Historic air pollution exposure and long-term mortality risks in England and Wales

Anna Hansell
Assistant Director, SAHSU
Historic air pollution exposure and long-term mortality risks in England and Wales: prospective longitudinal cohort study

Anna Hansell, Rebecca E Ghosh, Marta Blangiardo, Chloe Perkins, Danielle Vienneau, Kayoung Goffe, David Briggs, John Gulliver

ABSTRACT
Introduction Long-term air pollution exposure contributes to mortality but there are few studies examining effects of very long-term (>25 years) exposures.
Methods This study investigated modelled air pollution concentrations at residence for 1971, 1981, 1991 (black smoke (BS) and SO₂) and 2001 (PM₁₀) in relation to mortality up to 2009 in 367 658 members of the longitudinal survey, a 1% sample of the English Census. Outcomes were all-cause (excluding accidents), cardiovascular (CV) and respiratory mortality.
Results BS and SO₂ exposures remained associated with mortality decades after exposure—BS exposure in 1971 was significantly associated with all-cause (OR 1.02 (95% CI 1.01 to 1.04)) and respiratory (OR 1.05 (95% CI 1.01 to 1.09)) mortality in 2002–2009 (ORs expressed per 10 µg/m³). Largest effect sizes were seen for more recent exposures and for respiratory disease. PM₁₀ exposure in 2001 was associated with all outcomes in 2002–2009 with stronger associations for respiratory (OR 1.22 (95% CI 1.04 to 1.44)) than CV mortality (OR 1.13 (95% CI 1.01 to 1.25)). Adjusting...
Aims and research questions

To investigate very long health effects of air pollution exposure

• *Research questions:*
  
  – Is historic air pollution associated with later mortality risk?
  
  – Do risks decrease over subsequent decades?
  
  – Do past air pollution exposures interact with recent exposures?
Data

- Black Smoke (BS) and sulphur dioxide (SO$_2$) air pollution concentrations estimated in 1971, 1981 and 1991 using 1km grids (Gulliver et al, Environ Sci Technol 2011)

- PM$_{10}$ air pollution concentrations estimated in 2001 at 100m grids (Vienneau et al, Sci Total Environ 2009)


www.environment-health.ac.uk
Methods

Address linked at ONS to:

- 1971 census
- 1981 census
- 1991 census
- 2001 census
- End 2009
  - Total: N=367,658

Present at each census or died

- Black smoke \( \text{SO}_2 \)
- Black smoke \( \text{SO}_2 \)
- Black smoke \( \text{SO}_2 \)
- \( \text{PM}_{10} \)

Mortality 1972-81
Mortality 1982-91
Mortality 1992-01
Mortality 2002-09

Mortality 1972-2009
Methods: analysis in brief

- Analyses for all-cause, cardiovascular and respiratory diseases
- Sensitivity analyses
Results: air pollution concentrations over time
## Results: descriptive statistics

<table>
<thead>
<tr>
<th>Air pollution</th>
<th>Mean(SD)</th>
<th>Median</th>
<th>10th centile</th>
<th>90th centile</th>
</tr>
</thead>
<tbody>
<tr>
<td>BS 1971 µg/m³</td>
<td>42.7 (20.4)</td>
<td>41</td>
<td>18.5</td>
<td>70.5</td>
</tr>
<tr>
<td>SO₂ 1971 µg/m³</td>
<td>85.2 (36.8)</td>
<td>77</td>
<td>44.5</td>
<td>137</td>
</tr>
<tr>
<td>BS 1981 µg/m³</td>
<td>16.2 (5.2)</td>
<td>16</td>
<td>8.5</td>
<td>25</td>
</tr>
<tr>
<td>SO₂ 1981 µg/m³</td>
<td>43.1 (12.1)</td>
<td>41.5</td>
<td>25.5</td>
<td>66</td>
</tr>
<tr>
<td>BS 1991 µg/m³</td>
<td>11.8 (4.7)</td>
<td>12</td>
<td>3</td>
<td>19</td>
</tr>
<tr>
<td>SO₂ 1991 µg/m³</td>
<td>29.6 (6.5)</td>
<td>29.5</td>
<td>19</td>
<td>40.5</td>
</tr>
<tr>
<td>PM₁₀ 2001 µg/m³</td>
<td>20.7 (2.5)</td>
<td>20</td>
<td>18</td>
<td>24</td>
</tr>
</tbody>
</table>

### Number of deaths by year

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>All-cause excluding accidents</td>
<td>48,834</td>
<td>47,775</td>
<td>45,736</td>
<td>31,744</td>
</tr>
<tr>
<td>Cardiovascular (CVD)</td>
<td>26,140</td>
<td>23,923</td>
<td>20,054</td>
<td>11,876</td>
</tr>
<tr>
<td>Respiratory</td>
<td>6,959</td>
<td>5,300</td>
<td>7,302</td>
<td>4,598</td>
</tr>
</tbody>
</table>
Results – ORs by decade of exposure
Persistent effects of 1971 exposures

All - cause mortality

OR

1.6

1.4

1.2

Mortality 1982-91
Mortality 1992-01
Mortality 2002-09

Decade of outcome

BS71
BS81
BS91

PM2001

www.environment-health.ac.uk
Results – ORs by decade of exposure
Fall in subsequent decades
Results – ORs by decade of exposure
Changes in effect size over time

BS in 1971
2% higher risk per 10µg/m³

PM$_{10}$ in 2001
24% higher risk per 10µg/m³
Results – BS in 1971 and mortality in subsequent decades highest for respiratory

<table>
<thead>
<tr>
<th>Decade of outcome</th>
<th>Adjusted (age, sex, social class, area-level deprivation, region, pop density)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All-cause mortality excluding accidents</strong></td>
<td></td>
</tr>
<tr>
<td>1972-1981</td>
<td>1.05 [1.02;1.08]</td>
</tr>
<tr>
<td>1982-1991</td>
<td>1.03 [1.01;1.06]</td>
</tr>
<tr>
<td>1992-2001</td>
<td>1.04 [1.02;1.05]</td>
</tr>
<tr>
<td>2002-2009</td>
<td>1.02 [1.01;1.04]</td>
</tr>
<tr>
<td><strong>Cardiovascular mortality</strong></td>
<td></td>
</tr>
<tr>
<td>1972-1981</td>
<td>1.03 [0.99;1.08]</td>
</tr>
<tr>
<td>1982-1991</td>
<td>1.04 [1.01;1.07]</td>
</tr>
<tr>
<td>1992-2001</td>
<td>1.04 [1.01;1.06]</td>
</tr>
<tr>
<td>2002-2009</td>
<td>1.01 [0.98;1.04]</td>
</tr>
<tr>
<td><strong>Respiratory mortality</strong></td>
<td></td>
</tr>
<tr>
<td>1972-1981</td>
<td>1.10 [1.02;1.18]</td>
</tr>
<tr>
<td>1982-1991</td>
<td>1.05 [0.99;1.12]</td>
</tr>
<tr>
<td>1992-2001</td>
<td>1.08 [1.04;1.13]</td>
</tr>
<tr>
<td>2002-2009</td>
<td>1.05 [1.01;1.09]</td>
</tr>
</tbody>
</table>
Results – Do past air pollution exposures interact with recent exposures?

- There was a 24% increase in mortality risk per 10 μg/m³ exposure related to PM$_{10}$ particle exposures in 2001.
- Adjusting for past air pollution exposures reduced this to a 21% increase.
- Higher exposures earlier in life did not have a multiplicative effect with recent exposures.
## Results: Correlations

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>BS 1971 n=367,658</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BS 1981 n=305,471</td>
<td>0.696</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BS 1991 n=259,649</td>
<td>0.651</td>
<td>0.769</td>
<td>1.000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM$_{10}$ 2001 n=221,148</td>
<td>0.195</td>
<td>0.200</td>
<td>0.077</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Population density n=367,658</td>
<td>0.441</td>
<td>0.252</td>
<td>0.044</td>
<td>0.380</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>RR lung cancer n=221,148</td>
<td>0.059</td>
<td>0.010</td>
<td>0.007</td>
<td>-0.191</td>
<td>-0.150</td>
<td>1.000</td>
</tr>
</tbody>
</table>
## Results – Sensitivity analyses for BS 1971 and all-cause mortality

<table>
<thead>
<tr>
<th>Decade of outcome</th>
<th>(i) Unadjusted (age and sex only)</th>
<th>(ii) Adjusted (age, sex, social class, area-level deprivation, region, pop density)</th>
<th>Adjusted (ii) plus lung cancer (smoking proxy)</th>
<th>Adjusted (ii) plus and later exposures</th>
<th>Adjusted (ii) - non-movers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All-cause mortality excluding accidents</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1972-2009</td>
<td>1.07 [1.07;1.08]</td>
<td>1.03 [1.02;1.05]</td>
<td></td>
<td></td>
<td>1.03 [1.01;1.05]</td>
</tr>
<tr>
<td>1972-1981</td>
<td>1.10 [1.08;1.11]</td>
<td>1.05 [1.02;1.08]</td>
<td></td>
<td></td>
<td>1.06 [1.02;1.09]</td>
</tr>
<tr>
<td>1982-1991</td>
<td>1.09 [1.08;1.10]</td>
<td>1.03 [1.01;1.06]</td>
<td></td>
<td></td>
<td>1.03 [1.00;1.06]</td>
</tr>
<tr>
<td>1992-2001</td>
<td>1.07 [1.07;1.08]</td>
<td>1.04 [1.02;1.06]</td>
<td></td>
<td>1.01 [0.99;1.03]</td>
<td>1.04 [1.02;1.07]</td>
</tr>
<tr>
<td>2002-2009</td>
<td>1.05 [1.05;1.06]</td>
<td>1.02 [1.01;1.04]</td>
<td>1.02 [1.0;1.04]</td>
<td>1.01 [1.00;1.03]</td>
<td>1.02 [1.00;1.04]</td>
</tr>
</tbody>
</table>
Answers to original research questions

- Is historic air pollution associated with later mortality risk?
  Yes

- Do risks decrease over subsequent decades?
  Yes

- Do past air pollution exposures interact with recent exposures?
  No
Conclusions

• Longest running air pollution follow-up study to date – up to 38 years follow-up

• Air pollution effects on mortality appear to persist over many decades

• Recent exposures are more important than past exposures – biological effect or changes in toxicity?

• Past exposures may confound risk estimates for current exposures, but effects are small and there was no evidence for interactions

• Risk estimates were higher for respiratory than for cardiovascular disease, consistent with other UK and European studies

Air pollution raises risk of death 'for decades after exposure'

Longest running study to date analyses long-term mortality risks of Britons exposed to historic particulate pollution.

Dameon Carrington

Tuesday 1 February 2022 15:05 EST

Air pollution in the 1970s is still being blamed for hundreds of deaths: People exposed to pollutants five decades ago more likely to die in recent years

- More people who lived in environment with dirty air have died since 1971
- Relationship held true even though 72 per cent of study moved house
- The pollution people in the UK face is more toxic now than in the past, the researchers suggested

By COLIN FERNANDES, ENVIRONMENT CORRESPONDENT FOR THE DAILY MAIL
PUBLISHED: 04/02/2012 | UPDATED: 13/02/2012

"Several Killed" In German Train Crash

MRC-PHE
Centre for Environment & Health

**Acknowledgements:**
The permission of the Office for National Statistics to use the Longitudinal Study is gratefully acknowledged, as is the help provided by staff of the Centre for Longitudinal Study Information & User Support (CeLSIUS). CeLSIUS is supported by the ESRC Census of Population Programme (Award Ref: ES/K000365/1).

The work of the UK Small Area Health Statistics Unit is funded by Public Health England as part of the MRC-PHE Centre for Environment and Health, funded also by the UK Medical Research Council. The study also received support from a Wellcome Trust Intermediate Clinical Fellowship study on Chronic Health Effects on Smoke and Sulphur (CHESS), grant number 075883
Appendix
ORIGINAL ARTICLE

Historic air pollution exposure and long-term mortality risks in England and Wales: prospective longitudinal cohort study

Anna Hansell,¹ ² Rebecca E Ghosh,¹ Marta Blangiardo,¹ Chloe Perkins,⁵ Danielle Vienneau,¹ ³ ⁴ Kayoung Goffe,¹ David Briggs,⁵ John Gulliver¹

ABSTRACT

Introduction Long-term air pollution exposure contributes to mortality but there are few studies examining effects of very long-term (>25 years) exposures.

Methods This study investigated modelled air pollution concentrations at residence for 1971, 1981, 1991 (black smoke (BS) and SO₂) and 2001 (PM₁₀) in relation to mortality up to 2009 in 367 658 members of the longitudinal survey, a 1% sample of the English Census. Outcomes were all-cause (excluding accidents), cardiovascular (CV) and respiratory mortality.

Results BS and SO₂ exposures remained associated with mortality decades after exposure—BS exposure in 1971 was significantly associated with all-cause (OR 1.02 (95% CI 1.01 to 1.04)) and respiratory (OR 1.05 (95% CI 1.01 to 1.09)) mortality in 2002–2009 (ORs expressed per 10 µg/m³). Largest effect sizes were seen for more recent exposures and for respiratory disease. PM₁₀ exposure in 2001 was associated with all outcomes in 2002–2009 with stronger associations for respiratory (OR 1.22 (95% CI 1.04 to 1.44)) than CV mortality (OR 1.12 (95% CI 1.01 to 1.25)). Adjusting

Key messages

What is the key question?

What is the impact of very long-term (>30 years) air pollution exposure on mortality?

What is the bottom line?

Historic air pollution exposure has long-term effects on mortality that persist over 30 years after exposure and these potentially also influence current estimates of associations between air pollution and mortality.

Why read on?

This is one of the longest running studies to look at health effects of air pollution, using air pollution estimates independently assessed at multiple time points using contemporaneous monitoring data in a large cohort followed for 38 years.

[www.envhealthatlas.co.uk](http://www.envhealthatlas.co.uk)
Notes

- Statistically significant associations between BS and SO2 exposure in 1971, 1981 and 1991 and mortality in all subsequent decades through to 2002-9

- Exposure to BS in 1971 was associated with a 2% increase risk in mortality in 2002-9 per unit (10 μg/m³) – remained significant with future BS exposures

- More recent exposures had higher ORs – suggests more recent exposures are more important (even though past exposures continue to have an influence) – or increasing toxicity of particulates

- Movers

- Highest effects on respiratory disease

Results – ORs by decade of outcome

All - cause mortality

OR vs Decade of outcome

Mortality 1982-91  Mortality 1992-01  Mortality 2002-09

BS71  BS81  BS91  BS81  BS91  BS91  PM2001