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

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ORIGINAL ARTICLE

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

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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

► Additional material is published online only. To view please visit the journal online (<http://dx.doi.org/10.1136/thoraxjnl-2015-207111>).

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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.

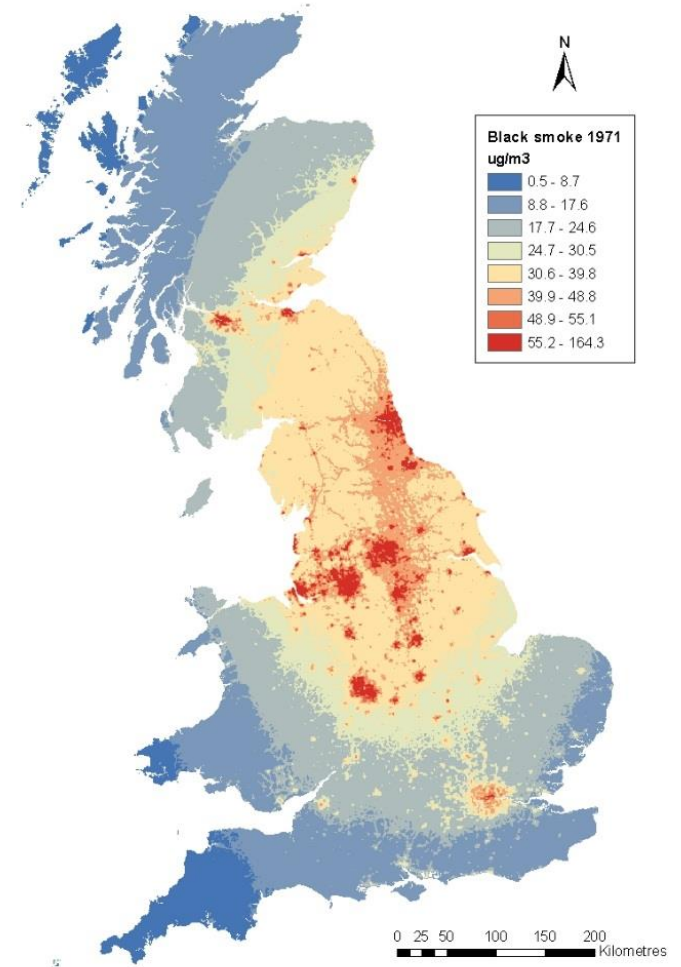
Aims and research questions

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?

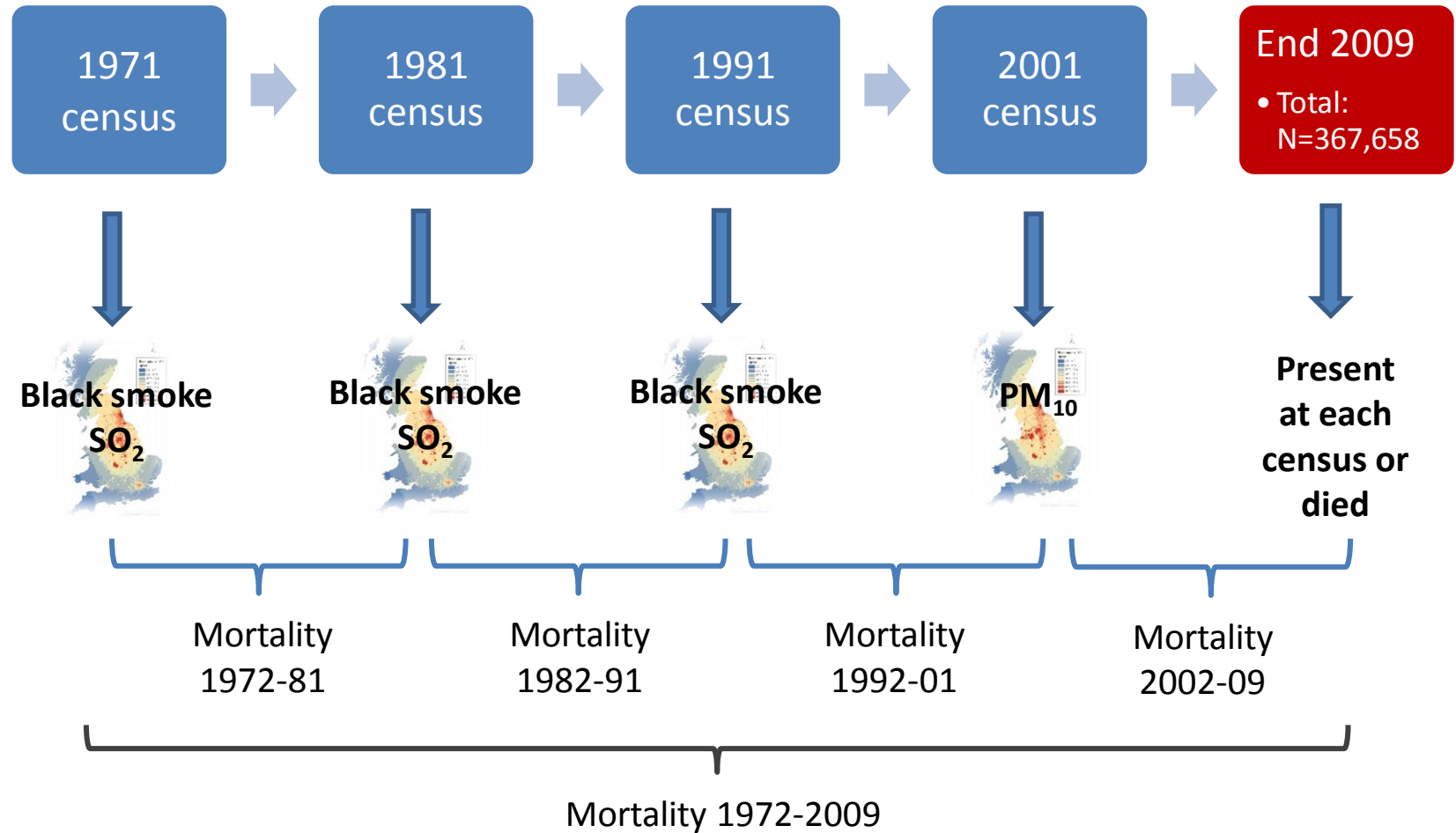
Data

- Black Smoke (BS) and sulphur dioxide (SO₂) air pollution concentrations estimated in 1971, 1981 and 1991 using 1km grids (Gulliver et al, Environ Sci Technol 2011)
- PM₁₀ air pollution concentrations estimated in 2001 at 100m grids (Vienneau et al, Sci Total Environ 2009)
- The ONS Longitudinal Study, started in 1971 with follow-up at Census in 1981, 1991, 2001.



Gulliver J, *et al.* Land use regression modeling to estimate historic (1962-1991) concentrations of black smoke and sulfur dioxide for Great Britain. *Environ Sci Technol* 2011;**45**:3526–32.

Methods

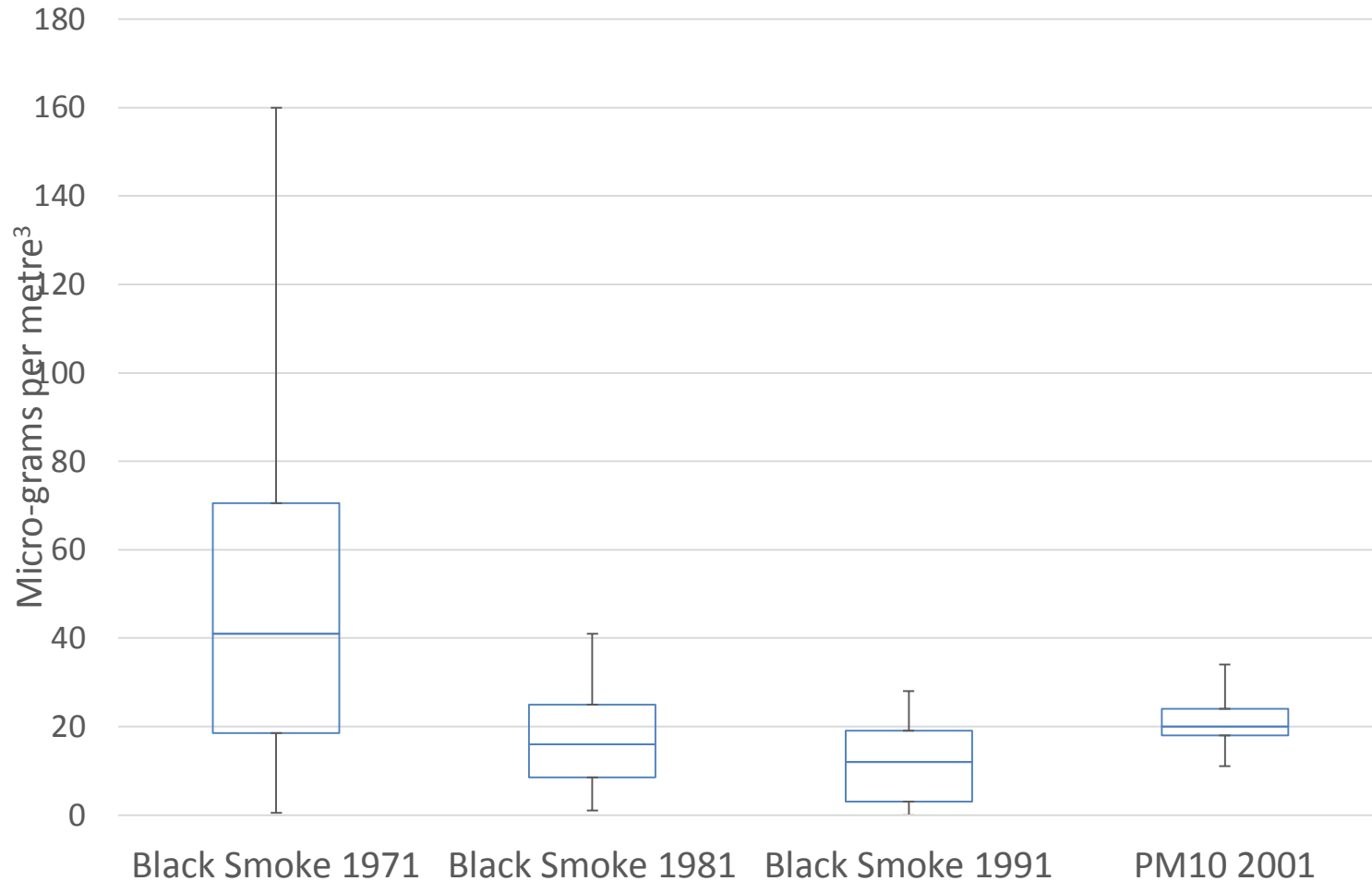


Address linked at ONS to:

Methods: analysis in brief

- Logistic regression analyses for combined years and by decade of death in relation to air pollution exposures 1971,1981, 1991, 2001
- Analyses for all-cause, cardiovascular and respiratory diseases
- Sensitivity analyses

Results: air pollution concentrations over time



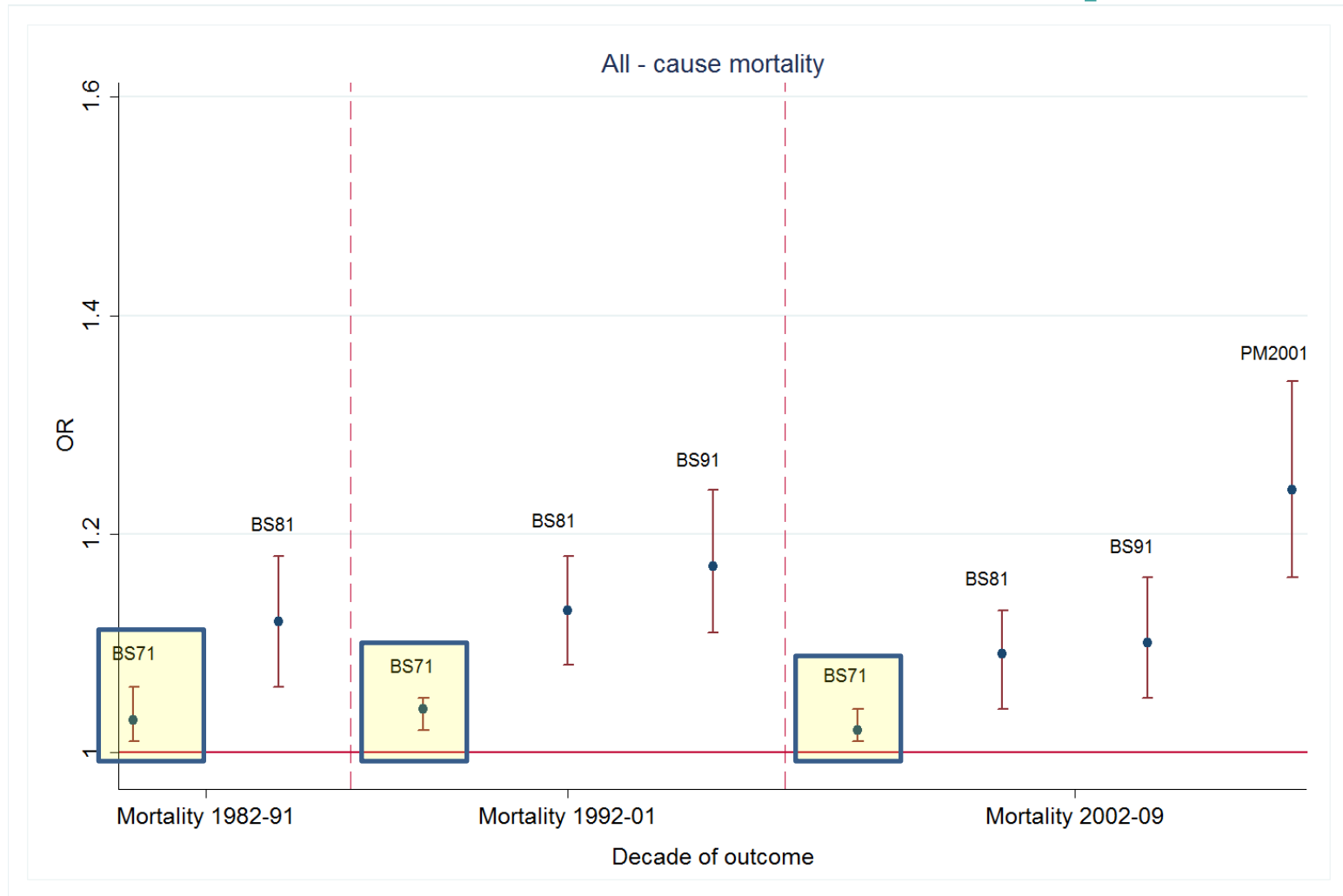
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Results: descriptive statistics

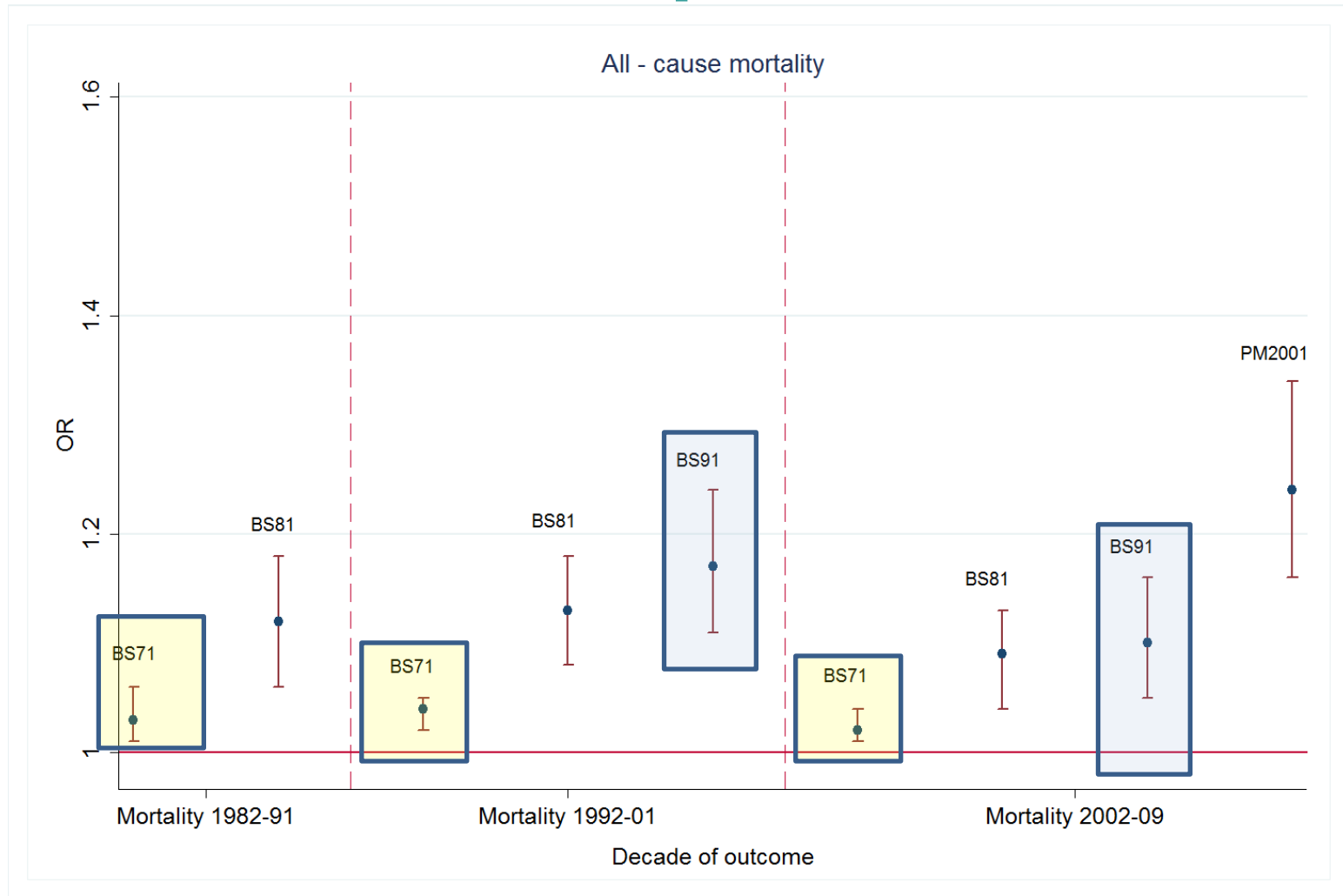
Air pollution	Mean(SD)	Median	10th centile	90th centile
BS 1971 $\mu\text{g}/\text{m}^3$	42.7 (20.4)	41	18.5	70.5
SO ₂ 1971 $\mu\text{g}/\text{m}^3$	85.2 (36.8)	77	44.5	137
BS 1981 $\mu\text{g}/\text{m}^3$	16.2 (5.2)	16	8.5	25
SO ₂ 1981 $\mu\text{g}/\text{m}^3$	43.1 (12.1)	41.5	25.5	66
BS 1991 $\mu\text{g}/\text{m}^3$	11.8 (4.7)	12	3	19
SO ₂ 1991 $\mu\text{g}/\text{m}^3$	29.6 (6.5)	29.5	19	40.5
PM ₁₀ 2001 $\mu\text{g}/\text{m}^3$ ³¹	20.7 (2.5)	20	18	24
Number of deaths by year	1972-1981	1982-1991	1992-2001	2002-2009
All-cause excluding accidents	48,834	47,775	45,736	31,744
Cardiovascular (CVD)	26,140	23,923	20,054	11,876
Respiratory	6,959	5,300	7,302	4,598

Results – ORs by decade of exposure

Persistent effects of 1971 exposures

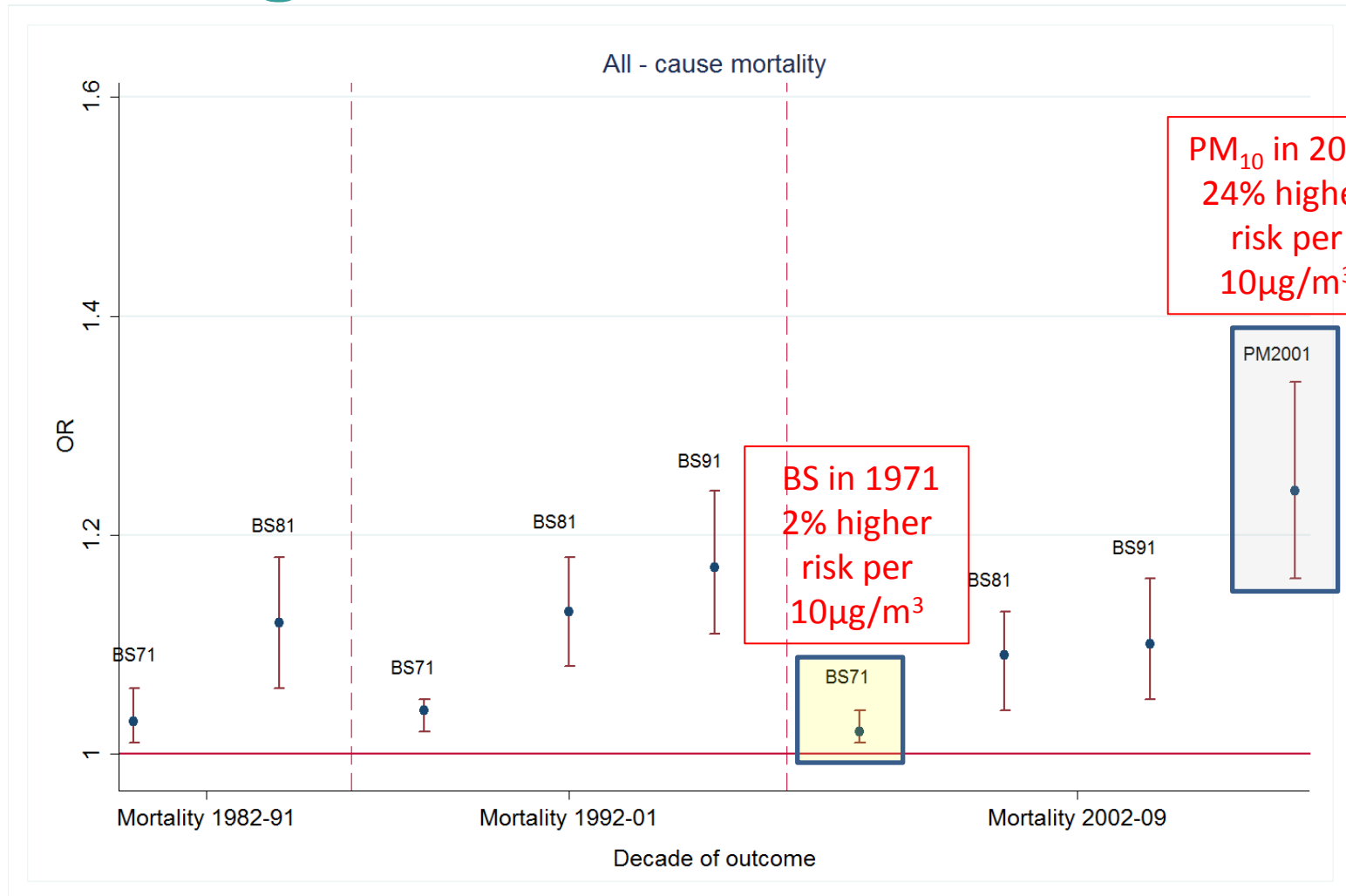


Results – ORs by decade of exposure Fall in subsequent decades



Results – ORs by decade of exposure

Changes in effect size over time



Results – BS in 1971 and mortality in subsequent decades highest for respiratory

Decade of outcome		Adjusted (age, sex, social class, area-level deprivation, region, pop density)
All-cause mortality excluding accidents		
1972-1981		1.05 [1.02;1.08]
1982-1991		1.03 [1.01;1.06]
1992-2001		1.04 [1.02;1.05]
2002-2009		1.02 [1.01;1.04]
Cardiovascular mortality		
1972-1981		1.03 [0.99;1.08]
1982-1991		1.04 [1.01;1.07]
1992-2001		1.04 [1.01;1.06]
2002-2009		1.01 [0.98;1.04]
Respiratory mortality		
1972-1981		1.10 [1.02;1.18]
1982-1991		1.05 [0.99;1.12]
1992-2001		1.08 [1.04;1.13]
2002-2009		1.05 [1.01;1.09]

Results – Do past air pollution exposures interact with recent exposures?

- There was a 24% increase in mortality risk per 10 $\mu\text{g}/\text{m}^3$ 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

	BS 1971	BS 1981	BS 1991	PM ₁₀ 2001	population density	RR lung cancer
BS 1971 n=367,658	1.000					
BS 1981 n= 305,471	0.696	1.000				
BS 1991 n=259,649	0.651	0.769	1.000			
PM ₁₀ 2001 n=221,148	0.195	0.200	0.077	1.000		
population density n=367,658	0.441	0.252	0.044	0.380	1.000	
RR lung cancer n=221,148	0.059	0.010	0.007	-0.191	-0.150	1.000

Results –Sensitivity analyses for BS 1971 and all-cause mortality

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

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



Great smog of London 1952

Hansell et al. Thorax. 2016 Apr;71(4):330-8

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1970s AIR POLLUTION COULD STILL CAUSE DEATHS, REPORT FINDS

09/02/2016 14:54:00 | Environment | No restrictions | 09/03/2016 12:00

Air pollution released decades ago could still be causing deaths today, according to a new study. The study - the largest of its kind ever undertaken in the UK - was not able to calculate how many deaths today were down to historic air pollution, but lead author Dr Anna Hansel said Public Health England had warned pollutants caused some 29,000 early deaths a year.

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Air pollution from 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 FERNANDEZ, ENVIRONMENT CORRESPONDENT FOR THE DAILY MAIL

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Pollution

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

Damian Carrington
@dpcarrington

Tuesday 9 February 2016 06:00 GMT

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Anna Hansell, Rebecca E Ghosh, Marta Blangiardo, Chloe Perkins, Danielle Vienneau, Kayoung Goffe, David Briggs, John Gulliver. Historic air pollution exposure and long-term mortality risks in England and Wales: prospective longitudinal cohort study. *Thorax* 2016. *In press*. doi:10.1136/thoraxjnl-2015-207111.

Acknowledgements:

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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



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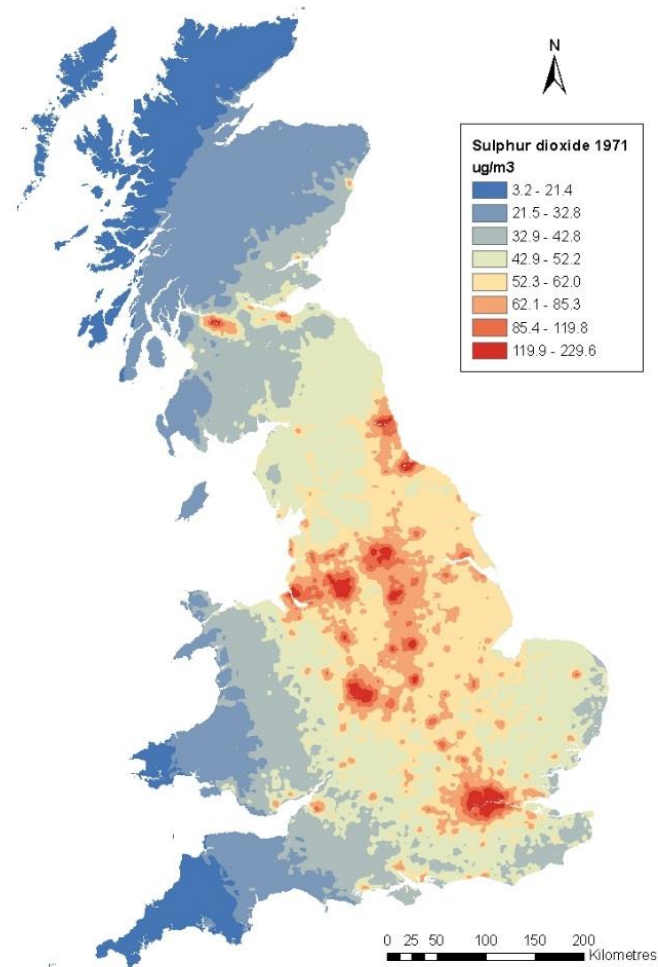
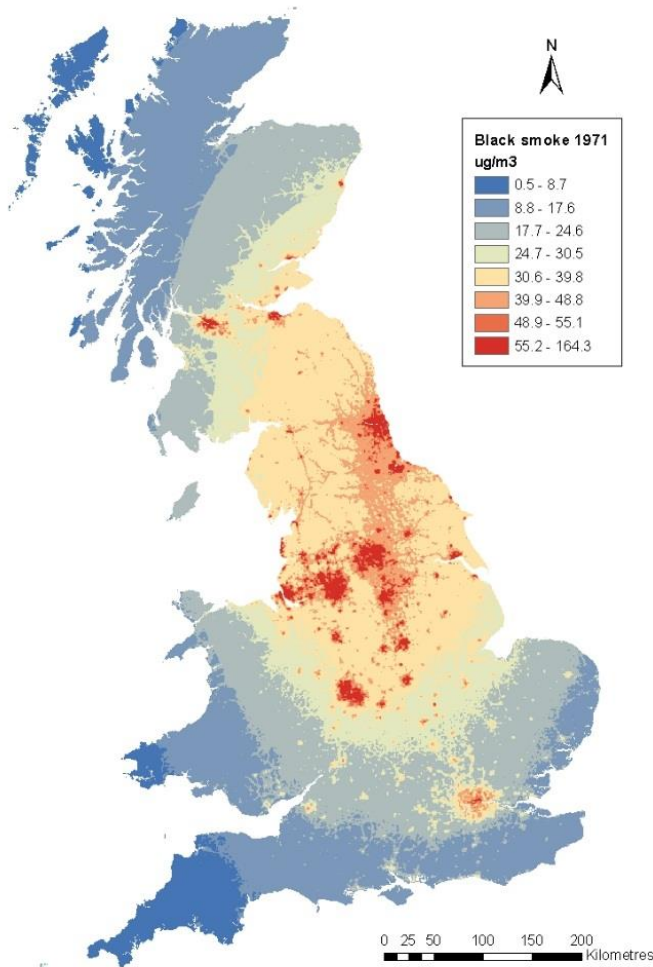
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Notes

- 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
- Similar results for SO₂ in 1971, 1981, 1991

Results – ORs by decade of outcome

BS 1971, 1981, 1991, PM₁₀ 2001

