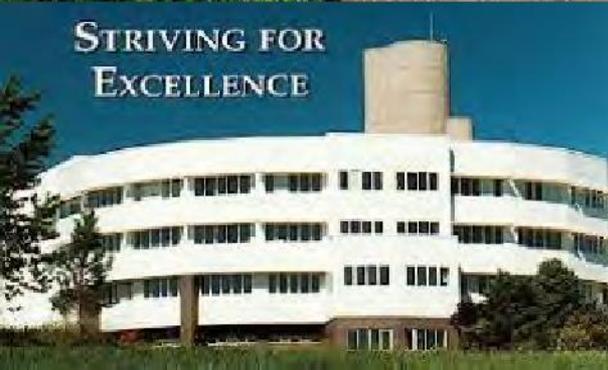
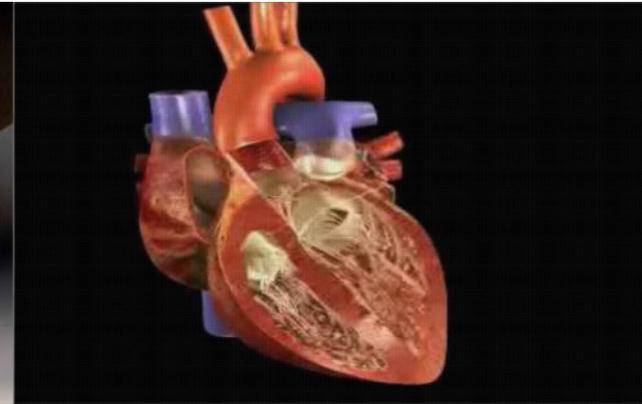


Air Pollution and Hospital Admissions



Jill Belch, Catherine Fitton, Bianca Cox, James Chalmers



Types of Pollution

- Noise
- Light
- Chemical
 - Water
 - Soil
 - Air



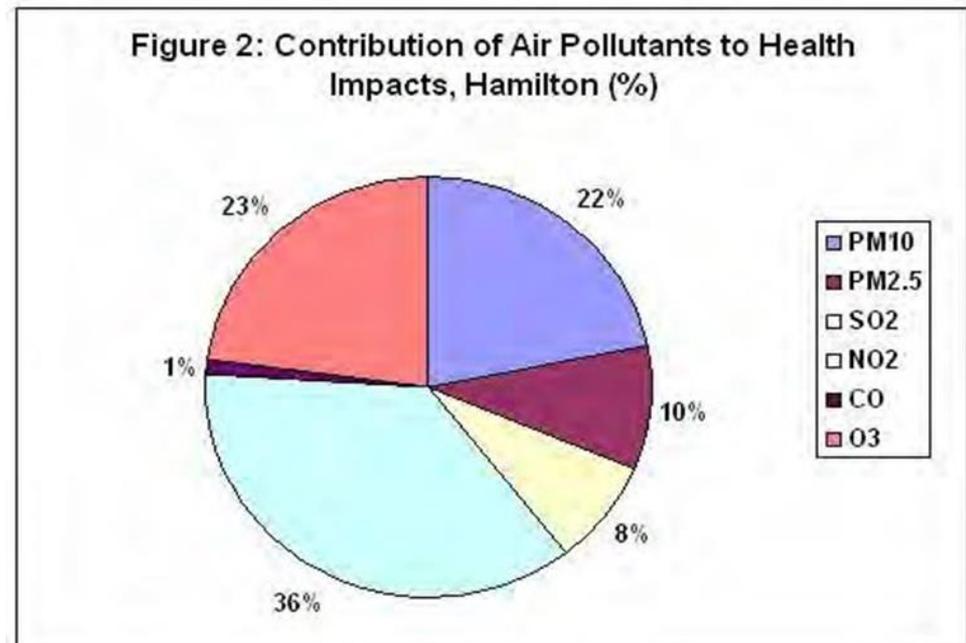
Air pollution - Transport

- Noise
- Light
- Chemical
 - Water
 - Soil
 - Air

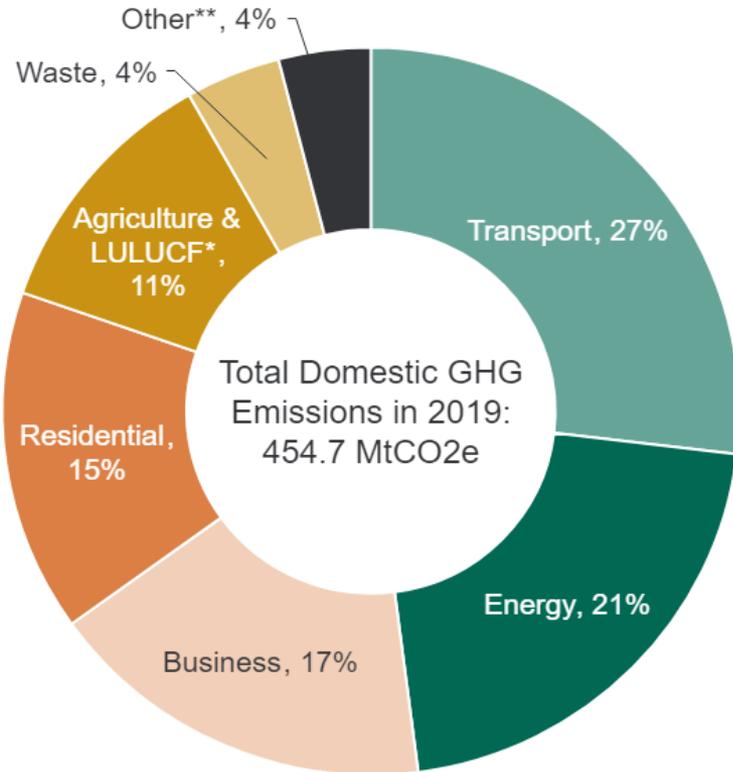


What are the Main Air Pollutants?

1. Nitric Oxide gasses (NoX)
2. Particulate Matter (PM) <10
3. PM <2.5
4. Ozone (O₃)
5. Sulphur Dioxide (SO₂)
6. Carbon Monoxide (CO)
7. **Ammonia**



Proportion of Emissions from our Roads



SCOTLAND

- Transport (inc international shipping, aviation) 37% of Scotland's emissions
- Road transport 68% of transport emissions.

<https://www.transport.gov.scot/publication/scottish-transport-statistics-no-37-2018-edition/chapter-13-environment-and-emissions/>

EU AIR QUALITY DIRECTIVE - NO₂ 2008/50/EC

Nitrogen dioxide and oxides of nitrogen

	Hourly limit value for the protection of human health (NO ₂)	Annual limit value for the protection of human health (NO ₂)	Annual critical level for the protection of vegetation and natural ecosystems (NO _x)	Legal nature ie level for legislation for human health (NO ₂)
Upper assessment threshold	70 % of limit value (140 µg/m ³ , not to be exceeded more than 18 times in any calendar year)	80 % of limit value (32 µg/m ³)	80 % of critical level (24 µg/m ³)	40µg/m ³ for NO ₂ 100µg/m ³ for NoX

The current EU directive legal value of 40µg/m³(annual mean) was set to protect the public from the health effects of gaseous NO₂.

Particulate Matter

1. Particulate Matter (PM) $<10\mu$ diameter

2. PM $<2.5\mu$



The smaller particles adversely affect health

- 10μ not filtered by nose and go into lung
- 2.5μ not filtered by lung and go into blood stream to damage other organs eg heart, brain

Particulate Matter

National air quality objectives and European Directive limit and target values for the protection of human health						
Pollutant	Applies	Objective	Concentration measured as ¹⁰	Date to be achieved by (and maintained thereafter)	European Obligations	Date to be achieved (by and maintained thereafter)
Particles (PM ₁₀)	UK	50 µg/m ³ not to be exceeded more than 35 times a year	24 hour mean	31 December 2004	50 µg/m ³ not to be exceeded more than 35 times a year	1 January 2005
	UK	40 µg/m ³	annual mean	31 December 2004	40 µg/m ³	1 January 2005
	Indicative 2010 objectives for PM ₁₀ (from the 2000 strategy and Addendum) have been replaced by an exposure reduction approach for PM _{2.5} (except in Scotland – see below)					
	Scotland	50 µg/m ³ not to be exceeded more than 7 times a year	24 hour mean	31 December 2010	50 µg/m ³ not to be exceeded more than 35 times a year	1 January 2005
	Scotland	18 µg/m ³	annual mean	31 December 2010	40 µg/m ³	1 January 2005
Particles (PM _{2.5}) Exposure Reduction	UK (except Scotland)	25 µg/m ³	annual mean	2020	Target value - 25 µg/m ³	2010
	Scotland	10 µg/m ³		31 December 2020	Limit value - 25 µg/m ³	1 January 2015
	UK urban areas	Target of 15% reduction in concentrations at urban background		Between 2010 and 2020	Target of 20% reduction in concentrations at urban background.	Between 2010 and 2020

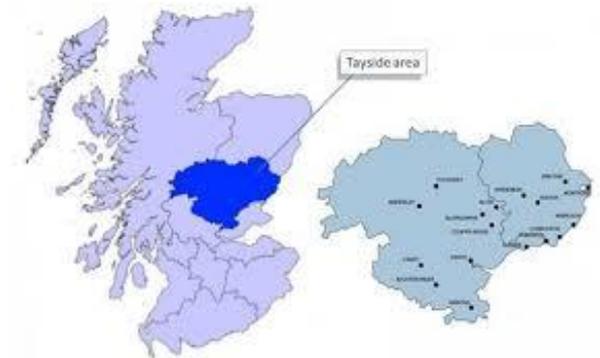
Tayside Pollution Research Programme (TPRP)

The Aim:

of our study was to determine the effect of regional air pollution, if any, on acute admissions to hospital

Study Design:

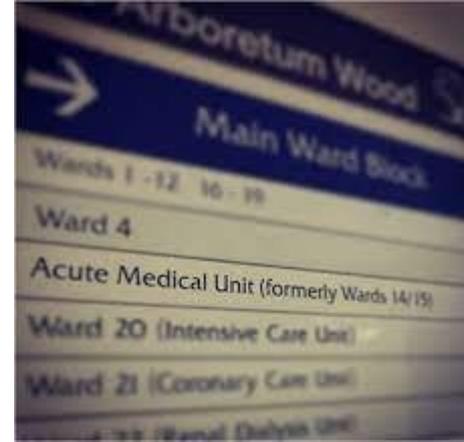
- Site: Tayside population circa 350,000
- Admissions to 2 Hospitals
 - Dundee & Perth
- Duration: 2000/2005 to May 2019



Study Design

Patients:

- Identified by Acute hospital admission at any point over 18y period
- Date of admission - Health Informatics Centre
- Linked to Postcode
 - 3 pre determined subgroup analyses



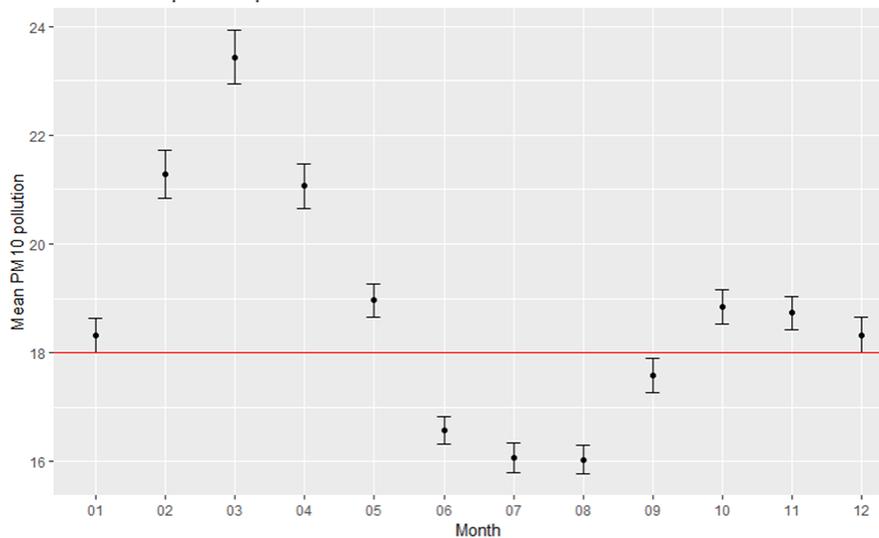
Pollution measures in cities of Perth and Dundee:

- NoX, NO₂, NO (2005-'18)
- PM10 (2000-'18)
- (PM2.5)

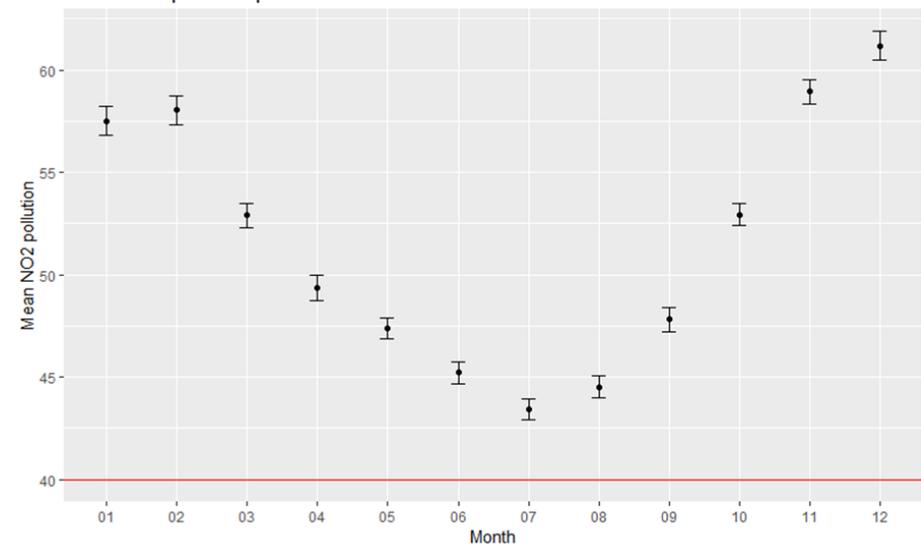
Adjusted for temp & humidity, weekends & holidays,
Season of year

Mean NO₂ & PM₁₀ pollution per month over the study period

The red lines are at the Scottish legal limit.



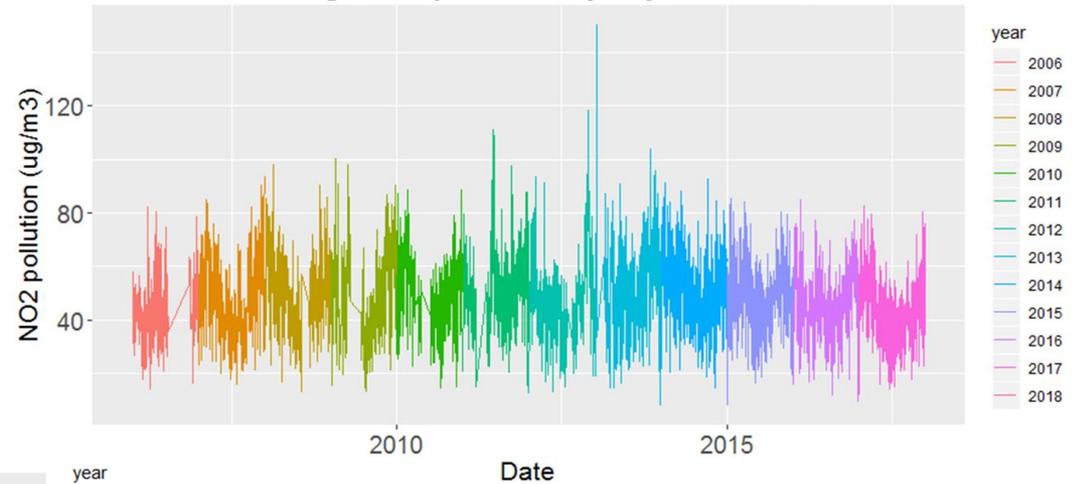
PM₁₀ µg/m³



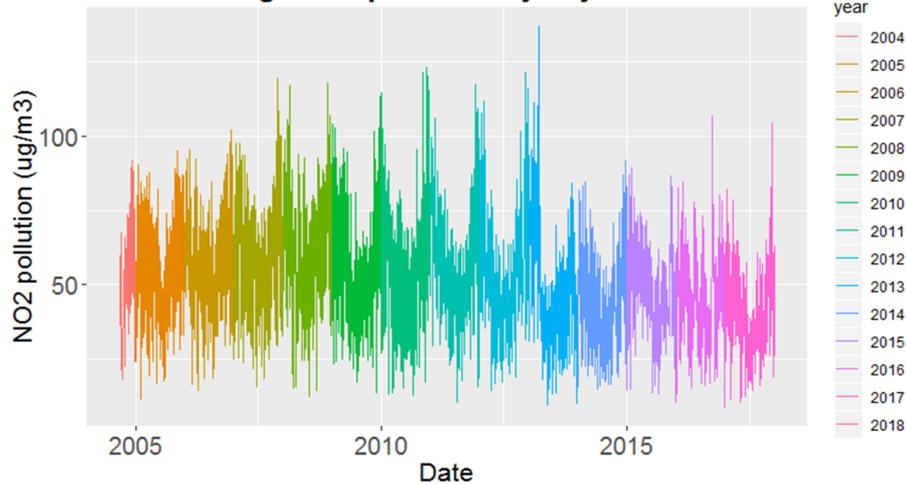
NO₂ µg/m³

Nitrogen Dioxide (NO₂) across Study Period

Average NO₂ pollution by day in Dundee

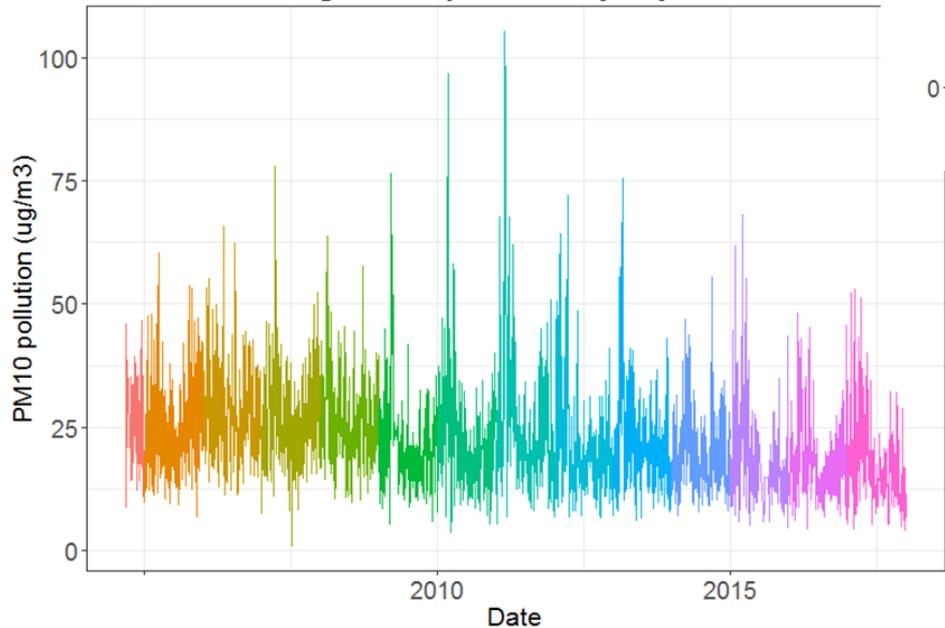


Average NO₂ pollution by day in Perth

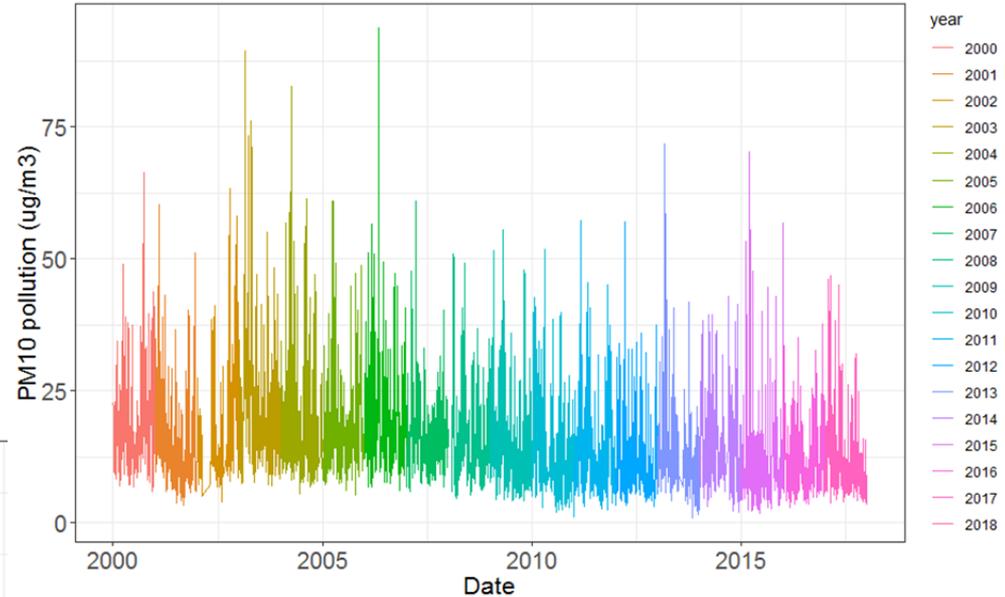


PM10 across Study Period

Average PM10 pollution by day in Perth



Average PM10 pollution by day in Dundee



2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018

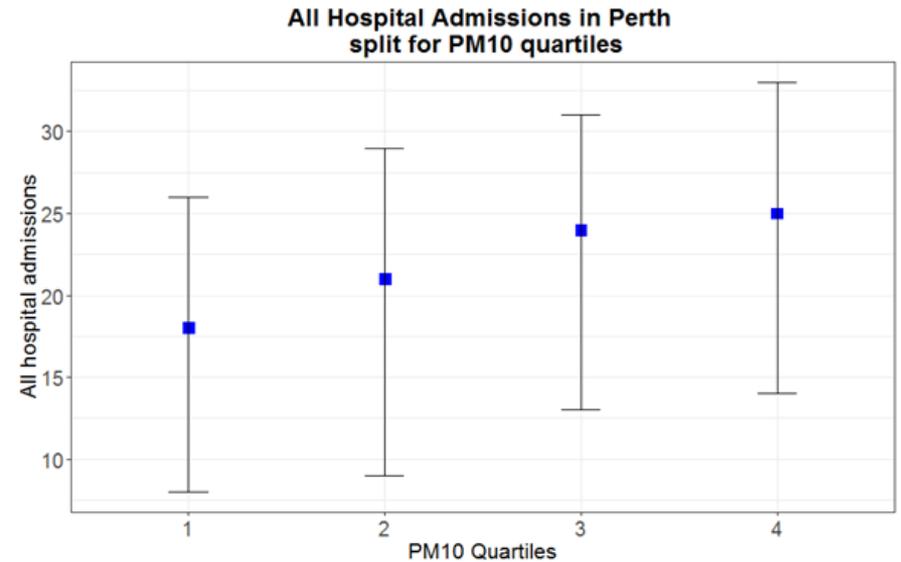
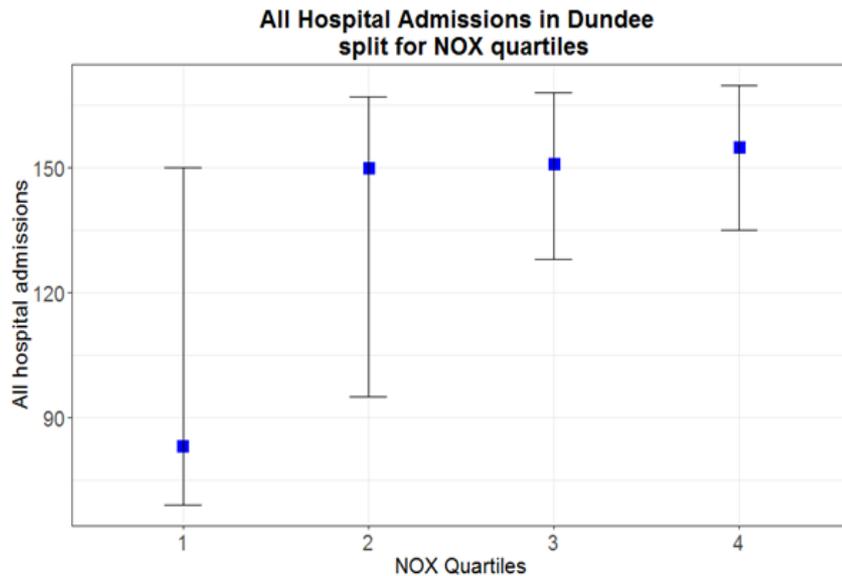
year
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018

Quartiles:

The pollution values for the Qs

Pollution type	Q1	Q2	Q3	Q4
NO2	<41.2	41-51.2	51.2-61.8	>61.8
NO	<44.2	44-61.8	61.8-84.7	>84.7
NOX	<109.4	109.4-146.2	146.2-190.8	>190.8
PM10	<12.5	12.5-16.9	16.9-22.8	>22.8

Results: All Admissions of any Age NoX and PM10



% Increase in Admissions between Low (Q1) & High (Q4) Pollution Days

Mean hospital admissions/day
for days with low and high pollution, with % increase, for **Dundee**

ALL admins	Mean admins/day		% increase
	Low Q1	High Q4	
NO2	91	149	64.7
NO	80	154	91.5
NOX	81	154	89.0
PM10	123	138	12.2

Mean hospital admissions/day
for days with low and high pollution, with % increase, for **Perth**

ALL admins	Mean admins/day		% increase
	Low Q1	High Q4	
NO2	47	72	53.3
NO	45	73	64.4
NOX	45	73	63.4
PM10	52	68	30.2

Potential Reduction of all Hospital Admissions & for CVD/year for each Pollutant,

Pollutant	Mean total admins/yr	% reduction	Mean total reduction
NO2			
All Adm			07
All CVD			
NO			
All Adm			73
All CVD			58
NOx			
All Adm			03
All CVD	10,297	11.73%	1,208
PM10			
All Adms	74,975	1.62%	1,212
All CVD	10,297	1.43%	147

Potential to reduce admissions to both hospitals by 7,606 admissions/year by bringing levels under legal limits

Pollution: All Admissions

Adjusted Risk Ratios with 95%

All admin.	Dundee	P value	Perth	P value
10ug/m3 increase				
PM10	1.021 (1.012-1.031)	<0.0001	1.045 (1.033-1.057)	<0.0001
NOX	1.016 (1.015-1.018)	<0.0001	1.012 (1.011-1.014)	<0.0001
NO2	1.072 (1.065-1.080)	<0.0001	1.048 (1.041-1.054)	<0.0001
NO	1.030 (1.028-1.033)	<0.0001	1.023 (1.020-1.026)	<0.0001
Quartile 4				
PM10	1.041 (1.018-1.063)	<0.0001	1.089 (1.059-1.120)	<0.0001
NOX	1.276 (1.241-1.313)	<0.0001	1.181 (1.148-1.214)	<0.0001
NO2	1.197 (1.165-1.231)	<0.0001	1.169 (1.136-1.202)	<0.0001
NO	1.293 (1.256-1.330)	<0.0001	1.184 (1.151-1.218)	<0.0001
Quintile 10				
PM10	1.072 (1.038-1.107)	<0.0001	1.130 (1.083-1.179)	<0.0001
NOX	1.448 (1.388-1.510)	<0.0001	1.224 (1.173-1.277)	<0.0001
NO2	1.304 (1.250-1.359)	<0.0001	1.244 (1.191-1.299)	<0.0001
NO	1.478 (1.417-1.542)	<0.0001	1.223 (1.173-1.276)	<0.0001

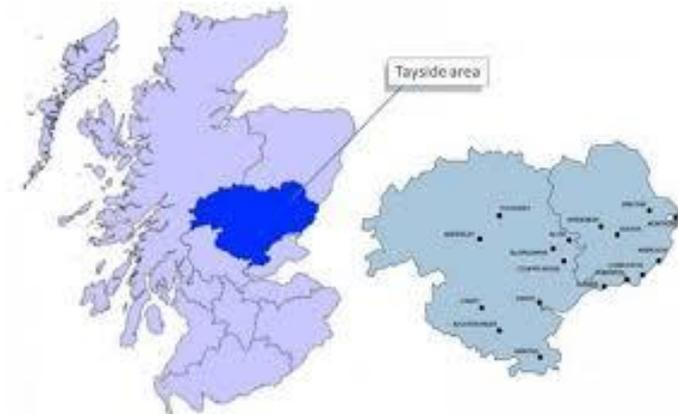
Acute Limb Ischemia (Pre-specified)

The Aim:

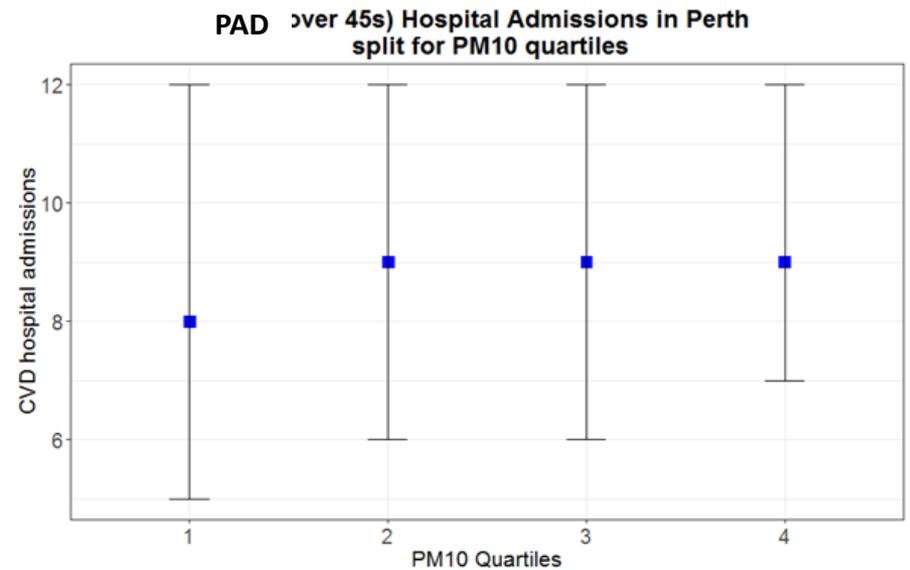
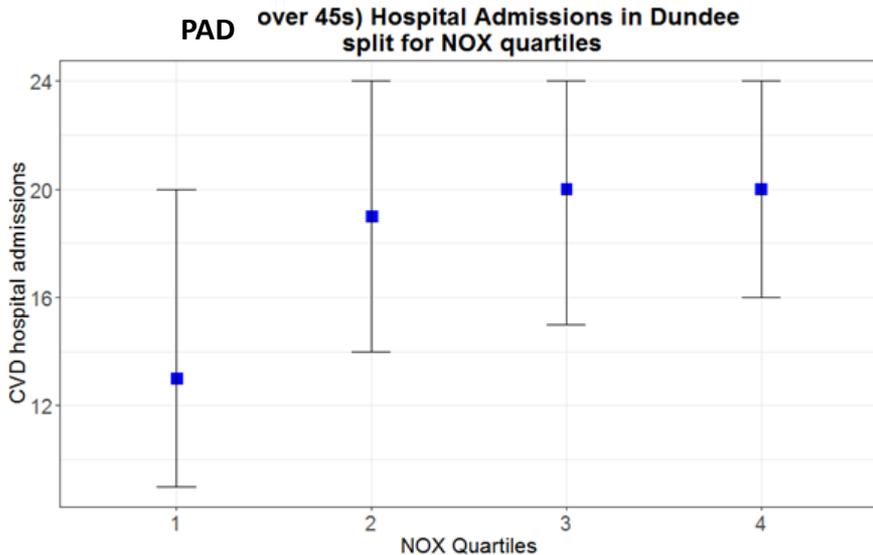
of our study was to determine the effect of regional air pollution, if any, on admissions to hospital for **acute limb ischaemia**

Study Design:

- Site: Tayside population circa 350,000
- Admissions to 2 Hospitals – Dundee & Perth
- Duration: 2000/2005 to May 2019



Results: Acute Limb Ischemia in patients >45y of age



Mean Acute Limb Ischemia Admissions/Year

ALI Admissions	Mean admissions/year				% increase low to high
	Low Q1	Q2	Q3	High Q4	
NO2	160.1	197.0	196.3	210.8	31.7
NO	151.6	196.7	206.7	209.2	38.1
NOX	152.0	198.8	204.4	209.1	37.5
PM10	165.9	180.4	183.8	194.7	17.4

Excess admissions in Q2, Q3 and Q4 (high) compared to Q1 (low pollution).

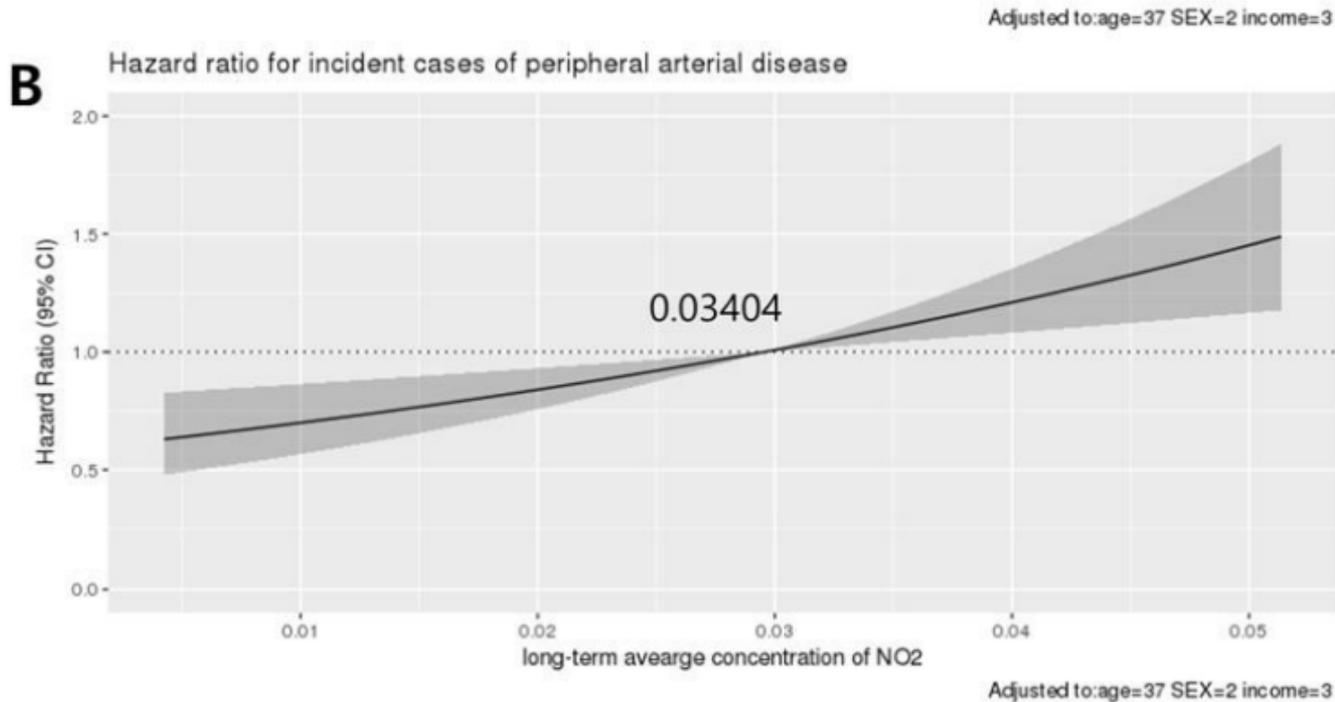
ALI Admissions	Mean admins/ year	Excess admissions in Qs per year			Total excess admins/ year
	Low	Q2	Q3	High	
NO2	160.1	36.9	36.2	50.7	123.8
NO	151.6	18.1	55.1	57.6	130.8
NOX	152.0	46.8	52.4	57.1	156.3
PM10	165.9	14.5	17.9	28.8	61.2

Pollution: ALI

Adjusted Risk Ratios (95%CI)

All admin.	Dundee	P value	Perth	P value
10ug/m3 increase				
PM10	1.021 (1.012-1.031)	<0.0001	1.045 (1.033-1.057)	<0.0001
NOX	1.016 (1.015-1.018)	<0.0001	1.012 (1.011-1.014)	<0.0001
NO2	1.072 (1.065-1.080)	<0.0001	1.048 (1.041-1.054)	<0.0001
NO	1.030 (1.028-1.033)	<0.0001	1.023 (1.020-1.026)	<0.0001
Quartile 4				
PM10	1.041 (1.018-1.063)	<0.0001	1.089 (1.059-1.120)	<0.0001
NOX	1.276 (1.241-1.313)	<0.0001	1.181 (1.148-1.214)	<0.0001
NO2	1.197 (1.165-1.231)	<0.0001	1.169 (1.136-1.202)	<0.0001
NO	1.293 (1.256-1.330)	<0.0001	1.184 (1.151-1.218)	<0.0001
Quintile 10				
PM10	1.072 (1.038-1.107)	<0.0001	1.130 (1.083-1.179)	<0.0001
NOX	1.448 (1.388-1.510)	<0.0001	1.224 (1.173-1.277)	<0.0001
NO2	1.304 (1.250-1.359)	<0.0001	1.244 (1.191-1.299)	<0.0001
NO	1.478 (1.417-1.542)	<0.0001	1.223 (1.173-1.276)	<0.0001

Exposure to Long-Term Air Pollution and Incidence of Peripheral Arterial Disease in the General Population: Korea 2021



Epidemiological Data of PAD against Data of the Concentrations of the main Environmental Pollutants: 2021

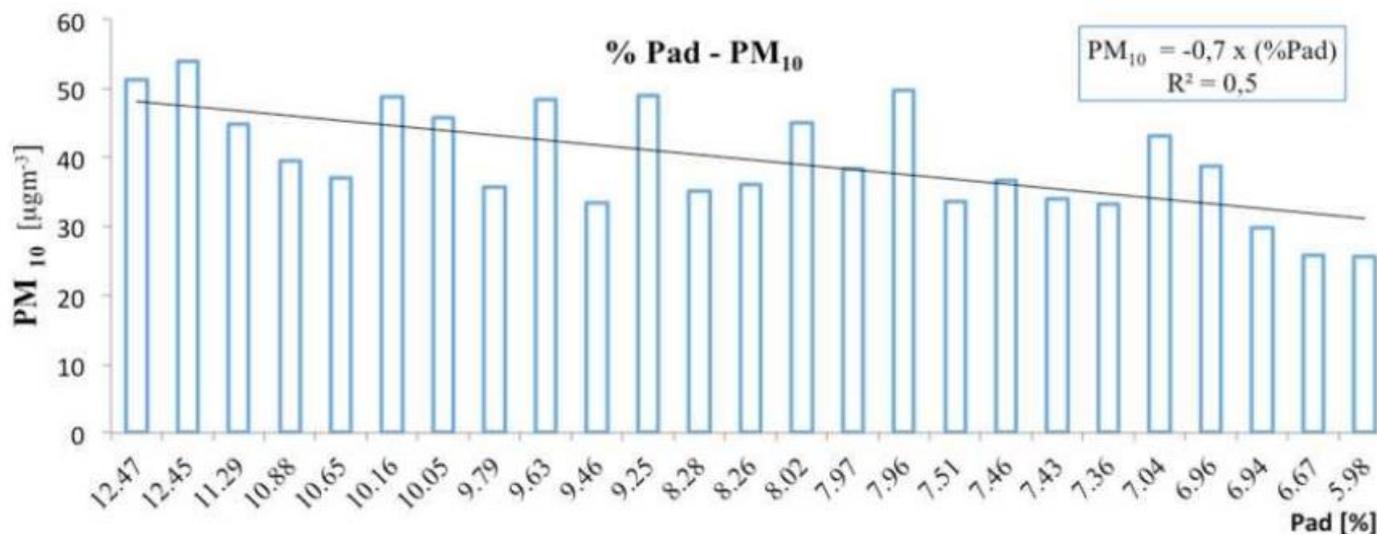


Figure I Correlation between PM₁₀ and PAD.

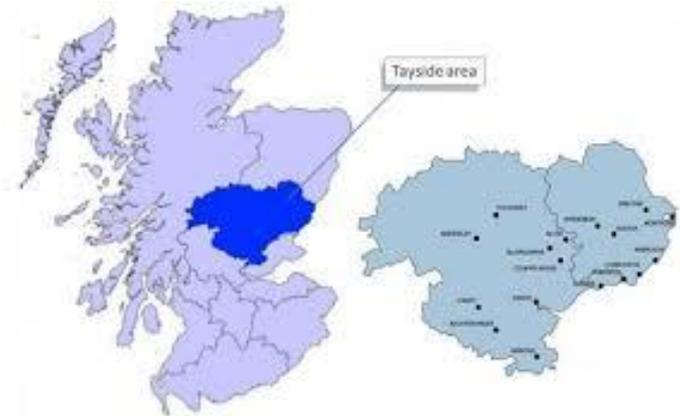
Childhood Admissions <16y of Age (Pre-specified)

The Aim:

of our study was to determine the effect of regional air pollution, if any, on admissions to hospital of **children <16y of age**

Study Design:

- Site: Tayside population circa 350,000
- Admissions to 2 Hospitals
- Duration: 2000/2005 to May 2019



Mean Childhood (<16y) Admissions / Year

All child admins	Mean admissions/year			
	Low Q1	Q2	Q3	Q4
Both Dundee & Perth				
NO2	871.8	1084.5	1223.6	1179.0
NO	803.6	1059.7	1156.9	1230.0
NOX	806.8	1056.7	1131.6	1234.4
PM10	946.1	1013.2	1050.6	1110.7

All child admins	Mean admins/year	Excess admissions in Qs per year			Total excess admins/year
		Low Q1	Q2	Q3	
Both Dundee & Perth					
NO2	871.8	212.7	352.0	307.2	871.9
NO	803.6	256.1	353.3	427.3	1036.8
NOX	806.8	249.9	324.9	427.7	1002.3
PM10	946.1	67.1	104.5	164.7	336.3

Childhood Skin Admissions & Excess Admissions

skin admins	Mean admissions/year			
	Low Q1	Q2	Q3	Q4
Skin admissions				
NO2	30.8	31.4	37.2	46.3
NO	28.8	31.2	33.7	37.2
NOX	28.3	32.4	33.7	36.4
PM10	31.3	32.9	35.2	37.8

skin admins	Mean admins/year	Excess admissions in Qs per year			Total excess admins/year
		Low Q1	Q2	Q3	
Excess skin admissions					
NO2	30.8	0.623	6.4	15.5	22.5
NO	28.8	2.403	5.0	8.5	15.8
NOX	28.3	4.094	5.4	8.1	17.6
PM10	31.3	1.602	3.9	6.5	12.0

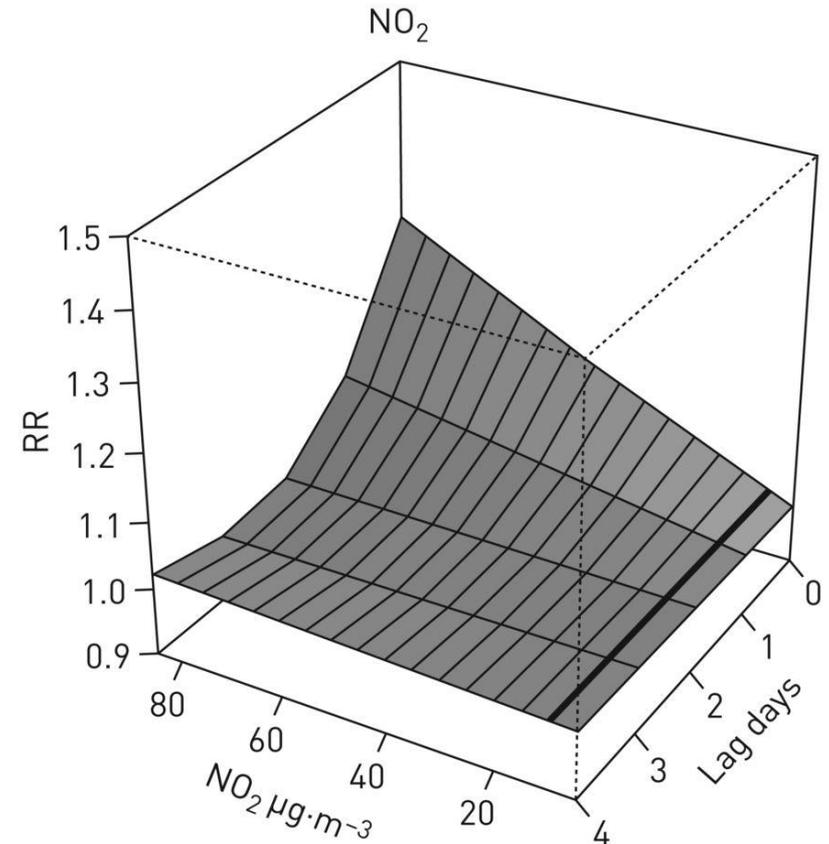
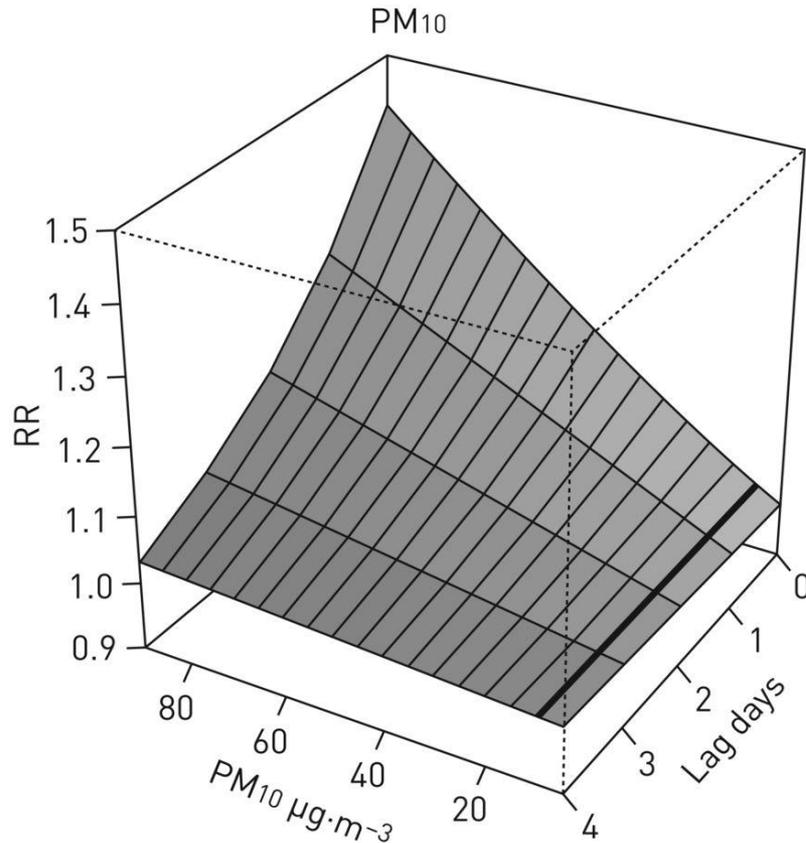
Childhood GI Admissions & Excess Admissions

GI child admins	Mean admissions/year			
	Low Q1	Q2	Q3	Q4
Both				
NO2	185.3	280.8	297.7	291.5
NO	161.4	272.7	292.3	297.3
NOX	162.3	274.3	294.9	294.2
PM10	244.6	260.0	275.8	299.0

GI admins	Mean admins/year	Excess admins in Qs per year			Total excess admins/year
		Q2	Q3	Q4	
Both					
NO2	185.3	95.5	112.4	106.2	314.1
NO	161.3	111.3	130.9	135.9	378.2
NOX	162.3	112.0	132.5	131.8	376.3
PM10	244.6	15.4	31.2	54.4	101.0

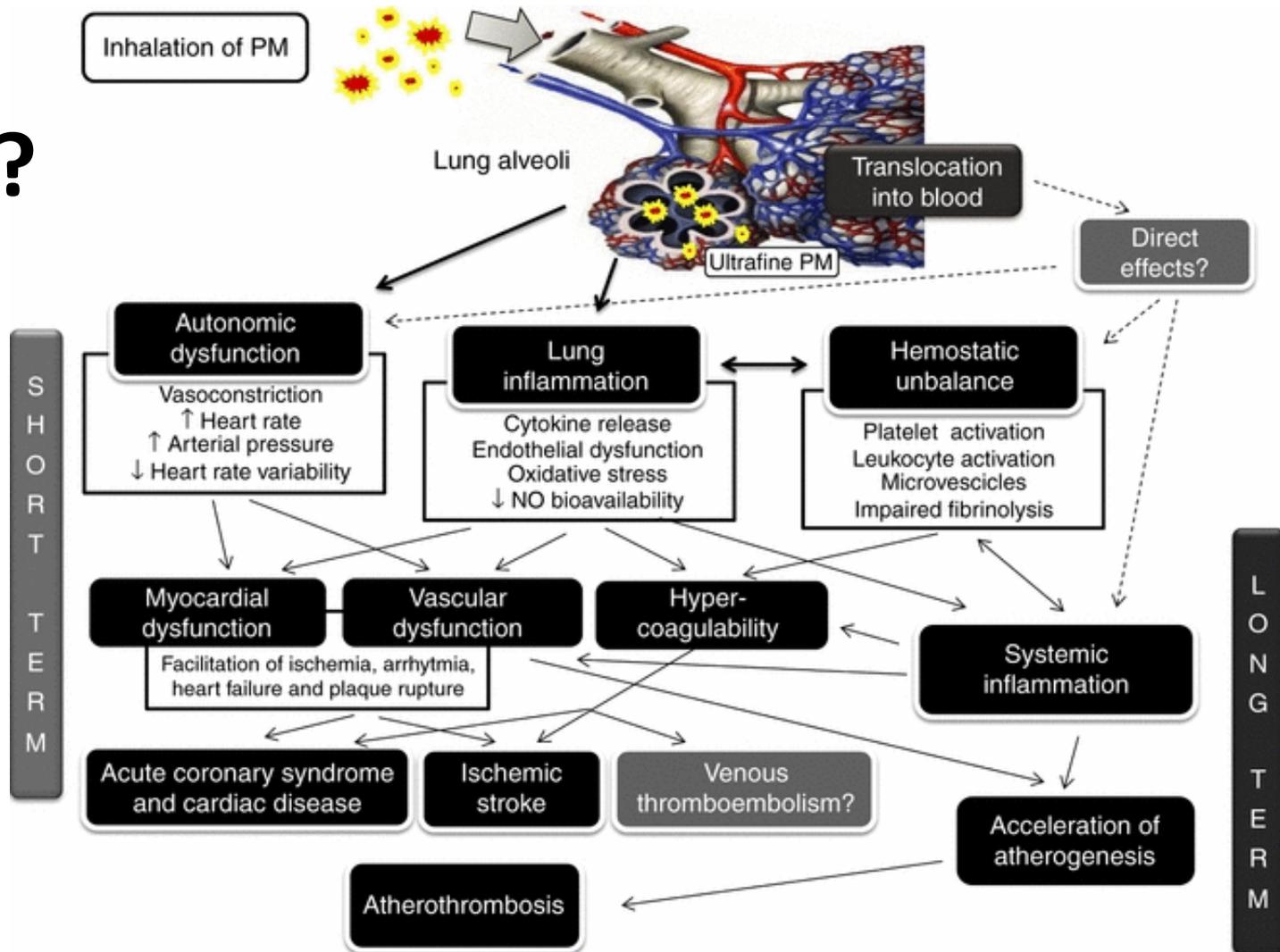
The impact of acute air pollution fluctuations on bronchiectasis pulmonary exacerbation

J Chalmers et al

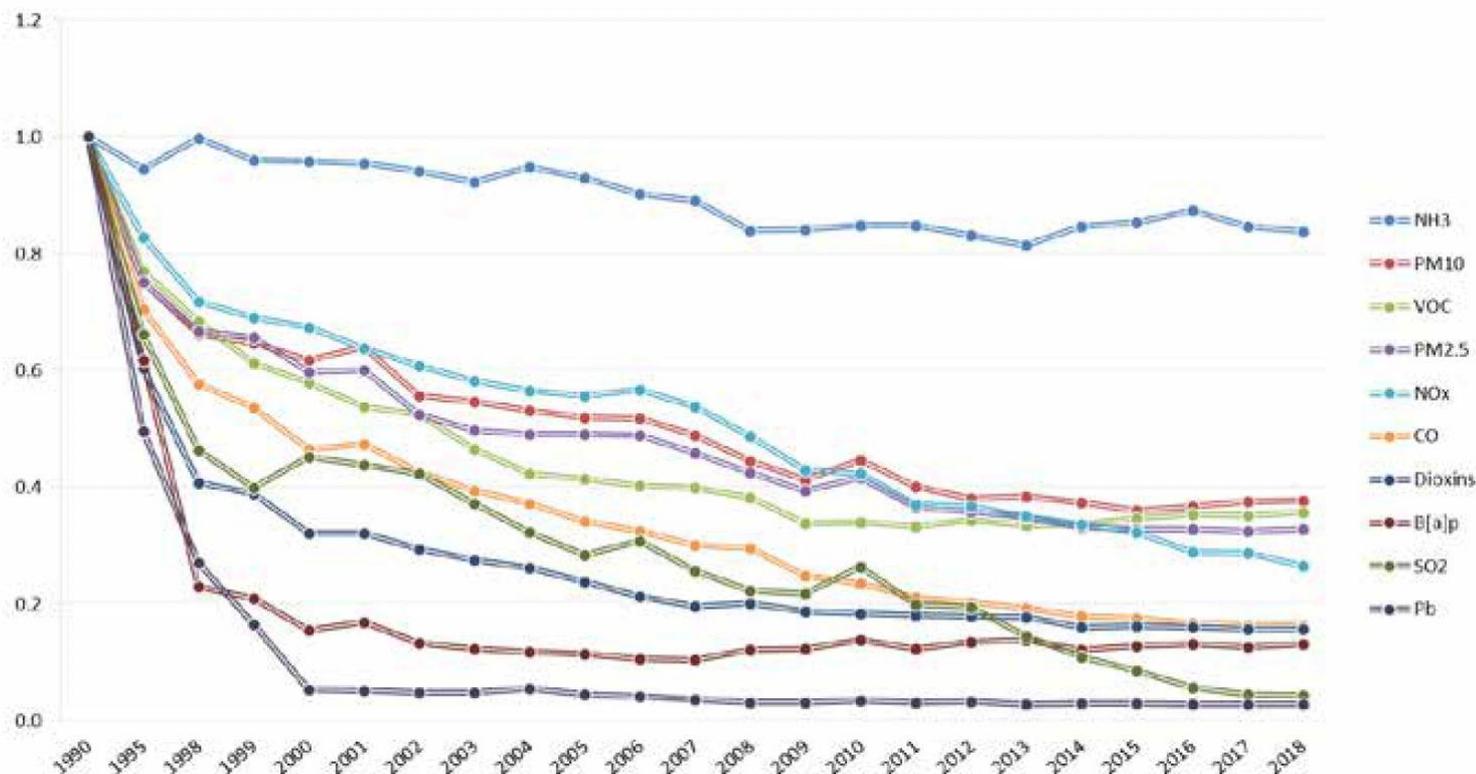


Exposure–lag–response surfaces for the association between bronchiectasis exacerbations and exposure to particles with a 50% cut-off aerodynamic diameter of 10 μm (PM₁₀) and nitrogen dioxide (NO₂). Relative risks (RRs) are relative to the reference value of 10 $\mu\text{g}\cdot\text{m}^{-3}$ (bold line). A lag of zero is the day of exacerbation, while a lag of one is the day before the exacerbation. A lag of two, three and four corresponds to 2, 3 and 4 days before the exacerbation.

Why?

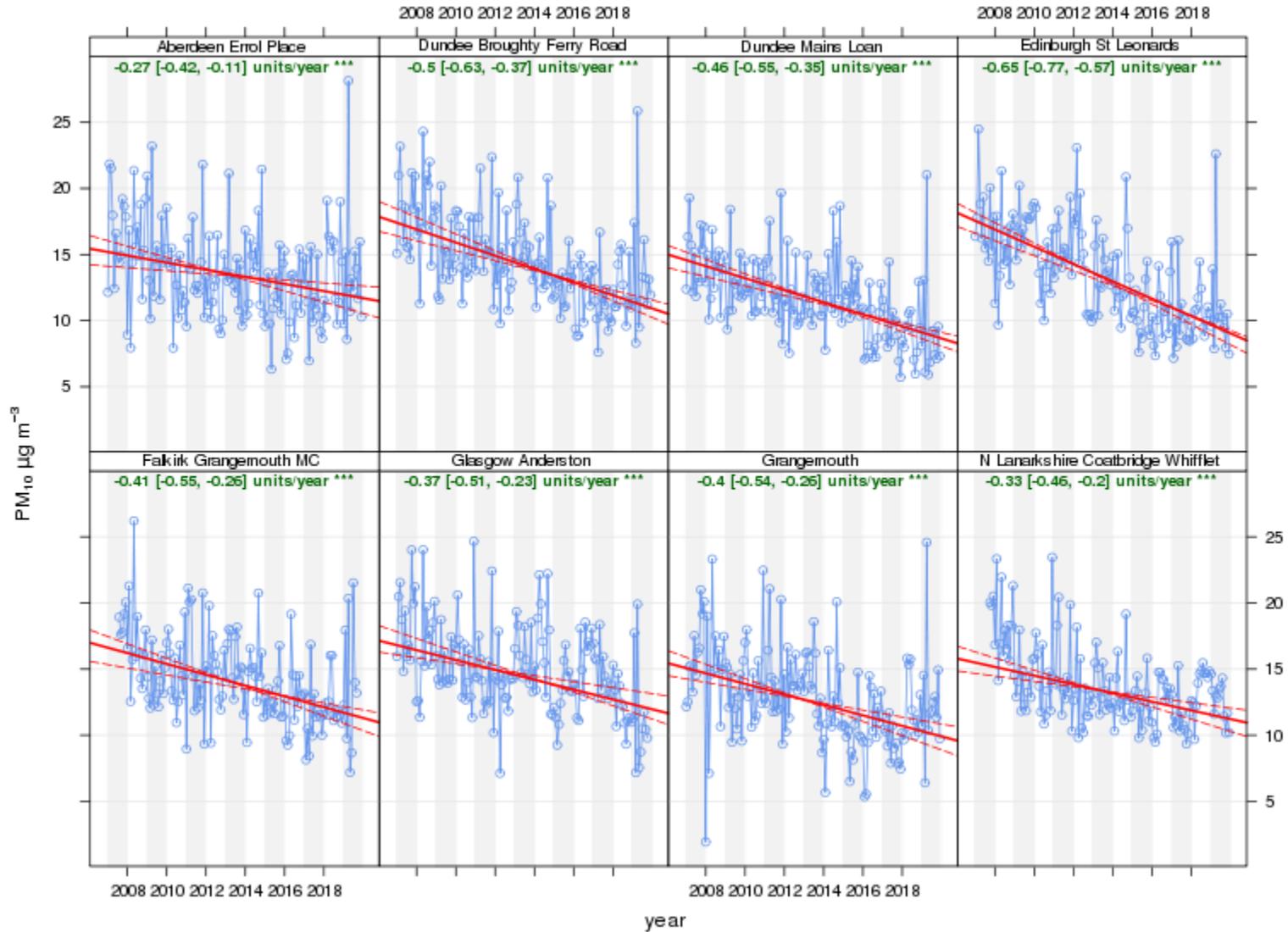


Emissions trends in Scotland since 1990



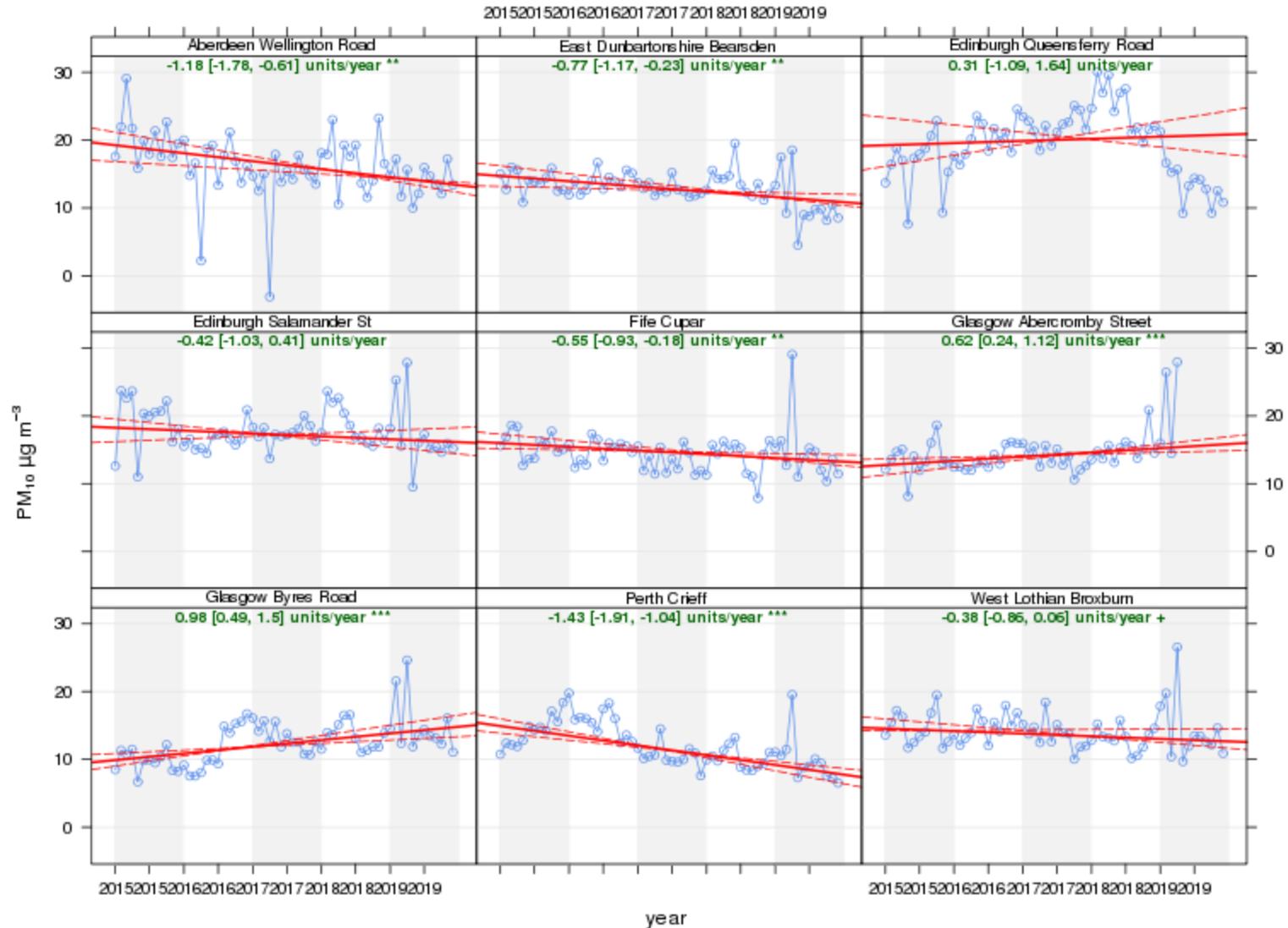
PM₁₀ 2007 to 2019

De-seasonalised PM₁₀ trends for the period 2007 to 2019



PM10 2015-2019

De-seasonalised PM₁₀ trends for the period 2015 to 2019



Statement by Scottish Government: 2019

Emissions trends – 1990 to 2018

- Emissions of the eight main air pollutants - lower 1990 to 2018
- But rate of decline has started to level off
- Ammonia (NH₃) emissions have declined at a slower rate and even increased slightly over recent years.
- Ditto Ozone

it was recognised, that despite strategic measures, areas of poor air quality would likely remain

- Local Air Quality Management (LAQM) regimes
- **In 2019 - 38 active Air Quality Management Areas (AQMA)**

Glasgow figures 2019

Glasgow City Council

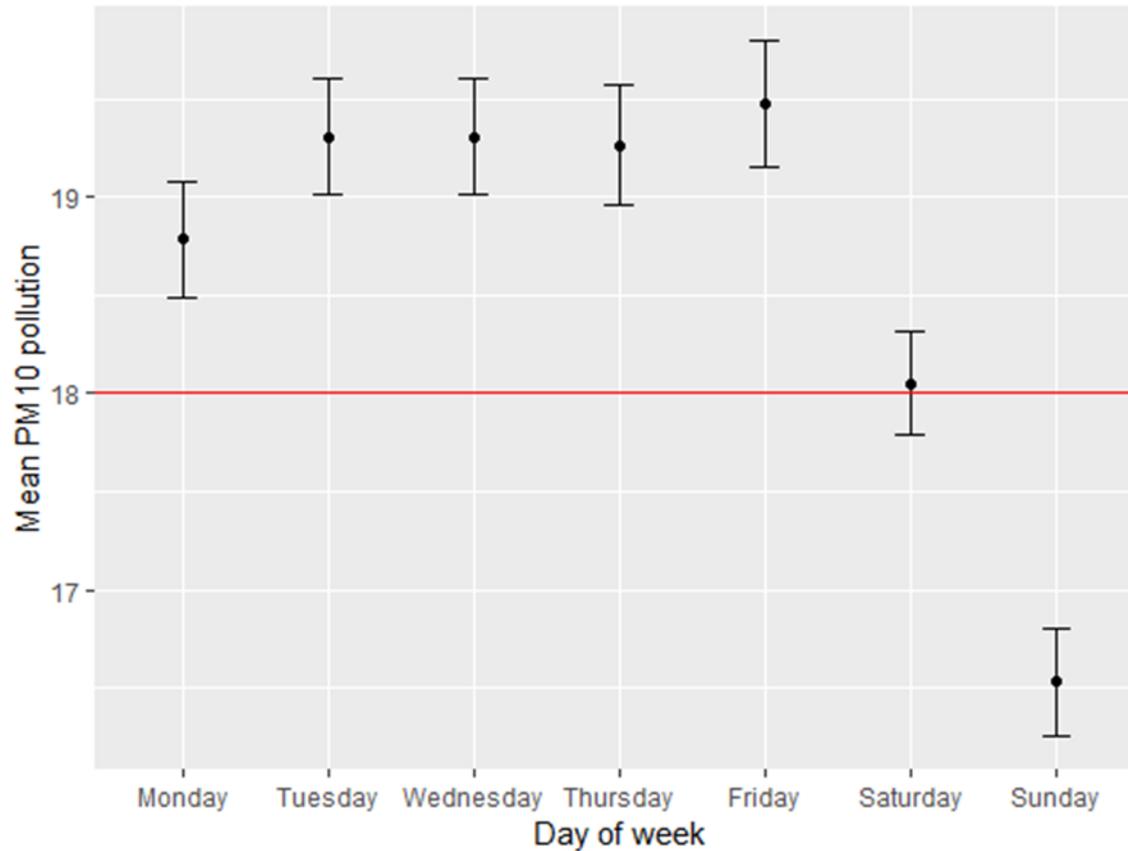
Site ID	Site Type	Monitoring Type	Valid Data Capture for Monitoring Period (%) ⁽¹⁾	Valid Data Capture 2019 (%) ⁽²⁾	NO ₂ Annual Mean Concentration (µg/m ³) ⁽³⁾				
					2015	2016	2017	2018	2019
CC12	North St. (Roadside)	Diffusion Tube	100	100	22	23	28	30	27
CC13	Hope St. 1 (Roadside)	Diffusion Tube	92	92	<u>63</u>	<u>65</u>	<u>68</u>	<u>63</u>	56
CC14	Gordon St. (Roadside)	Diffusion Tube	92	92	<u>67</u>	58	<u>64</u>	60	59
CC15	Heilanmans Umbrella N (Roadside)	Diffusion Tube	83	83	<u>69</u>	60	54	48	52
CC16	Saltmarket (Roadside)	Diffusion Tube	100	100	32	31	38	27	31
CC17	High St. (Roadside)	Diffusion Tube	83	83	40	45	43	40	42
CC18	Dobbies Loan (U Background)	Diffusion Tube	100	100	24	24	27	27	23
CC20	Dundasvale St. (U Background)	Diffusion Tube	92	92	30	29	34	30	28
CC21	Royston Rd. (Roadside)	Diffusion Tube	83	83	34	35	34	29	29
CC22	St. Mungo Ave. (U Background)	Diffusion Tube	100	100	28	29	32	27	26
CC23	Brown St (Roadside)	Diffusion Tube	100	100	23	24	27	29	24

Edinburgh figures 2019

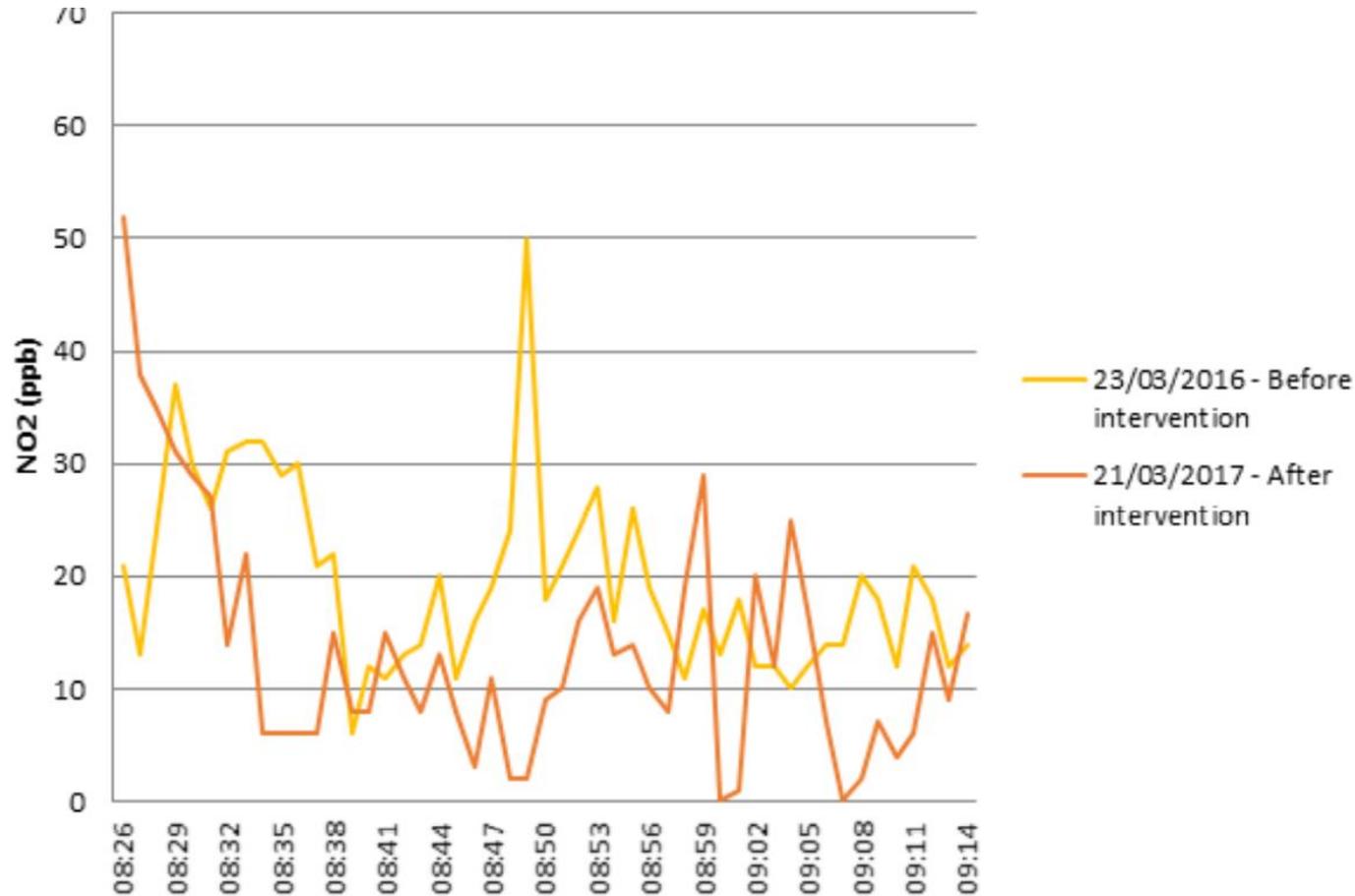
The City of Edinb

Site address	Site ID	NO ₂ Mean Concentrations (µg/m ³)													An
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Raw Data	
Midmar Drive	42	23.3	20.7	15.6	15.2	9.7	11.1		12.9	12.1	7.0	23.9	13.7	15.0	
Morningside Road	8	32.0	32.0	18.3	25.4	26.8	21.3	20.6	20.9	31.8	24.8	35.0	24.5	26.1	
Morrison Street 91	62C	75.5	38.7	47.2	48.9	42.5				56.0	49.5	53.0	40.2	50.2	
Morrison Street	49	54.8	36.8	38.1	48.0	40.2		39.6	41.2	56.5	41.3	51.1	39.2	44.3	
Nicholson Street 69	135a	57.7	50.1	53.5	34.3	49.2	41.2	44.4						47.2	
Nicholson Street 59-61	135b								47.9	52.3	49.3	45.2	37.7	46.5	
Nicholson Street 92	136	38.0	33.6	28.6	47.3	45.3	32.3		32.0	32.8	48.5	42.5	40.5	38.3	
North Bridge South	27	47.9	42.0	42.3	73.7	49.1	49.9	49.8	42.4	42.4	44.5	58.8	36.5	48.3	
Princes Street (Eastbound)	47		46.9	48.7	39.1	49.1	41.8		44.1	37.8	37.1	44.8	41.2	43.1	
Princes Street/Mound	24	62.1	69.5	74.5	57.3	59.7		60.8			62.1	64.1	59.4	63.3	
Queen Street No66	33b	38.4	45.2	26.9	37.3	33.2	33.4	32.9	36.7	31.2	32.5	30.4	38.7	34.7	
Queen Street/Albyn Pl	33a	51.0	42.5	37.8	31.9	29.1	29.1	27.9	33.2	33.9	31.9	31.8	29.4	34.1	
Queen Street/North David Street	33	50.8	49.6	37.8	35.4	39.9	38.4	38.5	45.2	37.1	52.7	39.8	48.2	42.8	
Shandwick Place Hostel	SH1	39.9	40.2	44.3	51.0	46.8	43.0	45.6	39.6		45.7		44.1	44.0	
South Bridge 59	144	54.5	47.3		53.2	49.3		44.6	50.1	41.9	22.6	49.0	40.8	45.3	
South Clerk Street 41a	142	41.2	38.5	38.2	38.9	38.4	32.1	33.1		27.7	33.1	40.5	28.3	35.5	
South Clerk Street 84	141	44.7	45.7	46.9	36.2	40.2	31.8	37.2	35.1	34.7	45.2	44.7	26.9	39.1	
St Colme Street/4	75d	34.8	27.5	27.5	29.3	29.9	24.9	26.6	10.9	25.3	30.6	37.0	22.3	27.2	
New Arthur Place	153	26.3	20.0	22.5	10.3	17.0	12.8			17.7	19.0	35.7	19.7	20.1	
Teviot Place 14	10c	36.9	37.6	30.8	28.0	25.0		33.2	37.6	33.0	35.5	42.8	28.6	33.5	
Torphichen Place 1	3b	56.0	50.4	46.3	51.1	50.6	47.1	46.4	37.4	44.7	49.7	50.9	40.4	47.6	
Torphichen Place/Chiropractice	3	54.9	45.0	55.2	44.9	53.7	44.5	43.4		42.3		53.1	45.2	48.2	

Mean PM10 Values - Day of Week



Staggering Arrival Times at School



Cameron, Valerie, et al. "Simple traffic measures significantly reduce the exposure of primary school children to NO2." *Environmental Health Scotland* 31.2 (2019): 29-34.

Open letter to 1ST Minister: All these data are EVIDENCE based

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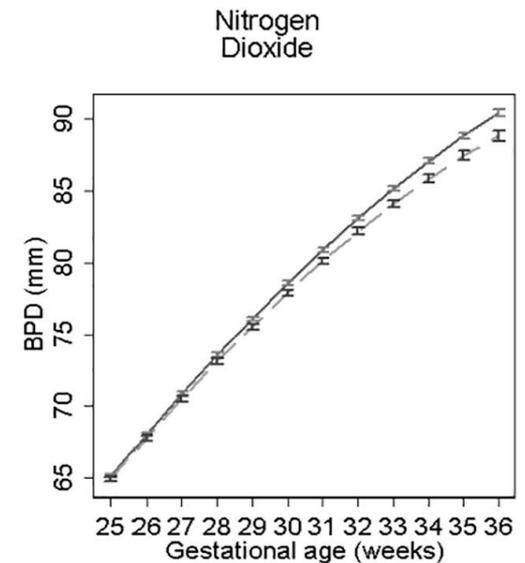
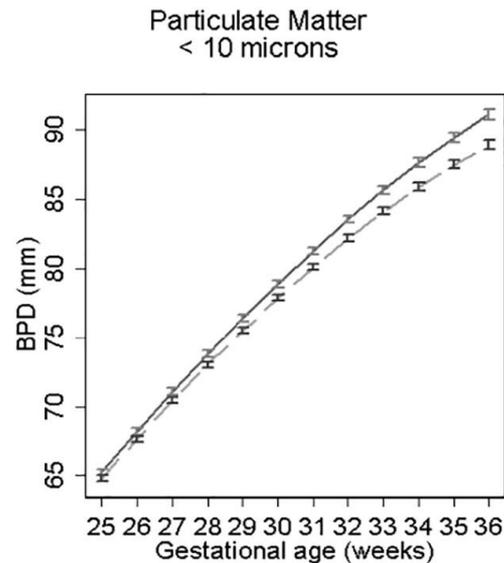
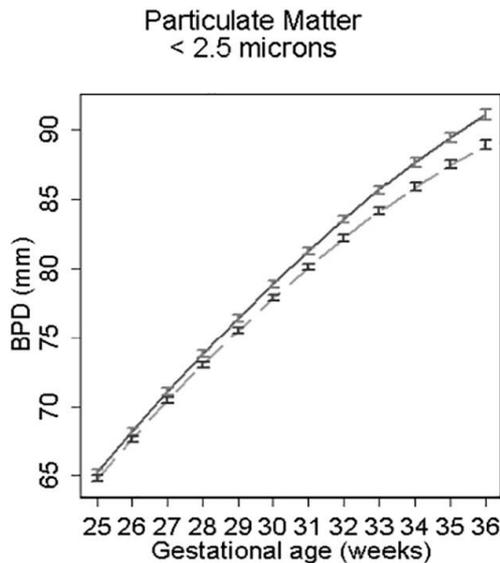
Air Pollution Exposure & Admission with Very Pre-term Birth

Pollutant	Crude	Adjusted*
NO2		
Very Preterm	1.10 (1.02,1.18)	1.08 (1.00,1.17)
PM10		
Very Preterm	1.02 (1.01,1.03)	1.013 (1.00,1.03)

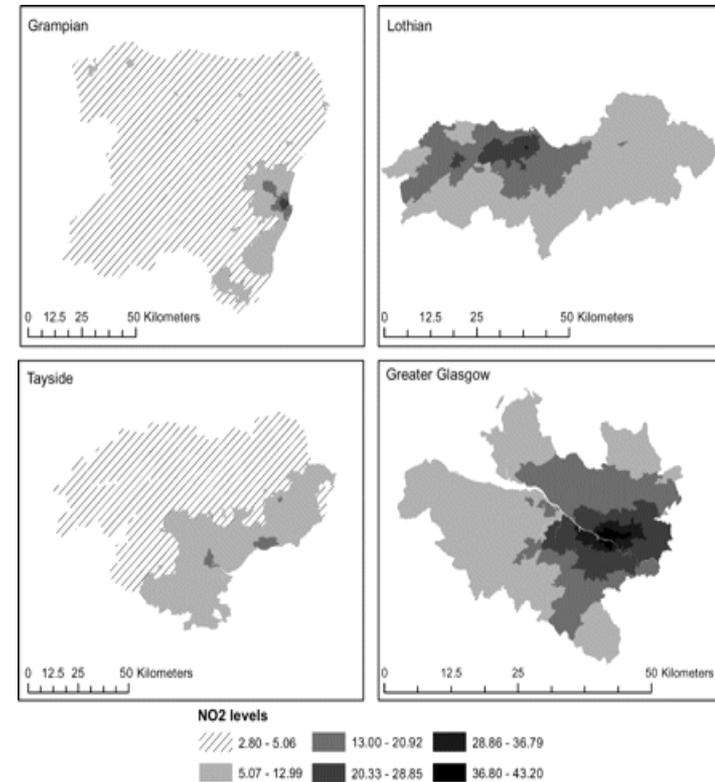
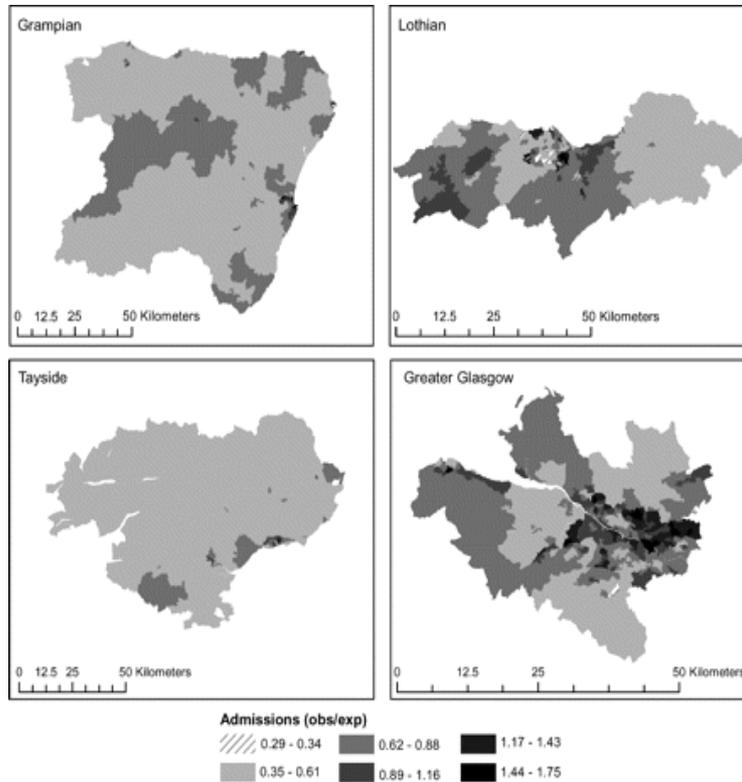
*Adjusted for social class, parity, individual estimated income, ethnicity, smoking, area log crime rate, mother's age, mothers education, season of birth, loneparent at birth registration and year of birth.

Bi-parietal diameter growth trajectories & relative differences for different levels of pollutant exposure

minimum exposure (solid lines) maximum exposure (dashed line)



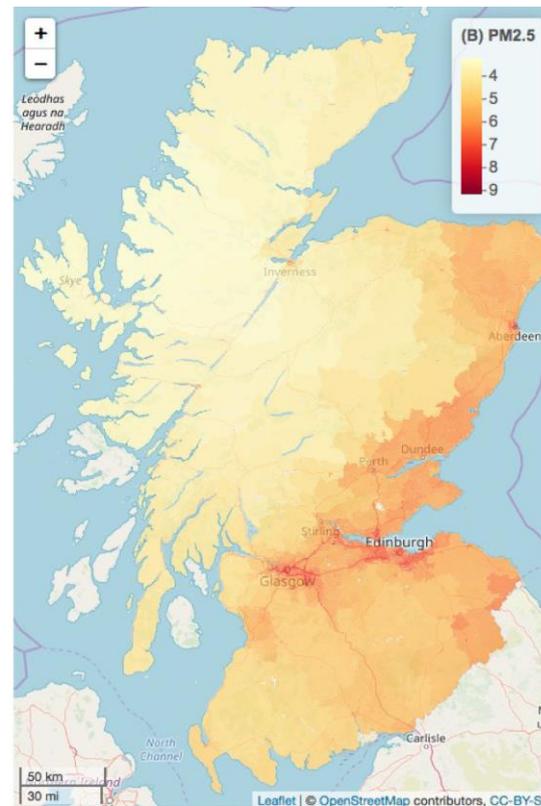
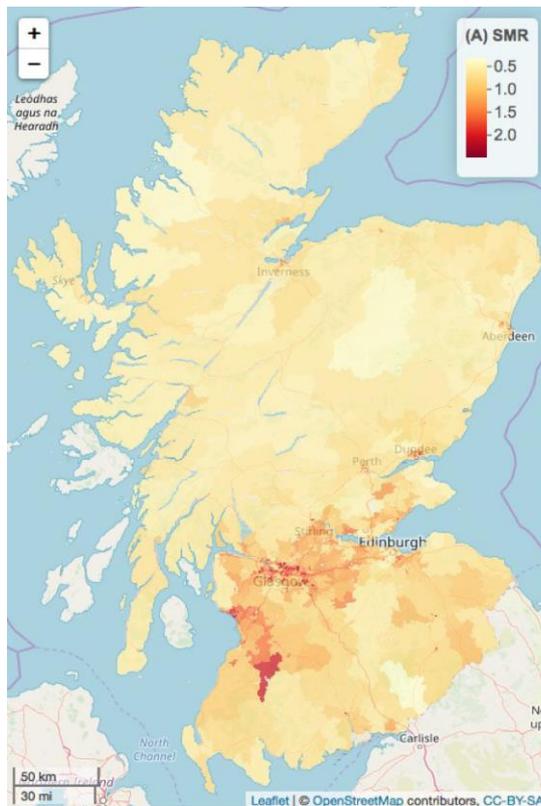
A multicity study of Air Pollution



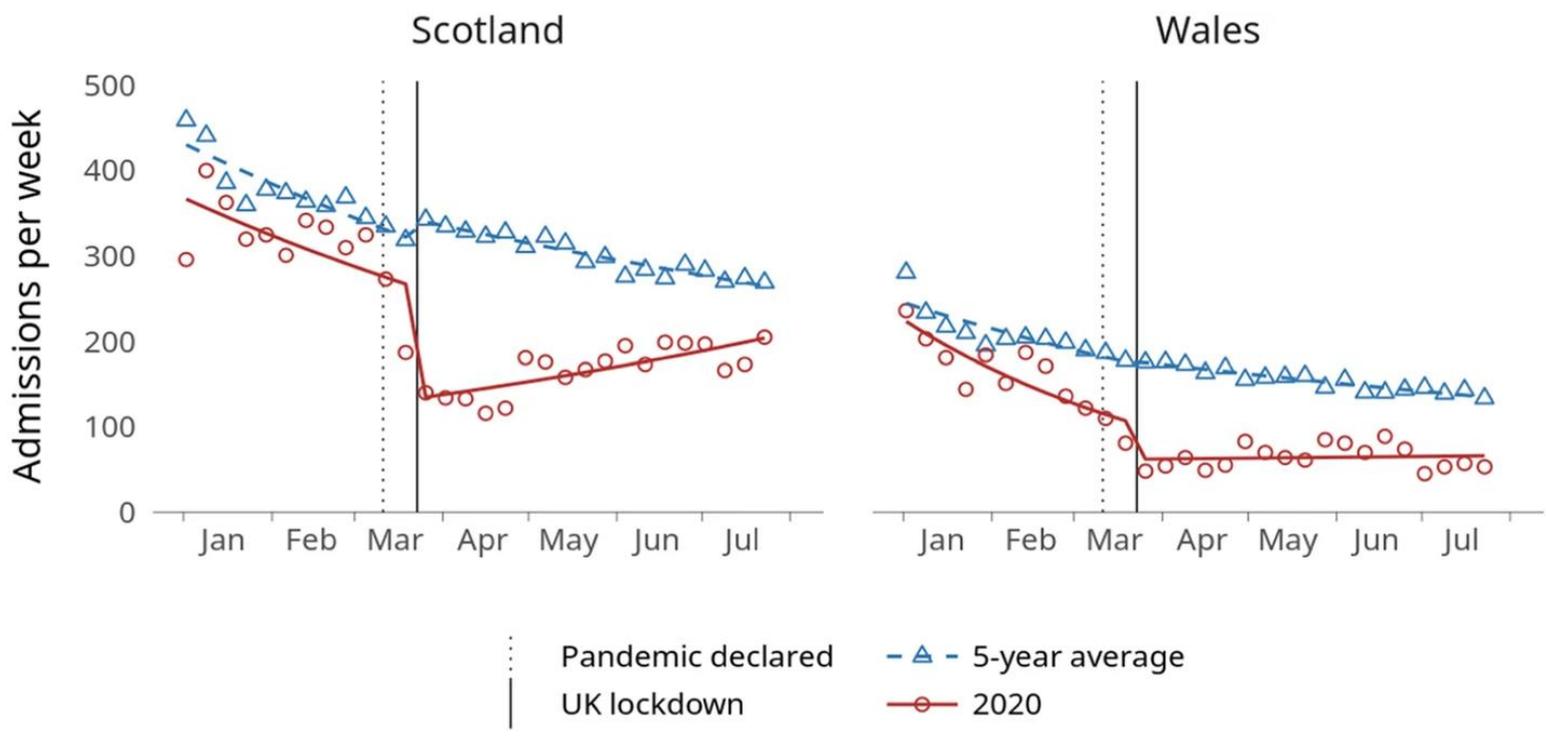
The standardized morbidity ratios
(observed/expected)
for respiratory hospital admissions

Average NO₂ concentrations ($\mu\text{g m}^{-3}$)

On the left (A) - standardised morbidity ratio for **respiratory** hospitalisations
On the right (B) - average concentrations of PM_{2.5}.

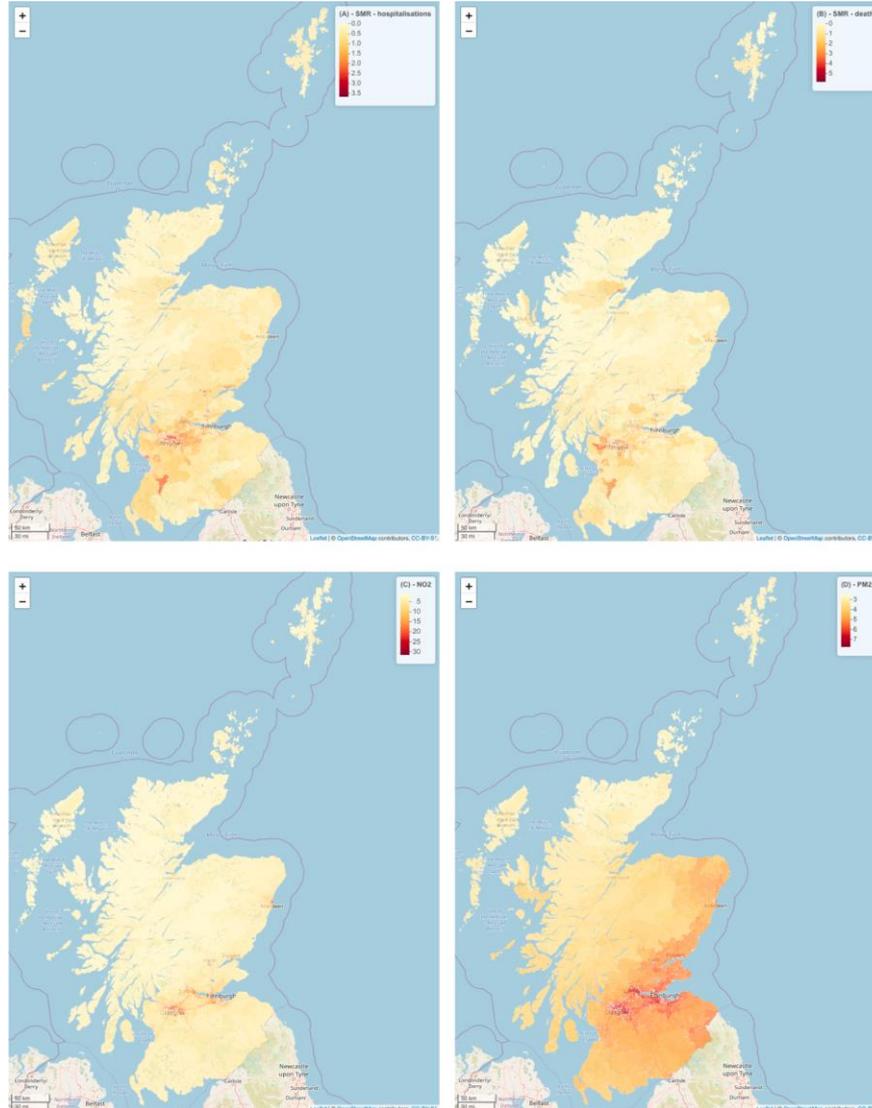


Admissions to Hospital during Pandemic correlates to Air Pollution



SMR For Covid-19 Hospitalisations & Deaths

Lower Panels Depict NO₂ & PM_{2.5} Concentrations

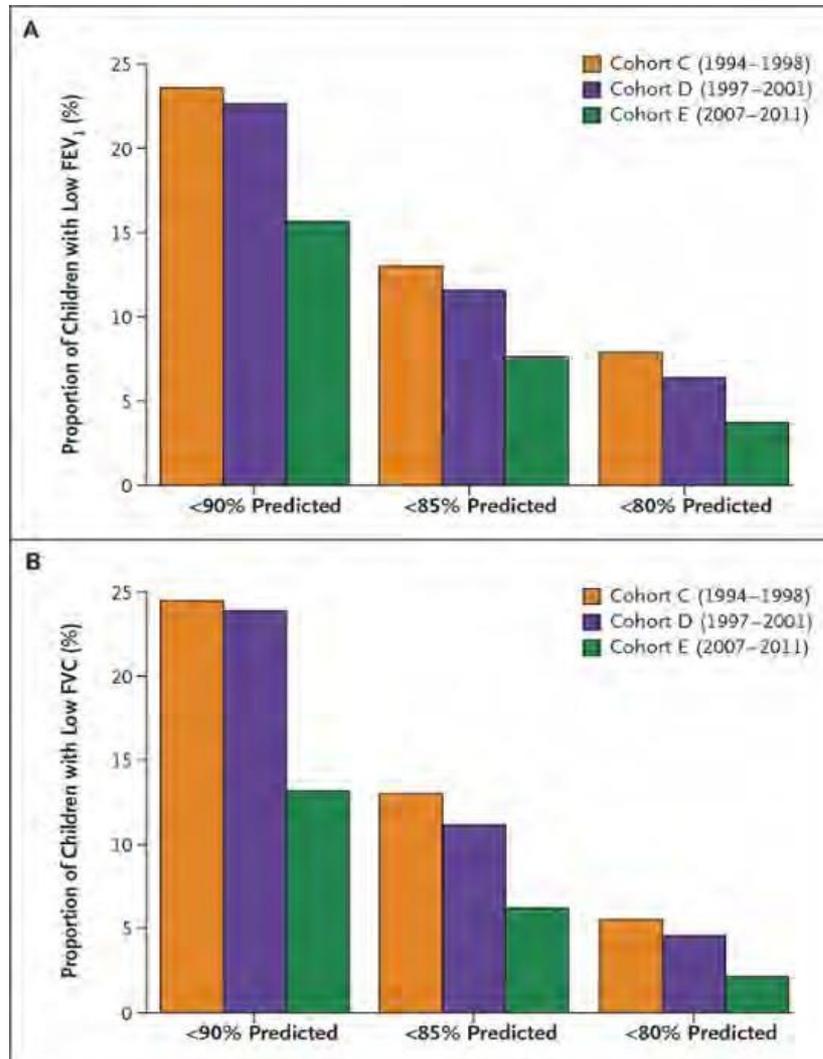


Results of Clean-up

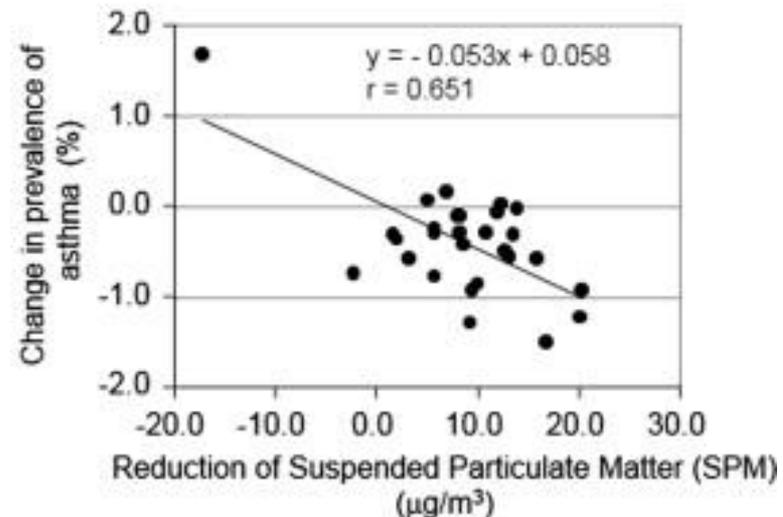
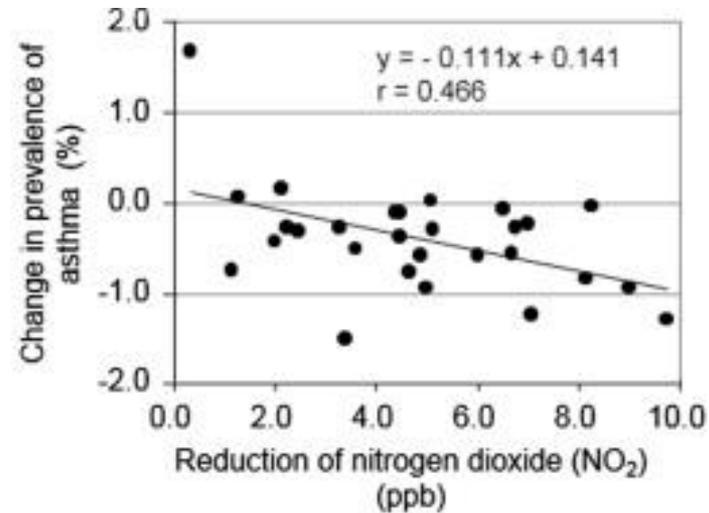
- Ireland banned coal burning:
 - Cardiovascular death rates dropped 10.5%
- Hong Kong banned high-sulfur fuel oil:
 - Cardiovascular death rates dropped 25%
- 1996 Atlanta Summer Olympics, reduced traffic
 - significant drop in children's asthma
- After German reunification, pollution ↓
 - children's respiratory symptoms decreased dramatically



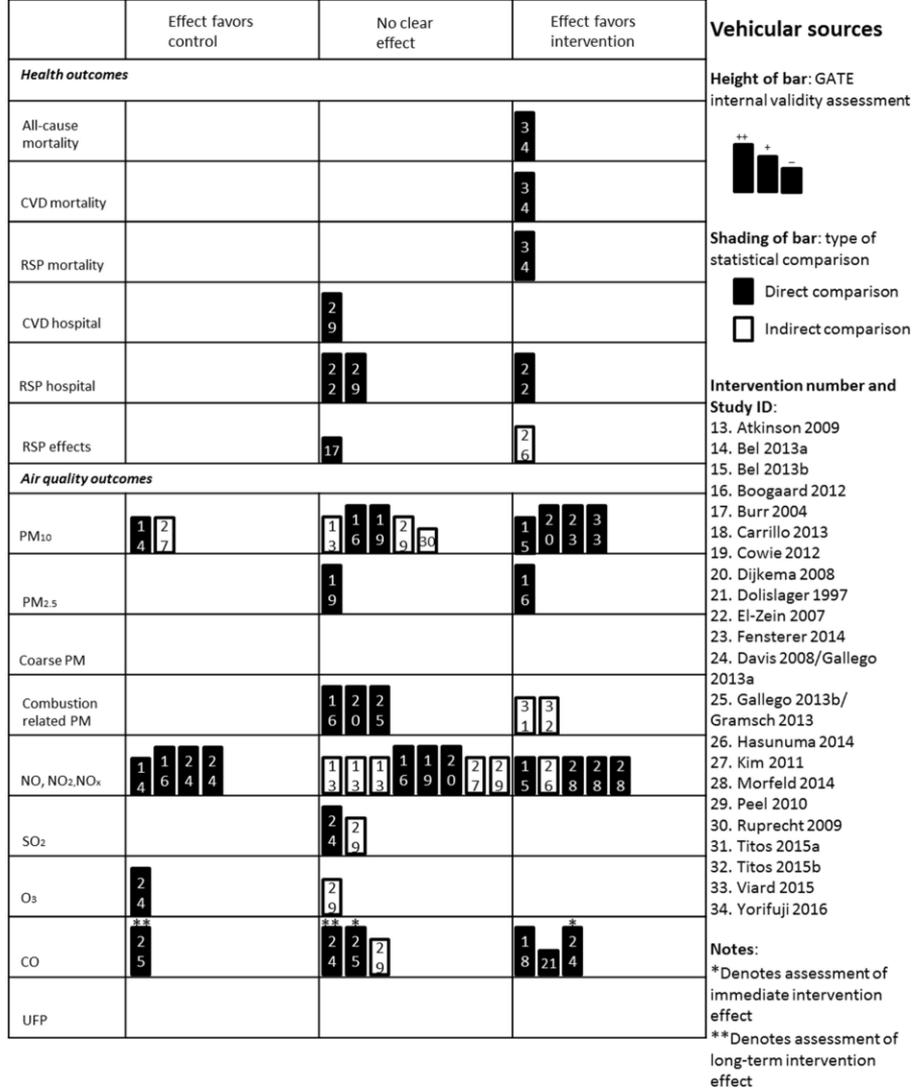
Improved Lung Development as Pollution decreases



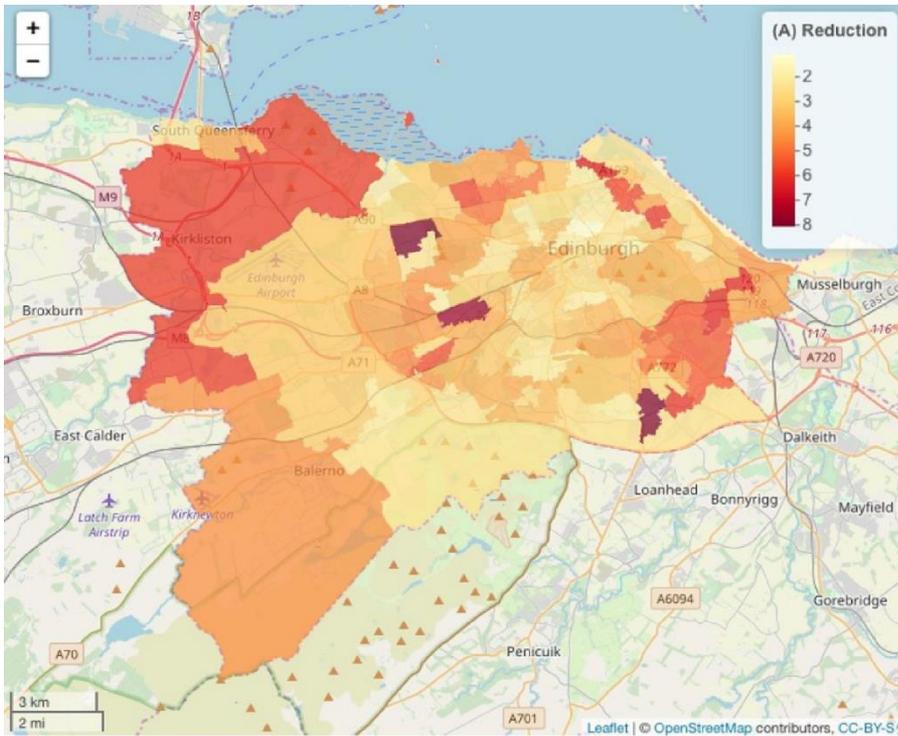
Asthma in Children & Air Pollution reduction



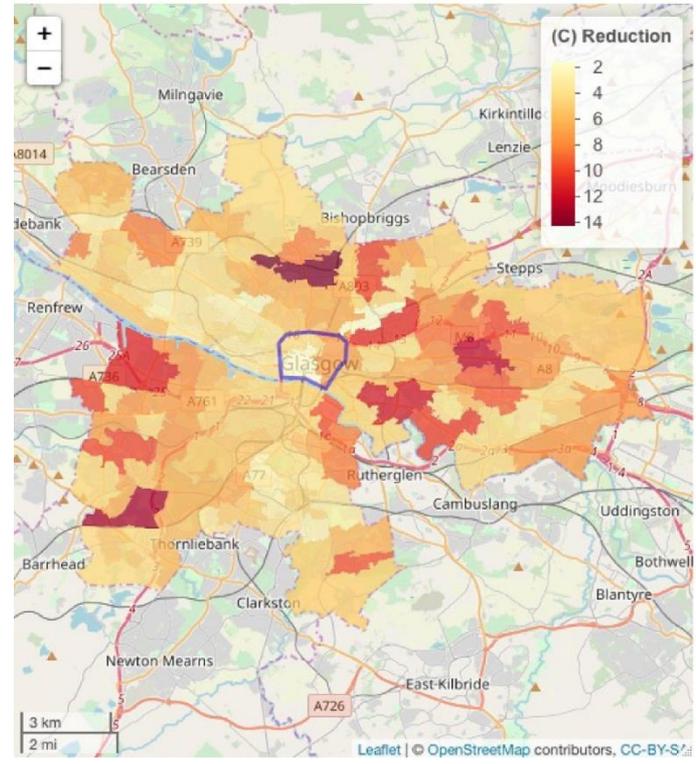
Assessment of Interventions on Health



Estimated reductions in respiratory hospitalisations due to a $5 \mu\text{g m}^{-3}$ reduction in NO_2 concentrations, The blue line denotes the boundary of the Glasgow LEZ.



Edinburgh



Glasgow

What can we do as Professionals ?

NO₂/PM₁₀/PM_{2.5}

40, 40, 25
μg/m³



40, 18, 10
μg/m³



10, 10, 5
μg/m³



- Remove disconnect between central and local Government – enforce legislation
- Look at your own Region's data & publish
- Engage with Local Councils, Engage with patients

**Insist on compliance –
THESE VALUES ARE THE LAW**

Air pollution: Conclusion

- Linked to MANY DISEASES
- Increases all cause mortality
- Damage to other organisms such as food crops
- Preventable
- Is now a health and legislative priority

