HEALTH EFFECTS OF AIR POLLUTION

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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 (NO₂), which has been linked to asthma, stunted lung growth in children and premature death. The fumes on certain stretches of roads breach safety 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.

UK hotspots
Stretches of road breaching air pollution limit in 2010 (miles)

<table>
<thead>
<tr>
<th>Region</th>
<th>Miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>West Yorkshire</td>
<td>48</td>
</tr>
<tr>
<td>Greater Manchester</td>
<td>129</td>
</tr>
<tr>
<td>West Midlands</td>
<td>116</td>
</tr>
</tbody>
</table>

Source: Department for Environment, Food and Rural Affairs

NO₂ emissions*

Greater London 97

How the UK compares

95% % of cities and regions exceeding limit

Germany 52%
Italy 42%
France 21%
Spain 14%

*Micrograms of nitrogen dioxide per cubic metre

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

Air Quality Strategy
- Monitoring of AQ - applying strategy

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

Percentage change for 10mcg/m$^3$ increase in PM$_{10}$
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):
  - $\text{PM}_{10}$ £0.93 - £540m pa
  - $\text{SO}_2$ £0.45 - £440m pa
  - $\text{O}_3$ £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 2\textsuperscript{nd} quantification report (in progress)
  - COMEAP 2\textsuperscript{nd} 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

Based on a fall of 1 µg/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

Changes in pollutants and mortality in Dublin – 1984-97

- 35.6μg/m³ (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

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

Despite PM$_{10}$ annual mean to 20 $\mu$g/m$^3$ (EC LV for 2010) in each city would prevent 21,828 premature deaths annually,

...of PM$_{10}$ annual mean by 5 $\mu$g/m$^3$ in each city would prevent 6,143 premature deaths annually...

(Modelling for a range of European cities)
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