Supplementary material to:

Associations between metal constituents of ambient particulate matter and mortality in England; an ecological study

Table S1: Descriptive statistics of health outcomes, modelled particulate metal concentrations, deprivation score, and ethnicity covariates for the 1533 wards in the study area in 2008-11.

	10th centile	mean	median	90th centile	LOOCV* R^2 (for LUR**)
Health outcomes	Rates of health outcome (number of cases per hundred thousand people)				
Cardiovascular mortality	117.50	215.97	203.20	327.87	
Respiratory mortality	42.85	96.34	87.85	160.41	
Lung cancer incidence	25.06	48.44	45.75	75.86	
Modelled metal concentrations using LUR	Metals in ng/m^3				
Cu PM_{10}	7.0	13.3	13.1	19.8	0.95
Fe PM_{10}	223.2	378.9	357.0	596.7	0.95
Zn PM_{10}	113.5	135.2	139.5	153.0	0.77
Cu $PM_{2.5}$	2.6	4.3	4.6	5.7	0.79
Fe $PM_{2.5}$	51.6	86.8	82.8	129.0	0.92
Area-level confounders					
Deprivation (modified IMD)	3.45	7.08	6.47	11.78	
% of Asian	2	13	9	33	
% of White	38	72	77	95	
Tobacco expenditure (pounds/week/inhabitant)	3.40	4.61	4.48	6.03	

*LOOCV Leave one out cross validation

** LUR Land Use Regression

Table S2: Poisson regression confounder effects from the two models (i) using metals from PM_{10} and (ii) metals from $PM_{2.5}$ for all the health outcomes. Mean, lower and upper bound of the 95% credible interval (CI) of the inter-decile relative risk (RR).

Outcomes	Model	Confounders	RR	CI 95%
Cardiovascular mortality	All Metals in PM_{10} VIF^2=9.14	IMD[1]	1.098	(1.02,1.182)
		% Asian	0.982	(0.921,1.046)
		% White	0.817	(0.729,0.915)
		Tobacco expenditure	1.197	(1.133,1.265)
	All Metals in $PM_{2.5}$ VIF^2=9.04	IMD[1]	1.095	(1.02,1.177)
		% Asian	0.987	(0.926,1.052)
		% White	0.824	(0.737,0.922)
		Tobacco expenditure	1.192	(1.135,1.253)
		IMD[1]	1.188	(1.073,1.315)

Respiratory mortality	All Metals in PM$_{10}$ VIF^2=8.93	% Asian	0.887	(0.813,0.967)
		% White	0.822	(0.704,0.959)
		Tobacco expenditure	1.301	(1.206,1.403)
	All Metals in PM$_{2.5}$ VIF^2=8.81	IMD^1	1.183	(1.07,1.306)
		% Asian	0.892	(0.817,0.973)
		% White	0.846	(0.725,0.986)
		Tobacco expenditure	1.301	(1.214,1.393)
Lung cancer incidence	All Metals in PM$_{10}$ VIF =8.60	IMD^1	1.390	(1.261,1.532)
		% Asian	0.851	(0.790,0.916)
		% White	0.932	(0.818,1.062)
		Tobacco expenditure	1.472	(1.366,1.586)
	All Metals in PM$_{2.5}$ VIF^2=7.72	IMD^1	1.404	(1.276,1.544)
		% Asian	0.846	(0.786,0.910)
		% White	0.955	(0.839,1.086)
		Tobacco expenditure	1.468	(1.373,1.569)

^{1}IMD Indices of multiple deprivation
^{2}VIF Variance Inflation Factor

Table S3: Pearson Correlation(r) between the adjusted annual mean concentrations of PM-metals and the adjusted annual mean PM concentrations (PM$_{2.5}$ and PM$_{10}$).

N=1533		PM$_{2.5}$ CU	PM$_{2.5}$ FE	PM$_{10}$ CU	PM$_{10}$ FE	PM$_{10}$ ZN	PM$_{2.5}$	PM$_{10}$
PM$_{2.5}$	Correlation	0.86	0.89	0.89	0.89	0.73	1.00	0.92
PM$_{10}$	Correlation	0.82	0.87	0.86	0.88	0.74	0.92	1.00

All the correlation significant at p< 0.001

Figure S1. A graphical presentation of the confounding and causal mechanism, linking exposure and adverse health outcomes.
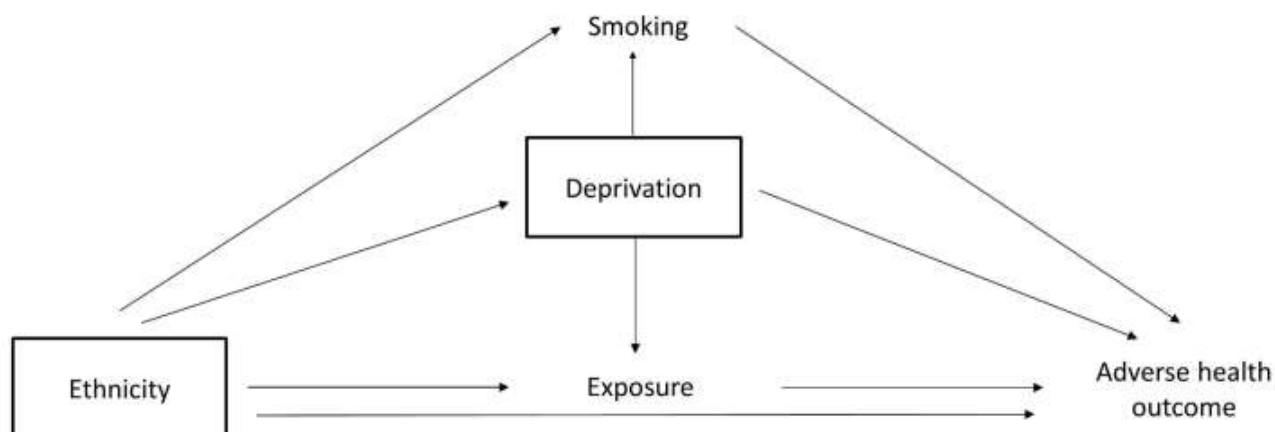
Figure S2. Maps of the confounders in quintiles: proportion of Asian people, proportion of white people, modified index of multiple deprivations, and tobacco spends. Contains National Statistics data © Crown copyright and database right 2018; Contains OS data © Crown copyright and database right 2018. All rights reserved.