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Impacts of London's road traffic air and noise pollution on foetal growth

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Background

Previous research – air pollution + noise

Study	Exposure	Gehring et al 2014	Dadvand et al 2014	Hjortebjerg et al 2016
Setting		Vancouver	Barcelona	Denmark
Size		n=68,238	n=6,438	n=75,166
Single-exposure models:	Air pollution	↓ BW	↓ BW	Null
	Noise	↓ BW	↓ BW	Null
Joint air pollution-noise models:	Air pollution (adj. for noise)	Null	↓ BW	Null
	Noise (adj. for air pollution)	↓ BW	Null	Null

(Gehring et al. Epidemiology. 2014; 25: 351-358. Dadvand et al. Epidemiology. 2014; 25: 518-525. Hjortebjerg et al. Environ Int. 2016; 95:1-7.)

- Extent to which observed air pollution associations attributable to road traffic noise co-exposures is poorly understood

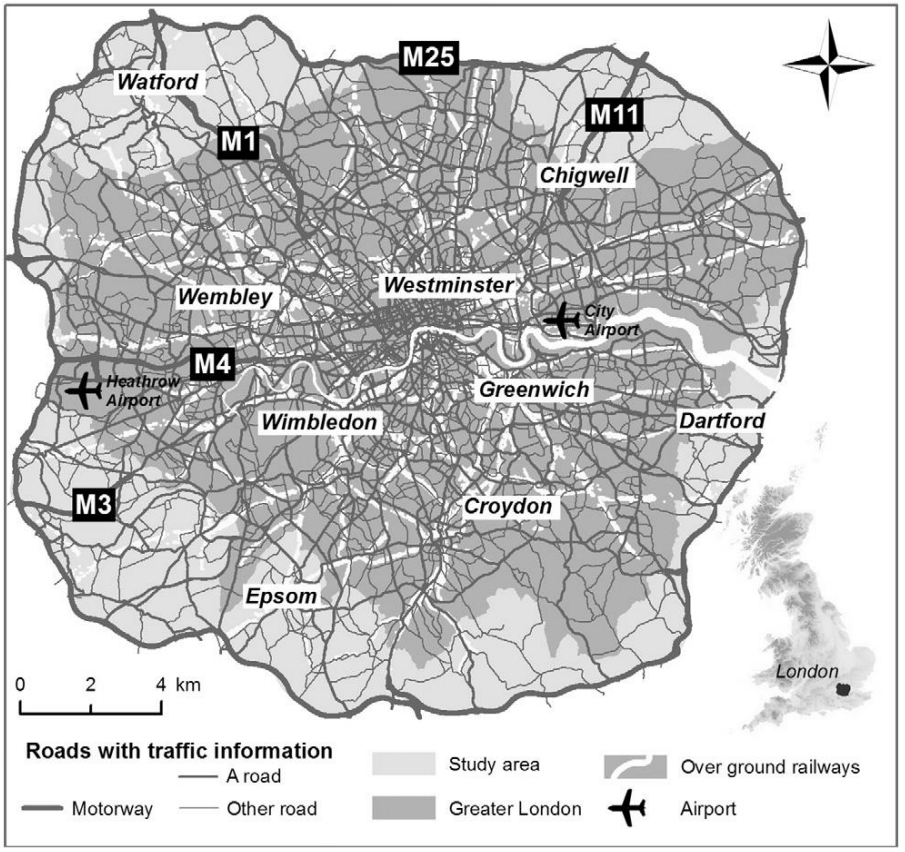
Aim

To investigate long-term exposure to traffic-related air pollution and noise in relation to foetal growth.

Study design

- **Greater London area** bounded by the M25 motorway, **2006-2010**

- Retrospective population-based cohort



Fecht et al. Environ Int. 2016; 88: 235-242. Reproduced with permission.

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Exposure assessment – air pollution

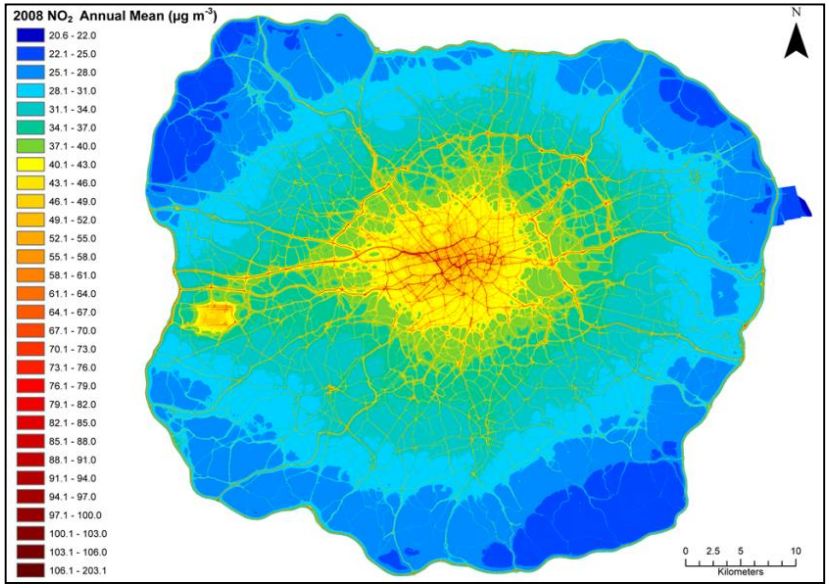
Primary traffic air pollutants:

- NO2
- NOX
- PM2.5 from traffic-exhaust
- PM2.5 from traffic non-exhaust (brake/tyre wear and re-suspension)

Regional/urban background air pollutants:

- PM2.5
- PM10
- Ozone

Fig 1. Modelled annual mean NO2 (2008)



From Traffic Pollution & Health project website: http://www.kcl.ac.uk/lsm/research/divisions/aes/research/ERG/research-projects/traffic/ TRAFFIC-SM-Air-pollution-Model.pdf

- Dispersion model (KCLurban) at 20m x 20m grid resolution (1)
- Monthly concentrations for Jan 2003 - Dec 2010
- Time-weighted average for pregnancy, each trimester, and postnatal time periods

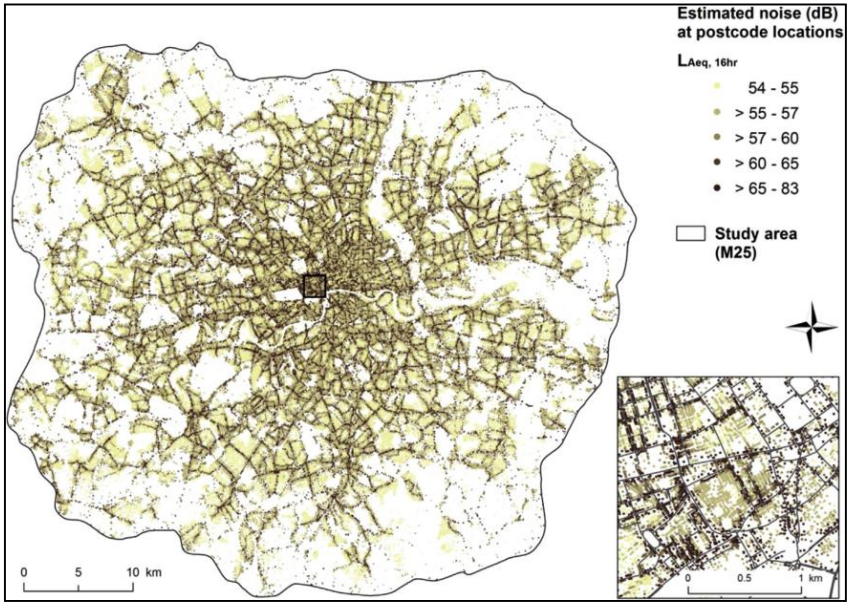
(1) Beevers et al. J Exp Sci Environ Epidemiol. 2013; 23, 647-653.

Exposure assessment – noise

Road traffic noise

- A-weighted **day- and night-time noise** exposures estimated
- $\mathbf{L_{Aeq,16hr}}$ (average sound level 0700 – 2300 hours)
- $\mathbf{L_{night}}$ (average sound level 2300 – 0700 hours)
- modelled at address-level for 2007 using the TRAffic Noise EXposure (TRANEX) model (1)

Fig 1. Modelled road traffic noise across study area



Gulliver et al. Environ Modelling Software. 2015;183-193. Reproduced with permission.

Rail/aircraft noise

- Exposure to Lday>50dB(A) from railways or aircraft (Heathrow Airport and City Airport) – for sensitivity analyses

(1) Gulliver et al. Environmental Modelling & Software. 2015; 75: 183-193

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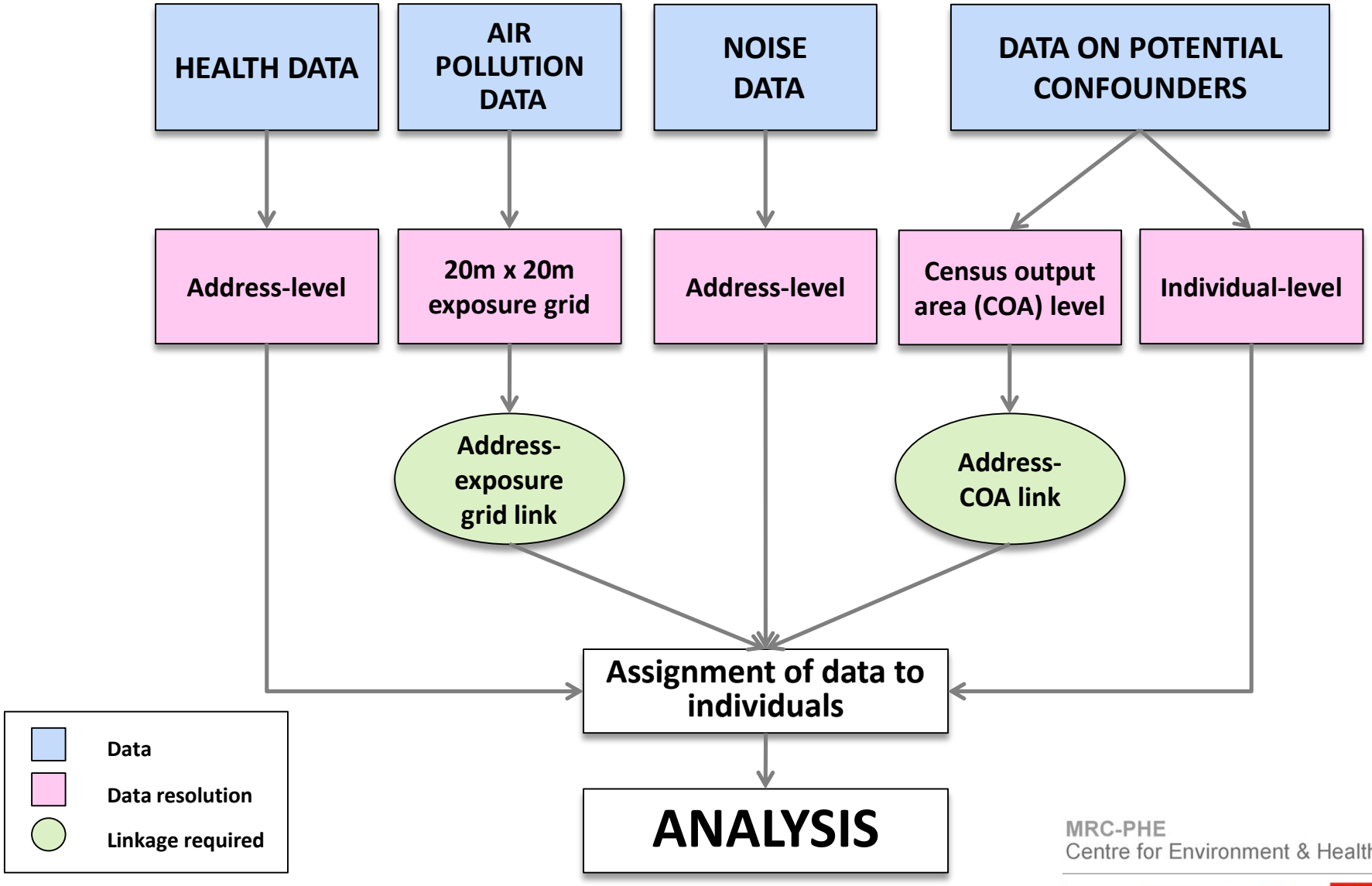
Outcome and confounder data

- 572,910 singleton live births from National Births Register

- **Continuous birth weight** (grams) - limited to term births (≥37 wks gestation)

- Confounders: maternal age, birth registration type, ethnicity, infant sex, gestational age, season, year, Carstairs deprivation index, tobacco expenditure, MSOA random intercept

Data linkage



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Methods – epidemiological analysis

Linear regression

Exposures:

- Air pollutants – continuous (per IQR)
- Noise – categorical

Models:

- Single exposures
- Two air pollutant exposures
- Joint air pollutant + noise exposures

Adjustment for potential confounders

Exposure profile of the study population

Exposures	Mean	Min	25th	75th	Max
Primary traffic-related air pollutants (µg/m³)					
NO_2	**40.6**	20.6	36.0	44.6	191.6
NOx	**72.5**	26.6	59.9	82.7	543.7
$PM_{2.5}$ traffic-exhaust	**0.61**	0.16	0.45	0.72	7.10
$PM_{2.5}$ traffic non-exhaust	**0.73**	0.20	0.56	0.84	6.59
Regional/urban background air pollutants (µg/m³)					
$PM_{2.5}$	**14.4**	10.3	13.4	15.4	26.6
PM_{10}	**23.1**	13.6	21.8	24.5	48.8
O_3	**31.9**	4.9	27.6	36.2	55.8
Noise (dB)					
Day-time noise ($L_{Aeq,16hr}$)	**58.1**	54.7	55.0	58.5	86.0
Night-time noise (L_{night})	**53.2**	49.6	49.9	53.8	80.0

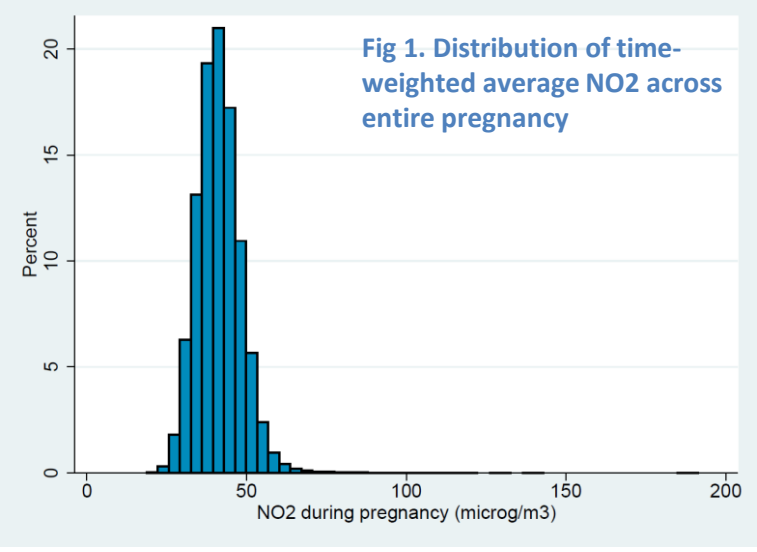


Fig 1. Distribution of time-weighted average NO2 across entire pregnancy

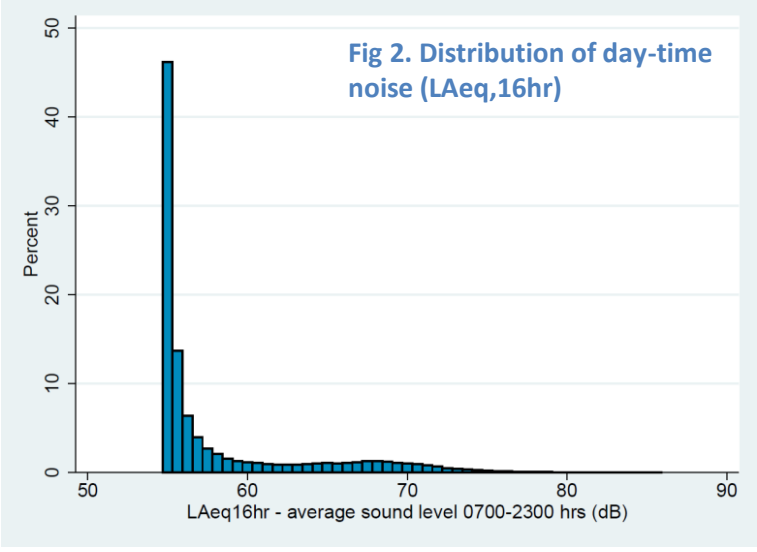


Fig 2. Distribution of day-time noise (LAeq,16hr)

Correlations between exposures

Spearman's correlation	NO_2	NO_X	$PM_{2.5}$ traffic-exhaust	$PM_{2.5}$ traffic non-exhaust	$PM_{2.5}$	PM_{10}	O_3	$L_{Aeq,16hr}$	L_{night}
NO_2	1.00								
NO_X	1.00	1.00							
$PM_{2.5\ traffic\text{-}exhaust}$	0.95	0.95	1.00						
$PM_{2.5\ traffic\ non\text{-}exhaust}$	0.90	0.89	0.93	1.00					
$PM_{2.5}$	0.68	0.69	0.68	0.46	1.00				
PM_{10}	0.77	0.78	0.78	0.58	0.95	1.00			
O_3	-0.76	-0.77	-0.68	-0.66	-0.46	-0.53	1.00		
$L_{Aeq,16hr}$	0.31	0.29	0.38	0.47	0.15	0.23	-0.14	1.00	
L_{night}	0.33	0.32	0.41	0.50	0.16	0.24	-0.15	1.00	1.00

- Air pollutant exposures were positively correlated, except with O3
- Primary traffic-related air pollutant exposures highly correlated
- Day- and night-time noise exposures highly correlated
- Weak to moderate correlation between exposures to traffic-related air pollutants and road traffic noise

Selected characteristics, birth outcomes, exposures

Variable		N	Mean birth weight (g)	LBW (%)	NO_2 - Mean pregnancy average (µg/m3)	$L_{Aeq, 16hr}$ (% exposed ≥65dB)
	Total population	572,910	3330	5.68	40.6	14.2
Ethnicity	**White**	301,426	3415	4.25	39.8	12.9
	Asian	99,773	3135	8.78	40.9	15
	Black	98,687	3275	7.06	42.0	15.3
	Other	73,024	3318	5.45	41.4	16.6
Carstairs quintile	**1 - least deprived**	89,401	3418	3.82	37.3	9.2
	2	97,039	3380	4.56	39.3	13.6
	3	106,936	3337	5.53	40.4	15.2
	4	126,815	3303	6.28	41.1	15.9
	5 - most deprived	152,719	3263	7.08	43.0	15.2
Year of birth	**2006**	108,190	3317	6.08	42.3	13.7
	2007	113,092	3324	5.82	40.6	13.9
	2008	113,213	3330	5.74	42.1	14.1
	2009	116,454	3336	5.51	41.0	14.2
	2010	121,961	3340	5.29	37.2	14.8

Results: Traffic-related air pollution

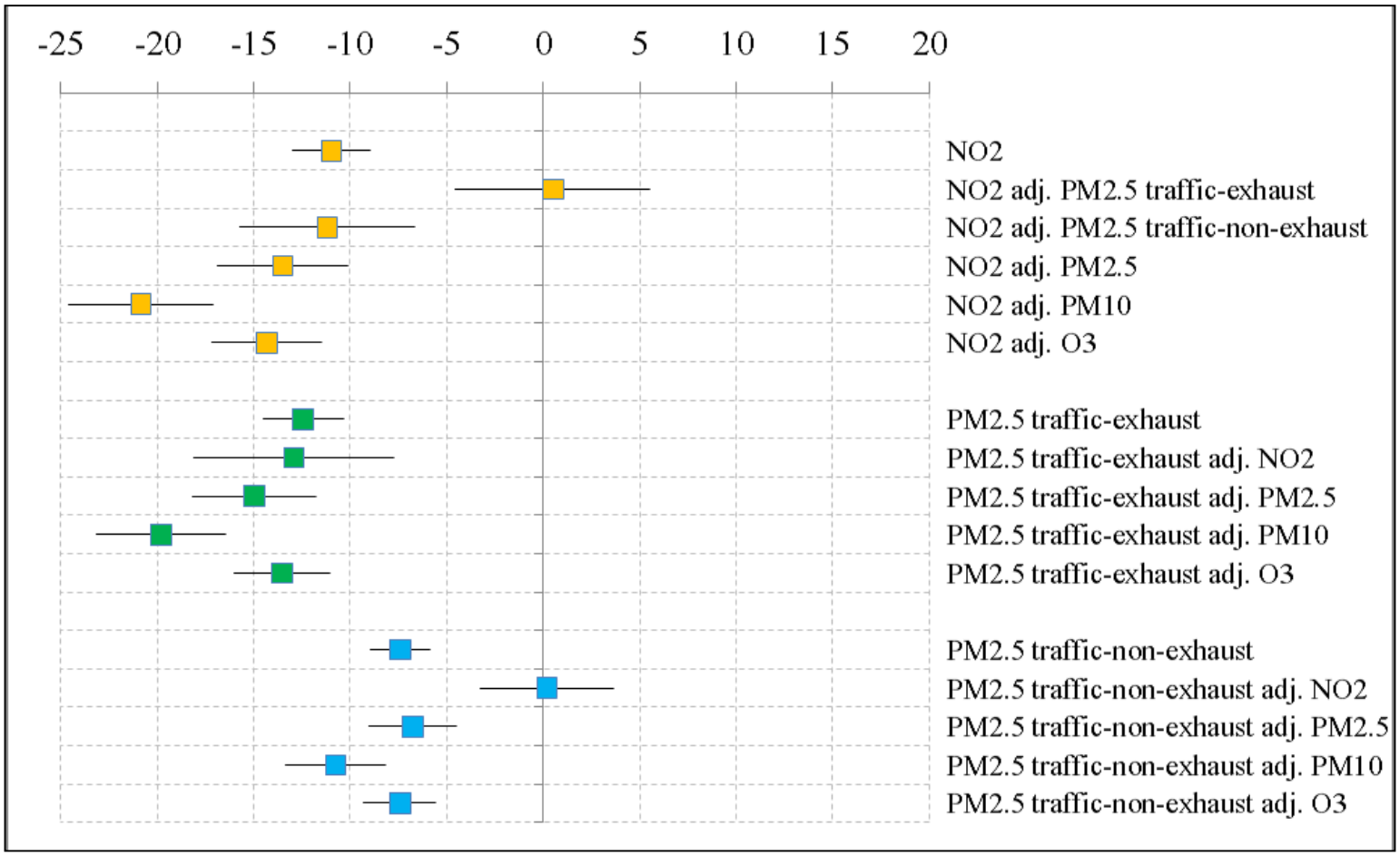
Mean difference in term birth weight (g) associated with air pollutant exposure across entire pregnancy (N=540,365)

	Unadjusted		Adjusted*	
	Term birth weight (g)		Term birth weight (g)	
Exposure	**MD (95%CI)**	**p-value**	**MD (95%CI)**	**p-value**
NO2 (per IQR, 8.6 µg/m^3)	-20.67 (-22.30, -19.04)	**<0.001**	-10.97 (-12.98, -8.96)	**<0.001**
NOX (per IQR, 23.7 µg/m^3)	-20.15 (-21.81, -18.49)	**<0.001**	-10.74 (-12.76, -8.73)	**<0.001**
PM2.5 traffic- exhaust (per IQR, 0.35 µg/m^3)	-23.09 (-24.89, -21.29)	**<0.001**	-12.43 (-14.51, -10.35)	**<0.001**
PM2.5 traffic non-exhaust (per IQR, 0.29 µg/m^3)	-17.24 (-18.68, -15.80)	**<0.001**	-7.41 (-8.96, -5.86)	**<0.001**

***Linear regression model** adjusted for Sex, Maternal age, Birth registration type, Tobacco expenditure (COA-level), Carstairs quintile (COA-level), individual-level ethnicity, gestational age as linear and quadratic terms, Season of birth, Year, and random intercept for Middle Layer Super Output Area (MSOA)

Results: two air pollutant models

Adjusted* mean difference in term birth weight (g) per IQR increase in two air pollutant models:



***Linear regression model** adjusted for Sex, Maternal age, Birth registration type, Tobacco expenditure (COA-level), Carstairs quintile (COA-level), individual-level ethnicity, gestational age as linear and quadratic terms, Season of birth, Year, and random intercept for Middle Layer Super Output Area (MSOA), in addition to the air pollutant indicated in the figure.

IQR values for air pollutants: NO2 (per IQR, 8.6 μg/m^3), **PM2.5 exhaust** (per IQR, 0.35 μg/m^3), **PM2.5 non-exhaust** (per IQR, 0.29 μg/m^3)

Results: Road traffic noise

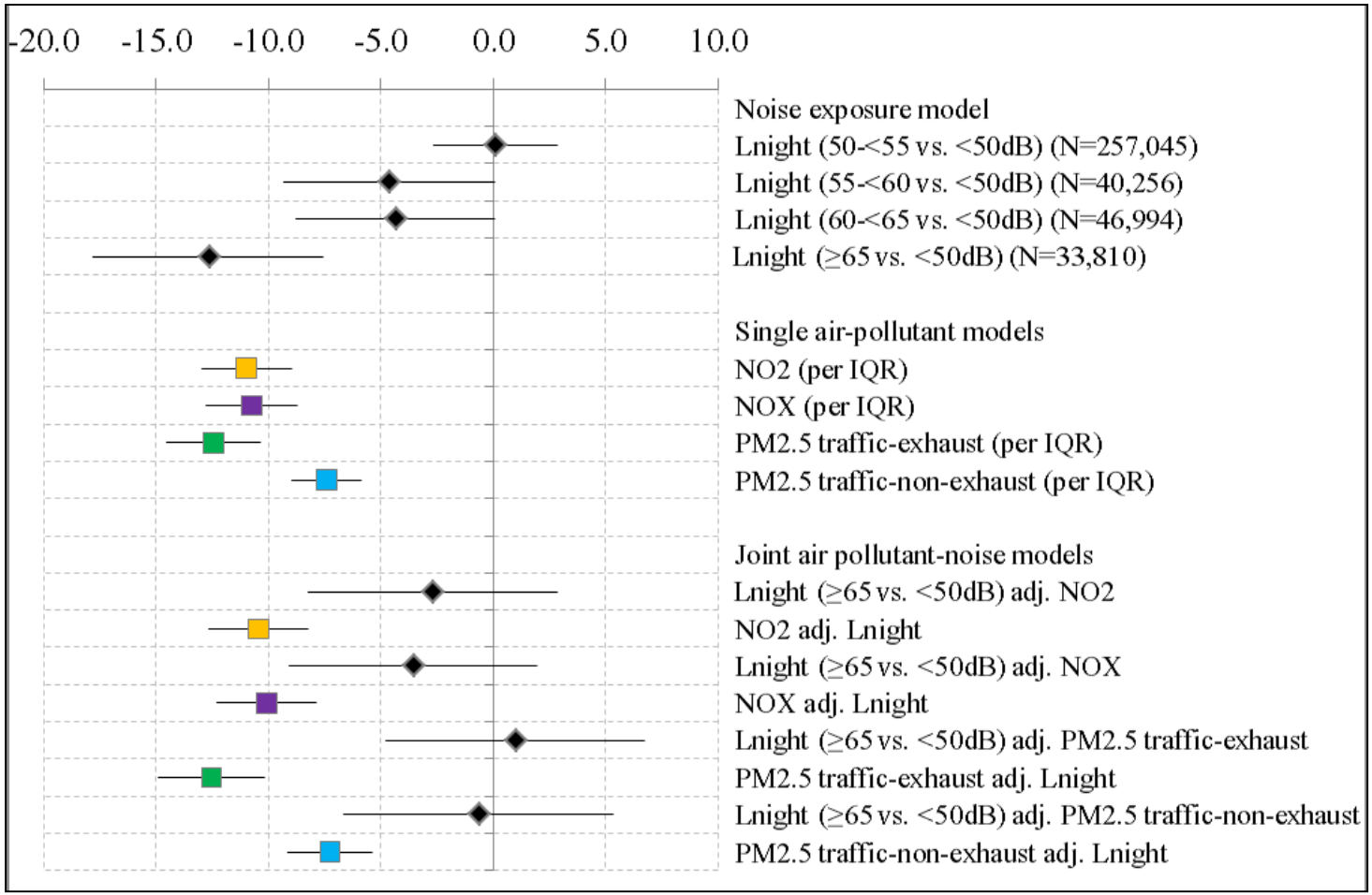
Mean difference in term birth weight (g) associated with road traffic noise

		Unadjusted		Adjusted*	
		Term birth weight (g)		Term birth weight (g)	
Exposure	**N**	**MD (95%CI)**	**p-value**	**MD (95%CI)**	**p-value**
Day-time noise $L_{Aeq,16hr}$					
<55dB	157,491	Reference		Reference	
55-<60 dB	265,603	-3.80 (-6.74, -0.87)		2.02 (-0.73, 4.78)	
60-<65 dB	40,755	-14.63 (-19.76, -9.49)		-4.70 (-9.39, -0.02)	
>=65dB	76,516	-19.88 (-23.95, -15.81)		-5.23 (-9.00, -1.45)	
p for trend	540,365		**<0.001**		**<0.001**
Night-time noise L_{night}					
<50dB	162,260	Reference		Reference	
50-<55 dB	257,045	-6.63 (-9.56, -3.70)		0.08 (-2.67, 2.83)	
55-<60 dB	40,256	-14.62 (-19.76, -9.47)		-4.64 (-9.33, 0.06)	
60-<65 dB	46,994	-17.33 (-22.17, -12.49)		-4.34 (-8.76, 0.09)	
>=65dB	33,810	-31.65 (-37.17, -26.13)		-12.66 (-17.77, -7.55)	
p for trend	540,365		**<0.001**		**<0.001**

***Linear regression model** adjusted for Sex, Maternal age, Birth registration type, Tobacco expenditure (COA-level), Carstairs quintile (COA-level), individual-level ethnicity, gestational age as linear and quadratic terms, Season of birth, Year, and random intercept for Middle Layer Super Output Area (MSOA)

Results: traffic-related air pollution & noise

Adjusted* mean difference in term birth weight (g) associated with night-time noise (L_{night}) and primary traffic air pollutants in single-exposure and joint air pollutant-noise models:



***Linear regression model** adjusted for Sex, Maternal age, Birth registration type, Tobacco expenditure (COA-level), Carstairs quintile (COA-level), individual-level ethnicity, gestational age as linear and quadratic terms, Season of birth, Year, and random intercept for Middle Layer Super Output Area (MSOA).
IQR values for air pollutants: NO2 (per IQR, 8.6 μg/m^3), **NOX** (per IQR, 23.7 μg/m^3), **PM2.5 exhaust** (per IQR, 0.35 μg/m^3), **PM2.5 non-exhaust** (per IQR, 0.29 μg/m^3)

Summary

- **Largest study** to date, and **first in UK**, of foetal growth and joint air pollution and noise exposures.

- **Long-term exposure to traffic-related air pollution during pregnancy associated with reduced birth weight**. Robust to adjustment for road traffic noise → associations not attributable to road traffic noise.

- Specifically, **near-road exposure to fine particulate matter from road traffic exhaust emissions (PM2.5 traffic-exhaust)** appears to drive the air pollutant associations with reduced birth weight in London.

Impact of London's road traffic air and noise pollution on birth weight: retrospective population based cohort study

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Abstract

Objective To investigate the relation between exposure to both air and noise pollution from road traffic and birth weight outcomes.

Design Retrospective population based cohort study.

Setting Greater London and surrounding counties up to the M25 motorway (2317 km^2), UK, from 2006 to 2010.

Participants 540 365 singleton term live births.

Main outcome measures Term low birth weight (LBW), small for gestational age (SGA) at term, and term birth weight.

Results Average air pollutant exposures across pregnancy were 41 $\mu g/m^3$ nitrogen dioxide (NO_2), 73 $\mu g/m^3$ nitrogen oxides (NO_x), 14 $\mu g/m^3$ particulate matter with aerodynamic diameter <2.5 µm ($PM_{2.5}$), 23 $\mu g/m^3$ particulate matter with aerodynamic diameter <10 µm (PM_{10}), and 32 $\mu g/m^3$ ozone (O_3). Average daytime ($L_{Aeq,16hr}$) and night-time (L_{night}) road traffic A-weighted noise levels were 58 dB and 53 dB respectively. Interquartile range increases in NO_2, NO_x, $PM_{2.5}$, PM_{10}, and source specific $PM_{2.5}$ from traffic exhaust ($PM_{2.5}$

Smith et al. *Impact of London's road traffic air and noise pollution on birth weight: retrospective population based cohort study*. BMJ. 2017 Dec 5;359:j5299

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