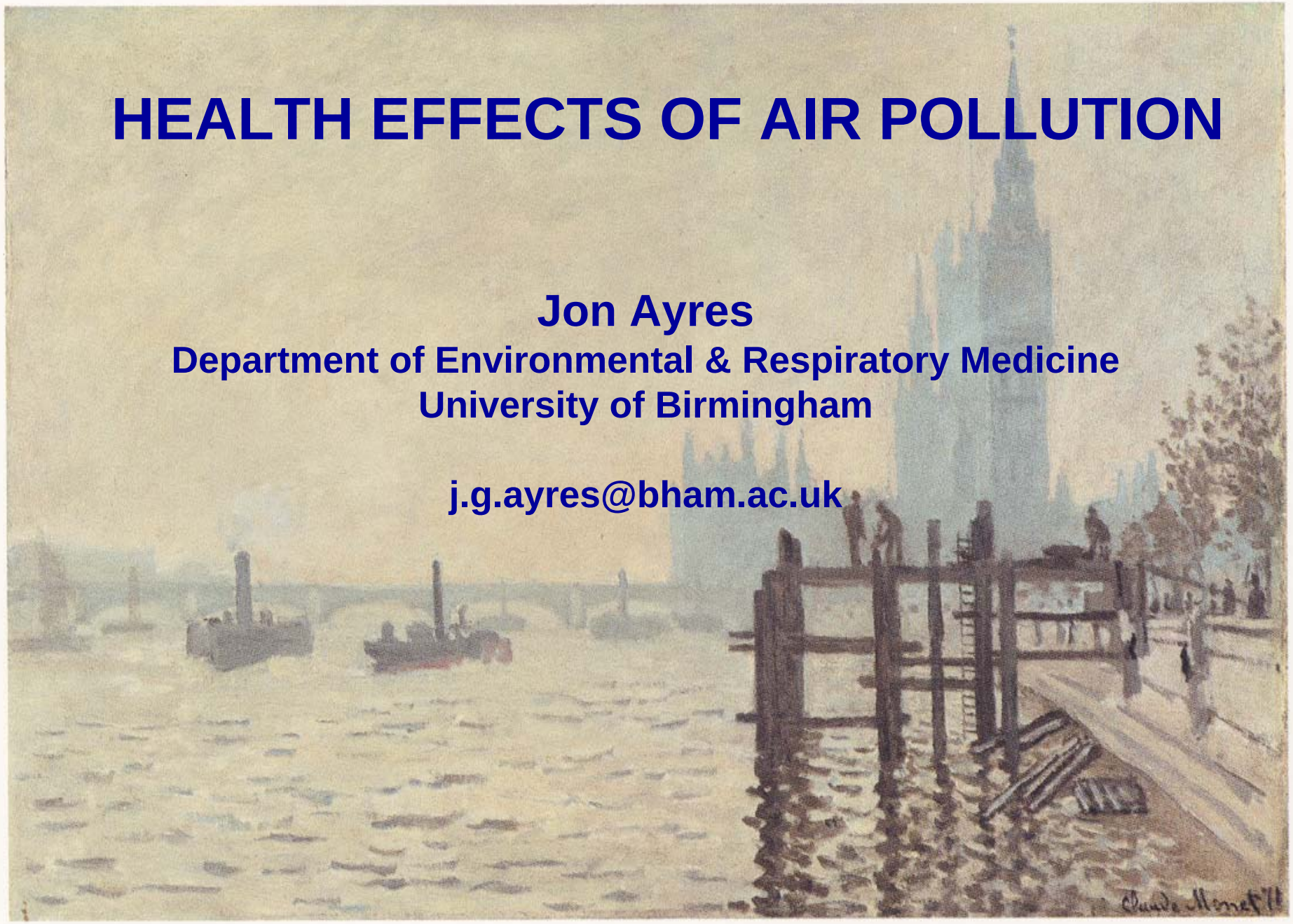
HEALTH EFFECTS OF AIR POLLUTION

Jon Ayres
Department of Environmental & Respiratory Medicine
University of Birmingham

j.g.ayres@bham.ac.uk

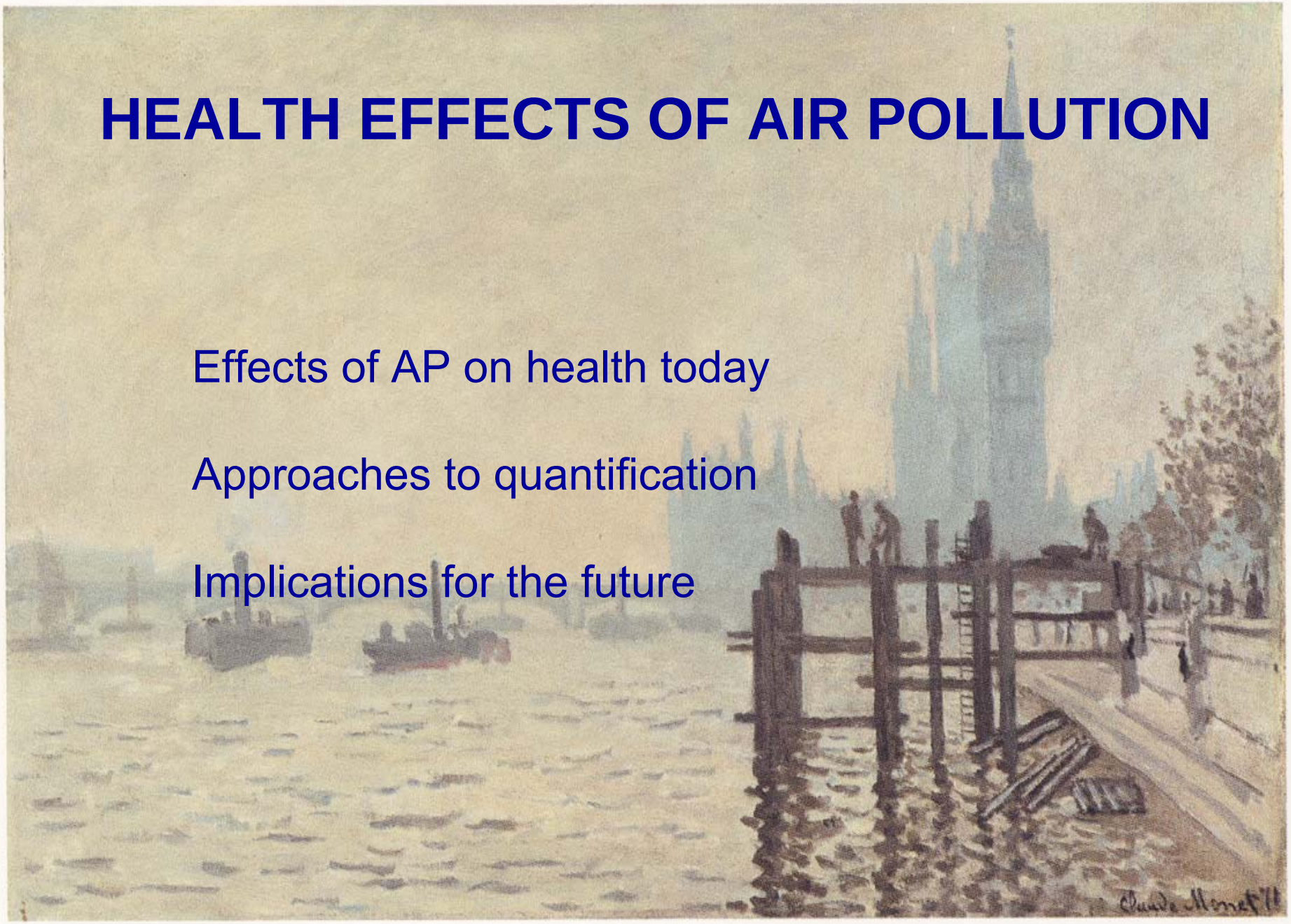


HEALTH EFFECTS OF AIR POLLUTION

Effects of AP on health today

Approaches to quantification

Implications for the future



UK tops league for toxic traffic fumes

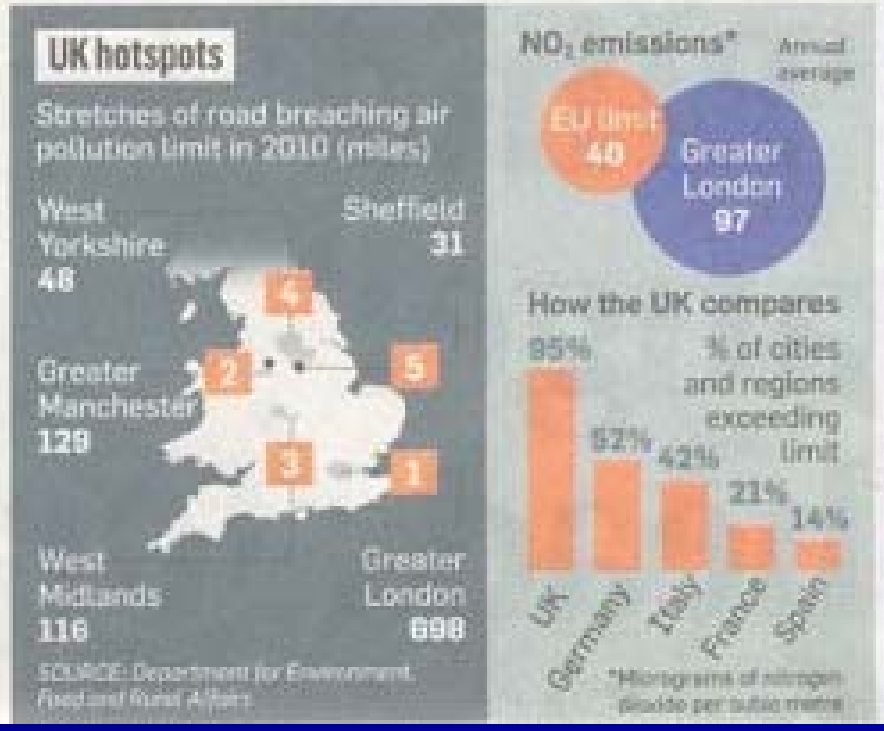
Environment We have the worst road pollution in Europe, reports **Steven Swinford**

BRITAIN suffers from the most widespread levels of dangerous traffic fumes in Europe, posing a serious risk to health, according to a government report.

Hundreds of local authorities breach European Union limits for nitrogen dioxide (NO_2), which has been linked to asthma, stunted lung growth in children and premature death. The fumes on certain stretches of roads breach safety

ing fines unless it takes radical measures such as introducing subsidies for electric cars or a national road pricing scheme. It raises the spectre of Britain reverting to its past status as the "dirty man" of Europe as economic pressures lead to cuts in environmental standards.

Last month Boris Johnson, the mayor of London, dropped a pledge to force vans and minibuses to abide by the standards

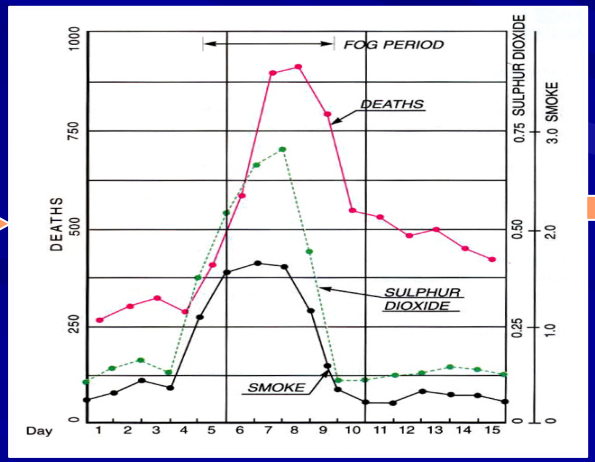


Sunday Times 1st March 2009

Air pollution legislation – a major step

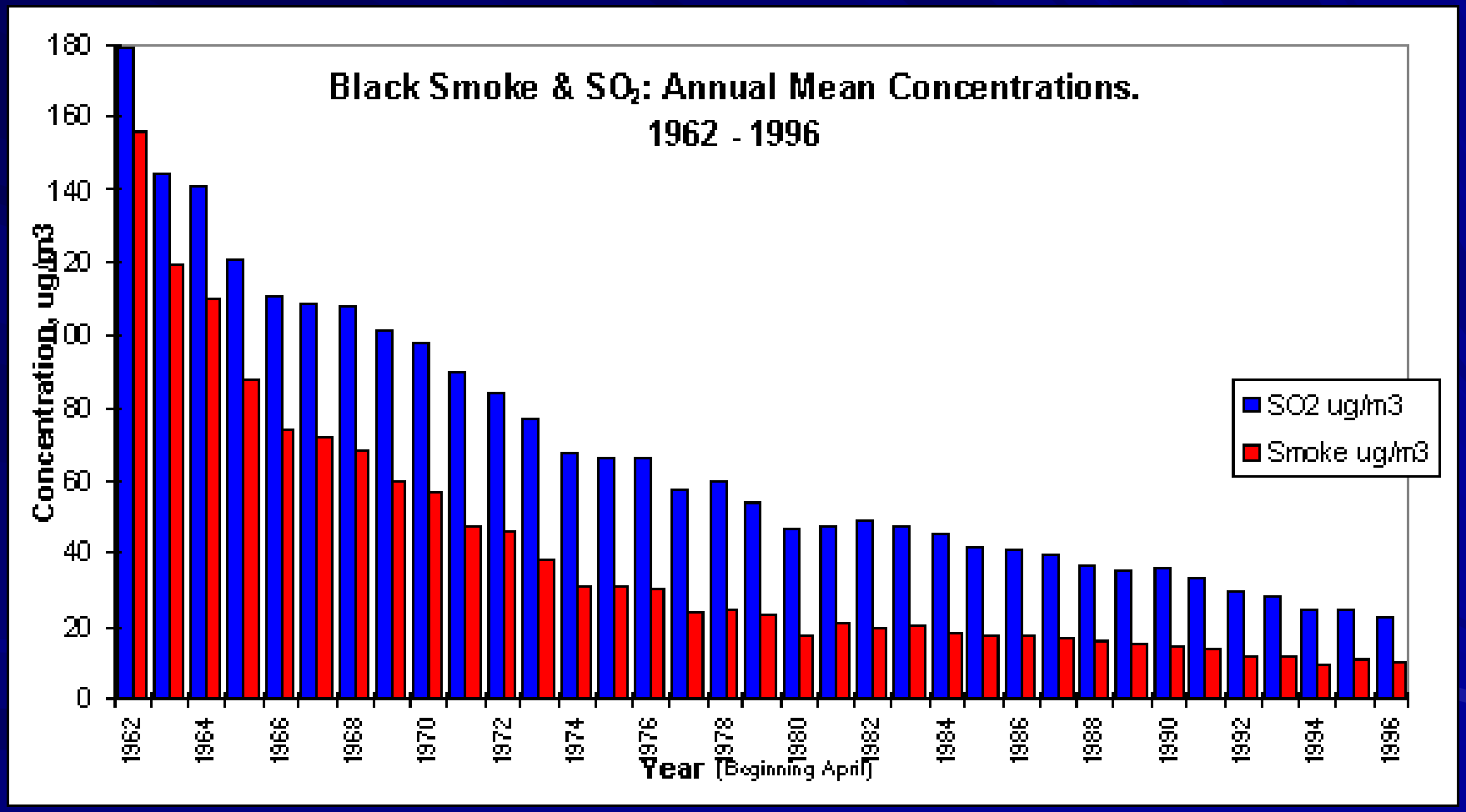
- Exposure driven event
- London smog, 1952

EMISSIONS → EXPOSURE (Time, person, place) → HEALTH EFFECT → CONTROL



Clean Air Act, 1956

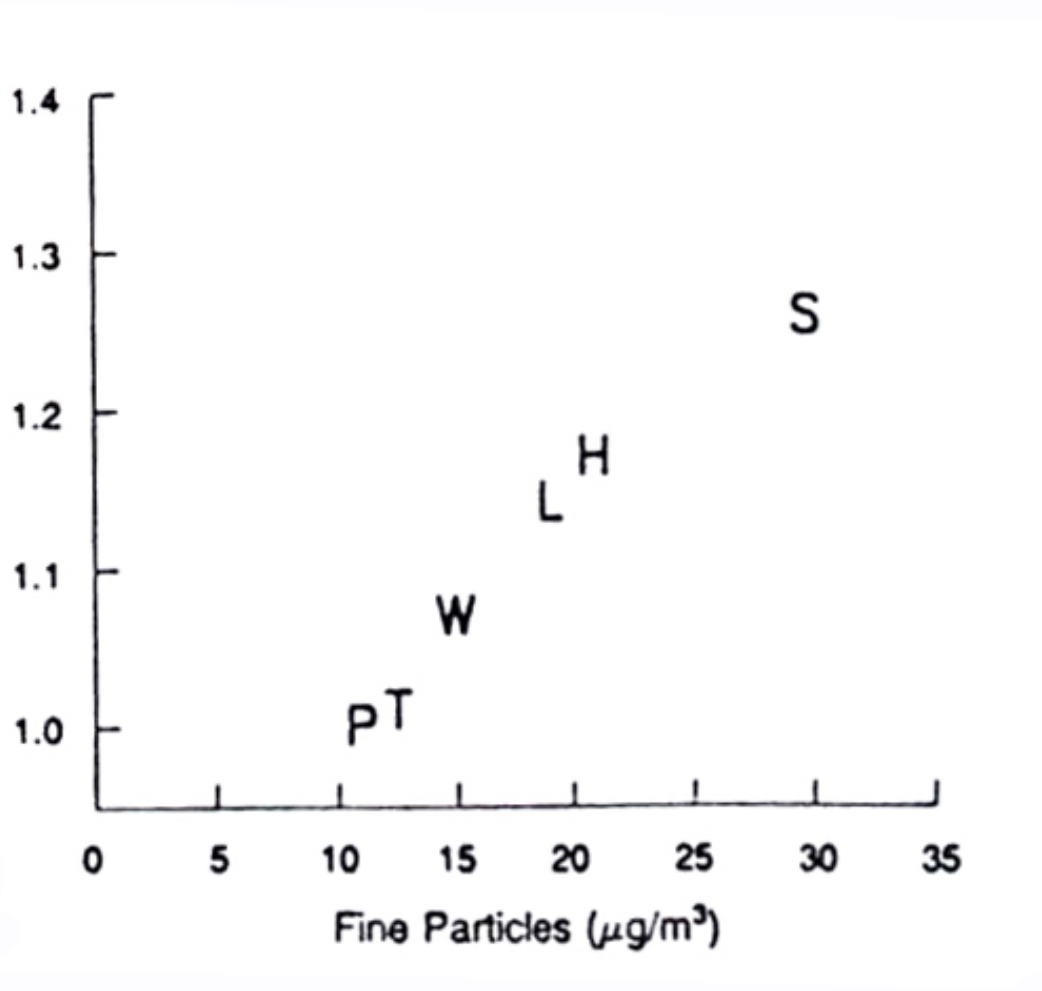
Black smoke and SO_2 post-clean air act



The Six Cities Study

Risk of Death

1.1 = 10% increased risk compared to Portage



Concerns…..

- **Essentially one study**
  - and that from the USA
- **Effect sizes were small**

Although

- **Good (we thought) exposure measures**
  - although not personal exposures
- **And outcomes seemed clear (and logical)**

- **Pressure from NGOs (and others) to heed Tom Lehrer**
  - "…don't breathe the air"!
  - Or at least do something about it

So where to go now?

- Set up committees!
- To consider:
  - Population based studies
  - Human exposure studies
  - Animal studies
  - Lab studies (cells largely)

Policy development and air pollution

DEFRA

- Monitor air quality
- EPAQS recommends Air Quality Standards

DoH

- MAAPE
- COMEAP
- Reports
  - Asthma, Particles, QUARK, EAHEAP, CVS, Asthma2, QUARK2
- Statements
- Not simply response mode

Air Quality Strategy

Monitoring of AQ - applying strategy

Outdoor air pollutants and their sources

Particles

- **Vehicles, power stations, industry, agriculture, surface dust, sea spray**

Nitrogen dioxide

- **Vehicles**

Sulphur dioxide

- **Power stations, vehicles**

Ozone

- **Sunlight on vehicle emissions**

Lead

- Vehicles

Carcinogens

- Vehicles (Benzene, 1,3 butadiene, PAHs)

Carbon monoxide

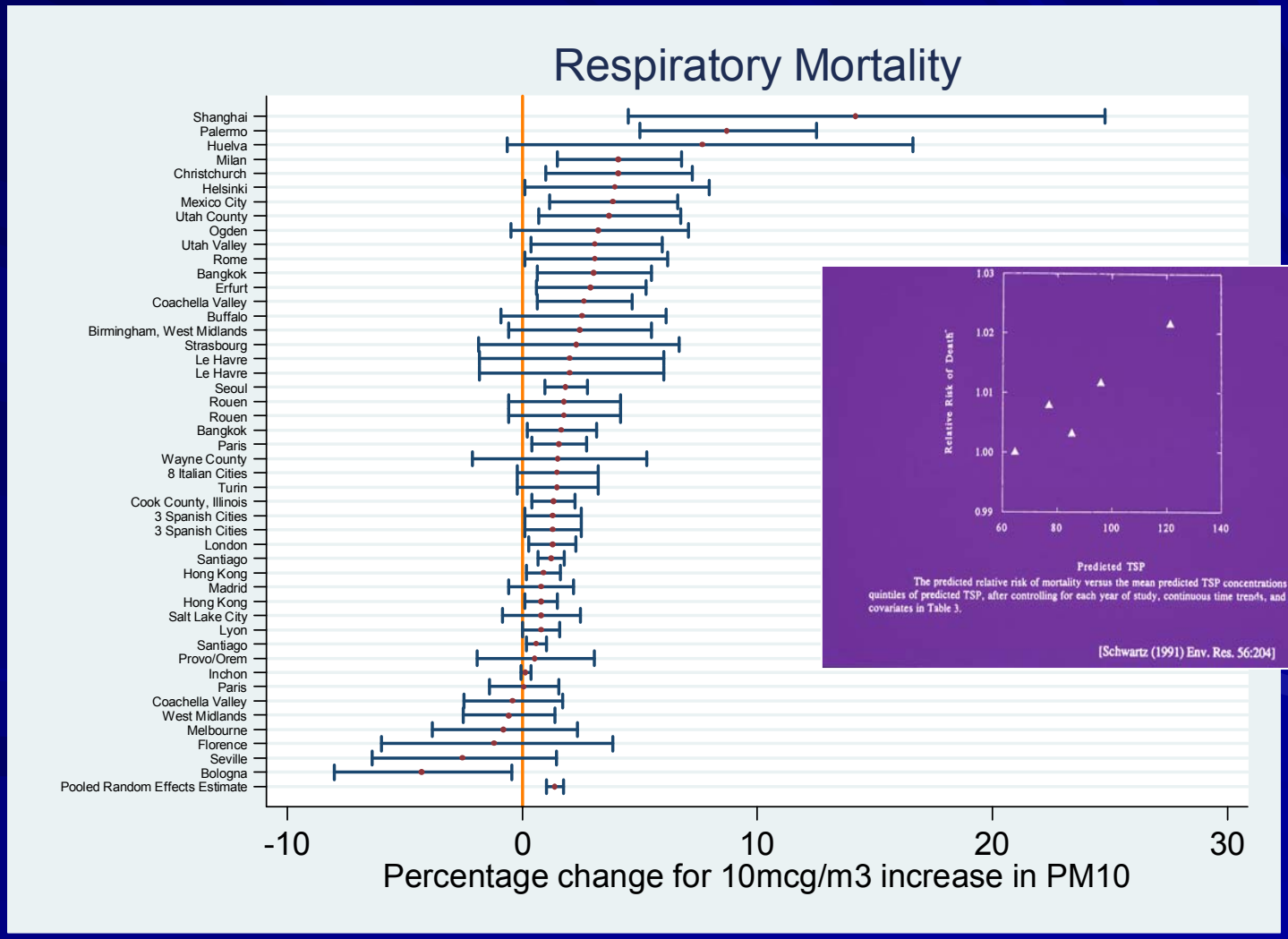
- **Vehicles**

Diseases associated with air pollution

- **Lungs**
  - asthma
  - COPD
  - changes in lung growth
- **Heart**
  - heart failure
  - arrhythmias
  - myocardial ischaemia
- **Cancer**
  - chronic myeloid leukaemia?
  - Lung cancer
- **Infections**
  - pneumonia
  - croup
- **Neo-natal survival**
- **Stroke**

Effects of short term exposure
Effects of long-term exposure
Latent effects

Respiratory mortality and PM_{10} (n=47)



Mortality and PM_{10}

%increase for 10 point rise in PM_{10}

Europe

- 0.6% for all cause mortality
- 0.8% for cardiovascular deaths
- 0.6% for respiratory deaths

USA

- 0.6% for all cause mortality
- 0.7% for cardio-respiratory deaths

Hospital admissions and PM_{10}

%increase for 10 point rise in PM_{10}

Europe

- Asthma – around 1.2%
- COPD – around 1%

USA

- Asthma & COPD – 1.5 to 2%

But how big are these effects when applied to the whole population exposed?

What is the public health load?

QUARK report

1998

Quantification of the health effects of air pollution: approach

- Identify relevant pollutants
- Identify “best” risk estimates (coefficients) for specific pollutants on specific health endpoints
- Apply these to populations using data on air quality *experienced by those populations*
- Estimate the number of people likely to be affected by each pollutant

Pollutants and outcomes studied
[Great Britain - excluding NI]

Pollutants

- Sulphur dioxide (U)
- Particles (U)
- Ozone (U&R)

- *Nitrogen dioxide*
- *Carbon monoxide*
- *Carcinogens*

Outcomes

- Deaths
- Hospital admissions

- *Symptoms*
- *RADs*
- *ERVs*

Quantification of the health impact of air pollution in the UK

QUARK report (COMEAP 1998)

GB urban

- **Deaths brought forward (all cause):**
  - **PM 8,100 pa**
  - **SO_2 3,500 pa**
  - **O_3 12,500 pa (no threshold)**
- **Respiratory hospital admissions brought forward & additional:**
  - **PM 10,500 pa**
  - **SO_2 3,500 pa**
  - **O_3 9,900 pa (no threshold)**

Estimates of the range of costs of air pollution in the UK

EAHEAP

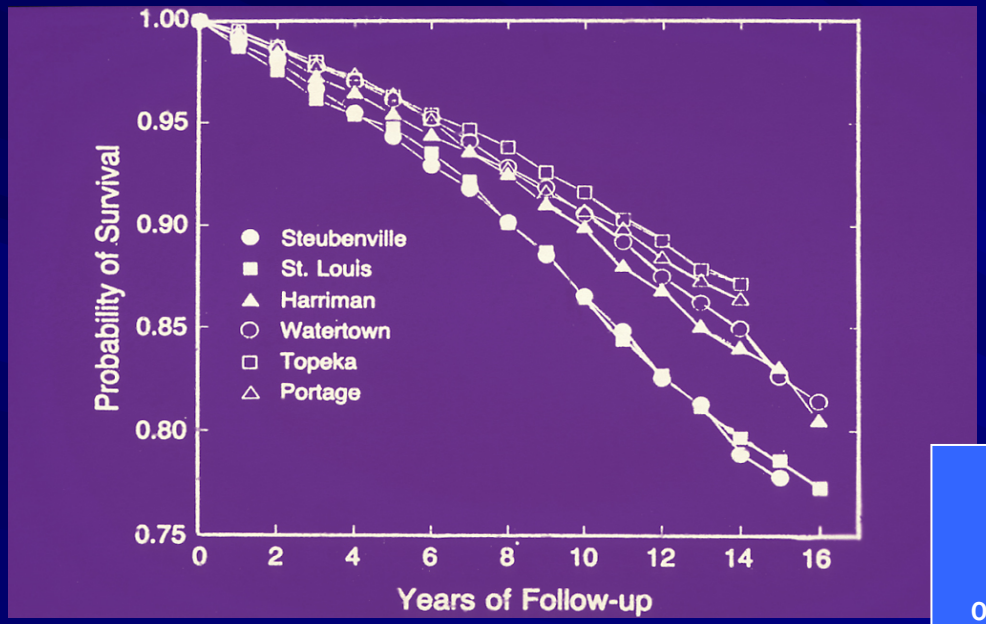
- **Total benefits** (net of NHS costs of saved morbidity/mortality) :
  - PM_{10} £0.93 - £540m pa
  - SO_2 £0.45 - £440m pa
  - O_3 £0.31 - £315m (summer only)

[DH, 1999]

Further issues….

- **Is mass the right metric for particles?**
  - Numbers?
  - Surface area?
- **What are the impacts of long term effects of exposure (rather than just the day-to-day effects)?**
  - Probably hugely exceed those of day-to-day
  - COMEAP 2nd quantification report (in progress)
  - COMEAP 2nd asthma report (in progress)
- **Why cardiovascular disease?**
  - COMEAP CVS report, 2006
- **What about asthma?**
- **How important is ozone?**
  - Effects on cardiac mortality but not hospitalisations
  - Is there a threshold?
  - COMEAP report (in progress)

Long term effects - 6 Cities study & ACS



[Dockery et al *NEJM* 1993;**329**:1753]

ACS

% increase for a 10 point rise in $PM_{2.5}$

All cause mortality – 6%
Cardio-pulmonary – 9%
Lung cancer – 14%

Pope et al 2002

Life expectancy and chronic effects of air pollution

COMEAP 2001.

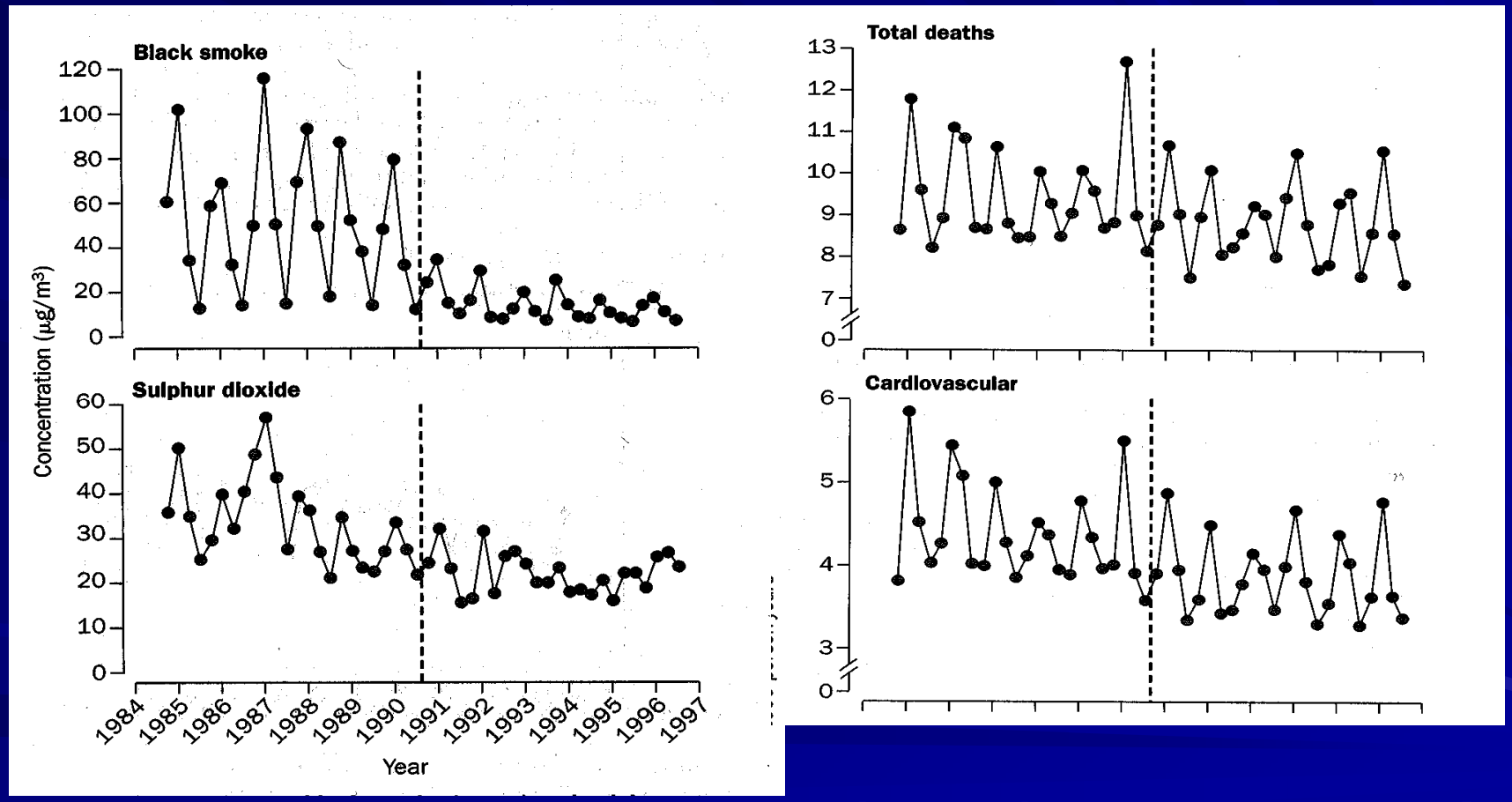
- Based on a fall of 1µg/m^3 in ambient $PM_{2.5}$
- On average over the whole population would amount to around 2.5d/person/lifetime (ca. 0.35m life years for the whole UK population)
- But if this applies only to a susceptible proportion the improvement would be greater
  - if 10% population susceptible would amount to around 1 month per susceptible person
  - if 1% susceptible would amount to around 1 year per person
- For a birth cohort born in 2000 the total population benefit would be greater at around 0.5 to 4.5 weeks

Can the rise in asthma seen in the 1970s and ‘80s be attributed to air pollution?

- Exacerbations – no argument
- Initiation?
  - Trends go in opposite directions
  - Plausible mechanisms
    - Including potentiation of allergen exposures
  - But epidemiology largely goes against it
    - But should we be more interested in symptoms rather than labels?
  - Real issues around diagnostic differences

Interventions

Changes in pollutants and mortality in Dublin – 1984-97



Clancy et al *Lancet* 2002;**360**:1210-4]

Changes in pollutants and mortality in Dublin – 1984-97

- 35.6µg/m^3 (70%) decline in black smoke
- Adjusted non-trauma deaths fell by 5.7% (95% CIs 4-7)
- Respiratory deaths fell by 15.5% (12-19)
- Cardiovascular deaths fell by 10.3% (8-13)

- This represents about 116 fewer respiratory and 243 cardiovascular deaths pa

Clancy et al *Lancet* 2002;**360**:1210-4]

Controlling emissions

- New fuels
- Different engine design
- Transport policy
- AQZs, congestion zones
- Changing the way we use the car

Natural gas bus - Barcelona

So how much air pollution-induced ill health can we prevent?

Reductions of PM_{10} levels

↓ of PM_{10} annual mean **to 20 µg/m³** (EC LV for 2010) in each city would prevent **21,828** premature deaths annually

↓ of PM_{10} annual mean **by 5 µg/m³** in each city would prevent **6,143** premature deaths annually

(Modelling for a range of European cities)

HEALTH EFFECTS OF AIR POLLUTION