

## Health Impacts of Air Pollution

Challenges for exposure science and epidemiology

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## Text for the day

Finagle's Law of Information

*"The information you have is not what you want"*

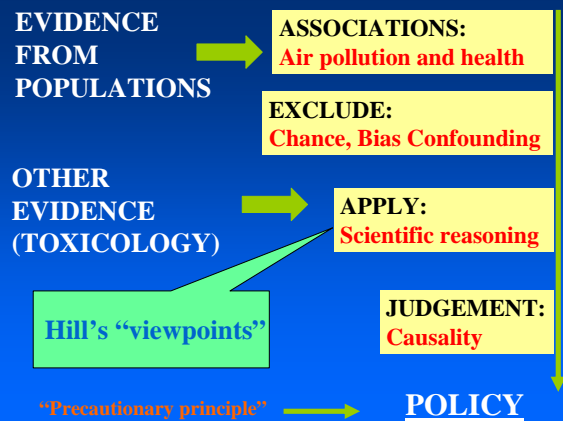
*The information you want is not what you need*

*The information you need is unobtainable"*

## Further platitudes

Health impact assessment is the art of the possible

Do not let the perfect be the enemy of the good.



## Short-term exposure studies

- Air pollution episodes
  - Winter episodes
  - Summer episodes
  - Biomass burning
  - Volcanic activity
  - Dust storms
- Time-series studies of daily data
  - populations – deaths, hospitalizations
  - panels – lung function, symptoms

## Health effects reported from short-term exposure studies:

- Mortality - cardiorespiratory
- Hospital admissions - cardiorespiratory
- Emergency room attendances - cardiorespiratory
- Primary care visits - upper and lower respiratory
- Respiratory symptoms - cough, phlegm, wheeze
- Use of medications - asthma drugs
- Lung function - restrictive and obstructive
- Blood - Increased viscosity, fibrinogen
- Heart - heart rate variability, arrhythmia (not sudden death)

**LONG-TERM EXPOSURE STUDIES:**  
**(1) Spatial correlations (regions, cities, point or line (e.g. road) sources**  
**(2) Long term time trends (over years)**



- **mortality or utilisation rates (ecological studies)**
- **prevalence (cross-sectional studies)**
- **incidence (cohort studies)**

**Health effects reported from long-term exposure studies**

- Adult cardiopulmonary mortality
- Permanent reduction in lung function
- Chronic respiratory symptoms
- Lung cancer incidence
- ? *Reproductive: Infant mortality, SIDS, prematurity, low birthweight.*
- ? *Asthma*

**Outdoor air pollutants**

**Gases**

- Oxides of nitrogen
- Ozone
- Sulphur dioxide
- Carbon monoxide

**"Air Toxics"**

- 1,3-butadiene
- Polycyclic organic matter e.g. PAH's.
- Benzene
- Aldehydes, e.g. formaldehyde

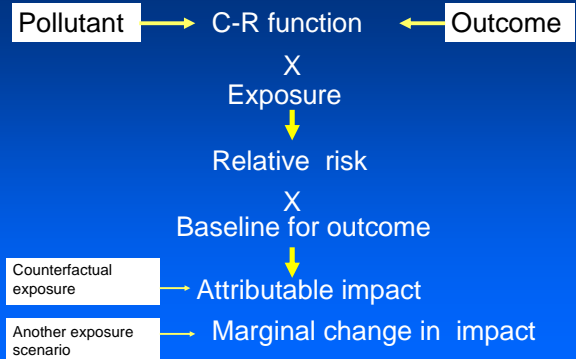
**Inhalable Particulates(PM<sub>10</sub>)**

- Fine (PM<sub>2.5</sub>) & Ultrafine (PM<sub>0.1</sub>)
- Created from **Combustion**
  - Primary: carbonaceous
  - Secondary: sulphates, nitrates
  - Lead

- Coarse (PM<sub>2.5-10</sub>)

- Mechanically** generated
  - Crustal source: siliceous
  - Non combustion mobile sources: eg Tyre and brake wear
  - Sea spray (coastal areas)
- Biological
  - Pollen fragments, fungal spores

**Estimation of health impact**



**HEALTH IMPACT OF AIR POLLUTION IN UK (Dept Health 1998)**

Pollutant	Outcome	GB Urban
PM <sub>10</sub>	Deaths (all causes)	8100
	Admissions (respiratory)	10500
SO <sub>2</sub>	Deaths (all causes)	3500
	Admissions	3500
NO <sub>2</sub>	Admissions (respiratory)	8700

**HEALTH IMPACT OF OZONE IN UK WARM SEASON ONLY (Dept Health 1998)**

	Threshold = 50 ppb	Threshold = 0 ppb
Deaths brought forward: all causes	700	12500
Hospital admissions (respiratory), brought forward and additional	500	9900

## Developments on the epidemiological side since the 1990's

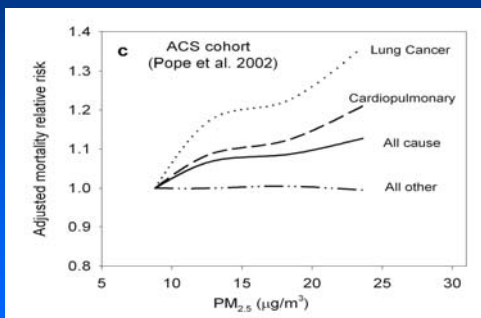
- Cohort evidence enabling estimation of life-years lost
- The dominance of cardiovascular disease as a cause of death
- Lack of a threshold in population studies

## American Cancer Society II Cohort 500,000 adults followed 1982 – 1998 (Pope et al JAMA 2002)

RR per 10 $\mu\text{g}/\text{m}^3$ PM <sub>2.5</sub> 1979-83		
	RR	95% CI
Cardiopulmonary	1.06	1.02-1.10
Lung Cancer	1.08	1.01-1.16

Random effects Cox proportional hazards model controlling for age, sex, race, smoking, education, marital status, body mass, alcohol, occupational exposure and diet

## ACS Cohort: exposure response relationship

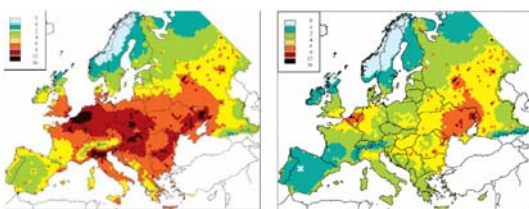


Pope 2002

## Cohort studies of all-cause mortality

Year	Study	PM metric	% change/unit PM
1993/2006	US: 6 Cities	PM <sub>2.5</sub>	1.6 (0.7, 2.6)
1995/2002	US: ACS	PM <sub>2.5</sub>	0.4 (0.1, 0.8)
1999/2000	US: ASHMOG	PM <sub>10</sub>	0.9 (-0.2, 2.1)(males)
2000	US: Veterans	PM <sub>2.5</sub>	0.03 (ns)
2002	Netherlands	BS (background)	1.7 (-2.4, 7.8)
		BS (near road)	4.1 (-0.6, 11.2)
2004	Canada: Hamilton	Near road	1.8 (0.2, 3.8)
2005	France: PAARC	BS	0.7 (-0.3, 1.0)
2005	US: LA (ACS)	PM <sub>2.5</sub>	1.7 (0.5, 3.0)
2006	Germany	PM <sub>10</sub> (5-yr av.)	1.8 (-0.1, 4.3)(females)
		Near road	29 (-0.7, 78)

Changes in loss of life expectancy in the EU in 2000 and in the interim objective in 2020 (Strategy)



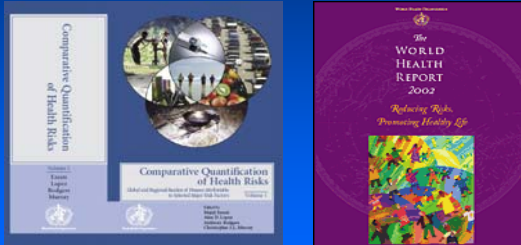
## Comparison of exposure reduction approach and current objective (standard/limit) approach: UK National Air Quality Strategy for 2020 (consultation)

	PM <sub>2.5</sub> % pop > 20 $\mu\text{g}/\text{m}^3$	Additional life years <sup>1</sup>	PM <sub>2.5</sub> % reduction	Costs
Baseline	26.7	0	11.5	0
Exposure reduction <sup>2</sup>	11.9	3.25m	17	£485m
Exceedance reduction	0	1.57m	13.4	Much higher

<sup>1</sup> Cohort evidence: Pope et al. 6% hazard rate per 10 $\mu\text{g}/\text{m}^3$

<sup>2</sup> Combined measures (EURO V, VI standards, penetration of low emission vehicles, small plant combustion)

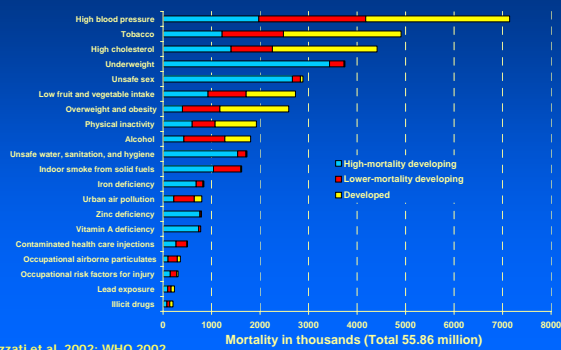
## CRA project and WHR 2002



## Estimated Impacts of Urban Air Pollution Worldwide (95% confidence intervals)

	AF (%)	Deaths (x 10 <sup>3</sup> )	DALYs (x 10 <sup>3</sup> )
CPD	3 (1, 6)	712 (245, 1107)	6360 (2140, 10129)
Lung Cancer	5 (1, 9)	62 (10, 114)	588 (104, 1089)
ARI (0-5 yr.)	1 (-1, 3)	26 (-24, 66)	913 (-846, 2358)

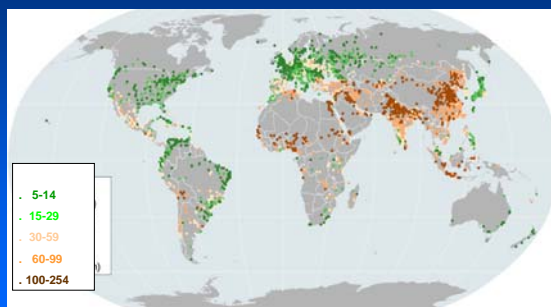
## Mortality attributable to leading risk factors



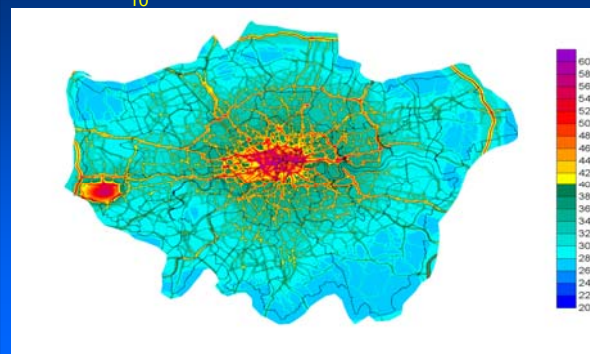
## Availability of Exposure Data at Fixed Monitoring Sites in Residential Areas (circa 2000)

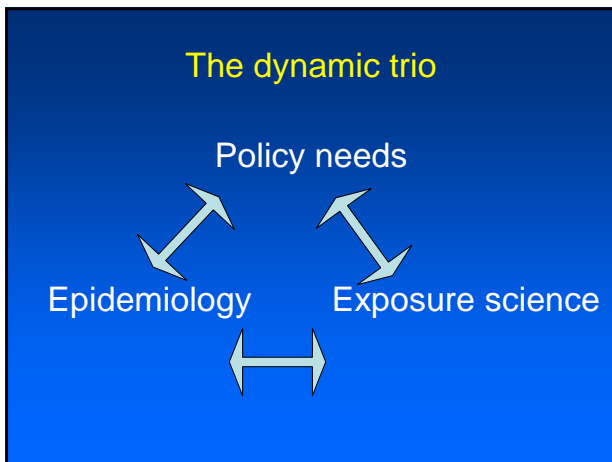
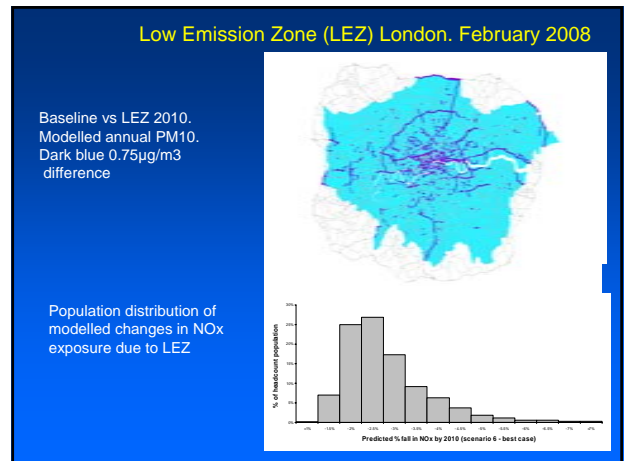
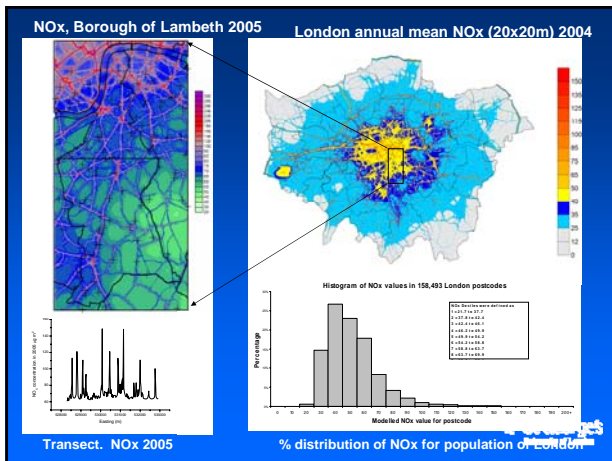


## Estimated PM<sub>10</sub> Concentration in World Cities (pop >=100,000) (World Bank GMAPS econometric model)



## PM<sub>10</sub> concentrations across London





**Thanks for listening**