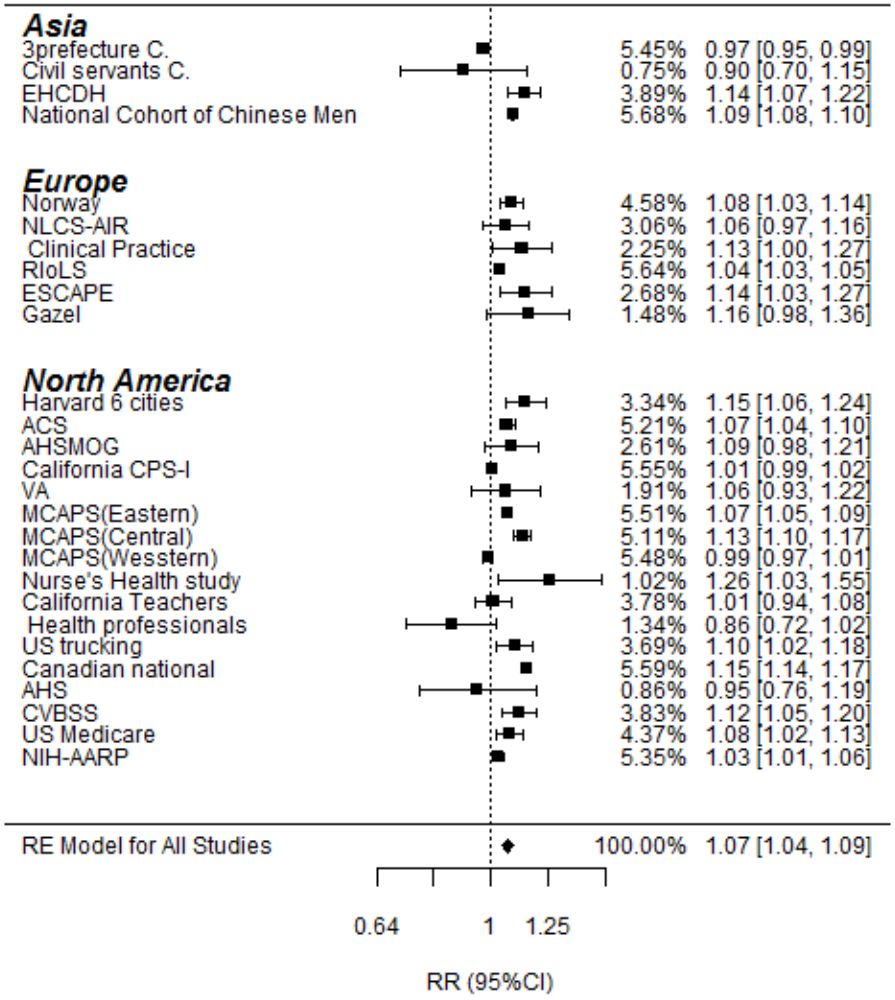
$$RR = e^{\beta(X - X_{th})} \quad if \quad X \ge X_{th}$$

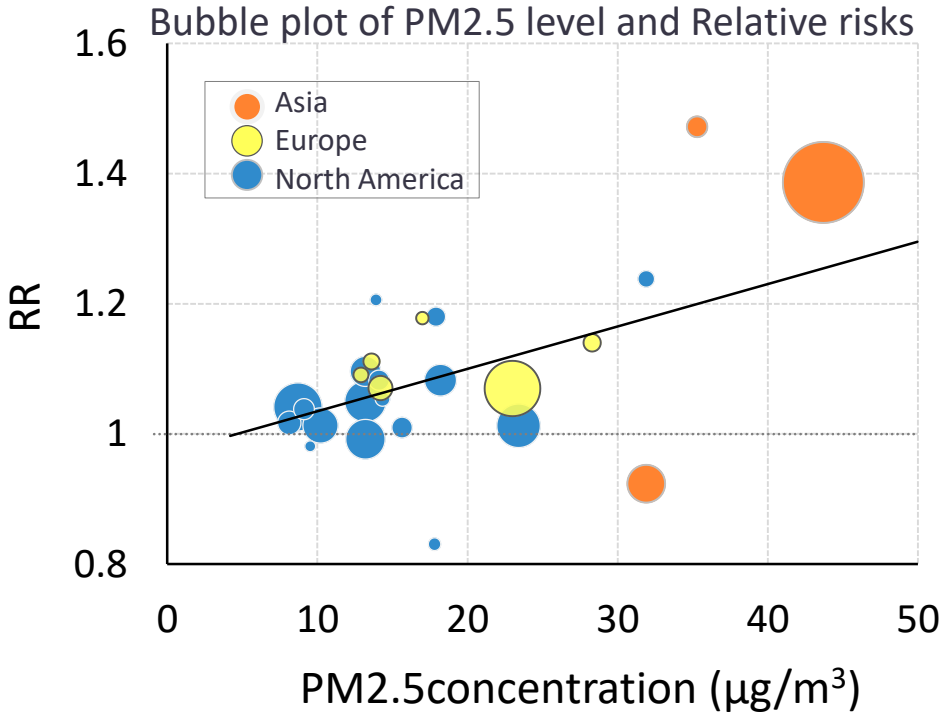
X: $PM2.5\ concentration$

X_{th} : Theoretical minimum risk exposure level
The value depends on the assumption.

β: parameters

Previous studies about PM2.5 and mortality





Ueda et al. JSAE(2015)

PM2.5 - Mortality risk function

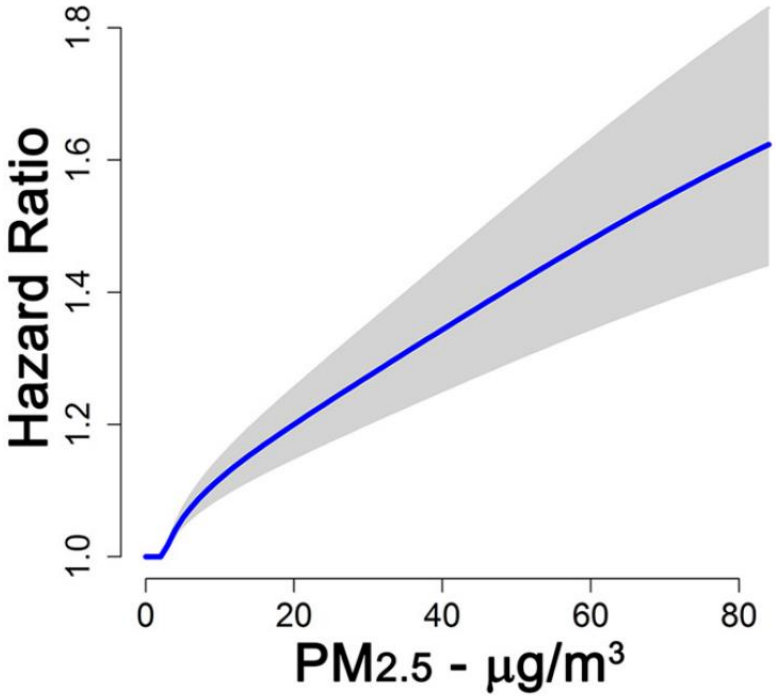
Non-linear function

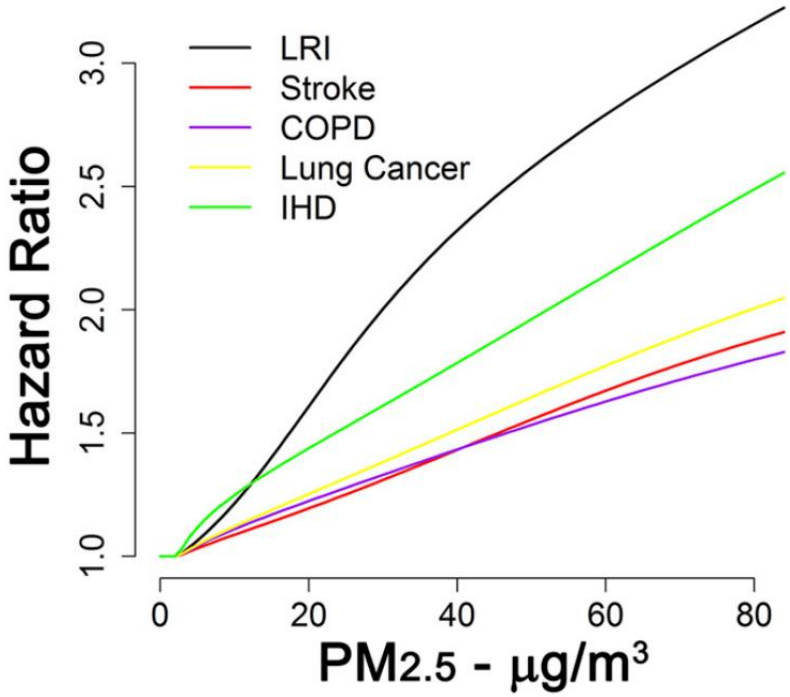
$$RR = IER(z) = 1 + \alpha \times (1 - e^{\beta(z-z_{cf})^{\gamma+}})$$

z: *Air pollution concentration*

z_f: Theoretical minimum risk exposure level

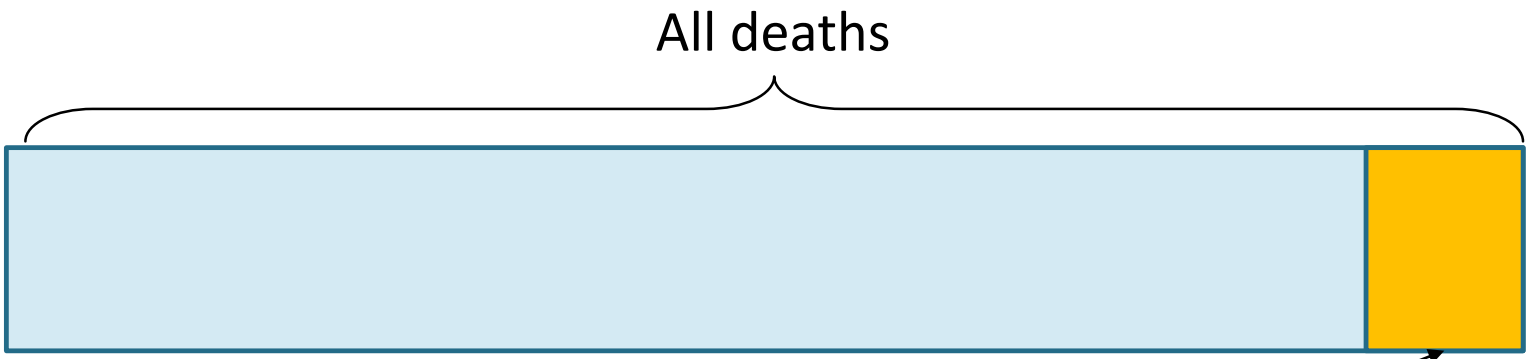
β, α, γ : parameters





Burnett et al. PNAS(2018)

How to estimate the number of deaths attributable to air pollution based on epidemiological studies?



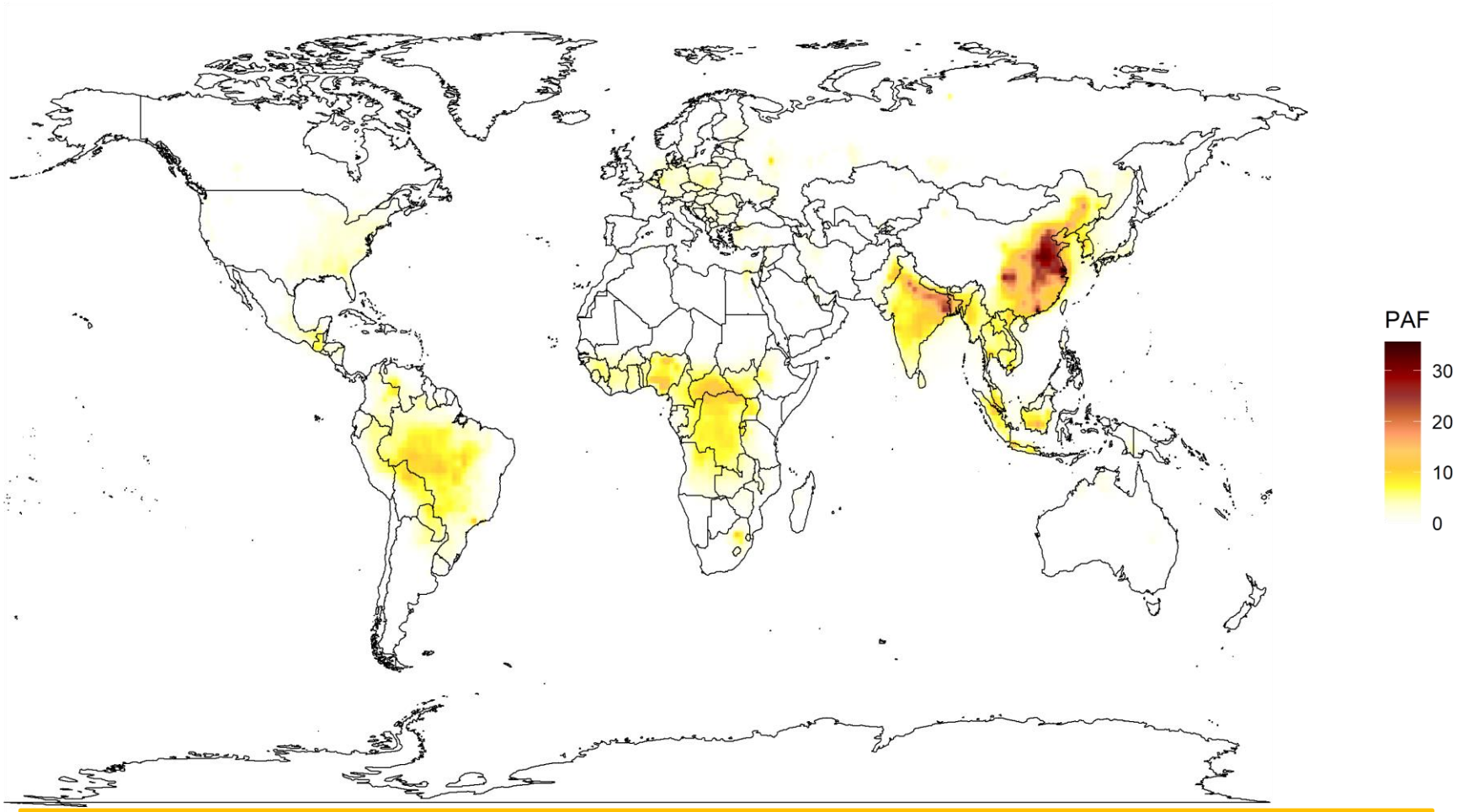
$$N_{airpol} = (All\ deaths) \times PAF$$

utable to air pollutants (? /year)

$$PAF = \frac{\mathrm{E(RR-1)}}{\mathrm{E(RR-1)+1}}$$

N_{airpol}	:Number of deaths attributable to air pollution
PAF	: Population Attributable Fraction
E	: Proportion of exposed among the population
RR	: Relative risk of the exposure derived from air pollution-mortality function

Global distribution of number of the deaths attributable to PM2.5 (% of all deaths)

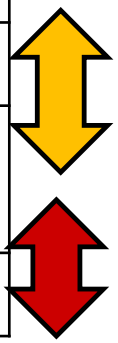


Approximately 4 million deaths are related to PM2.5 annually.

Can environmental policy reduce the health outcomes from air pollution?

- Interrupted time-series analysis for strict regulations on vegetation fire events in Thailand

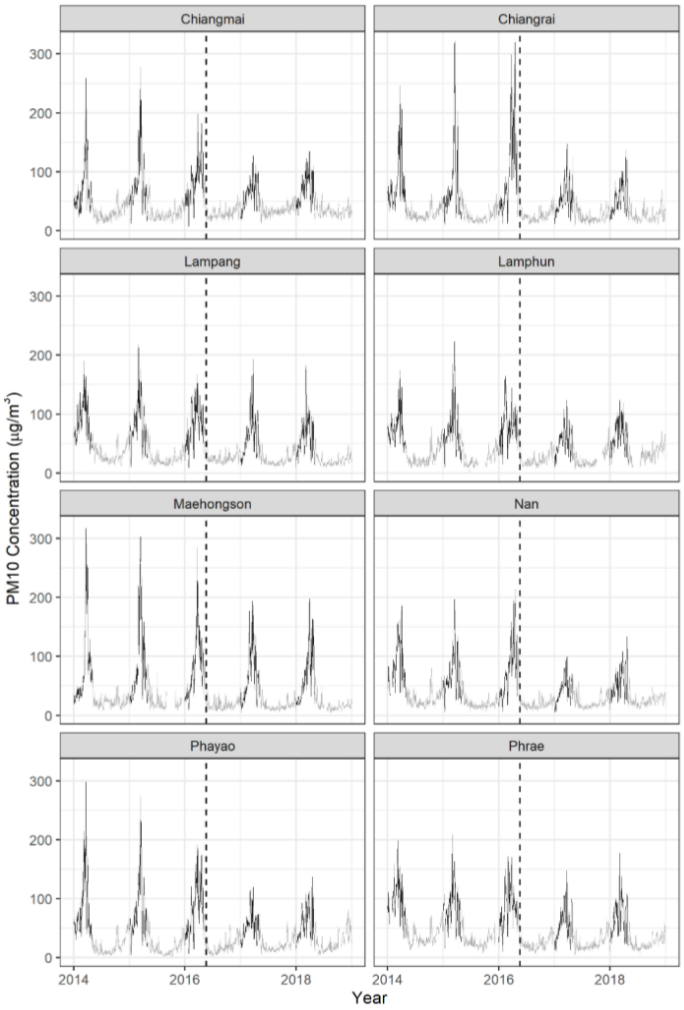
Time	
～2011	Mitigation of haze and open burning based on cooperation and education
2012	Public guide for agricultural residue management
2013	“Zero-burning” campaign
2014	Single command
2015	Action plan (Preparing, coping, remediation)
2016	Law of strict prohibition of burning activities with penalties
2017～2018	(Time period after ban enforcement)



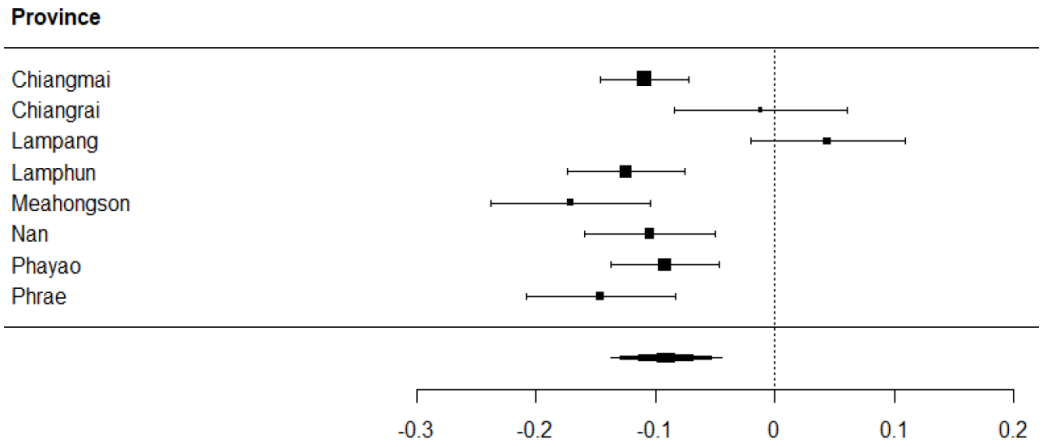
Uttajug, Ueda, et al. IJE, 2022

PM10 and hospital visits for respiratory diseases decreased after the ban.

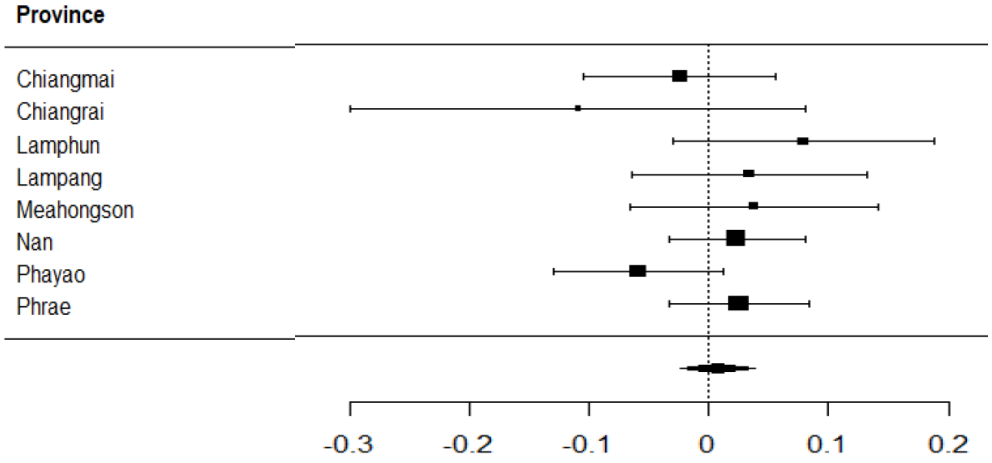
PM10 concentration for each province



Effect of the ban on respiratory diseases



Effect of the ban on gastrointestinal diseases



Uttajug, Ueda, et al. IJE, 2022

Summary

- Exposure to air pollutants causes various health outcome in addition to respiratory diseases.
- Specific particulate components/source may be more harmful than others.
- Using the epidemiological evidence, burden of disease (preventable deaths and health outcomes) can be estimated.
- Improving air quality is expected to prevent air pollution-related deaths : millions per year