



Epidemiology of NO₂, PM₁₀ and PM_{2.5} in Wales

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Background

Particulate matter (PM)	Nitrogen dioxide (NO ₂)
<ul style="list-style-type: none">▪ Inhaled particles <10µm in diameter (PM₁₀ 'thoracic' fraction) penetrate, and deposit in, the upper respiratory tract.▪ Fine PM_{2.5} 'respirable' fraction penetrate deeper into lung alveoli.▪ Both cause lung lining inflammation which places pressure on, and affects the function of, various body systems.▪ Chronic exposure increases morbidity and mortality risk through cardiovascular and respiratory impacts.▪ Exposure also linked with atherosclerosis, childhood respiratory disease, endocrine (diabetes) and nervous (cognitive function) system impacts, birth outcomes, liver and kidney damage.▪ Diesel exhaust and particulate air pollution is carcinogenic to humans.	<ul style="list-style-type: none">▪ Exposure causes airway inflammation and impaired lung function.▪ Positive and significant short-term associations have been reported with all-cause and cause-specific mortality.▪ Associations believed not to be confounded by the presence of most particulate matter metrics, especially vehicle emissions.▪ Evidence suggests stronger, likely causal, relationships between NO₂ and adverse health impacts, particularly respiratory effects and linked hospital admissions, but less-so cardiovascular morbidity.▪ There is some support, but not to the same degree as for short-term exposure, for the relationship to remain causal for chronic exposure to NO₂.

Health burden

- PM_{2.5}: 29,000 deaths; 307,000 lost life-years
- NO₂: 23,500 deaths; 277,000 lost life-years

Pollutant metric	Health outcome	Pollutant range	Concentration Response Function per 10µg/m ³ (95%CI)	All-Wales Relative Risk (95% CI)	Annual attributable deaths estimate (95% CI)	Annual estimate Years of Life Lost (95% CI)
NO ₂ (annual mean)	All-cause mortality (natural), age 30+ years	>20µg/m ³	1.055 (1.031 to 1.080)	1.16 (1.09 to 1.23)	1,328 (747 to 1908)	15,936 (8,964 to 22,896)
PM ₁₀ (annual mean)	All-cause mortality (natural), all ages	All	1.035 (1.004 to 1.066)	1.05 (1.01 to 1.10)	1,502 (300 to 2,703)	18,024 (3,600 to 32,436)
PM _{2.5} (annual mean)	All-cause mortality (natural), age 30+ years	All	1.062 (1.040 to 1.083)	1.06 (1.04 to 1.08)	1,791 (1,194 to 2,388)	21,492 (14,328 to 28,656)

- 7-8 months life expectancy reduction for every UK resident

Economic costs of health impacts

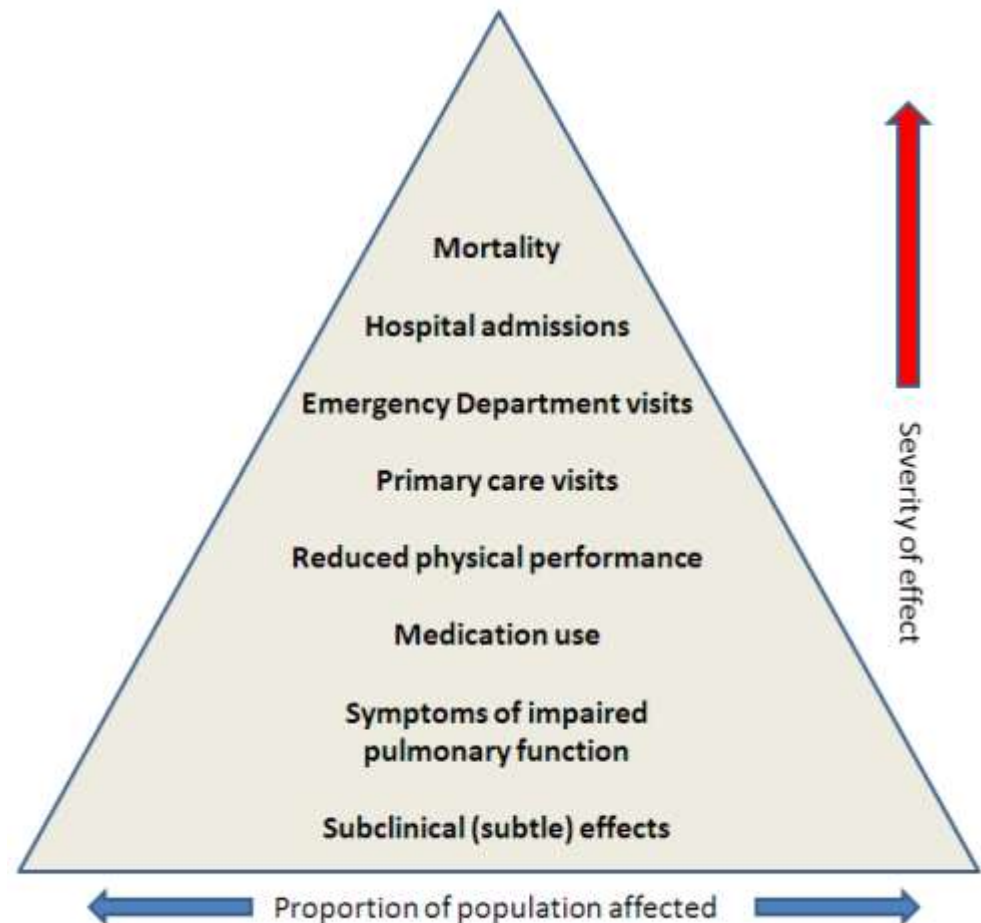
- Value of statistical life (2010) = \$3.55M or £2.35m
- Estimated annual cost of attributable mortality

NO₂ = £3.12b

PM₁₀ = £3.53b

PM_{2.5} = £4.21b

- Tip of the iceberg...



MORTALITY BURDEN ESTIMATES AT A LOCAL AUTHORITY LEVEL – RESULTS

TABLE 2 Wales: baseline population, modelled population-weighted mean concentrations ($\mu\text{g m}^{-3}$) and estimated effects on annual mortality in 2010 of anthropogenic $\text{PM}_{2.5}$ air pollution

Area	Population age 25+ ($\times 10^3$)	Deaths age 25+	Mean anthropogenic $\text{PM}_{2.5}$ ($\mu\text{g m}^{-3}$) ^a	Attributable fraction [†] (%)	Attributable deaths [‡] age 25+	Associated life-years lost [§]
WALES	2075.4	31041	7.5	4.3	1320	13549
Betsi Cadwaladr LHB	481.6	7462	6.7	3.8	280	2836
Isle of Anglesey	40.4	815	5.5	3.2	26	251
Gwynedd	81.2	1347	5.5	3.1	42	408
Conwy	81.6	1479	6.0	3.4	51	489
Denbighshire	69.6	1154	6.4	3.7	42	422
Flintshire	106.1	1366	8.0	4.5	62	670
Wrexham	93.5	1301	7.6	4.3	56	595
Powys LHB	98.5	1445	6.2	3.6	51	509
Powys	98.5	1445	6.2	3.6	51	509
Hywel Dda LHB	264.5	4190	6.6	3.7	157	1562
Ceredigion	51.8	745	5.8	3.3	25	273
Pembrokeshire	83.8	1347	6.6	3.8	51	500
Cardiganshire	128.8	2098	6.9	3.9	82	789
Abertawe Bro Morgannwg LHB	349.0	5362	7.4	4.2	227	2314
Swansea	157.1	2405	7.4	4.2	102	1048
Neath Port Talbot	97.3	1573	7.4	4.2	66	662
Bridgend	94.6	1385	7.5	4.3	59	604
Cardiff and Vale LHB	299.1	3843	9.0	5.1	196	2100
Vale of Glamorgan	86.5	1190	7.9	4.5	53	557
Cardiff	212.6	2653	9.5	5.4	143	1543
Cwm Taf LHB	198.5	3081	7.7	4.4	135	1399
Rhondda, Cynon, Taff	160.4	2491	7.8	4.4	110	1130
Merthyr Tydfil	38.1	590	7.5	4.3	25	269
Aneurin Bevan LHB	386.4	5658	8.5	4.8	273	2829
Caerphilly	118.7	1687	8.3	4.7	80	822
Blaenau Gwent	47.4	797	7.9	4.5	36	356
Torfaen	62.8	951	8.5	4.8	46	473
Monmouthshire	63.6	874	7.9	4.5	39	404
Newport	93.8	1350	9.4	5.4	72	774

Attributable mortality
fraction between 3-5%
in Wales

Limitations

- Useful profile and scope
 - Mask small-area variations in levels, risks and impacts
 - Local influences on air pollution concentrations
 - Not just differential exposures that influence risks/impacts
 - Individual and population-level susceptibilities
- “Intrinsic” age, sex, genetics, ethnicity
- “Acquired” income, education, housing, employment,
 service access, chronic illness, lifestyle/behaviours

TRIPLE JEOPARDY

Study aim and objectives

Aim	<i>To assess local air pollution, deprivation and health associations in Wales</i>
Objectives	<i>To determine any added value of:</i> <ol style="list-style-type: none"><i>1. considering local air pollution problems and solutions in a broader public health context</i><i>2. Increasing Public Health integration and engagement in local air quality assessment and management</i>





Methods

Data	Geography	Lower Super Output Areas (LSOA) - Wales
	Air pollution	Modelled population-weighted 3-year (2011 to 2013) averaged annual mean concentrations for NO ₂ , PM ₁₀ , PM _{2.5}
	Health	All-cause mortality; Cardiovascular, cerebrovascular, respiratory and chronic liver disease mortality and morbidity
	Deprivation	Welsh Index of Multiple Deprivation – Income Deprivation
Analysis	Variation	Data linked and mapped at local level. Air pollution and deprivation status assigned to LSOAs.
	Associations	Separate <i>air pollution-health</i> and <i>deprivation-health analyses</i> . Air pollution and deprivation interactions; combined association with health outcomes.

Results

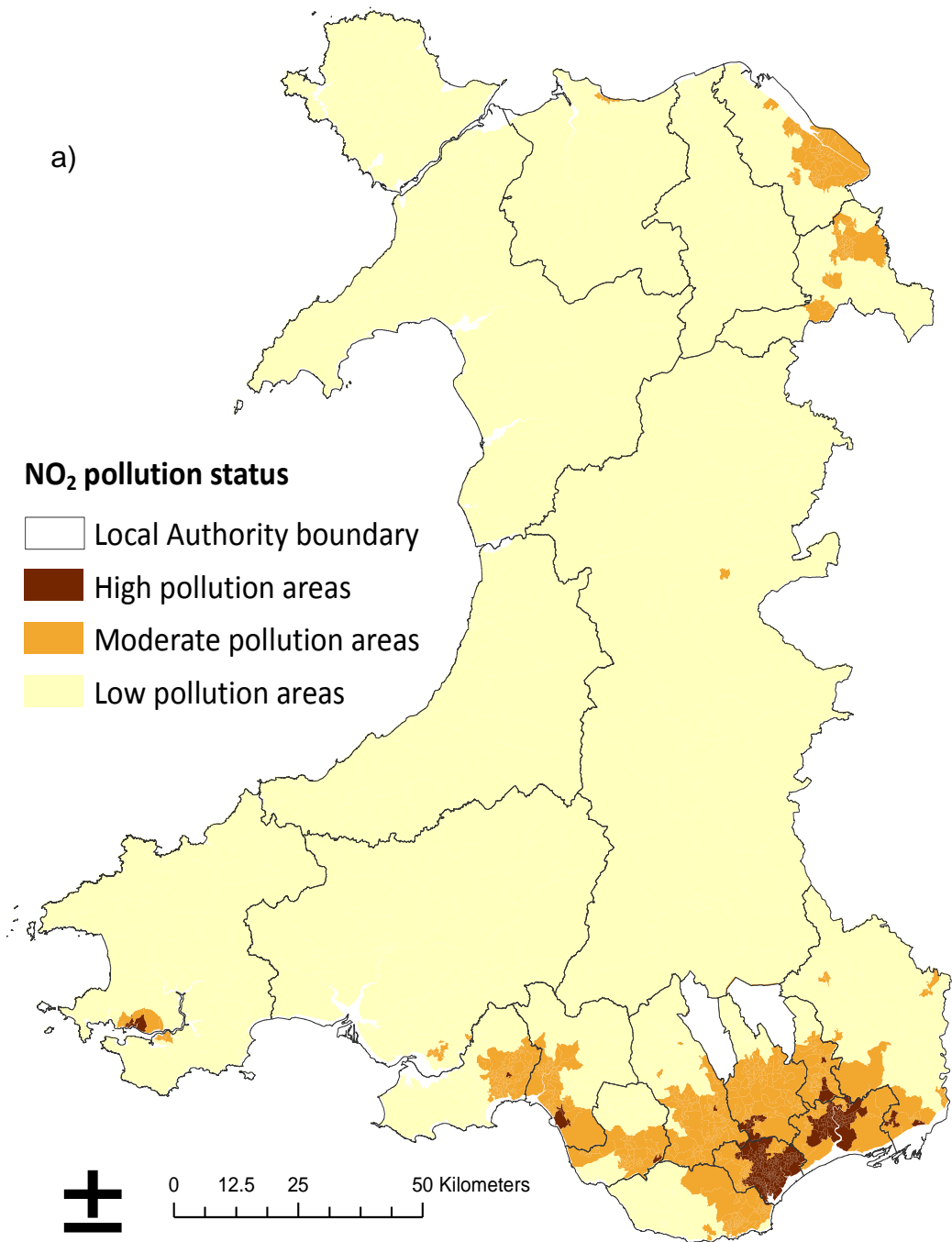
a)

NO₂ pollution status

-  Local Authority boundary
-  High pollution areas
-  Moderate pollution areas
-  Low pollution areas








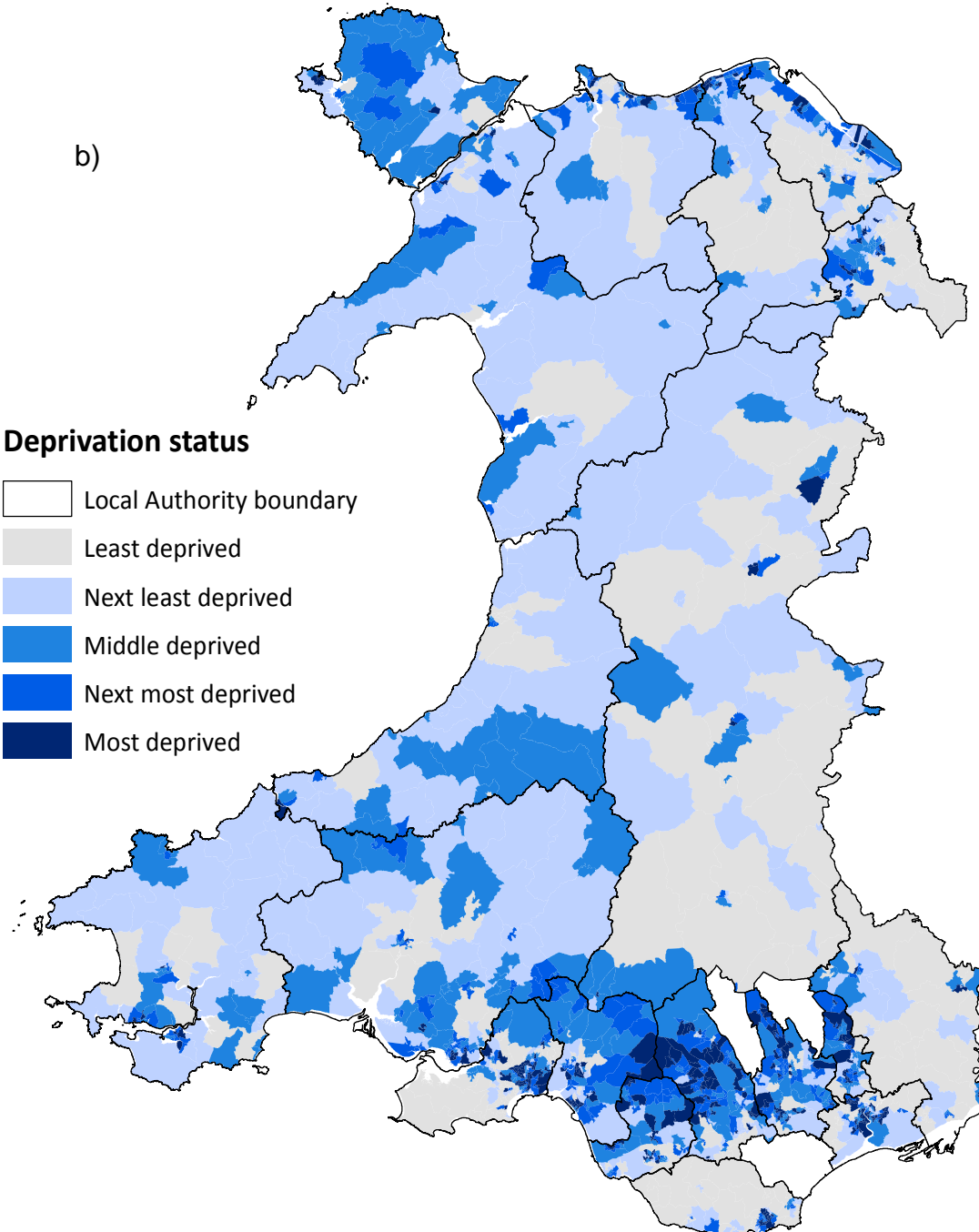
0 12.5 25 50 Kilometers

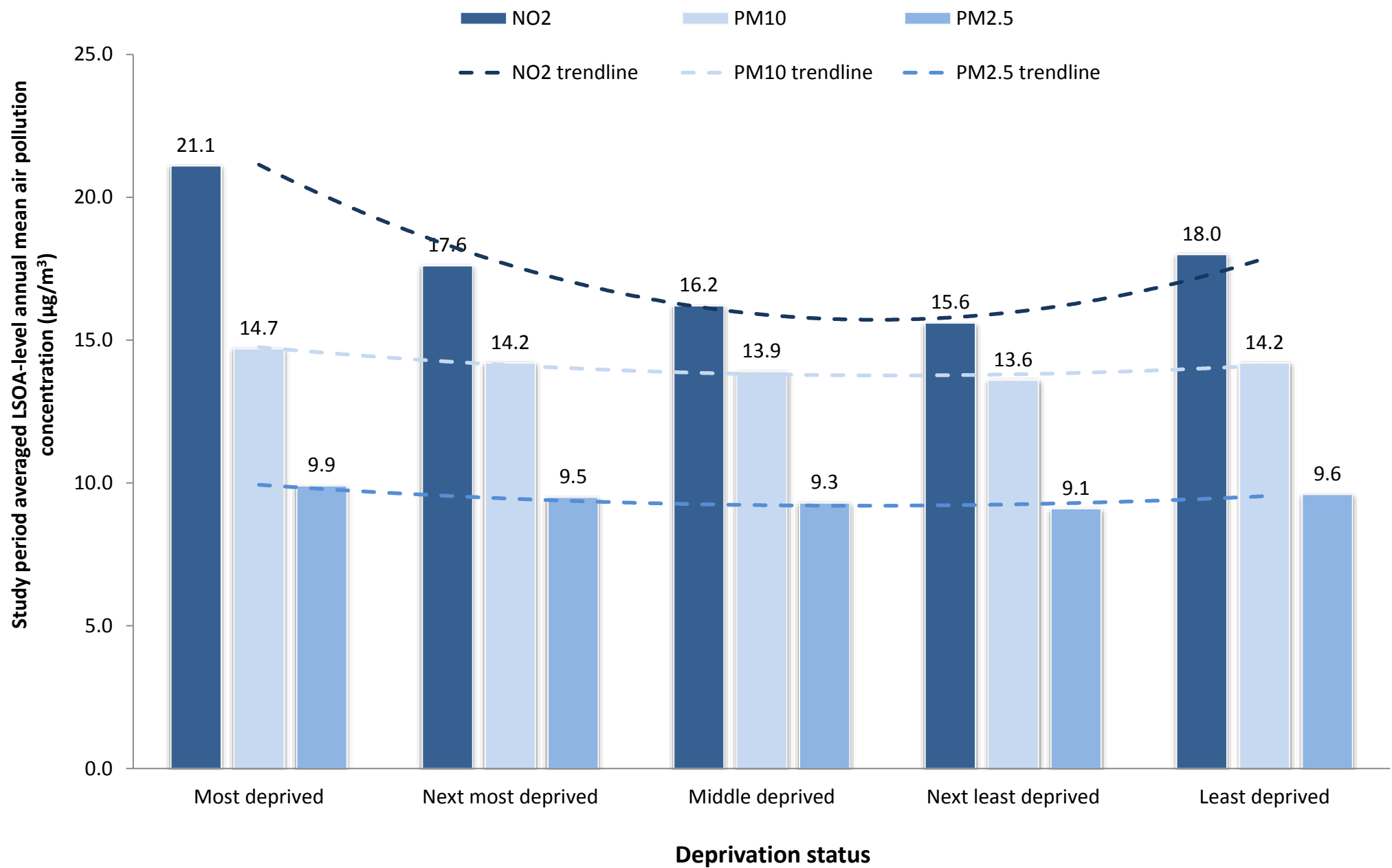


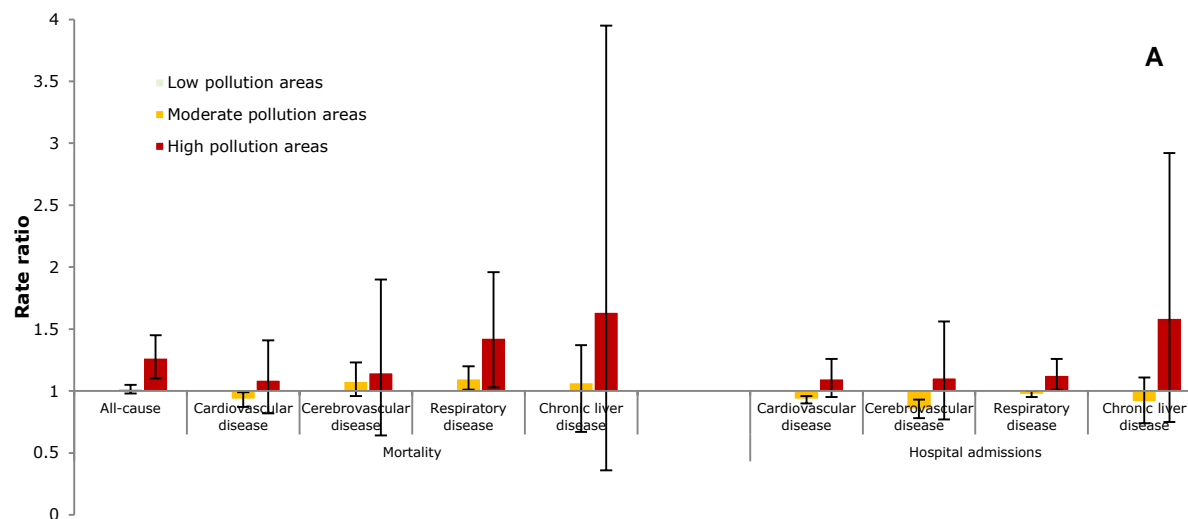
b)

Deprivation status

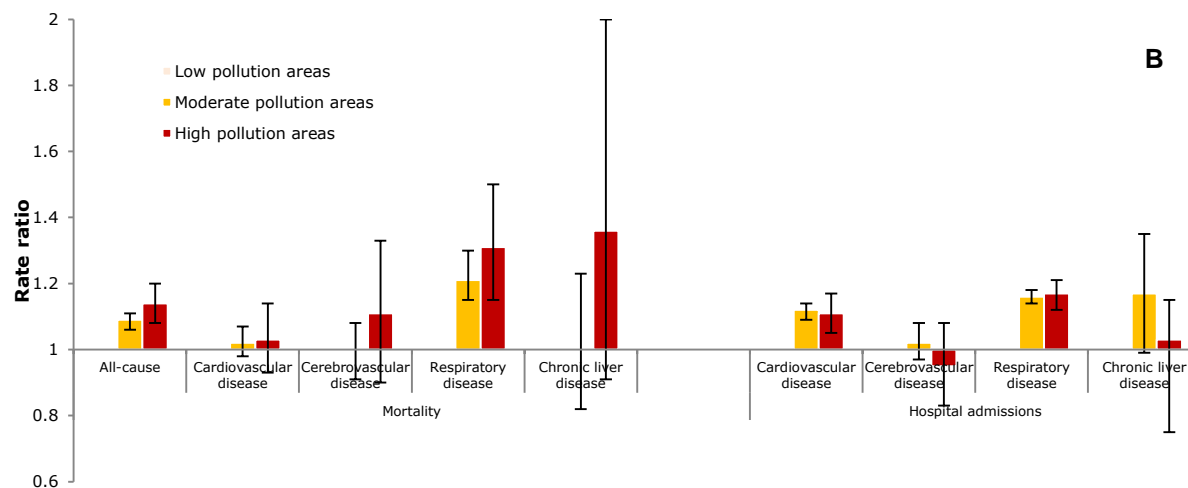
-  Local Authority boundary
-  Least deprived
-  Next least deprived
-  Middle deprived
-  Next most deprived
-  Most deprived



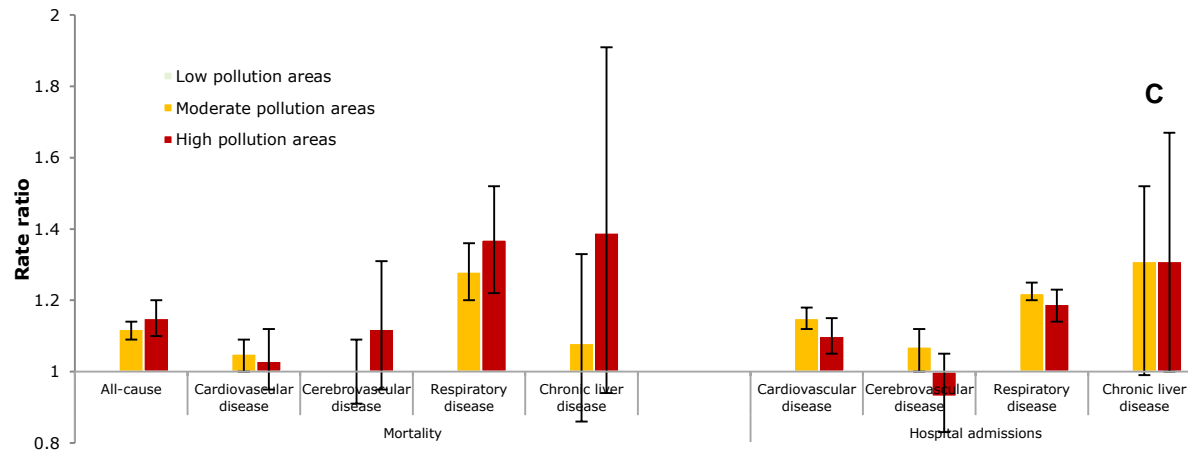




NO₂: all-cause and respiratory disease mortality

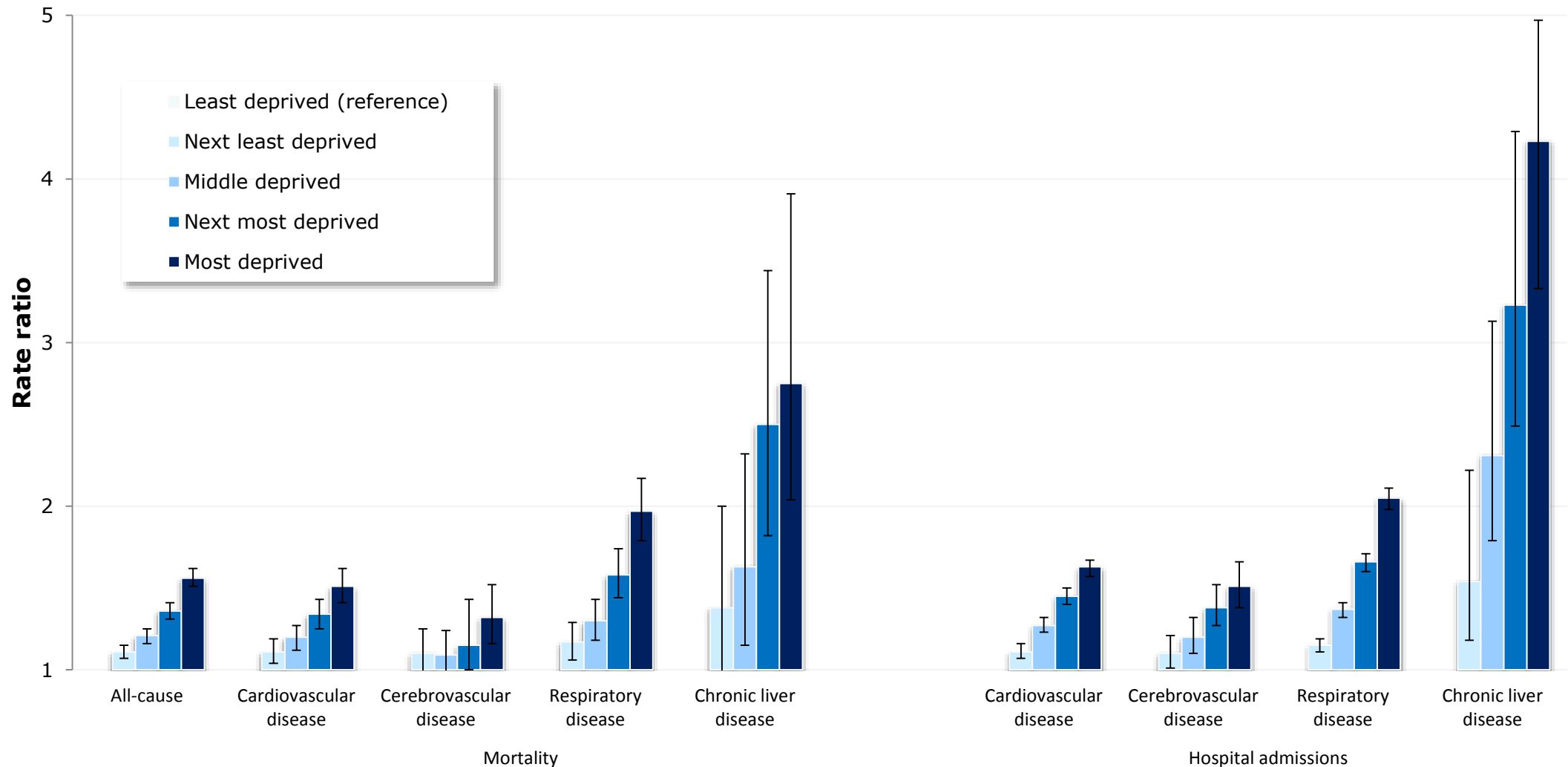


PM₁₀: all-cause and respiratory disease mortality; cardiovascular disease and respiratory morbidity



PM_{2.5}: all-cause and respiratory disease mortality; cardiovascular disease and respiratory morbidity

Deprivation-health association



- Evidence of strong positive associations
- Rates of all health outcomes ↑ as deprivation levels ↑
- All health outcome rates (except cerebrovascular mortality) significantly higher

Air pollution-deprivation-health association

				Air pollution status		
				Low	Moderate	High
Nitrogen dioxide (NO ₂)	Mortality rate ratio (95%CI)	All-cause	Least	-	1.01 (0.92 to 1.07)	1.09 (0.28 to 2.09)
			Most	1.41* (1.36 to 1.45)	1.43* (1.34 to 1.52)	1.62* (1.37 to 1.89)
		Cardiovascular disease	Least	-	0.94 (0.84 to 1.06)	1.17 (0.03 to 3.95)
			Most	1.40* (1.32 to 1.48)	1.26* (1.14 to 1.40)	1.32 (0.93 to 1.78)
		Cerebrovascular disease	Least	-	1.04 (0.83 to 1.27)	0.41 (0.01 to 2.84)
			Most	1.15* (1.03 to 1.29)	1.31* (1.05 to 1.59)	1.39 (0.67 to 2.44)
	Respiratory disease	Least	-	1.14 (0.97 to 1.32)	1.17 (0.04 to 15.94)	
		Most	1.70* (1.57 to 1.84)	1.80* (1.58 to 2.06)	2.10* (1.38 to 3.03)	
	Morbidity rate ratio (95%CI)	Chronic liver disease	Least	-	1.00 (0.54 to 1.88)	0.67 (0.22 to 4.58)
			Most	2.33* (1.81 to 3.17)	2.33* (1.49 to 3.62)	3.56 (0.88 to 8.94)
		Cardiovascular disease	Least	-	0.92 (0.86 to 0.98)	1.05 (0.24 to 2.22)
			Most	1.51* (1.47 to 1.56)	1.39* (1.31 to 1.47)	1.44* (1.20 to 1.69)
		Cerebrovascular disease	Least	-	0.80* (0.68 to 0.94)	0.95 (0.01 to 6.81)
			Most	1.42* (1.32 to 1.53)	1.22* (1.05 to 1.39)	1.37 (0.87 to 2.05)
Respiratory disease		Least	-	0.92 (0.87 to 0.97)	1.02 (0.11 to 1.65)	
		Most	1.80* (1.75 to 1.85)	1.73* (1.66 to 1.80)	1.70* (1.49 to 1.93)	
Chronic liver disease	Least	-	0.75 (0.42 to 1.25)	0.81 (0.13 to 6.44)		
	Most	3.25* (2.66 to 4.11)	2.69* (1.96 to 3.71)	4.13* (1.79 to 8.24)		

Particulate matter (PM ₁₀)	Mortality rate ratio (95%CI)	All-cause	Least	-	1.02 (0.96 to 1.08)	1.06 (0.91 to 1.24)
			Most	1.56* (1.46 to 1.66)	1.58* (1.50 to 1.66)	1.65* (1.50 to 1.80)
		Cardiovascular disease	Least	-	0.95 (0.86 to 1.05)	1.05 (0.78 to 1.38)
			Most	1.54* (1.37 to 1.73)	1.46* (1.33 to 1.61)	1.38* (1.16 to 1.64)
		Cerebrovascular disease	Least	-	1.02 (0.82 to 1.24)	1.21 (0.68 to 1.96)
			Most	1.33* (1.04 to 1.68)	1.36* (1.11 to 1.64)	1.33 (0.91 to 1.87)
	Morbidity rate ratio (95%CI)	Respiratory disease	Least	-	1.19* (1.02 to 1.39)	1.35 (0.86 to 1.95)
			Most	2.05* (1.73 to 2.41)	2.21* (1.92 to 2.53)	2.38* (1.89 to 2.95)
		Chronic liver disease	Least	-	1.14 (0.60 to 2.17)	1.57 (0.28 to 5.50)
			Most	3.71* (2.07 to 7.16)	2.71* (1.62 to 5.04)	4.71* (2.32 to 9.79)
		Cardiovascular disease	Least	-	1.04 (0.98 to 1.10)	1.03 (0.8 to 1.20)
			Most	1.65* (1.55 to 1.76)	1.68* (1.60 to 1.77)	1.57* (1.43 to 1.72)
		Cerebrovascular disease	Least	-	0.97 (0.85 to 1.11)	0.93 (0.61 to 1.35)
			Most	1.58* (1.35 to 1.84)	1.48* (1.30 to 1.68)	1.31* (1.03 to 1.66)
		Respiratory disease	Least	-	1.04 (0.98 to 1.09)	0.96 (0.84 to 1.09)
			Most	2.03* (1.92 to 2.15)	2.11* (2.01 to 2.21)	2.02* (1.88 to 2.18)
		Chronic liver disease	Least	-	1.08 (0.70 to 1.82)	0.83 (0.16 to 2.82)
			Most	5.17* (3.39 to 8.16)	4.58* (3.12 to 7.01)	3.92 (0.22 to 6.84)

Particulate matter (PM _{2.5})	Mortality rate ratio (95%CI)	All-cause	Least	-	1.04 (0.98 to 1.10)	1.08 (0.91 to 1.18)
			Most	1.57* (1.49 to 1.70)	1.58* (1.50 to 1.67)	1.61* (1.48 to 1.74)
		Cardiovascular disease	Least	-	0.96 (0.87 to 1.07)	0.97 (0.79 to 1.18)
			Most	1.57* (1.38 to 1.78)	1.48* (1.34 to 1.63)	1.40* (1.20 to 1.62)
		Cerebrovascular disease	Least	-	1.05 (0.86 to 1.29)	1.11 (0.74 to 1.59)
			Most	1.41* (1.07 to 1.84)	1.33* (1.09 to 1.63)	1.50* (1.09 to 2.01)
	Morbidity rate ratio (95%CI)	Respiratory disease	Least	-	1.21* (1.04 to 1.42)	1.26 (0.89 to 1.60)
			Most	2.15* (1.79 to 2.59)	2.19* (1.90 to 2.53)	2.34* (1.91 to 2.85)
		Chronic liver disease	Least	-	1.14 (0.60 to 2.08)	1.43 (0.40 to 4.09)
			Most	4.29* (2.33 to 8.30)	2.86* (1.67 to 5.20)	3.71* (1.92 to 7.50)
		Cardiovascular disease	Least	-	1.05 (0.99 to 1.11)	0.95 (0.77 to 1.06)
			Most	1.60* (1.48 to 1.72)	1.71* (1.62 to 1.80)	1.56* (1.44 to 1.69)
		Cerebrovascular disease	Least	-	0.99 (0.86 to 1.13)	0.79 (0.59 to 1.06)
			Most	1.54* (1.29 to 1.83)	1.50* (1.32 to 1.71)	1.76* (1.46 to 2.12)
		Respiratory disease	Least	-	1.06* (1.01 to 1.12)	0.94 (0.85 to 1.04)
			Most	2.03* (1.91 to 2.15)	2.14* (2.04 to 2.24)	2.04* (1.91 to 2.18)
		Chronic liver disease	Least	-	1.17 (0.72 to 1.88)	0.83 (0.63 to 1.88)
			Most	4.75* (2.99 to 7.67)	4.58* (3.15 to 7.05)	4.58* (2.86 to 7.56)

		Air pollution status		
Dep		Low	Moderate	High
Respiratory disease mortality	Least	-	1.19* (1.02 to 1.39)	1.35 (0.86 to 1.95)
	Most	2.05* (1.73 to 2.41)	2.21* (1.92 to 2.53)	2.38* (1.89 to 2.95)

Conclusion

- Significant air pollution-related health burden and costs
National vs. regional vs. local
- Air pollution, deprivation status and health inextricably linked
- Interactions can modify and amplify associations
- Mixed approach: exposure reduction and targeted action (local problems and solutions considered in broad public health context)
- Maximise health gain and reduce inequalities
- Greater Public Health integration in local air quality assessment and management policy and practice required

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- Limitations – ecological study, modelled data, income deprivation, confounders, simple statistical methods



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