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Department of Epidemiology
Lazio Regional Health Service - Italy

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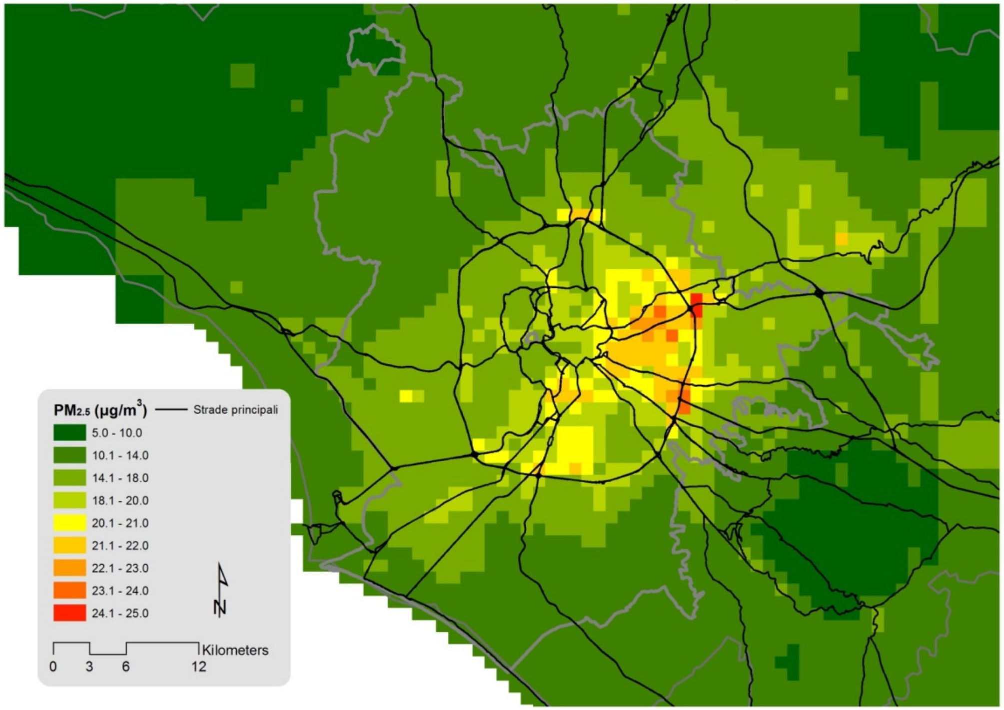
Environmental epidemiology, Risk Assessment and Health Impact Assessment: what's at stake?

Carla Ancona
Department of Epidemiology, Lazio Regional Health Service, Rome Italy

IEHIA of Air Pollution and Climate Change in Mediterranean Areas
Trieste, 23-27 Aprile 2018

ICTP
The Abdus Salam
International Centre
for Theoretical Physics

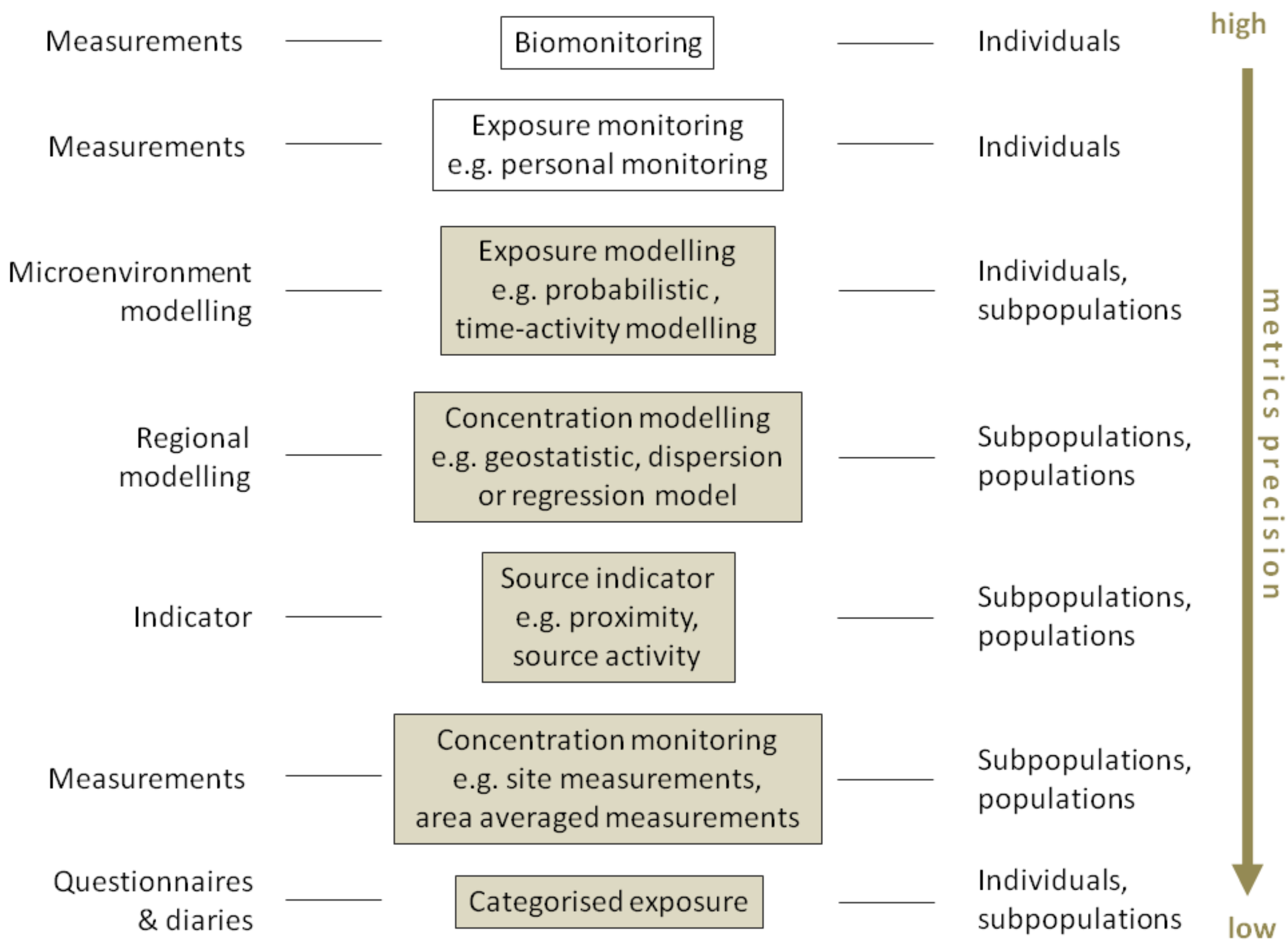
is the exposure to an environmental factor associated with an effect, or a change in the health status of population exposed?



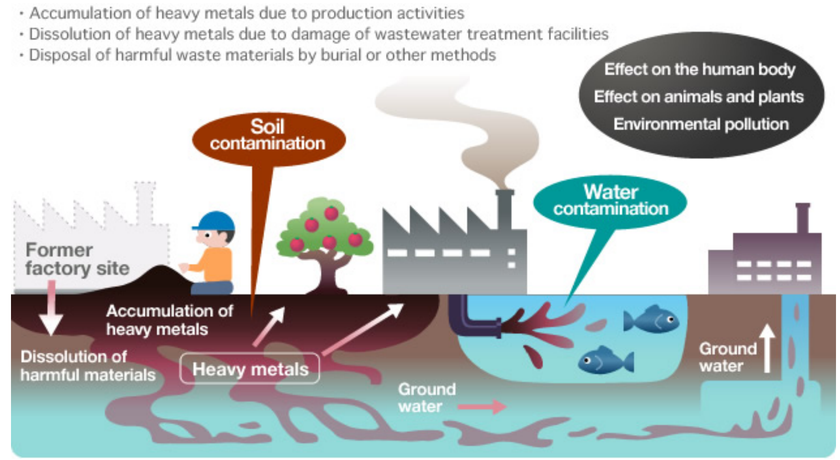
We need:

- ✓ an exposure that can be measured/estimated
- ✓ a completed pathway
- ✓ an exposed population (and an unexposed)
- ✓ a measurable effect that is plausibly related to the exposure

How can we assess exposures?



Biomonitoring the concentrations of biomarkers in blood or in urine allows to **assess the human contamination** to environmental pollutants through **all routes of exposure**



Contamination of soil, plants and animals

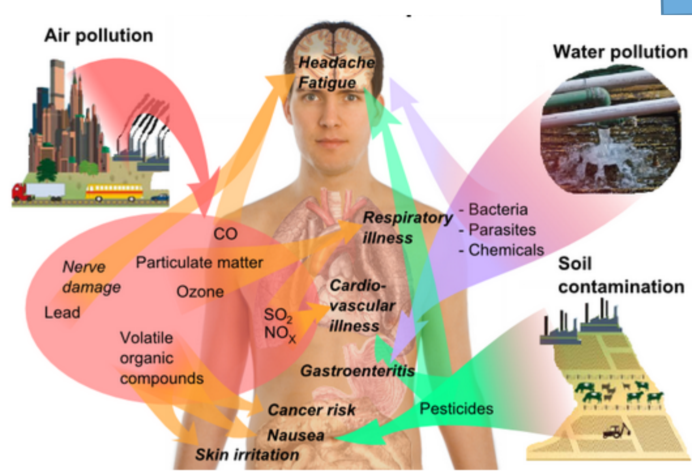
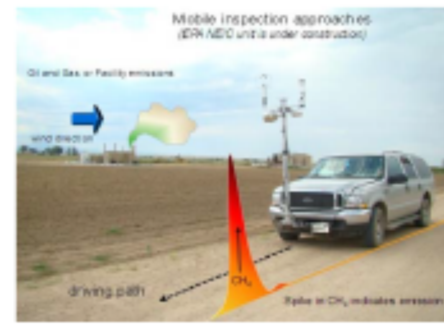


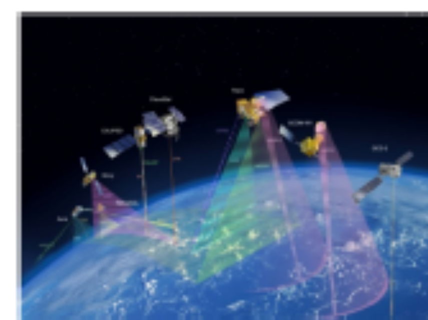
Figure 2: Human Health Effects of Environmental Pollution from Pollution Source to Receptor
Figure shows the human health effects of environmental pollution from pollution source to receptor. *Source: Mikael Häggström via Wikimedia Commons*

exposure assessment: from fixed monitors to sensors and satellites

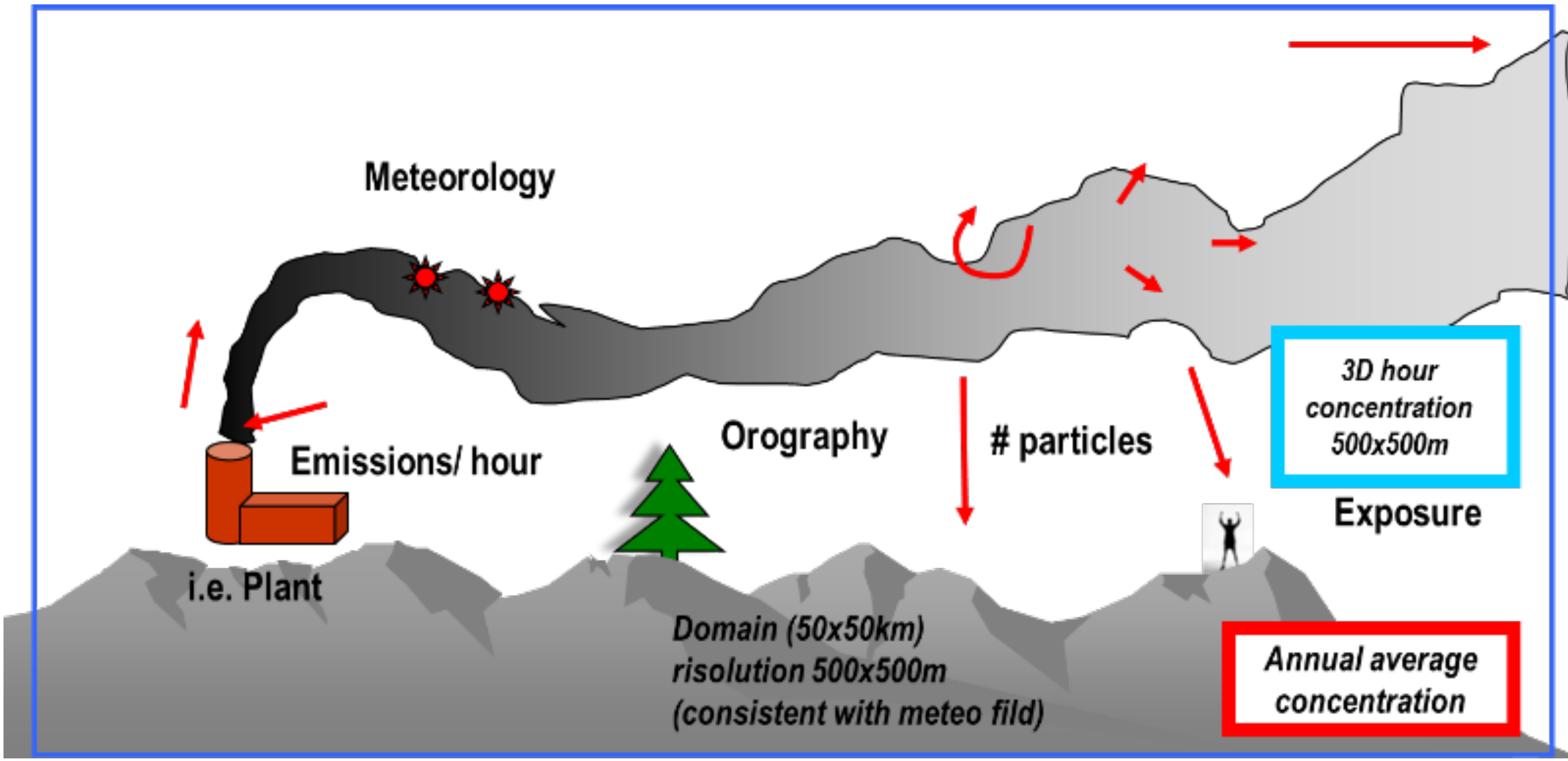
- Sensors
  - Evaluate a range of technologies
  - Fenceline to community/personal
- Satellites
  - Evaluate / enhance air quality applications
  - Leverage investments of NASA / NOAA
- Models
  - Multiscaled: integrate emission-ambient
- Data Fusion
  - Integrate modeling with monitoring data to fill spatial and temporal gaps.

(communitysensing.org)

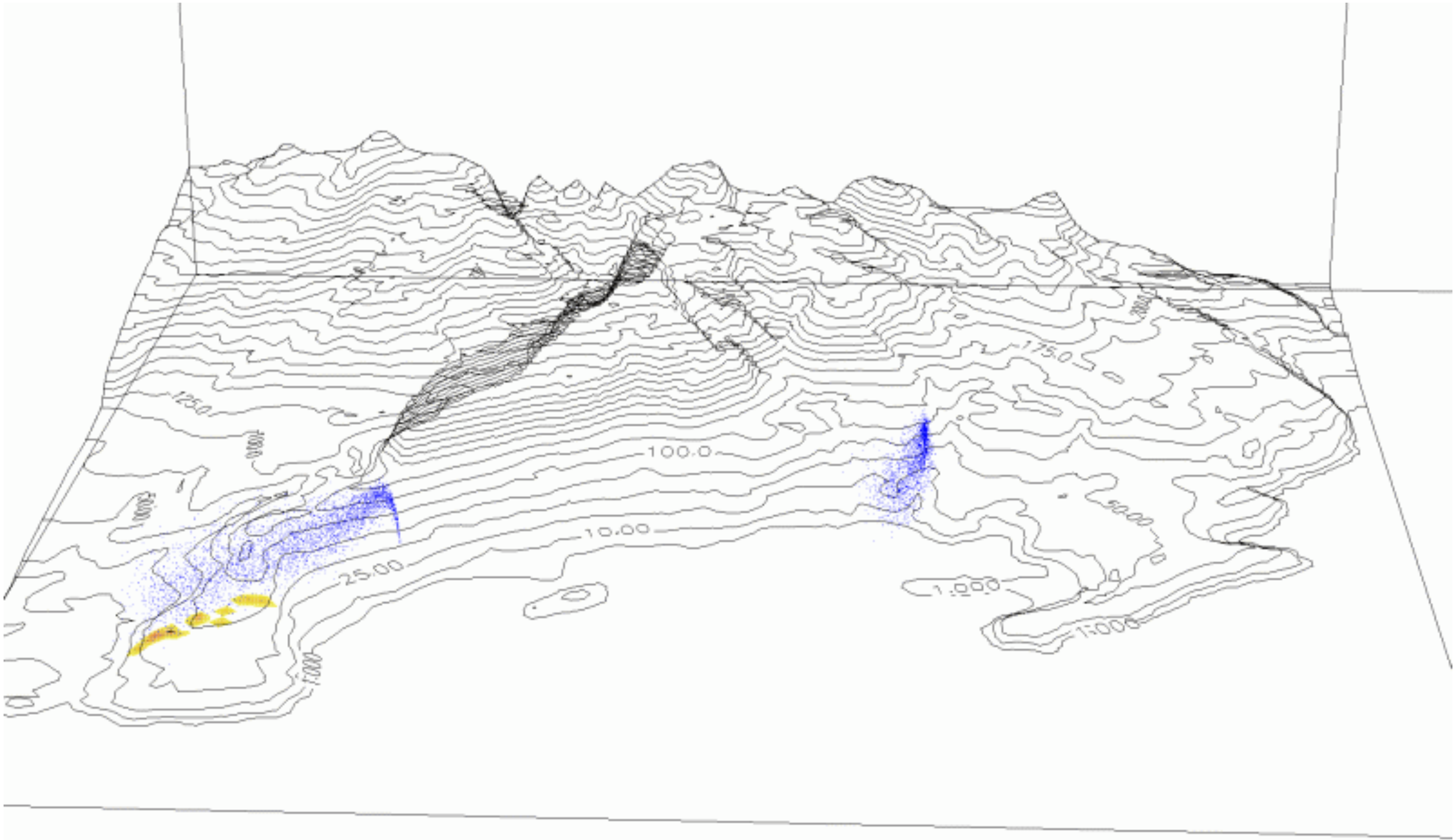




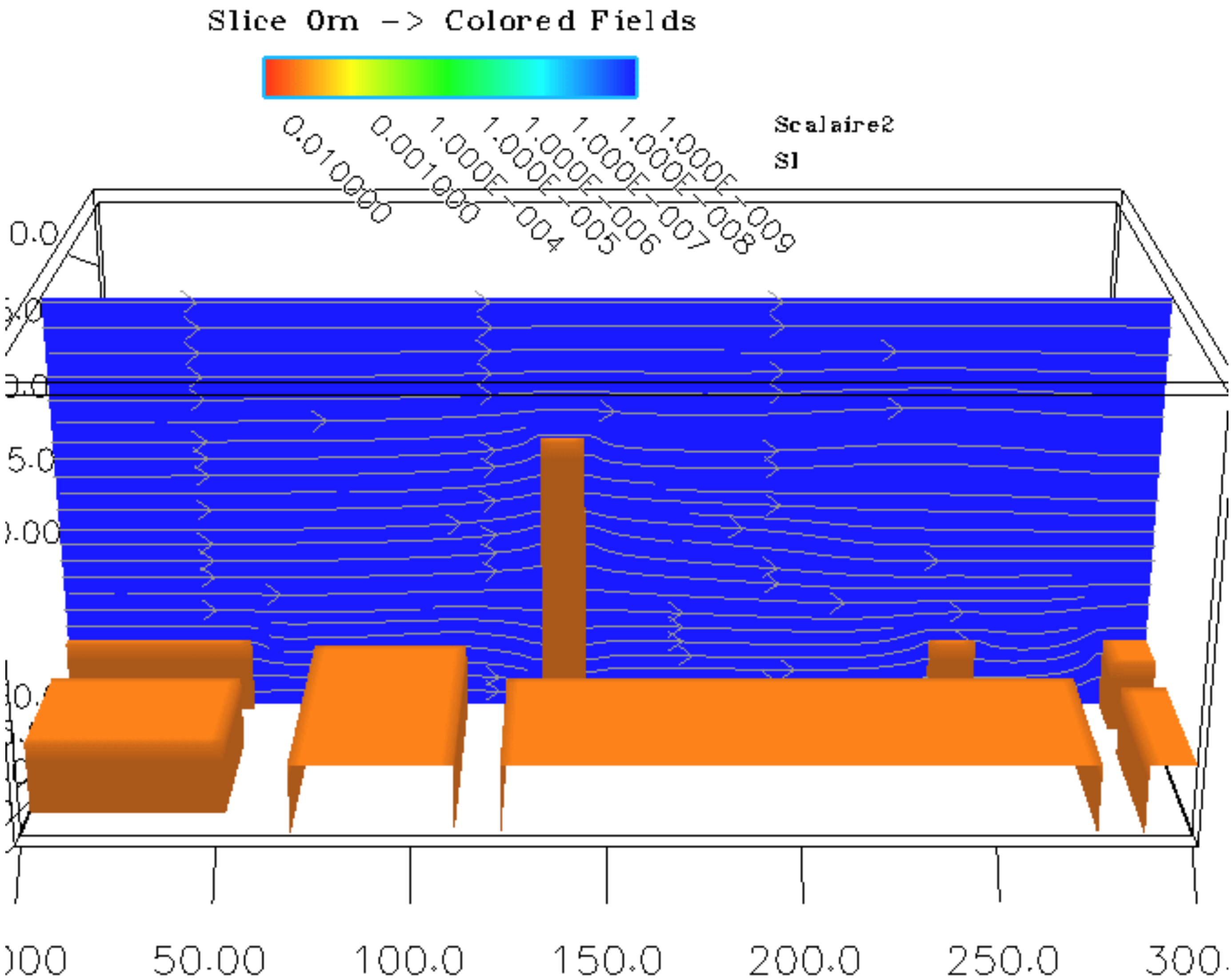
Dispersion model



Test simulation - hourly images

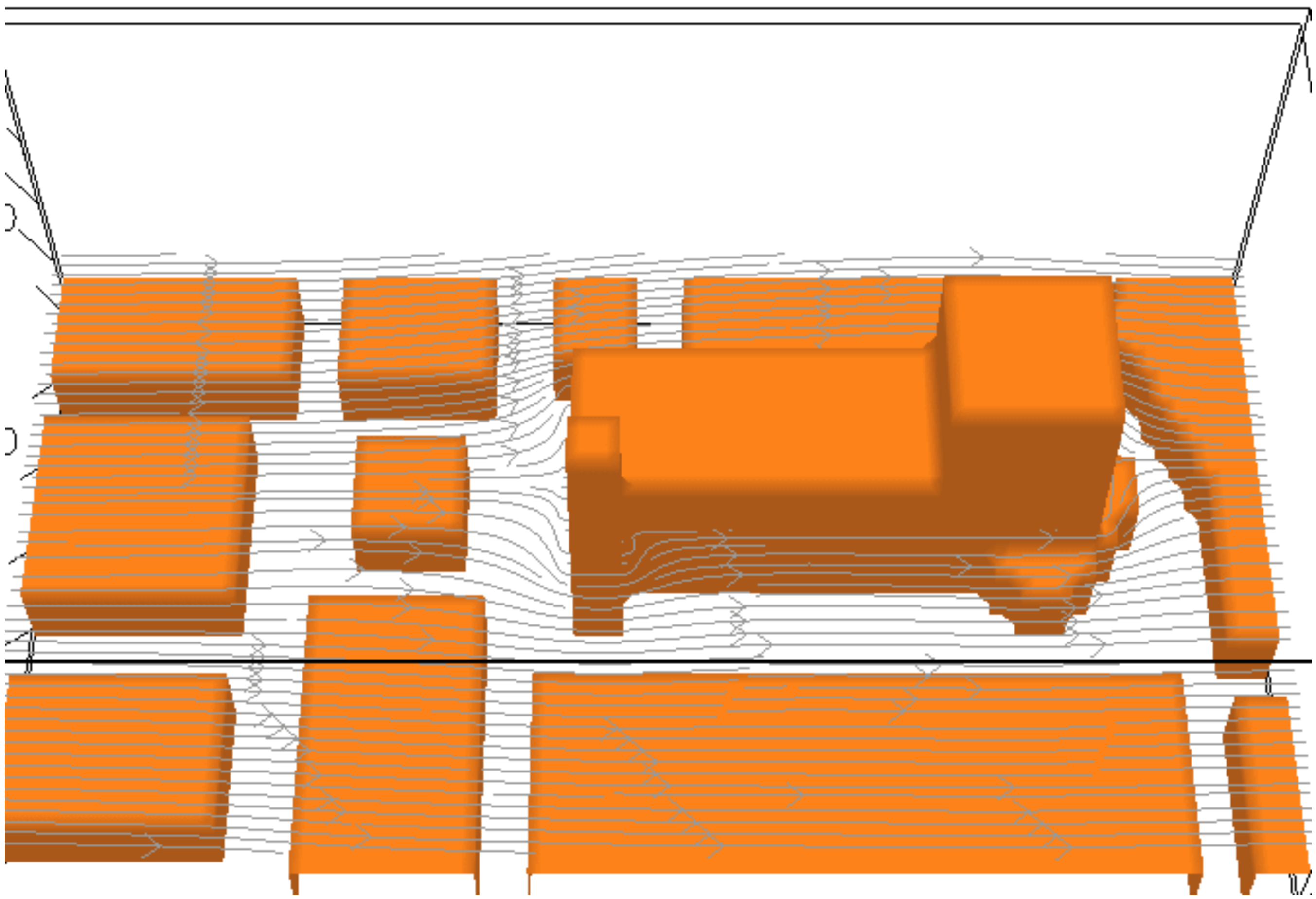


Vertical streamlines and concentrations across Campanile di Giotto



Total elapsed time = 1 h
Frames time step = 100 sec

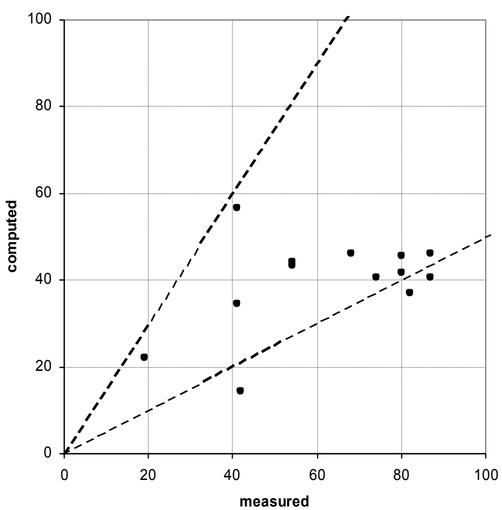
Streamlines and 3D concentration plumes



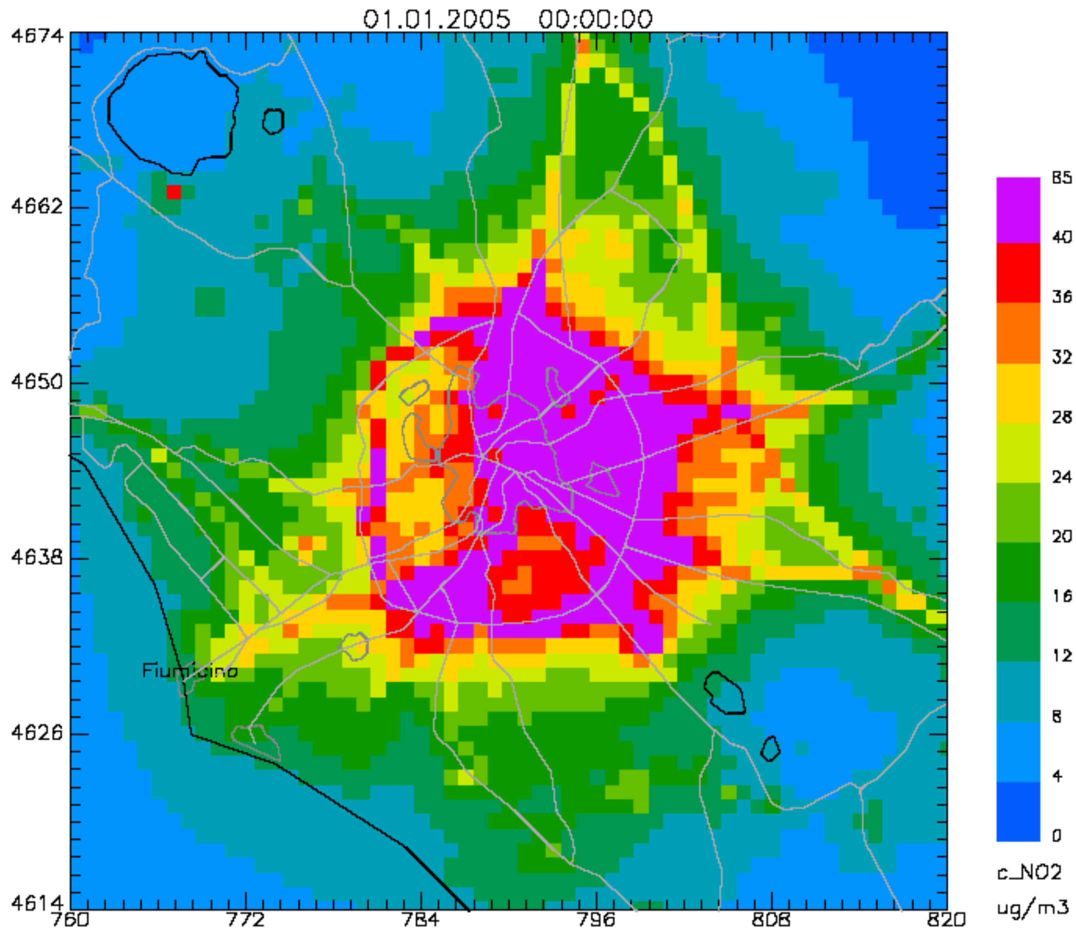
Total elapsed time = 1 h
Frames time step = 100 sec

NO_2
Concentrazioni medie annuali

Valore limite per la protezione della salute: 40 μg m^{-3}



Area Metropolitana

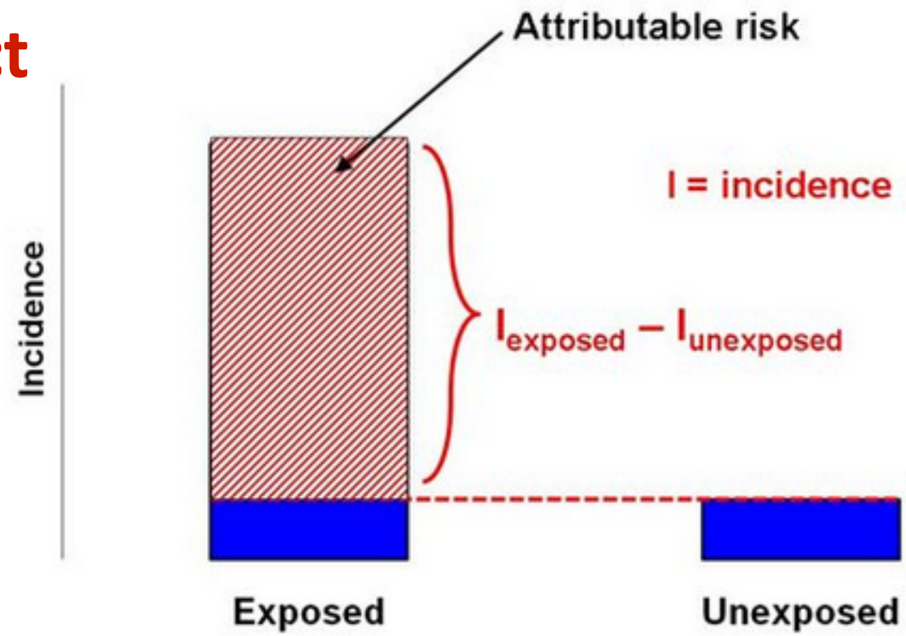


Lesson learned on dispersion models and biomonitoring

- Dispersion models useful for «footprint»
- Spatial differences in concentrations could be used to rank individuals
- Predicted absolute values depend on the quality of emission data and of the meteo models
- Biomonitoring of some contaminants reflects recent exposures
- Human contamination is mostly due to ingestion
- Air contamination is a weak determinant of body burden
- Some associations emerged and indicate human contamination related to specific sources

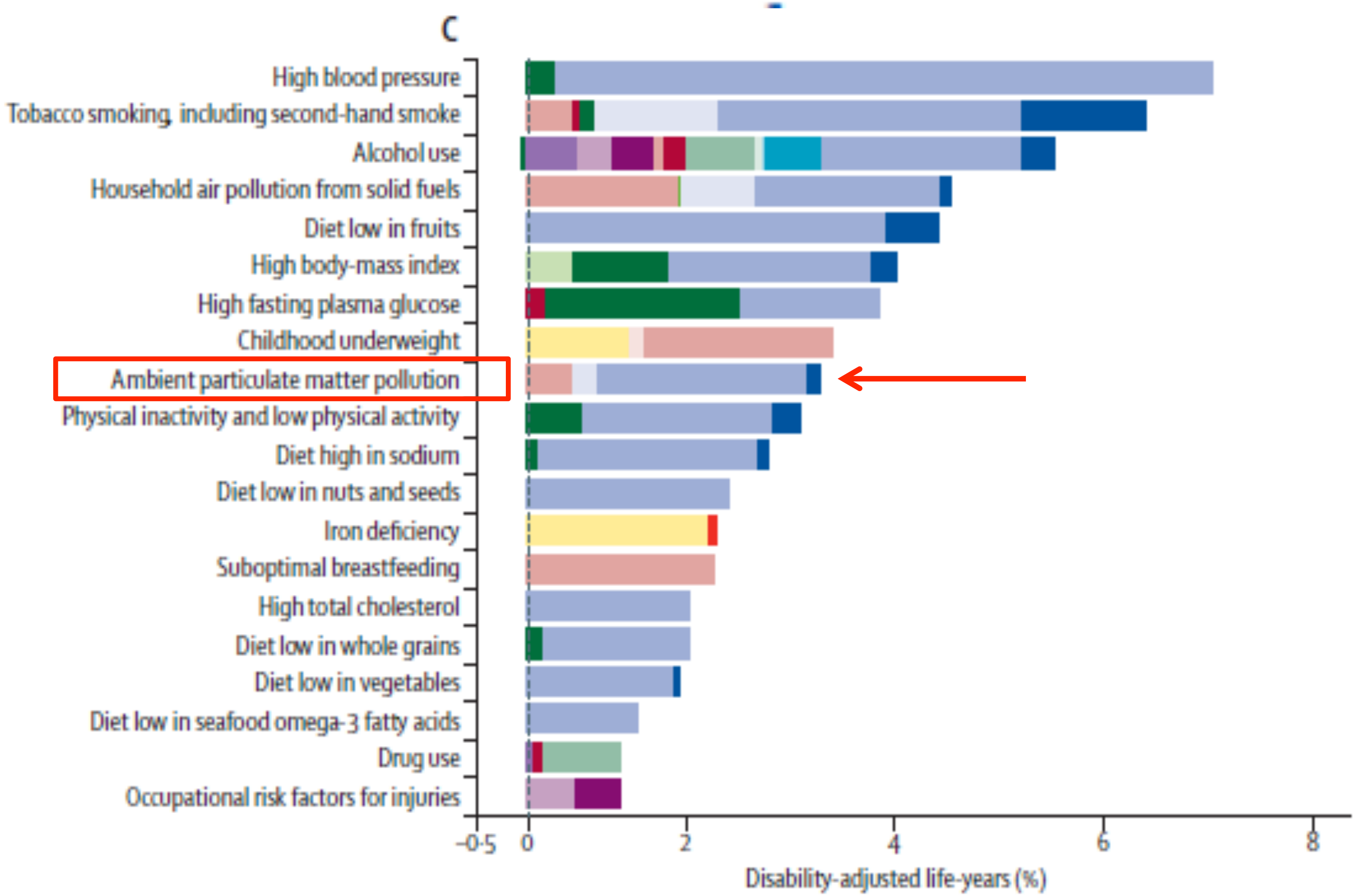
Global Burden of Disease

- The **burden of disease** is the total quantity of ill health caused by a particular disease or risk factor.
  - **Magnitude of impact**



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

Lancet 2012; 380: 2224–60



Definition Health Risk Assessment

•A human health risk assessment is the process to estimate the nature and probability of adverse health effects in humans who may be exposed to chemicals* in contaminated environmental media, now or in the future. [USEPA]

•*Stressors or environmental hazard:

- Chemicals
- Radiation
- Physical (dust, heat)
- (Micro)biological
- Nutritional (diet, fitness)
- Socio-economic (health care access)

objective: to estimate toxicity of a substance

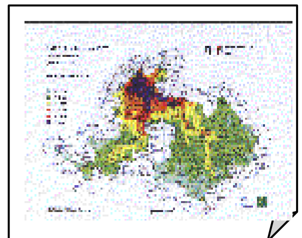
Tool for translating the findings of research into science-based risk management

Health Risk Assessment

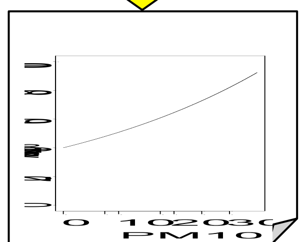
1. Hazard identification

Noise,
air pollution

2. Exposure assessment



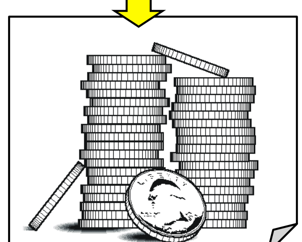
3. Exposure-outcome association



How much risk ↑ when exposed?

Number of attributable cases =
exposure x exposure-outcome association

4. Risk characterization



YLL (Years of life lost), DALY's or Costs

Risk assessment

Risk assessment is, to the highest extent possible, a scientific process. Risk depends on the following factors:

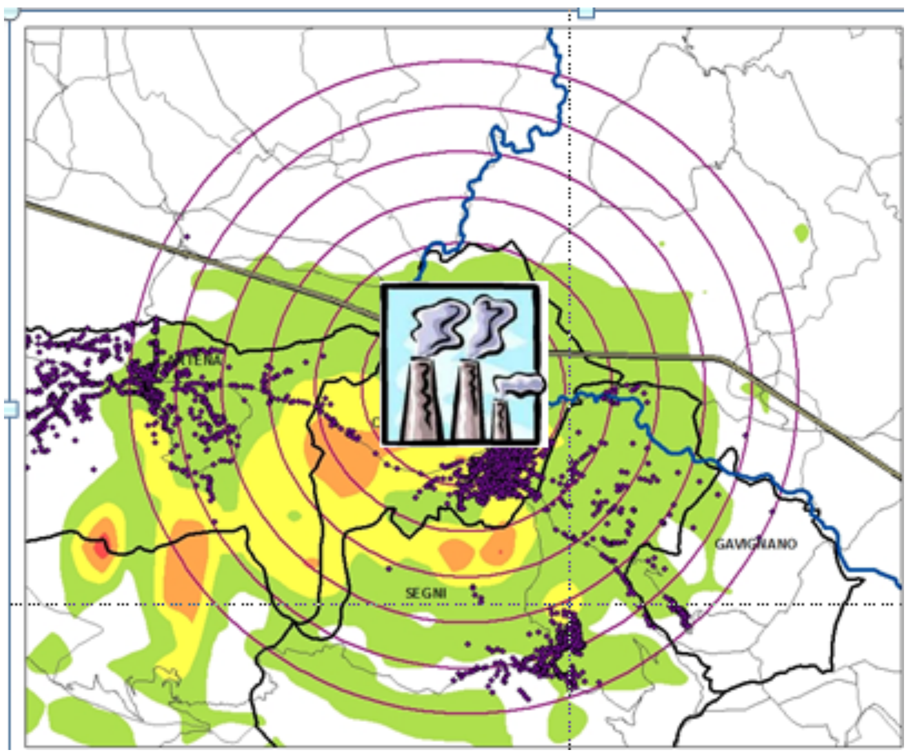
- How much of a chemical is present in an environmental medium (soil, water, air)
- How much contact (exposure) a person or ecological receptor has with the contaminated environmental medium
- The inherent toxicity of the chemical.

Environmental Epidemiology

the aim is to estimate the effect of exposure of interest

Exp$^+$

cases



Exp$^-$

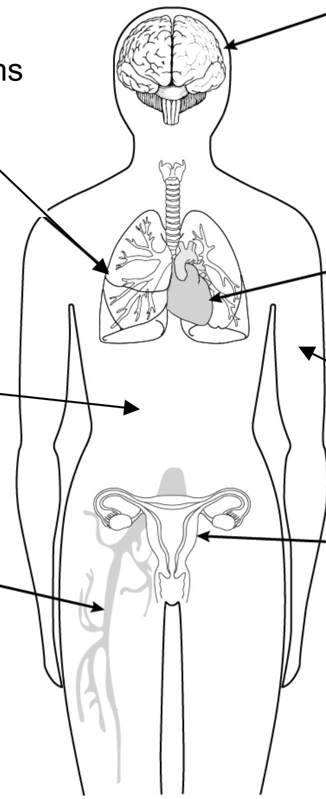
cases

(the ambition would be to measure causal effects)

- **Respiratory Disease Mortality**
- **Respiratory Disease Morbidity**
- **Lung Cancer**
- **Pneumonia**
- Upper and lower respiratory symptoms
- Airway inflammation
- Decreased lung function
- Decreased lung growth

- Insulin Resistance
- **Type 2 diabetes**
- **Type 1 diabetes**
- Bone metabolism

- **High blood pressure**
- Endothelial dysfunction
- Increased blood coagulation
- Systemic inflammation
- **Deep Venous Thrombosis**



- **Stroke**
- Neurological development
- Mental Health
- **Neurodegenerative diseases**

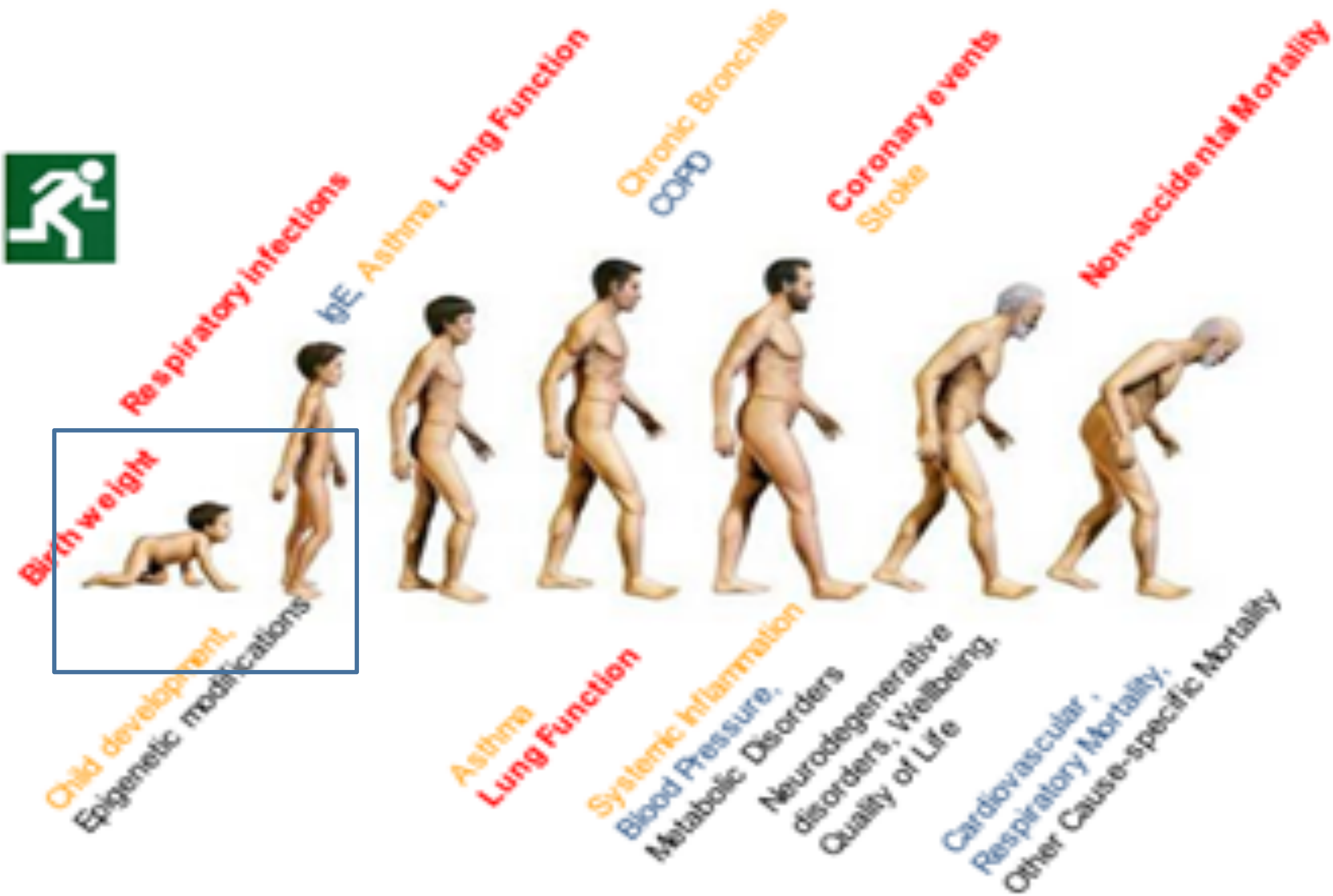
- **Cardiovascular Disease Mortality**
- **Cardiovascular Disease Morbidity**
- **Myocardial Infarction**
- **Arrhythmia**
- **Congestive Heart Failure**
- Changes in Heart Rate Variability
- ST-Segment Depression

- Skin Aging

- **Premature Birth**
- **Decreased Birth Weight**
- Decreased foetal growth
- In uterine growth retardation on
- Decreased sperm quality
- Preclampsia

Joint ERS / ATS statement (ERJ, i2017)

Lifetime course



to assess dose-response relationships between exposure and risk

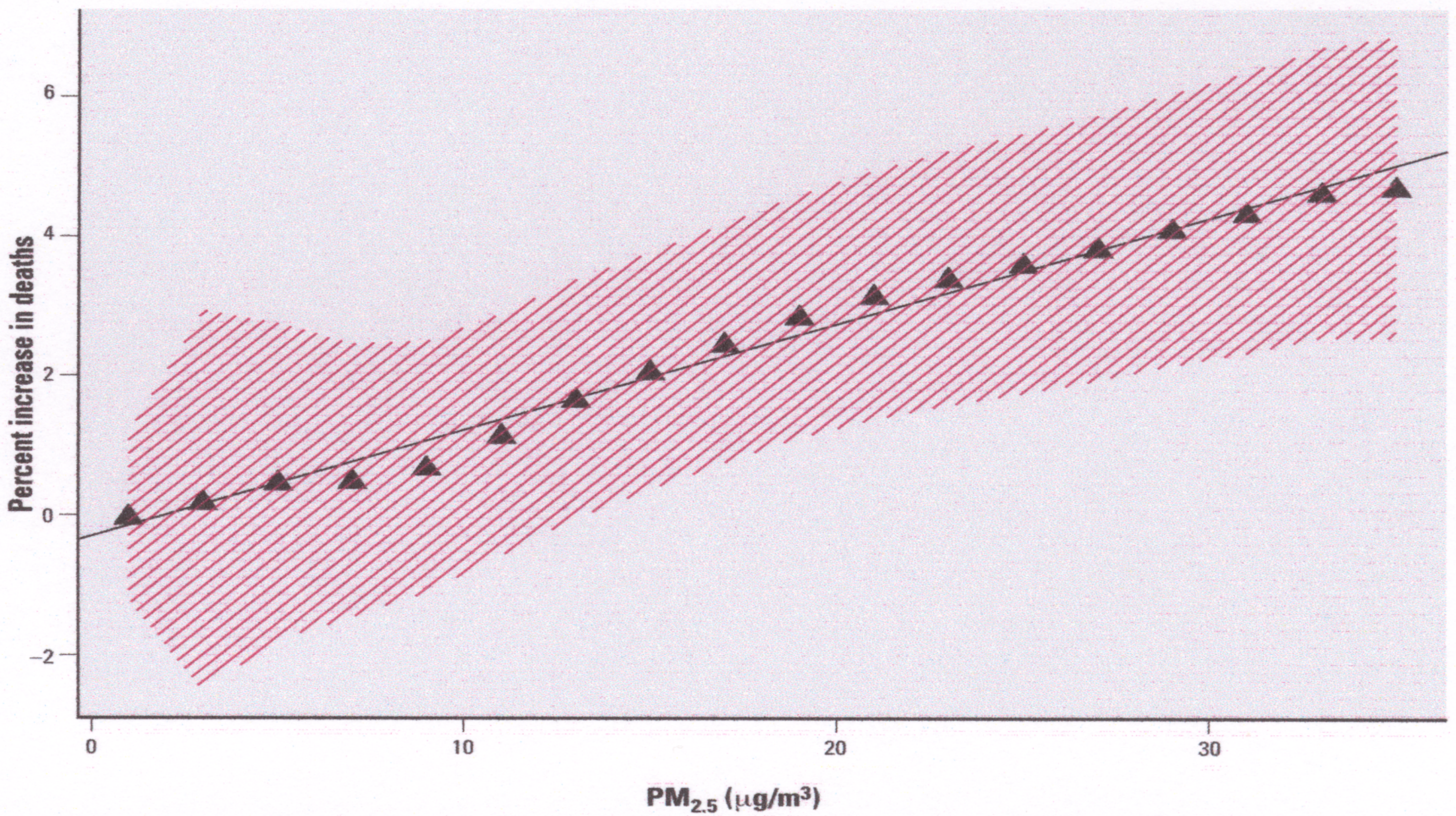
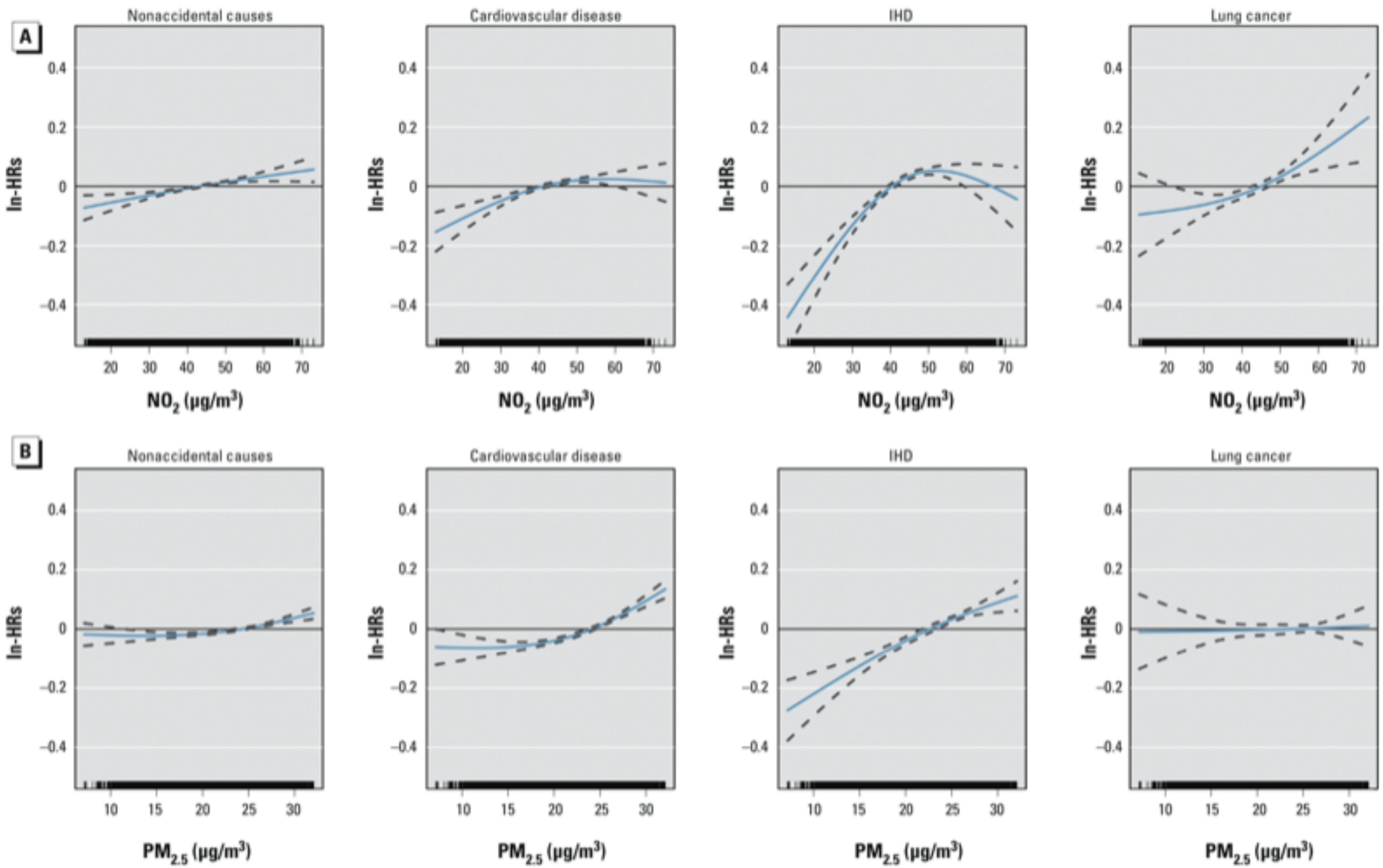


Figure 1. Overall estimated dose–response relation between total $PM_{2.5}$ and daily deaths in six U.S. cities. The estimate is obtained by combining the estimated smoothed curves in each of the cities, after controlling for weather, season, and day of the week. The shaded area indicates the pointwise 95% confidence intervals at each point. The line shown is a least-squares regression line through the estimated points.

Schwartz, EHP 2002

Exposure-response relationships



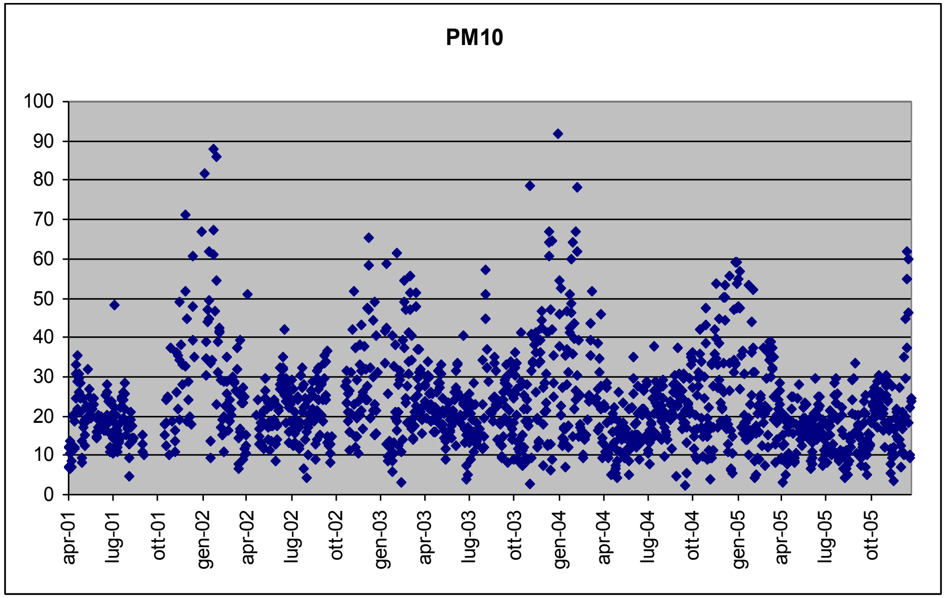
Cesaroni, 2013 EHP

effects of air pollution

<u>short-term</u> and <u>long-term</u> effects

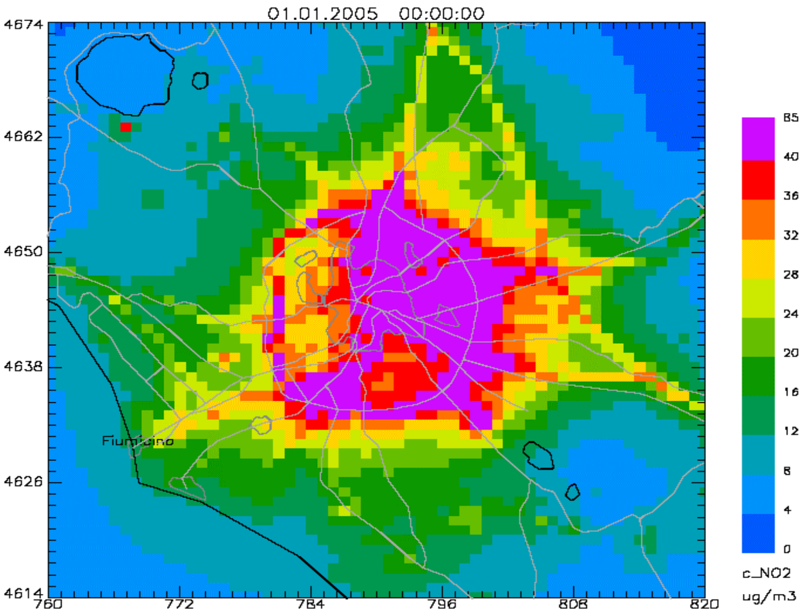
Short-term increase in mortality
Short- term increase in morbidity (cardiovascular and respiratory conditions)
Decreased survival
Increased lung cancer risk

(although there is probably a continuum of effects in the time scale, which are not yet fully understood)



Acute effects

Temporal differences



Chronic effects

Spatial differences

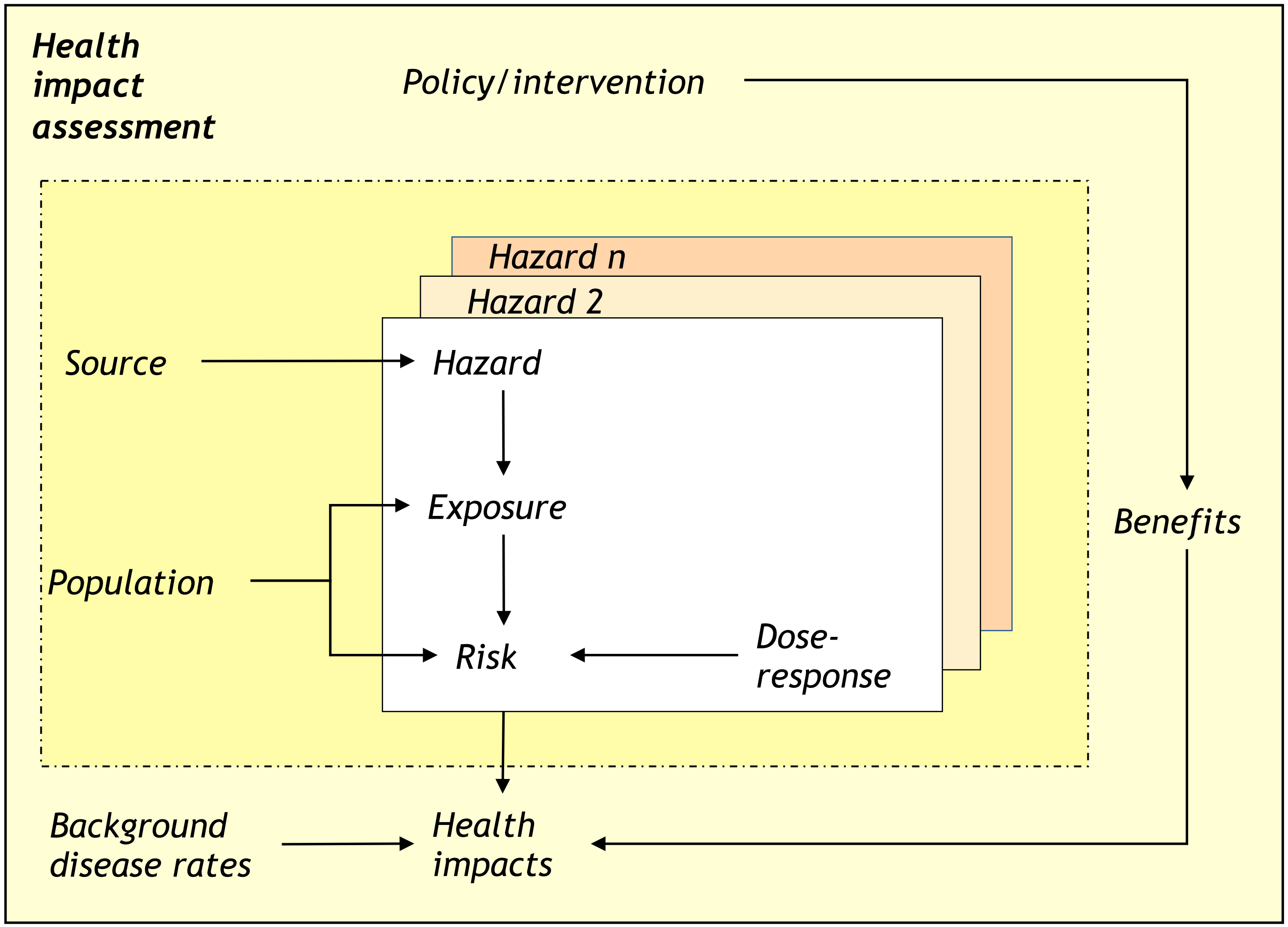
Epidemiology is one of the essential disciplines of public health, its major aim is to contribute to fulfilment of the definition of public health as “a science and art to promote health and prevent disease by organized effort of society”.

However, to improve the health status of the population, the knowledge produced by epidemiology needs to be used and translated into intervention

Definition HIA

A combination of procedures, methods and tools by which a policy, program or project may be judged as to its potential effects on the health of a population, and the distribution of those effects within the population.

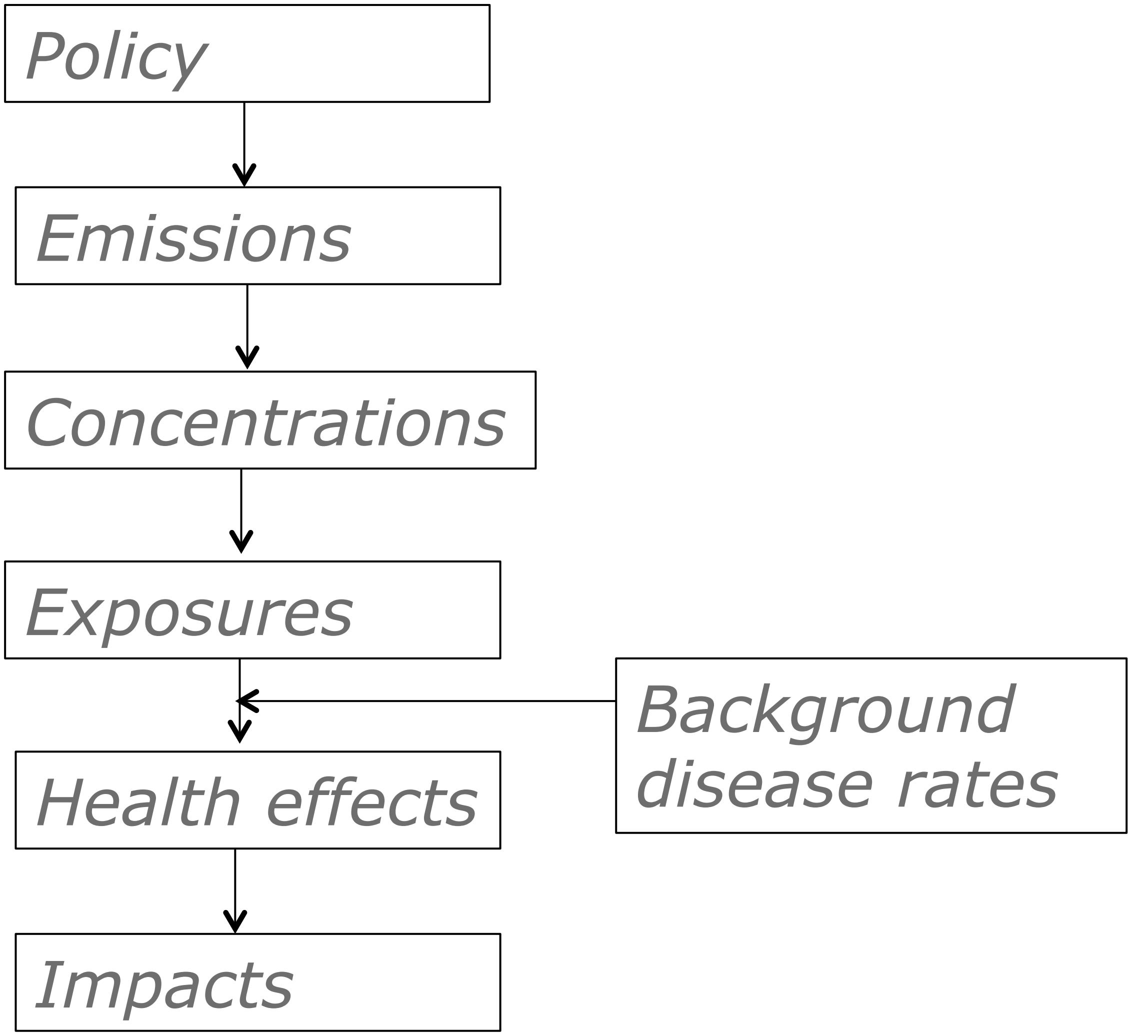
[European Centre for Health Policy, WHO Regional Office for Europe. Gothenburg Consensus Paper (1999)]


Health
impact
assessment
Policy/intervention
Hazard n
Hazard 2
Source
Hazard
Exposure
Benefits
Population
Risk
Dose-
response
Background
disease rates
Health
impacts

Major steps in HIA

1. Specify purpose and framework of the HIA
2. Decide which exposure-effect pathways will be quantified
3. Identify and characterise population at risk
4. Select or develop a suitable set of exposure-response functions (ERFs)
5. Derive population exposure distribution
6. Estimate background disease rates
7. Calculate burden of disease in population
8. Valuate the burden of disease
9. Assess and quantify uncertainty of the HIA

Impact pathway



Definition IEHIA

A means of assessing health-related problems deriving from the environment, and health-related impacts of policies and other interventions that affect the environment, in ways that take account of the complexities, interdependencies and uncertainties of the real world.

Websites:

http://www.integrated-assessment.eu

http://en.opasnet.org/w/IEHIAS

EU funded projects: INTARESE and HEIMTSA

Key references:

Briggs 2008. DOI: 10.1186/1476-069X-7-61

Key features in IEHIA

- Specifically designed to deal with **complex issues**, usually beyond the scope of health risk or impact assessment
- Both positive and negative effects on health –the environment as a hazard and source of beneficial resources (environmental services and capital);
- More attention for defining the problem
- Provides a synoptic and balanced measure of impacts, by weighting and summing the various health effects;
- Designed to be participatory –involve all key stakeholders with interests in the issue.

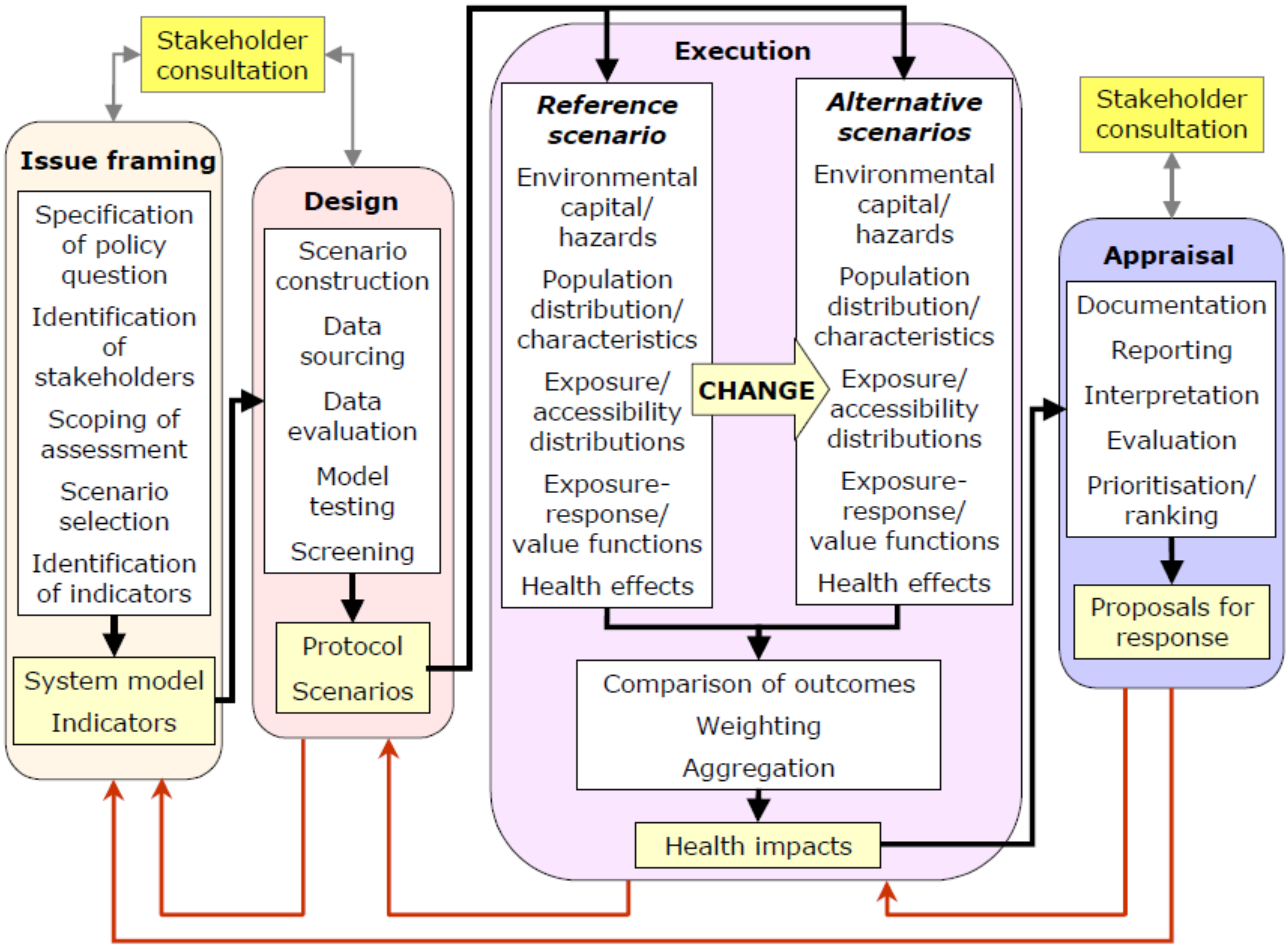


Figure 2. The analytical framework

Issue framing

- Specifying the question
- Identifying and engaging key stakeholders
- Agreeing an overall approach to the assessment (**scoping**)
- Selecting and constructing the **scenarios** for the assessment (diagnostic, summative or prognostic)
- Defining the indicators that will be used to describe the impacts.

Protocol

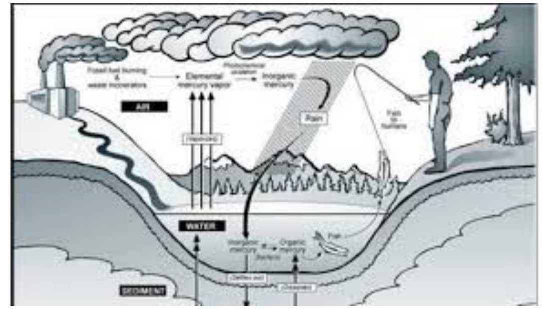
- Study areas and populations
- Scenarios
- Timescales (exposure periods, impact periods)
- Causal factors, exposure pathways and health outcomes
- Health effects and associated impacts
- Outcome indicators used to represent the results;
- Data sources and models
- Main sources of uncertainty

Appraisal

- To bring together, communicate and interpret the results of the assessment. This involves two key steps:
  – Reporting the assessment results - i.e. delivering them to the end-users in a synthesised and understandable form;
  – Comparing and ranking outcomes - i.e. identifying and interpreting the messages that the results imply.


exposed
Public
environmental
collection
Enviromental
Population
status
data
Socioeconomic
Medicine
Size
exposure
time
food
soil
water
age
Variable
air
Epidemiology
contamination
groups
worries
pressure
model
Law
media
Different
outcomes
Health
Science
citizen
justice
pollutants
Industrial

Environment and Health studies



- ✓ Multiple sources
- ✓ Different pathways
- ✓ Variable time of contamination

- ✓ Population size (and size of the exposed groups)
- ✓ Socioeconomic status (environmental justice)

- ✓ Occupational exposure

- ✓ Outcomes definition and data collection
- ✓ Enviromental worries and media pressure

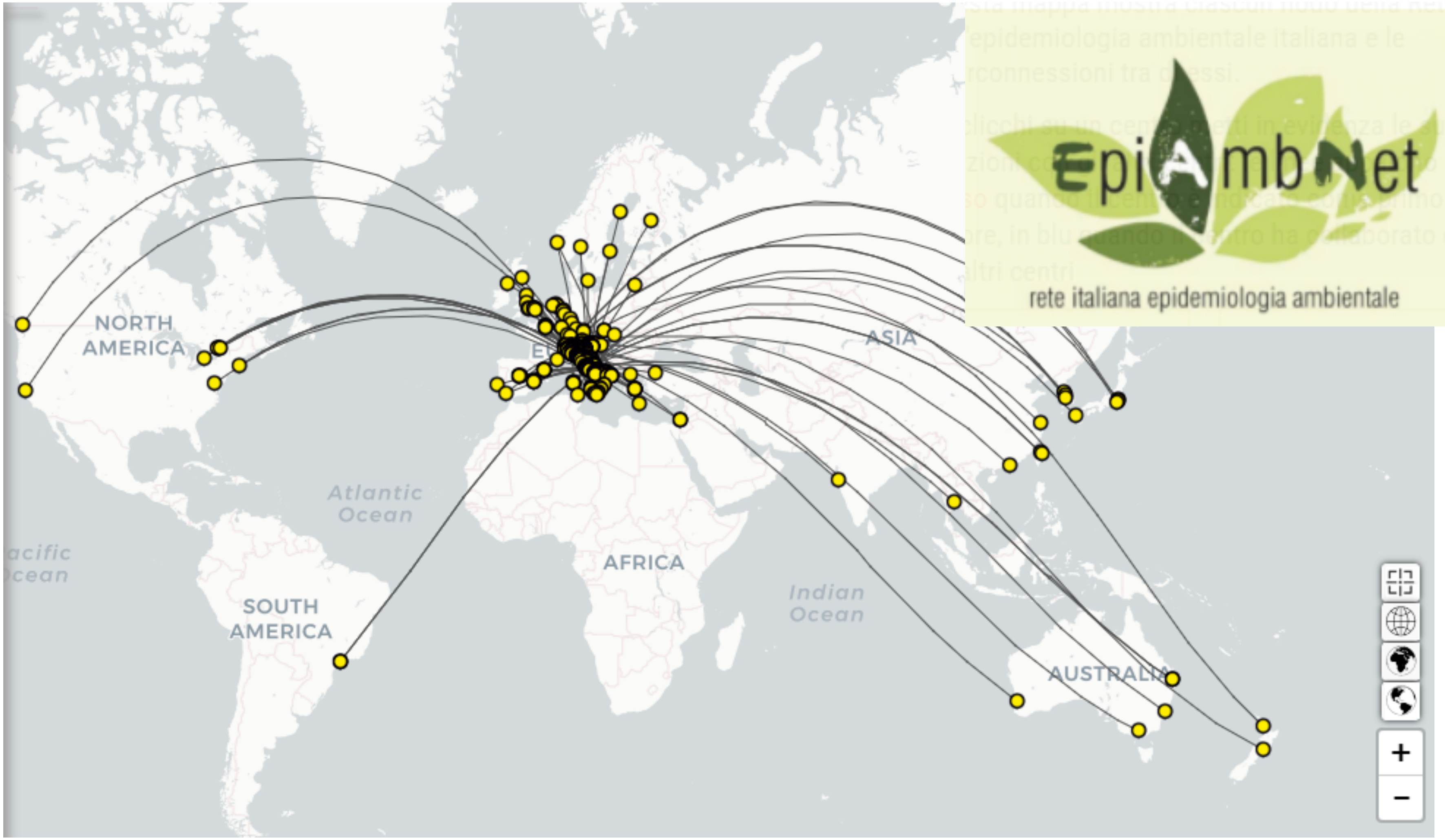
Multidisciplinary context

- Environmental Science
- Toxicology
- Laboratory & biomonitoring
- Statistics
- Epidemiology
- Occupational Medicine
- Industrial Hygiene
- Medicine
- Public Health
- Comunication
- Journalism
- Law

the discipline requires well-trained experts!

Integration

- Without the participation of epidemiologists in risk assessments, the fields of risk assessment and epidemiology are likely to become unnecessarily and artificially segregated.
- On the other hand, the epidemiologist who moves from the research to the risk assessment arena needs to be prepared for the shift from hypothesis-testing to application.



https://reteambientesalute.epiprev.it

In conclusion, a close collaboration of researchers (the network) is a “must”

Such collaboration can support the development of public health and have a long-term positive impact on population health

No CoI

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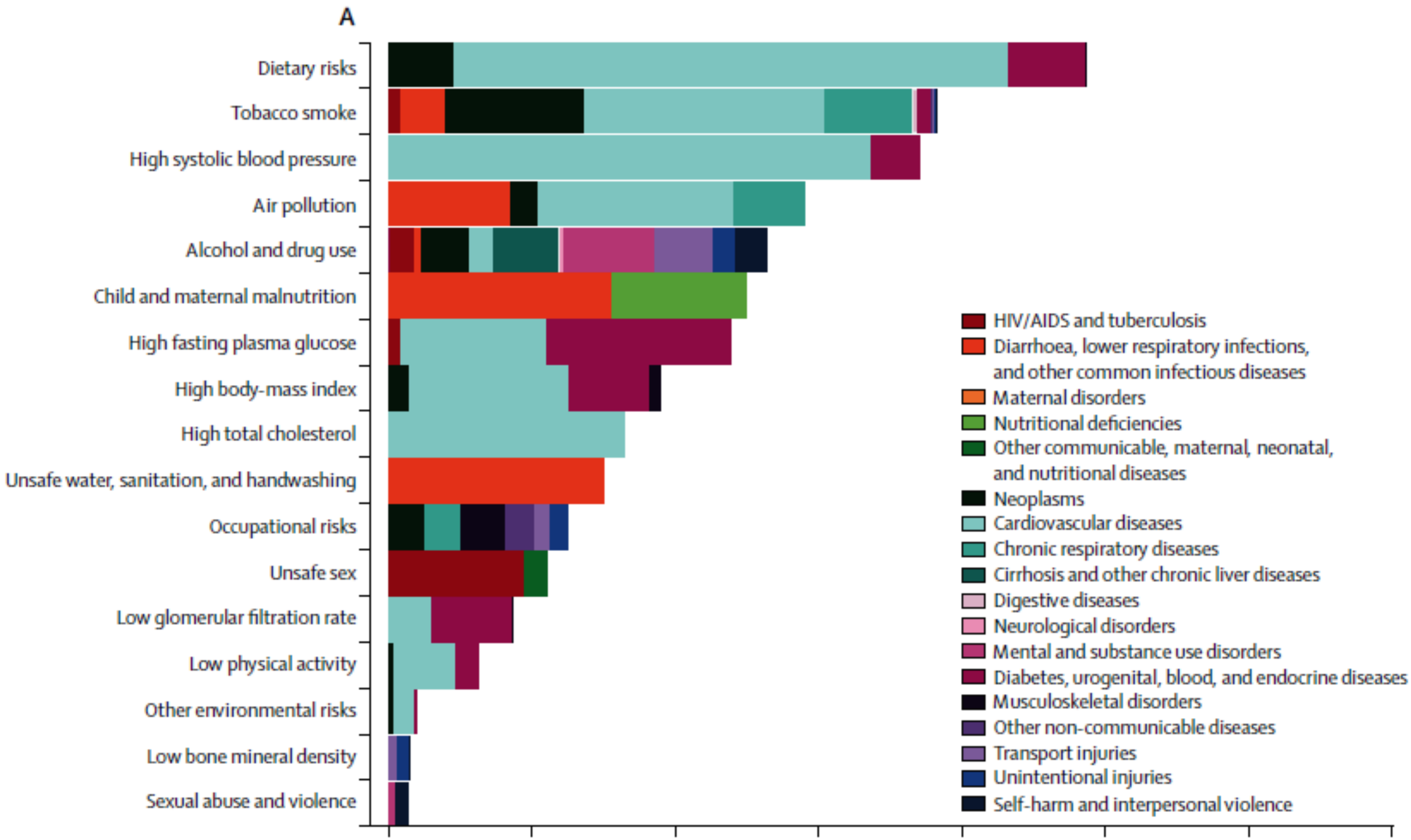
Study design

- Long-term effects
  – Ecological studies (municipalities, small area statistics)
  – Cross-sectional (biomonitoring)
  – Cohort studies
  – Case-controls

Global DALYs attributable to Level 2 risk factors for (A) men in 2015



DALYs=disability-adjusted life-years.

American Journal of
EPIDEMIOLOGY

Volume 148
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Sponsored by the Society for Epidemiologic Research

COMMENTARIES

Invited Commentary: Epidemiology and Risk Assessment

INTRODUCTION

The intent of this commentary is to introduce readers of the *Journal* to risk assessment and the use of epidemiologic data in risk assessment. A seminal 1983 National Research Council report, *Risk Assessment in the Federal Government: Managing the Process* (1)—often called the "Red Book" because of its cover—defined risk assessment as ". . . the use of the factual base to define the health effects of exposure of individuals or populations to hazardous materials and situations" (1, p. 3). While epidemiologists and epidemiologic data may have prominent roles in this field, the epidemiologic literature contains surprisingly few discussions of risk assessment.

Samet et al, 1998

- The 1983 National Research Council report: risk assessment as a tool for translating the findings of research into science-based risk management strategies.
- Risk assessment evaluates and incorporates the findings of all relevant lines of investigation, from the molecular to the population levels, through the application of a systematic process
- four elements of risk assessment : hazard identification, dose-response assessment, exposure assessment,and risk characterization (table 1).

TABLE 1. The "Red Book" paradigm: the four steps of risk assessment*

Step	Definition
1. Hazard identification	A review of the relevant biologic and chemical information bearing on whether an agent may pose a carcinogenic hazard and whether toxic effects in one setting will *occur in other settings*.
2. Dose-response assessment	The process of quantifying a dosage and evaluating its relation to the incidence of adverse health effects response.
3. Exposure assessment	The determination or estimation (qualitative or quantitative) of the magnitude, duration, and route of exposure.
4. Risk characterization	An integration and summary of hazard identification, dose-response assessment, and exposure assessment presented with assumptions and uncertainties. This final step provides an estimate of the risk to public health and a framework to define the significance of the risk.

* Source: National Research Council, Committee on the Institutional Means for Assessment of Risks to Public Health. *Risk Assessment in the Federal Government: Managing the Process.* Washington, DC: National Academy Press, 1983 (**1**).

Some epidemiologists may not accept a distinction between "risk assessment" as defined above and the practice of epidemiology, since a primary objective of epidemiologic research is to measure or assess the risk of disease in a group of individuals. Epidemiologic research also describes exposures to populations and assesses dose-response relationships between exposure and risk, two components of risk assessment.

Hazard identification seems indistinguishable from assessing causality, which is fundamental to interpreting epidemiologic evidence. Risk characterization is similar to extending findings from one population to others—i.e., assessing the generalizability of a study's results and perhaps to estimating the attributable risk.

Thus, on first look, the formalism of risk assessment may seem a somewhat confusing and arbitrary redefinition of common epidemiologic practice.

- Education for epidemiologists should begin to incorporate training in risk assessment and other approaches for the translation of epidemiologic evidence into policy. Epidemiologic curricula in academic institutions have focused on research methods, leaving the uses of research findings for policy purposes to be illustrated by anecdote.

- This void should be filled with offerings on the use of epidemiologic evidence in policy-making generally and on risk assessment specifically.

- We need to educate epidemiologists who can enter policy-making arenas and work there comfortably and effectively.