A journey through time – series analyses

Richard Atkinson
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Contents

1. Concept
2. Literature
3. Methodological
   - Seasonal control
   - Lag structure
   - Multi-centre studies
4. Systematic review
5. Traffic study
6. Developments
## Exposure and effect

<table>
<thead>
<tr>
<th></th>
<th>Short term effect</th>
<th>Long term effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short term exposure</td>
<td>√</td>
<td>√</td>
</tr>
<tr>
<td>Long term exposure</td>
<td></td>
<td>√</td>
</tr>
</tbody>
</table>
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)

SPATIAL VARIATION IN ANNUAL MEAN PM$_{10}$ IN UK 1991
Short-term exposure studies - Panel

FVC and PM$_{10}$ daily over 46 days Surrey UK, June 1994
(Scarlett et al 1996)
Short-term exposure studies – Ecological

London
RR=1.0025 per 10 μg/m³
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Air Pollution Epidemiology Database

• >600 studies since 1980s
• > 21,000 effect estimates (protocol)
• 470 single-city studies
• 141 multi-city studies
• Mortality (52%) / Admissions (33%) / Other (15%)
• Particles (PM10, PM2.5, BS, BC etc.)
• Gases (NO2, O3, SO2, CO)
• Elemental composition
# published studies by lustrum
Studies by WHO Region

- Amr A: 35%
- Amr B: 7%
- Eur A: 33%
- Eur B: 2%
- Sear B: 1%
- Sear D: 1%
- WPR A: 4%
- WPR B: 17%
- WPR B: 17%
- Amr B: 7%
Policy interface

Review of evidence on health aspects of air pollution – REVIHAAP Project
Technical Report
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Methodological Developments

Seasonal control

[Graphs showing seasonal control over time]

- Left graphs: Seasonal variation from 01/01/2002 to 01/01/2007
- Right graphs: Seasonal variation from 01/07/2002 to 01/07/2006
Methodological Developments

Lag structure

Day

Deaths

Ozone
Methodological Developments

Lag structure

Days:
- Lag 1
- Lag 3
- Lag 5

Deaths:
- Day 1: 50
- Day 2: 100
- Day 3: 150
- Day 4: 200
- Day 5: 250

Ozone:
- Day 1: 10
- Day 2: 20
- Day 3: 30
- Day 4: 40
- Day 5: 50
Methodological Developments
Lag structure

Figure 1 - Lag structure of the effects of an interquartile range increase in SO₂ (10.73 μg/m³) on total, male, and female cardiovascular disease (CVD) hospital admissions. São Paulo, Brazil, 1996-2001.
Methodological Developments

Multi-city studies

• Multiple locations included
• Common approach
  – Exposure
  – Statistical models
• Increased power
• Sources of heterogeneity
• APHENA: 90 US cities, 12 Canadian cities, 32 European cities.
APHENA Study

PM$_{10}$ and all cause mortality
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Traffic Pollution and Health in London

• Research Council Environmental Exposure and Health Initiative
• NERC/MRC/DOH - £2m
• KCL, ICL, SGUL, LSHTM, UoB, UoA
• To describe and understand the patterns of exposure of the population to traffic pollution and their relationships to health
TPHL – Work Packages

1. PM oxidative potential and exploitation of the NERC ClearfLo project

2. Modelling of population exposure to traffic pollution

3. Epidemiological studies of health effects of long-term exposure to traffic pollution
TPHL – Time series (WP1.3)

• SGUL, University of Athens

• Aim: “…to investigate the relative effects of different particle metrics and components, including oxidative potential on daily mortality and hospital admissions for cardiorespiratory conditions”.

• Clearflo & Defra data sets

• London, 2011-2012
TPHL – Pollutant Metrics

- PM10, PM2.5, PM10-2.5
- BC/EC/OC
- PNC
- Elemental composition
- PMF
- Background/Urban increments
- Oxidative Potential
- Gases
Challenges

100+ pollutant metrics
x 2 outcomes x 3 disease x (? age groups)
x 2 seasons x ? lags x ? multi-pollutants
= LOT OF MODELS
= BIG HEADACHE

• Characterise markers of traffic sources
• A priori list for epidemiological analyses
<table>
<thead>
<tr>
<th>Rationale</th>
<th>Metric</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Source</strong></td>
<td></td>
</tr>
<tr>
<td>Traffic - general</td>
<td>NOX</td>
</tr>
<tr>
<td>Traffic – general</td>
<td>PMF Traffic source</td>
</tr>
<tr>
<td>Traffic – general</td>
<td>- Composition</td>
</tr>
<tr>
<td>Traffic – general</td>
<td>- Particle size</td>
</tr>
<tr>
<td>Traffic - exhaust – Diesel</td>
<td>BC/EC in PM$_{2.5}$</td>
</tr>
<tr>
<td>Traffic - exhaust – Petrol</td>
<td>CO</td>
</tr>
<tr>
<td>Traffic - non-exhaust – Brake</td>
<td>Cu</td>
</tr>
<tr>
<td>Traffic - non-exhaust – Tyre</td>
<td>Zn</td>
</tr>
<tr>
<td>Traffic - non-exhaust - Re-suspension</td>
<td>Al</td>
</tr>
<tr>
<td>Rationale</td>
<td>Metric</td>
</tr>
<tr>
<td>--------------------</td>
<td>-------------------------</td>
</tr>
<tr>
<td><strong>Regulated</strong></td>
<td></td>
</tr>
<tr>
<td>Particles</td>
<td>( \text{PM}_{10} )</td>
</tr>
<tr>
<td>Particles</td>
<td>( \text{PM}_{2.5} )</td>
</tr>
<tr>
<td>Gaseous</td>
<td>( \text{NO}_2 )</td>
</tr>
<tr>
<td>Gaseous</td>
<td>( \text{SO}_2 )</td>
</tr>
<tr>
<td>Gaseous</td>
<td>( \text{O}_3 )</td>
</tr>
<tr>
<td><strong>Novel</strong></td>
<td></td>
</tr>
<tr>
<td>Oxidative Potential</td>
<td>\text{OP1A, OP1G, OP1T}</td>
</tr>
<tr>
<td></td>
<td>\text{OP2A, OP2G, OP2T}</td>
</tr>
<tr>
<td><strong>Wish List</strong></td>
<td></td>
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<tr>
<td>Heavy fuel oil combustion</td>
<td>( \text{Ni, V} )</td>
</tr>
<tr>
<td>Regional secondary particles</td>
<td>\text{SO4, NO3}</td>
</tr>
<tr>
<td>Carbon source apportionment</td>
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Delta study

• Nuredin Mohammed, Jon Ayres, Hubert Lam (UoB)
• Hypothesis: delta not concentration
• Pattern analysis

![Graph showing total ozone exposure: Total ozone exposure = 72 μg/m³]
AIR POLLUTION AND WEATHER-RELATED HEALTH IMPACTS: METHODOLOGICAL STUDY BASED ON SPATIO-TEMPORALLY DISAGGREGATED MULTI-POLLUTANT MODELS FOR PRESENT-DAY AND FUTURE (AWESOME)

• PI Paul Wilkinson, LSHTM, UoE, SGUL
• Modelled daily pollution concentrations at 5x5km spatial resolution
• National coverage
Comparative evaluation of Spatio-Temporal Exposure Assessment Methods for estimating the health effects of air pollution (STEAM)

- MRC Methodology panel (PI: Katsouyanni)
- KCL, SGUL, UOA, Harvard
- Fine spatial and temporal resolution
- Range of modelling techniques/data sources
- Simulation
- Integration of long and short term exposures and long and short term health effects
In conclusion:

• Extensive literature
• Greater geographical coverage
• Ever increasing sophistication
• Ever more searching (policy related) questions
• Modelling developments
Thank you

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