Air pollution and associated health impacts

Dr Clare Heaviside\textsuperscript{1,2,3}, Dr Helen Macintyre\textsuperscript{1}, Prof John Thornes\textsuperscript{1,2}, Dr Sani Dimitroulopoulou\textsuperscript{1}, Dr Christina Mitsakou\textsuperscript{1}, Dr Sotiris Vardoulakis\textsuperscript{1,2,3}

\textsuperscript{1}Air Pollution and Climate Change Group
Centre for Radiation, Chemical & Environmental Hazards

\textsuperscript{2}University of Birmingham

\textsuperscript{3}London School of Hygiene and Tropical Medicine
Air pollution projects

Air pollution is a PHE priority area

Current and planned HRPU projects include:

• Air pollution episode analyses based on syndromic surveillance and health impact assessments (spring 2014 as case study)

• UK analysis of short term effects of ozone, following recent COMEAP recommendations on coefficients and more extensive modelling

• Implementation of the WRF-Chem atmospheric chemistry model to study urban scale air pollution and the relationship with the urban heat island

• Joint project with HPRU on Health Impacts on Environmental Hazards to investigate effectiveness of interventions
UK Air Pollution Episode March-April 2014.

Helen Macintyre

Smog shrouds London landmarks after 'perfect storm' increases pollution

Famous London landmarks hide behind the smog as high levels of air pollution causes problems across the east of England

Air pollution: High levels to spread across England

Government helpline advises people to avoid exertion in areas of high pollution as experts warn smog will stay until weekend
Observations

**DAQI (Daily Air Quality Index)** reached ‘high’ or ‘very high’ for several days across multiple regions in the UK.

![Map of UK air quality](image)
PM$_{2.5}$ levels reached over 80 µg m$^{-3}$ at some urban background sites.

Daily mean PM$_{2.5}$ levels from Jan – Jun show springtime peaks (2011-15) at urban background sites.

Observed daily mean PM$_{2.5}$ at an urban background site during January-June from 2011 to 2015 inclusive. (Data from AURN via Defra website)

DAQI = 4: ‘Moderate’. Health advice at 36 µg m$^{-3}$
Focus on two episodes: 12\textsuperscript{th} – 14\textsuperscript{th} March, and 28\textsuperscript{th} March – 3\textsuperscript{rd} April 2014

- \textbf{PM\textsubscript{2.5} concentrations} from the AQUM met office model, 12 km (now used for the Defra air quality forecasts) [Savage et al., 2013].

- \textbf{Population} weighting of daily PM\textsubscript{2.5} using gridded 100 metre population.

- UK countries and 9 GOR.

- Daily \textbf{mortality} and \textbf{emergency hospital admissions}.

- Published \textbf{exposure-response coefficients} for short-term effects [Atkinson et al., 2014]. No threshold.

\begin{tabular}{|l|l|}
\hline
\textbf{Health outcome} & \textbf{\(R_e\) PM\textsubscript{2.5}} \\
\hline
Mortality (all-cause excluding external) & 1.04\% increase per 10 \(\mu g\) m\textsuperscript{-3} \\
\hline
Emergency respiratory hospitalizations & 0.96\% increase per 10 \(\mu g\) m\textsuperscript{-3} \\
\hline
Emergency cardiovascular hospitalizations & 0.90\% increase per 10 \(\mu g\) m\textsuperscript{-3} \\
\hline
\end{tabular}
Mortality (all-cause)

- Analysed 12th – 14th March and 28th March – 3rd April.
- Total of 604 deaths brought forward associated with short-term exposure to PM$_{2.5}$ summed across the UK.
- Estimate that 302 of these would be expected due to more typical levels of PM$_{2.5}$ (based on available measurements from urban background sites).
- Estimate a two-fold increase in mortality attributable to short-term exposure to PM$_{2.5}$.

Observed daily mean PM2.5 at an urban background site during January-June from 2012 to 2015 inclusive. (Data form AURN via Defra website)
Impact of the presence of the episode based on more typical levels of PM$_{2.5}$ at this time of year is approximately double.

Some regional variation due to differing levels of PM$_{2.5}$ and baseline mortality levels.

<table>
<thead>
<tr>
<th>Region</th>
<th>Mean PM$_{2.5}$ concentration</th>
<th>Deaths brought forward associated with PM$_{2.5}$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2014 episodes</td>
<td>Number</td>
</tr>
<tr>
<td>London</td>
<td>49.1 µg m$^{-3}$</td>
<td>69</td>
</tr>
<tr>
<td></td>
<td>Typical levels</td>
<td>18.0 µg m$^{-3}$</td>
</tr>
<tr>
<td>West Midlands</td>
<td>41.9 µg m$^{-3}$</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Typical levels</td>
<td>19.3 µg m$^{-3}$</td>
</tr>
<tr>
<td>Scotland</td>
<td>21.4 µg m$^{-3}$</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>Typical levels</td>
<td>10.9 µg m$^{-3}$</td>
</tr>
<tr>
<td>Wales</td>
<td>34.5 µg m$^{-3}$</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Typical levels</td>
<td>15.1 µg m$^{-3}$</td>
</tr>
</tbody>
</table>

*Typical levels calculated as mean of 1 March – 31 May, 2011, 2012, 2013, 2015. Analysis could not be performed for all urban background sites due to missing data.
Air pollution episode in spring of 2014.
Analysed 12th – 14th March and 28th March – 3rd April.
Total of 604 deaths brought forward associated with short-term exposure to PM$_{2.5}$ summed across the UK over these 10 days.
Based on measurements from urban background observation sites, estimate two-fold increase in deaths brought forward associated with short-term exposure to PM$_{2.5}$.
Similar results for emergency hospitalizations (respiratory and cardiovascular).
May aid with future planning for air pollution events.
Health impacts of short term exposure to surface ozone in England, Wales and Scotland from 2001-2011
Ozone trends in the UK

Annual levels of PM$_{10}$ and Ozone in the UK, 1987 to 2015

Defra (2016)
COMEAP (Committee on Medical Effects of Air Pollution) published an update to concentration-response coefficients for short term ozone exposure in 2015 (Department of Health 2015).

Coefficients for mortality and emergency respiratory hospital admissions updated

Coefficient for emergency cardiovascular admissions added

Recommendation is for no threshold (0 ppb cut off)

<table>
<thead>
<tr>
<th>Health endpoint (all ages)</th>
<th>Concentration-response coefficient % increase per 10 μg/m³ daily maximum 8-hour running mean ozone (95% confidence interval)</th>
</tr>
</thead>
</table>
| All-cause mortality       | 0.34%*  
(0.12, 0.56%)          |
| Respiratory hospital admissions | 0.75%**  
(0.30, 1.20%)          |
| Cardiovascular hospital admissions | 0.11%  
(-0.06, 0.27%)          |

*previously 0.3%   **previously 0.7%
Results – Mortality, emergency respiratory and cardiovascular hospitalizations (England & Wales)

- Mean annual mortality from daily ozone was **12,500** from 2001-2011
- Range: from **11,100** in 2010, to **13,500** in 2003
- Mean annual **respiratory admissions** from daily ozone: **27,100** from 2001-2011
- Mean annual **cardiovascular admissions** from daily ozone: **3,900** for same period
Joint HPRU project:  
“Walking to school” study

Source: National travel Survey England 2014

Research question: How does the mode of travelling to school (walk, cycle, car, bus) affect school-going children’s health?

Methodological steps:
- Select 2-3 scenarios to explore the impact of introducing a modal shift intervention in a typical London school.
- Estimate the emissions released from the school trips (DEFRA Emission toolkit);
- Calculate the pollutant concentrations (NO₂, PM) in the local environment around schools (OSPM model);
- Apply INDAIR/EXPAIR modelling framework to estimate population exposure of “school going children”, considering also the indoor environment;
- Assess potential risks/benefits resulted from: a) changes in exposure to the above pollutant concentrations, b) active travel – walk, cycle, c) road accidents (use of WebTag or similar toolkit);
- Scale up to a larger number of schools with different configurations

Potential funding sources: Defra, DH, DoE, GLA


Helen Macintyre, Clare Heaviside, Lucy Neal, Paul Agnew, John Thornes, Sotiris Vardoulakis, **Mortality and emergency hospitalizations associated with atmospheric particulate matter episodes across the UK in spring 2014,** (Poster) 2016 Annual UK Review Meeting on Outdoor and Indoor Air Pollution Research, 26-27 September 2016, Solihull, UK.


Particulate air pollution

- Particles smaller than 2.5 µm in diameter; PM\textsubscript{2.5}
- Range of sources; combustion, dust, chemical reactions; natural and man-made.
- Finer particles more dangerous as they penetrate deeper into the lungs.
Long term exposure to particulate air pollution has an effect on health equivalent to 29,000 deaths across the UK annually [COMEAP].

**Short-term exposure to air pollution episodes also has negative effects on health.**

- Increased respiratory symptoms; sore throat and eyes, cough; emergency hospitalizations for respiratory and cardiovascular conditions.
- Asthma.
- Cardiac arrhythmias; heart attacks.

**Sensitive groups**

- People with pre-existing lung or heart conditions, e.g. asthma.
- Older adults, children.
Total of **1,566** emergency respiratory and cardiovascular hospitalizations associated with short-term exposure to PM$_{2.5}$ (out of ~45,000)

- **Respiratory** emergency admissions: **838** across the UK. Estimate that **419** would be from more typical PM$_{2.5}$ levels.

- **Cardiovascular** emergency admissions **728** across the UK. Estimate that **364** would be from more typical PM$_{2.5}$ levels.