Institute of Education

Investigating long run trends in health inequality: evidence from British birth cohort studies

CENTRE FOR LONGITUDINAL STUDIES

David Bann

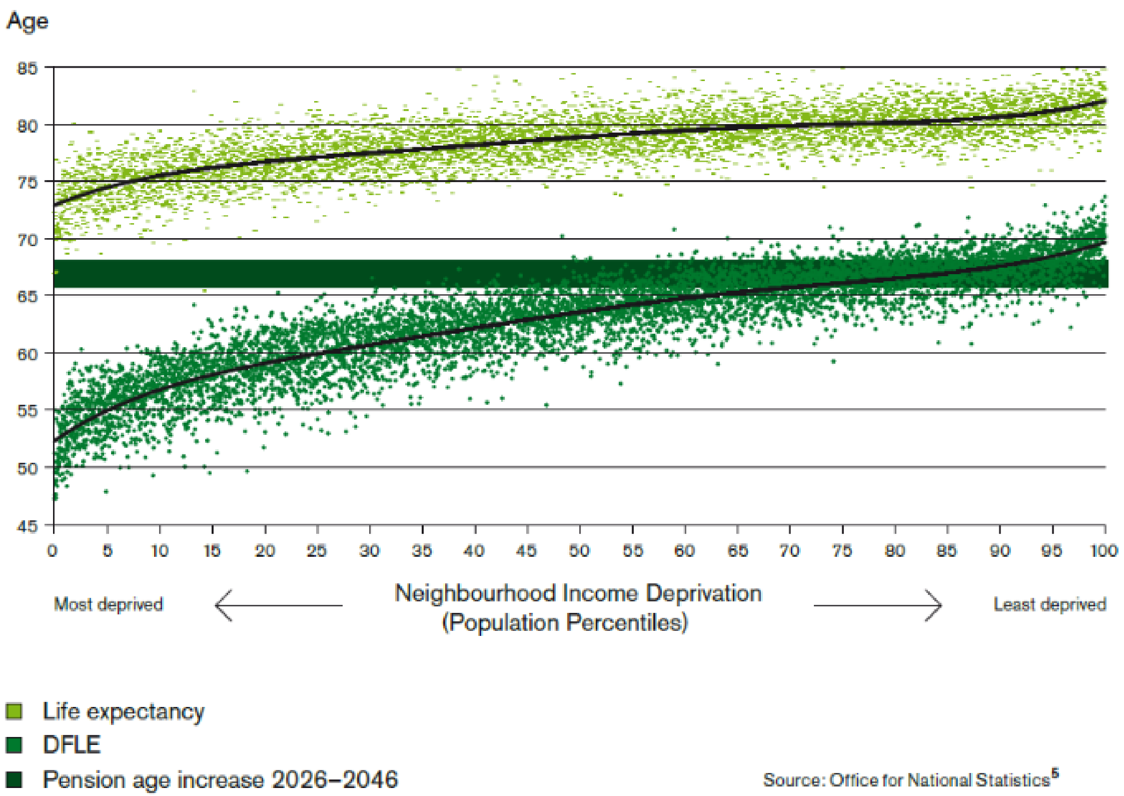
“60 years of our lives: A scientific conference celebrating the National Child Development Study at 60”

Session 1B

Overarching aim

CENTRE FOR
LONGITUDINAL
STUDIES

Figure 1 Life expectancy and disability-free life expectancy (DFLE) at birth, persons by neighbourhood income level, England, 1999–2003



- Substantial health inequalities exist
  - Yet understanding incomplete & complex

- This work:
  - Provide new evidence on long-run trends
  - Using birth cohort studies 1946-2001
  - Require comparable exposure (SEP) and outcomes (health) at similar age

"Socioeconomic inequalities in health: how have they changed in response to changing policy decisions and economic factors, and how may they be reduced?"
Academy Medical Sciences/Wellcome Trust: 2017-2019
PI: David Bann

Thus far, anthropometric outcomes

CENTRE FOR
LONGITUDINAL
STUDIES

PLOS | MEDICINE

RESEARCH ARTICLE

Socioeconomic Inequalities in Body Mass Index across Adulthood: Coordinated Analyses of Individual Participant Data from Three British Birth Cohort Studies Initiated in 1946, 1958 and 1970

David Bann[1]*, William Johnson[2], Leah Li[3], Diana Kuh[4], Rebecca Hardy[4]

1 Centre for Longitudinal Studies, UCL Institute of Education, London, United Kingdom, 2 School of Sport, Exercise and Health Sciences, Loughborough University, Loughborough, United Kingdom, 3 Population, Policy and Practice, UCL Institute of Child Health, London, United Kingdom, 4 MRC Unit for Lifelong Health and Ageing at UCL, London, United Kingdom

* david.bann@ucl.ac.uk

Check for updates

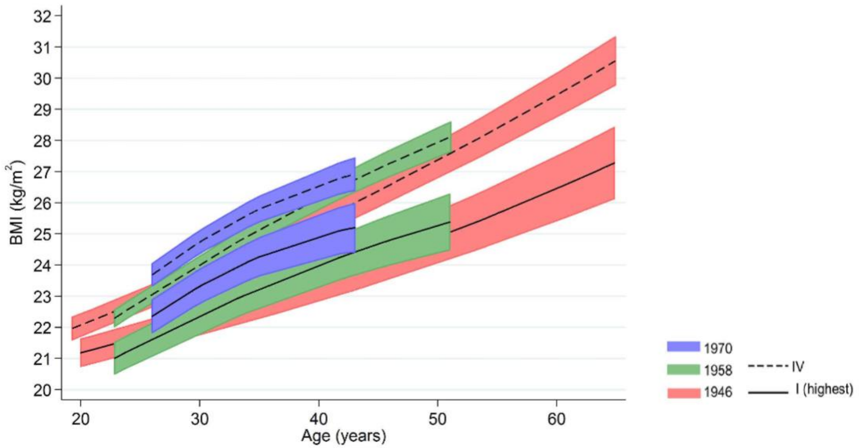


Fig 2. Female BMI across adulthood in relation to father's social class (10/11 y) in the 1946, 1958, and 1970 British birth cohort studies. Note: lines show estimated BMI along with 95% confidence intervals at each age, estimated using multilevel general linear regression models.

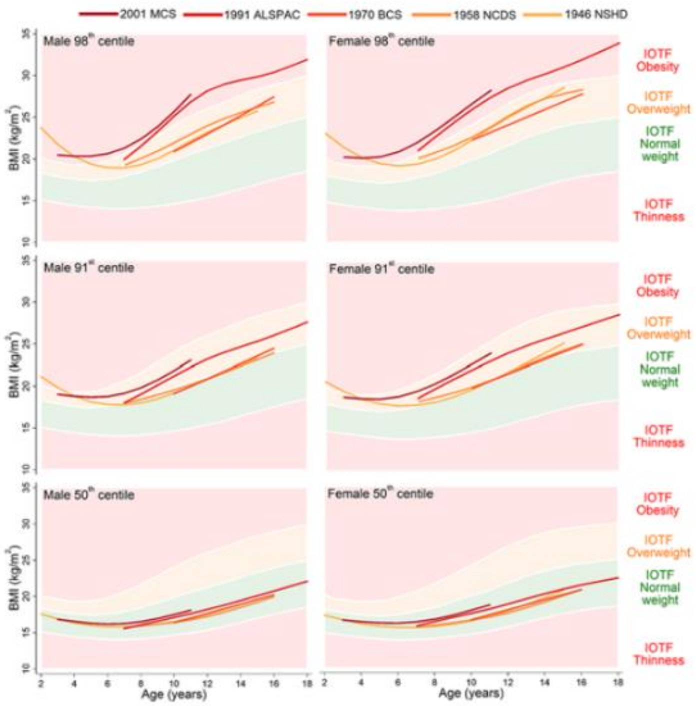
doi:10.1371/journal.pmed.1002214.g002

Socioeconomic Inequalities in Body Mass Index, Weight, and Height in Childhood-Adolescence from 1953 to 2015: Findings From Four British Birth Cohort Studies
David Bann, William Johnson, Leah Li, Diana Kuh, Rebecca Hardy
Lancet Public Health, In press.

Background

- BMI inequalities exist, unclear how changed

- Not well understood:
  1. Separate components of BMI: weight & **height**
  2. Nature of inequality across outcome distribution
  3. Δ age



Johnson et al, PLOS Med, 2015; Bann et al, PLOS Med, 2017

CENTRE FOR LONGITUDINAL STUDIES

Methods

- Weight, height and BMI measurement
  - 1946: 7, 11, 15 years
  - 1958: 7, 11, 16
  - 1970 10, 16
  - 2001: 7, 11, 14
- Father's social class at 10/11y (RGSC) -> ridit score
  - Sensitivity analyses: maternal education

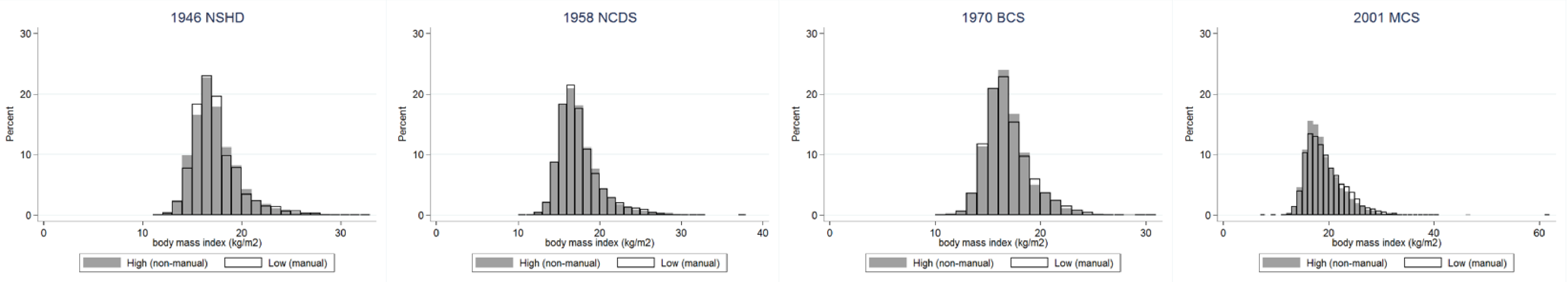
1. Mean difference in outcome in lowest/highest SEP (OLS)
2. SEP differences at different points of the outcome distribution (quantile reg)

Results: slope index of inequality at 11y

CENTRE FOR LONGITUDINAL STUDIES

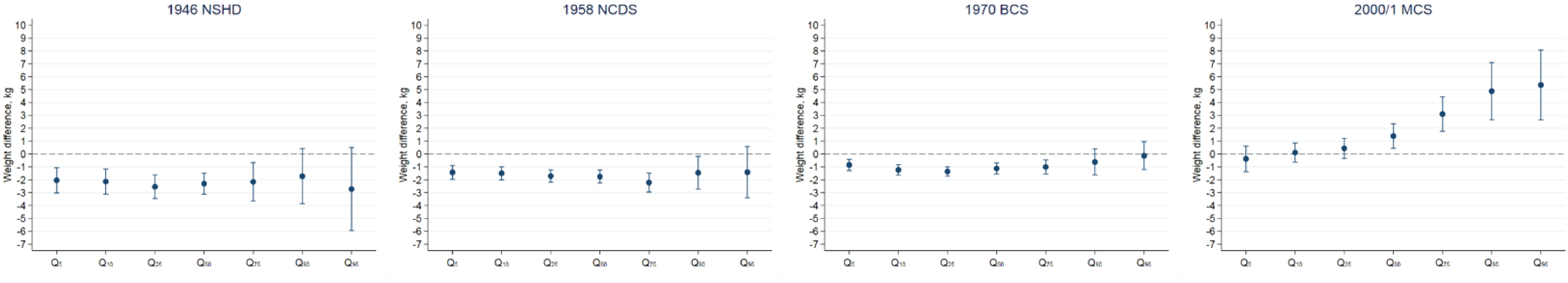
Cohort	N	BMI, kg/m^2	Weight, kg	Height, cm
1946	3629	-0.1 (-0.4, 0.3)	-2.0 (-3.0, -1.1)	-4.1 (-5.1, -3.2)
1958	11193	0.0 (-0.2, 0.1)	-1.8 (-2.3, -1.3)	-3.5 (-3.9, -3.0)
1970	11231	0.1 (0.0, 0.3)	-1.0 (-1.3, -0.6)	-2.7 (-3.1, -2.3)
2001	8820	1.3 (0.9, 1.6)	2.1 (1.2, 2.9)	-1.2 (-1.7, -0.6)

Results: histograms at 11y, by social class



CENTRE FOR LONGITUDINAL STUDIES

Results: quantile regression, weight at 11y



Weight quantile | Weight quantile | Weight quantile | Weight quantile

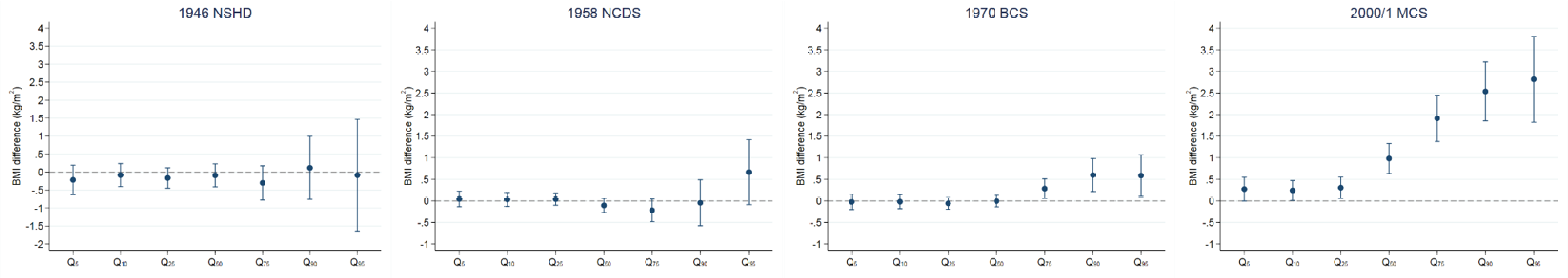
1.40 kg difference at the 50th percentile, 4.88 kg at the 90th

Coefficients are interpreted analogously to linear regression: eg, the median difference in outcome

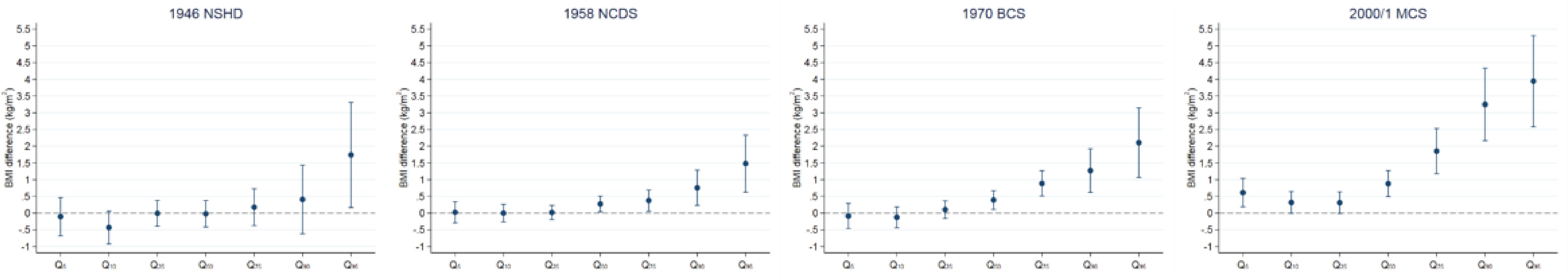
Quantiles at 5th, 10th, 25th, 50th (median), 75th, 90th, and 95th

Results: quantile regression, BMI at 11y

CENTRE FOR
LONGITUDINAL
STUDIES



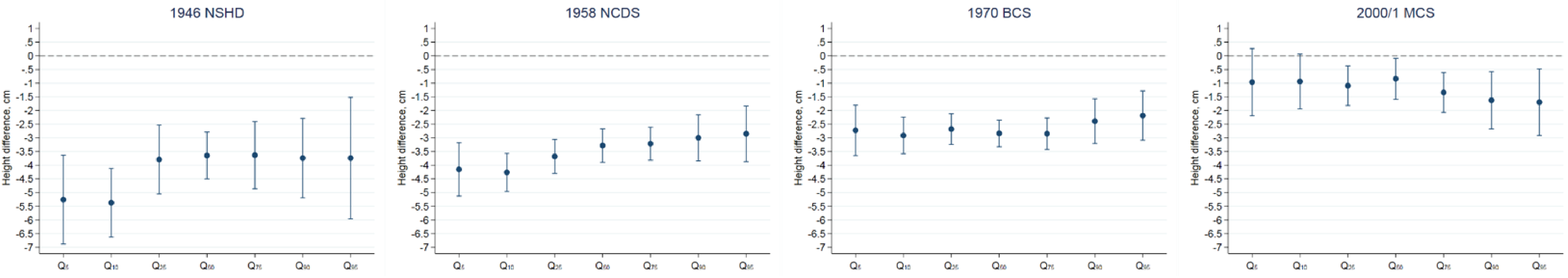
BMI at 15y



Quantiles at 5th, 10th, 25th, 50th (median), 75th, 90th, and 95th

CENTRE FOR LONGITUDINAL STUDIES

Results: quantile regression, height at 11y

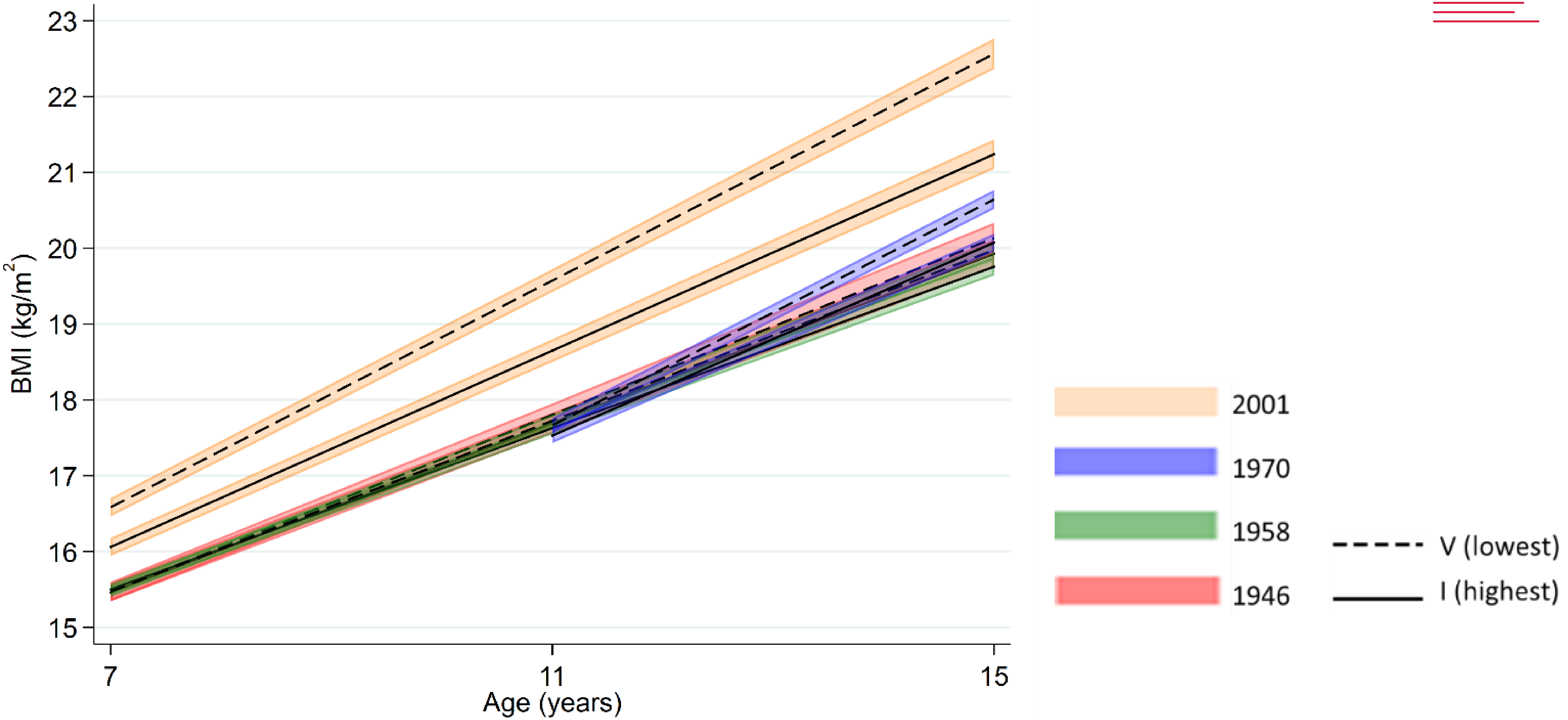


Height quantile Height quantile Height quantile Height quantile

Coefficients are interpreted analogously to linear regression: eg, the median difference in outcome
Quantiles at 5th, 10th, 25th, 50th (median), 75th, 90th, and 95th

Results: multilevel models, 7-15y

CENTRE FOR LONGITUDINAL STUDIES



Body mass index (BMI) across childhood and adolescence in relation to father's social class in 1946, 1958, 1970, and 2001 British birth cohort studies. Note: lines show estimated BMI along with 95% confidence intervals at each age among women, estimated using multilevel general linear regression models (full model estimates shown in S3 Table).

Summary of findings

CENTRE FOR LONGITUDINAL STUDIES

- From 1953 to 2015, absolute inequalities in:
  - Height narrowed
  - Weight reversed
  - BMI emerged
    - Larger at higher end of distribution
    - Widened from childhood-adolescence

Potential explanations

Social distribution of the determinants of weight/height

- Despite rationing, inequalities in diet evident at 4y in 1946c:
  - Lower SES -> ↓ total calories likely reversed in 2001
    ↓ micronutrients (eg, Zinc) potentially narrower in 2001
    lower infectious disease
    parental obesity in 2001

Distributional effects

- Larger SEP impact among those who…

  for environmental / genetic reasons, more susceptible to higher BMI

Prynne et al, 2002; Mayo-Wilson et al, 2014; Goisis et al, 2015; Costa et al, 2015

Strengths & limitations

CENTRE FOR LONGITUDINAL STUDIES

- 4 national studies, 1953-2015
  - Not powered to evaluate thinness, ethnic modification
  - 30-year gap from 1970 to 2001

- Findings robust to fathers social class & maternal education
  - Still crude SEP indicators & BMI !=fat
  - Attrition could potentially bias

- Causality not empirically demonstrated

Policy considerations (assuming causal, robust etc)

- Narrowing height inequalities vs emergence & widening BMI inequalities
  - BMI likely greater impact on population health

- Persistence of BMI inequalities to 2015
  - Widening w/age & expected to widen further (eg, to 60-64y in 2065)
  - Urgent need to reduce BMI inequalities via effective policies

CENTRE FOR
LONGITUDINAL
STUDIES

Acknowledgments

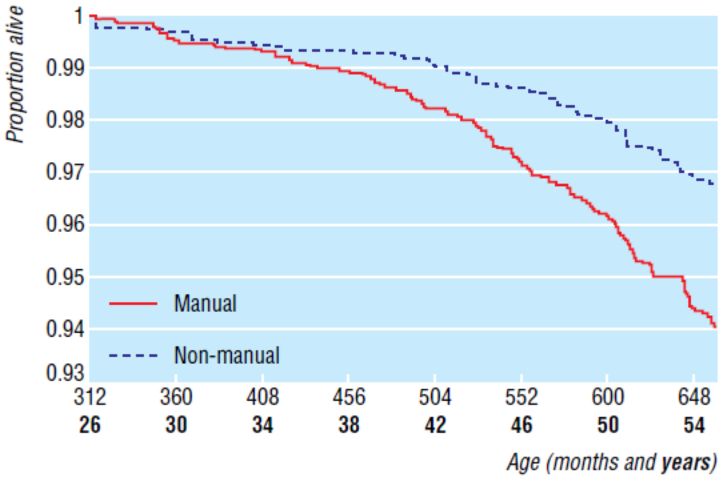
- Co-authors
- Colleagues, participants
- Funders
  - Academy of Medical Sciences/Wellcome Trust
  - ESRC
  - CLOSER (ESRC & MRC)

david.bann@ucl.ac.uk

Appendix

Potential future directions

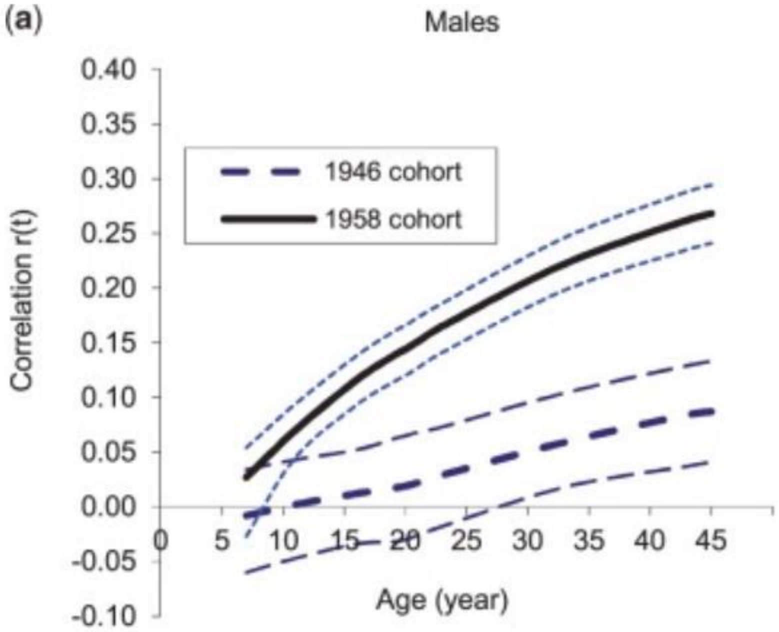
Mortality



Cumulative death rates age 26 to 54 years by father's social class in 4271 (201 deaths) men and women born in March 1946

Kuh et al, BMJ 2002

Blood pressure



Li et al, IJE 2015

Costs of *in utero* exposure to pollution across childhood

Claryn Kung[*], Martin Knapp[*], Jeroen Luyten[†], Martin Rossor[‡], Marcus Richards[‡]

[*]LSE; [†]KU Leuven; [‡]UCL

NCDS 60 years of our lives

March 8-9, 2018, London

Motivation and aim

Evidence for effects of early life exposure to pollution

- infant mortality (Chay & Greenstone 2003; Currie & Neidell 2005)
- birthweight (Bobak *et al.* 2001)
- childhood stature (Peet 2017)
- respiratory health (Bharadwaj *et al.* 2016)
- school performance (Bharadwaj *et al.* 2017)
- earnings (Isen *et al.* 2017)

Motivation and aim

Recent studies have quantified costs focussing on lifetime earnings:

- 10% ↓ in total suspended particulate matter associated with lifetime earnings gain of US$4340/person (Isen *et al.* 2017)
- 25% ↓ in ozone precursor emissions associated with US$1367/person (Peet 2017)
- 50% ↓ in CO emissions associated with US$1000/person (Bharadwaj *et al.* 2017)
- ↓ from 10 to 5 µg/dL in blood lead concentrations associated with US$507/person (Grönqvist *et al.* 2017)

Missing from estimations are further costs to society, particularly service use, which this study aims to quantify

Data

NCDS childhood waves: 7y, 11y, 16y

Cognitive and health outcomes

- School literacy and numeracy scores
- Whether received, or deemed by medical examiner or teacher to require, special education
- Probability of respiratory problems
- Whether seen by a doctor or received treatment for respiratory problems (e.g. asthma/wheezy bronchitis
- Mental and behavioural problems
- Whether seen by a mental health specialist or received treatment for mental or behavioural problems

Rich set of family covariates

Data

Pollution data for year ending March 31, 1958

- Monthly readings of sulphur dioxide concentrations, measured using lead peroxide method (1118 instruments across different local authorities in England, Scotland and Wales)
- Average across the year taken as *in utero* exposure of the NCDS cohort
- Matched to cohort members by local authority of birth

Public finance data

- Spending on education by local authority

Census data

- Unemployment rate, population size, % males classified as employers/managers/professionals

Method

$$Y_i = \beta pollution_i + X'_i\gamma + \varepsilon_i$$

- Y_i cognitive or health outcome
- $pollution_i$ indicates if cohort member born in most polluted quartile
- X'_i captures family, school, and local authority covariates

Descriptive statistics

Pollution/covariate	Quartiles 1-3		Quartile 4 (inc. London)	
	M	*SD*	*M*	*SD*
Concentration of pollutants				
Sulphur dioxide	1.47	0.57	2.72	0.35
Black smoke	16.80	10.05	23.15	5.41
Family economic conditions				
Father in professional, managerial, clerical, and skilled non-manual occupations (recorded at birth)	0.27	0.44	0.28	0.45
Father stayed in full-time education after min. age	0.40	0.49	0.39	0.49
Mother stayed in full-time education after min. age	0.51	0.50	0.49	0.50
Family experiencing financial difficulties at 7y	0.08	0.27	0.10	0.30
Family social background				
Child was breastfed	0.43	0.50	0.46	0.50
Mother smoked during pregnancy	0.33	0.47	0.36	0.48
Father appeared interested in child's educational progress (teacher-reported, 7y)	0.75	0.43	0.76	0.43
Mother appeared interested in child's educational progress (teacher-reported, 7y)	0.84	0.36	0.85	0.36
Mother read to, or with, child at 7y	0.49	0.50	0.45	0.50
N	7716		2548	

THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

PSSRU
Personal Social Services Research Unit

Descriptive statistics

Pollution/covariate	Quartiles 1-3		Quartile 4 (inc. London)	
	M	*SD*	*M*	*SD*
School environment at 7y				
Number of pupils in class	35.41	7.18	37.65	6.51
% pupils in class whose fathers were in professional, managerial, clerical, or skilled non-manual occupations	0.23	0.24	0.25	0.36
Local authority characteristics (1961 Census)				
Population size ('000)	821.37	669.74	2270.00	1194.06
Amount spent on education (£'000) at 16y	82.66	5.87	98.19	13.02
Unemployment rate	0.03	0.01	0.03	0.01
% occupied and retired males classified as employers, managers or professionals	0.14	0.04	0.11	0.01
N	7716		2548	

THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

PSSRU Personal Social Services Research Unit

Main results

Effects on cognitive ability

	(1)	(2)	(3)	(4)	(5)
General ability (11y)					
Verbal	-0.116***	-0.095***	-0.056*	-0.076***	-0.062**
N=10264	(0.031)	(0.029)	(0.029)	(0.029)	(0.031)
	0.015	*0.146*	*0.188*	*0.190*	*0.190*
Non-verbal	-0.164***	-0.143***	-0.103***	-0.121***	-0.054*
N=10264	(0.031)	(0.030)	(0.029)	(0.029)	(0.032)
	0.003	*0.121*	*0.162*	*0.164*	*0.167*
Family social background		Y	Y	Y	Y
Family econ. conditions			Y	Y	Y
School environment				Y	Y
LA characteristics					Y

Note: Coefficients describe the adjusted associations between being born in the NCDS cohort quartile with the highest average concentration of sulphur dioxide for the year ending March 31, 1958. All regressions additionally control for gender, number of instruments measuring SO_2 in each local authority, and an indicator for the capital city (London). Standard errors in parentheses and R^2 values are italicized.

$^{*}p<0.1$, $^{**}p<0.05$, $^{***}p<0.01$

Main results

Effects on physical and mental health

	(1)	(2)	(3)	(4)	(5)
Asthma/wheezy bronchitis					
7y	-0.006	-0.005	-0.004	-0.004	0.007
N=9223	(0.013)	(0.013)	(0.013)	(0.013)	(0.014)
	0.003	*0.008*	*0.009*	*0.009*	*0.010*
11y	-0.008	-0.008	-0.007	-0.008	0.013
N=9311	(0.015)	(0.015)	(0.015)	(0.016)	(0.017)
	0.003	*0.010*	*0.011*	*0.011*	*0.014*
BSAG score					
7y	0.064*	0.048	0.036	0.034	0.051
N=9388	(0.033)	(0.032)	(0.032)	(0.032)	(0.034)
	0.026	*0.117*	*0.122*	*0.122*	*0.123*
11y	0.072**	0.054*	0.039	0.042	0.044
N=10191	(0.032)	(0.031)	(0.031)	(0.031)	(0.034)
	0.027	*0.083*	*0.092*	*0.092*	*0.092*
Family social background		Y	Y	Y	Y
Family econ. conditions			Y	Y	Y
School environment				Y	Y
LA characteristics					Y

Note: Coefficients describe the adjusted associations between being born in the NCDS cohort quartile with the highest average concentration of sulphur dioxide for the year ending March 31, 1958. All regressions additionally control for gender, number of instruments measuring SO_2 in each local authority, and an indicator for the capital city (London). Standard errors in parentheses and R^2 values are italicized.

$^{*}p<0.1$, $^{**}p<0.05$, $^{***}p<0.01$

Associated costs

Estimated Pr(special education) for cohort members from most polluted quartile are higher (*ps*<0.05)

- 4.5 percentage points at 7y
- 4.1 percentage points at 11y
- Non-significant at 16y

Using the national average unit cost associated with special schools provision from public finance data from year ending March 31, 1977:

- A child born in this quartile would cost £125.39 for special education needs from ages 7y to 11y in present value terms (discounted to birth, 1977 prices)
- A 20% reduction in pollution exposure (if concentrations in worst quartile were on average similar to concentrations in other quartiles) would lead to these savings

Conclusion

Combining NCDS data with air pollution data records during *in utero* months, along with public finance and census data:

- After adjusting for family, school and local authority factors, births in more polluted areas associated with and poorer cognitive ability, school performance and Pr(special education)
- A 20% reduction in pollution can be associated with savings of around £732.79 per child (2017 prices)

A1: Robustness checks

Robustness checks for cognitive ability at 11y

	(1) Baseline	(2) ln(SO_2)	(3) Using ln(black smoke)	(4) Baseline + SO_2 at 3y
Verbal ability	-0.062**	-0.044*	0.031	-0.106**
	(0.031)	(0.023)	(0.025)	(0.042)
	0.190	*0.190*	*0.201*	*0.198*
Non-verbal ability	-0.054*	-0.037	-0.002	-0.082*
	(0.032)	(0.023)	(0.025)	(0.043)
	0.167	*0.167*	*0.177*	*0.173*
N	10264	10264	6406	7468
After multiple imputation				
Verbal ability			-0.021	-0.084**
			(0.022)	(0.034)
Non-verbal ability			-0.025	-0.067*
			(0.022)	(0.035)
N			10064	10034

In Column (1), coefficients describe the adjusted associations between being born in the NCDS cohort quartile with the highest average concentration of sulphur dioxide for the year ending March 31, 1958. Column (2) presents coefficients when the natural logarithm of sulphur dioxide concentrations in place of the indicator variable for being in the cohort quartile with the highest concentrations. Column (3) follows the baseline model in Column (1), but includes average sulphur dioxide concentrations measured in the year ending March 31, 1962 (and number of instruments measuring SO_2 that year in each local authority). Column (4) presents coefficients when using the natural logarithm of black smoke concentrations in place of the indicator variable for being in the cohort quartile with the highest concentrations. All regressions account for family social background and economic conditions, as well as school and local authority characteristics, as in Column (5) on cognitive effects. All regressions also control for gender, number of instruments measuring SO_2 in each local authority, and an indicator for the capital city (London). Regressions employing multiple imputation procedures additionally include an indicator variable for imputed values. Standard errors in parentheses and R^2 values are italicized. $^{*}p<0.1$, $^{**}p<0.05$, $^{***}p<0.01$

A2: Limitations

Not causal, estimates likely downward biased

- Seen also in OLS estimates of past studies
- Negative confounders e.g. unobserved LA conditions (+vely) assoc with pollution and (+vely) assoc with cognitive and health endowments and development, also parental avoidance behaviours, compensatory investments (Currie et al. 2014; Bharadwaj et al. 2017)

Cohort effects

- Improvements in air quality due to CAA
- MCS poses an opportunity for comparison

Cannot attribute to single pollutant

In utero vs later life exposure

- Checked with concentrations at age 2
- Isen *et al.* (2017) found no differences in earnings between groups born in polluted conditions but with different adult exposure