SUPPLEMENTARY MATERIALS

Estimated effects of air pollution and space-time-activity on cardiopulmonary outcomes in healthy adults: a repeated measures study

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FIGURES

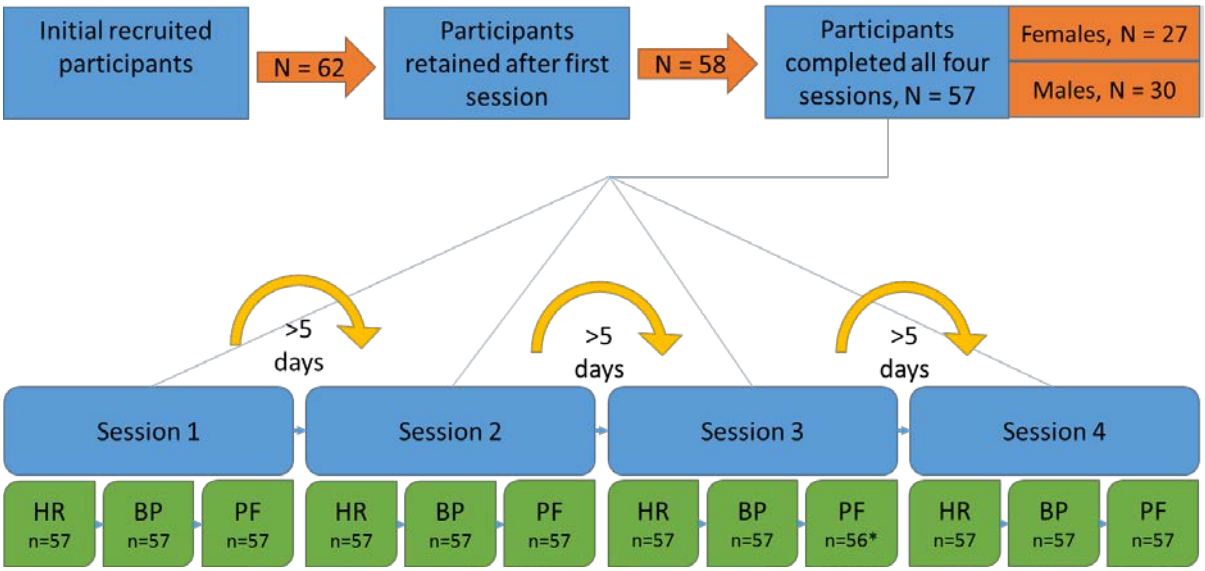


Figure S1 – Flow chart for study design

(From main text, Methods, 2.1. Study Design and Protocol)

The study had a repeated-measures design, and incorporated two separate (but methodologically comparable) experimental case-crossover studies within the TAPAS (de Nazelle et al. 2011) and EXPOsOMICS (Vineis et al. 2016) projects. Up to six participants of either comparable study each performed outcome measures at the research unit site on four separate occasions of at least five days apart; on Tuesdays, Wednesdays and Thursdays. These measures were taken as the baseline health measurement for either of the two comparable studies (not further reported here). To minimise diurnal variation on health measures, all measurements were performed in the morning between 07:00 to 08:00 h.

** one spirometric session did not fulfill reproducibility criteria and so this single participant-session data point was excluded from all analyses*

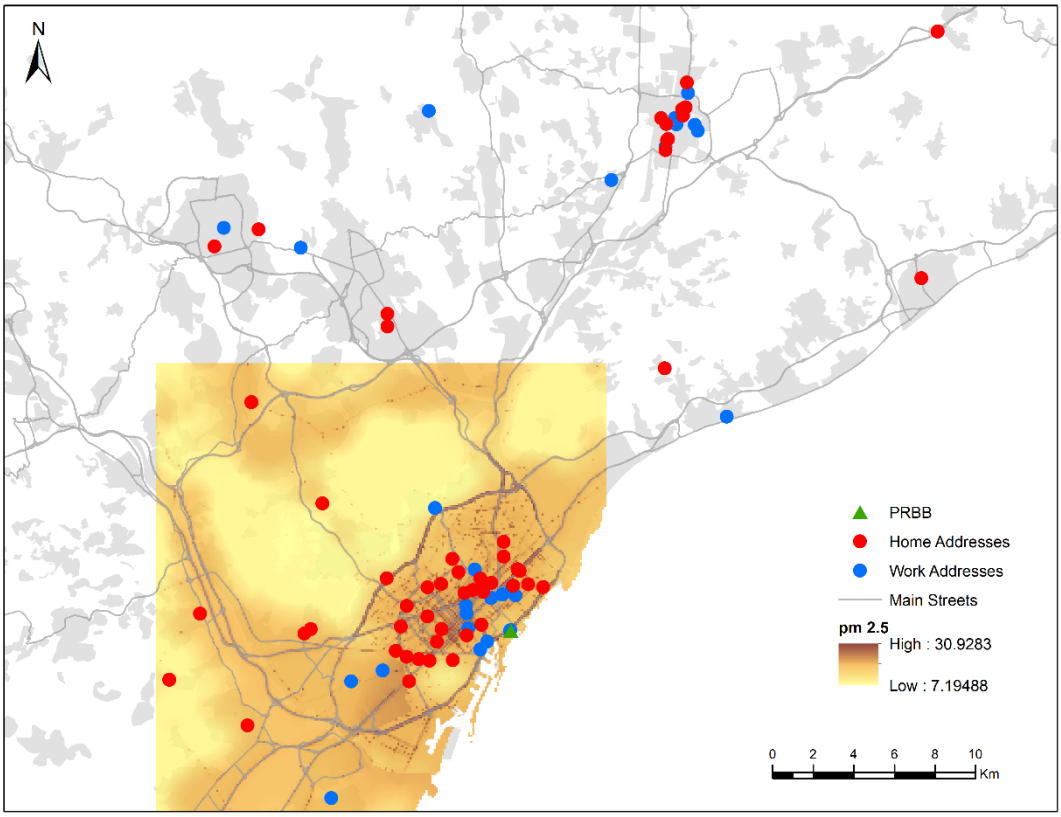
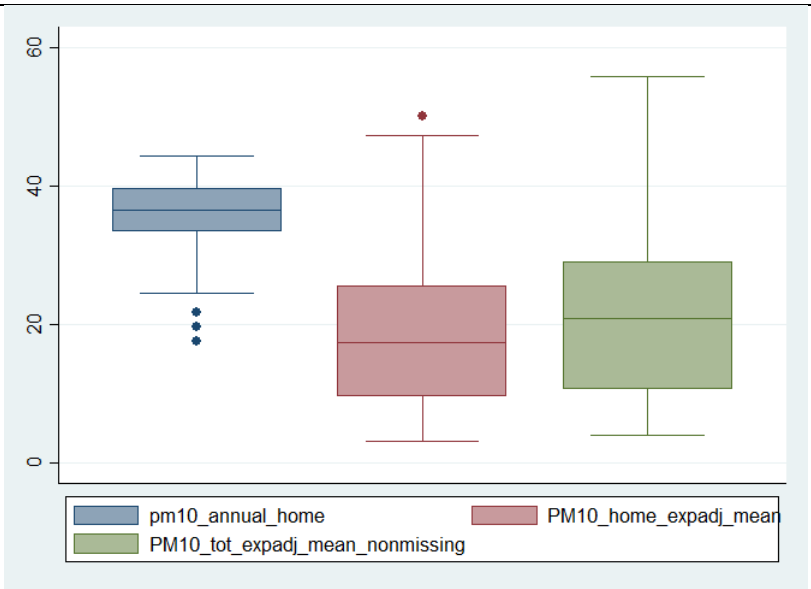
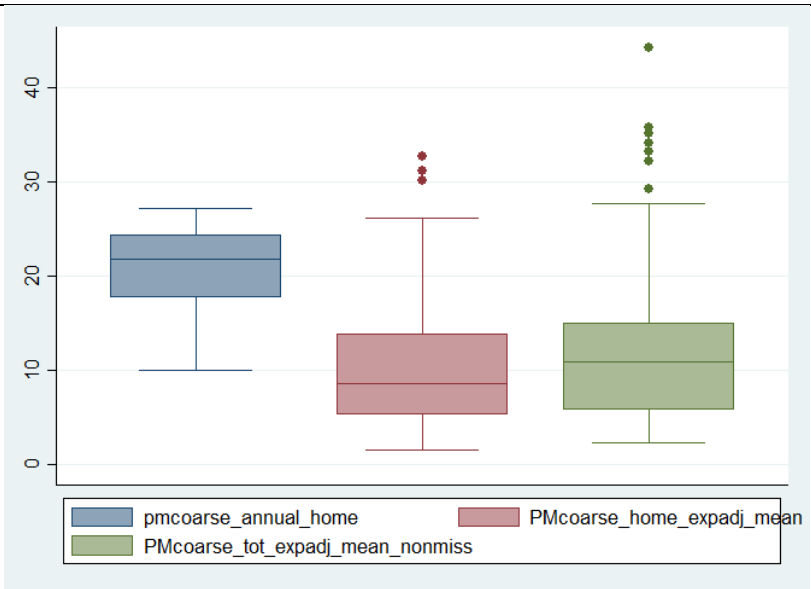
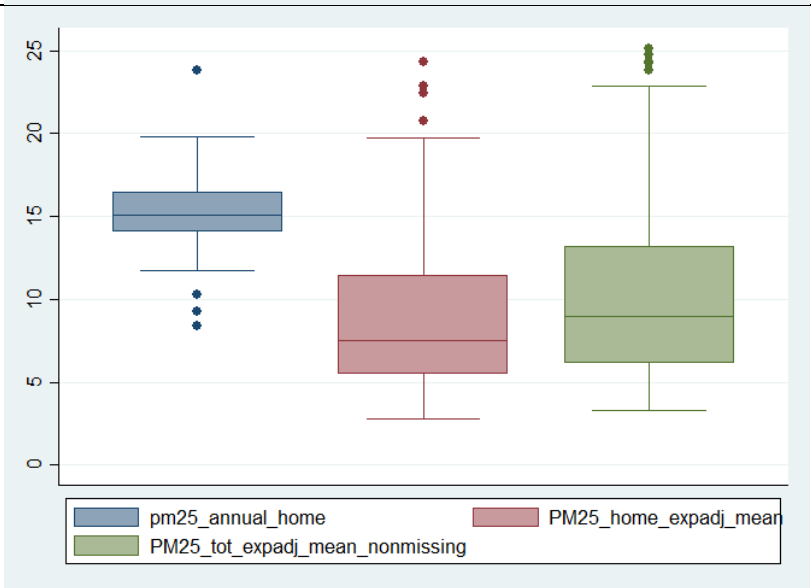


Figure S2 – Residential and Work addresses of participants in Barcelona and greater surroundings; visualising the extent of the 2009 annual-spatial ESCAPE-LUR model for $PM_{2.5}$.

PRBB = research unit (health measurement) site. Grey shading = Urban areas.

(S3a) PM_{10} [µg/m^3]	
(S3b) PM_{Coarse} [µg/m^3]	
(S3c) $PM_{2·5}$ [µg/m^3]	

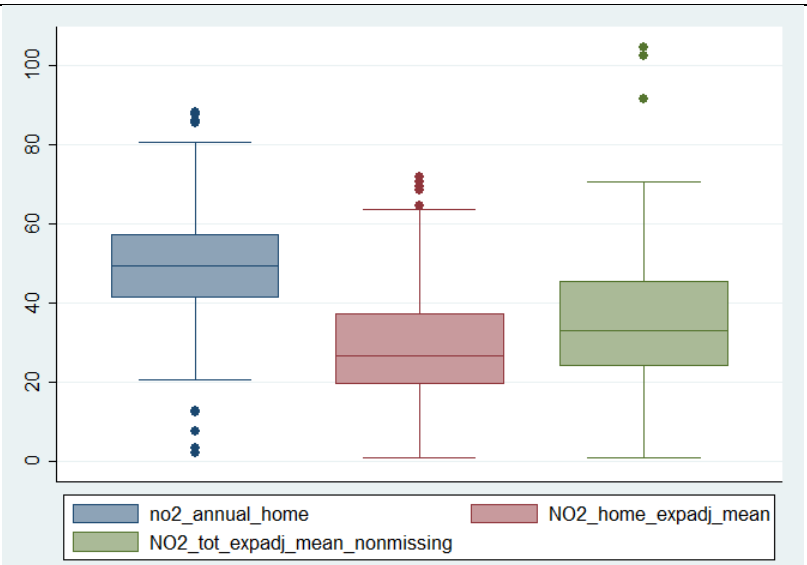
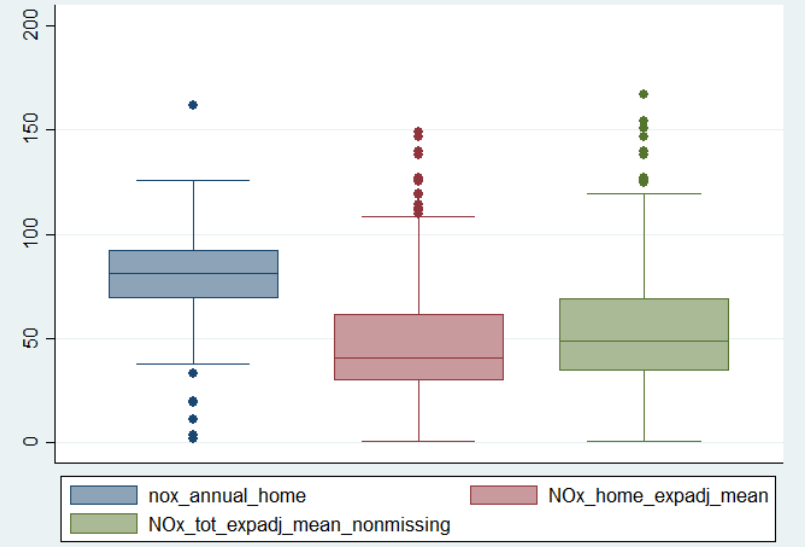
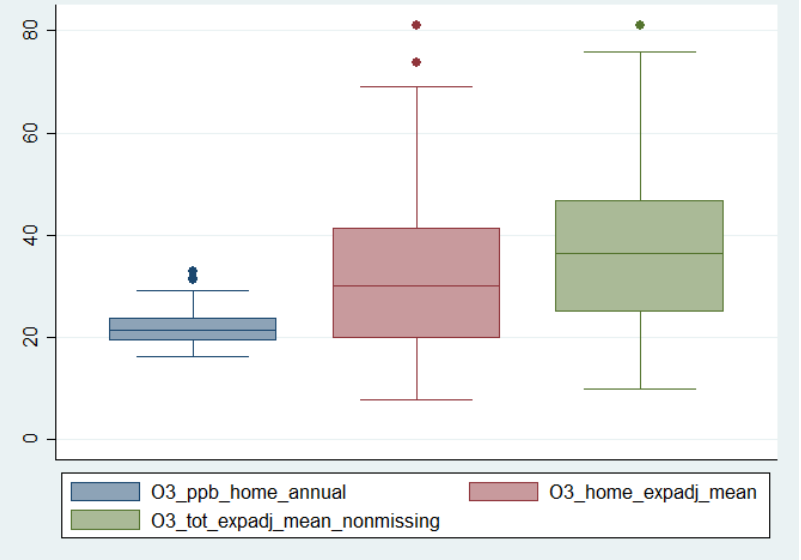
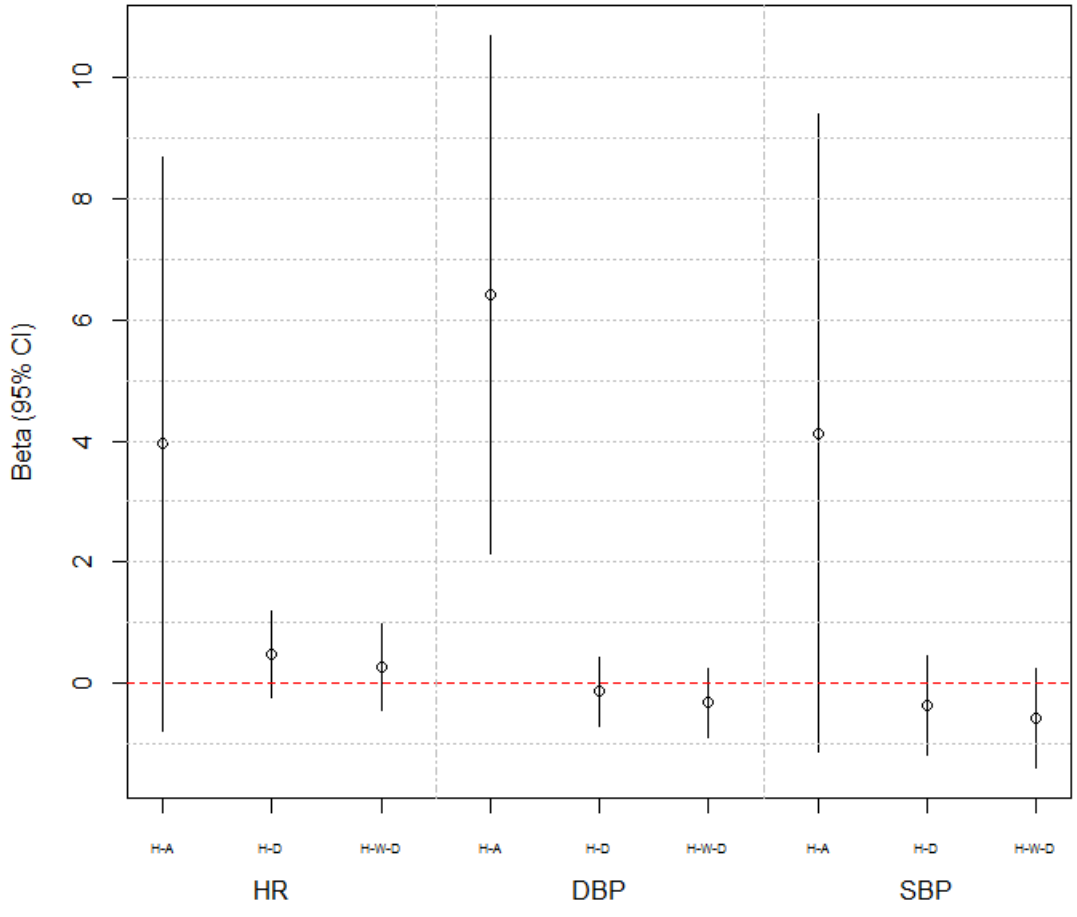
(S3d) NO_2 [ppb]	
(S3e) NOx [ppb]	
(S3f) Ozone [ppb]	

Figure S3 - Participant exposure estimates of air pollution: (a) PM_{10} , (b)PM_{Coarse}, (c) $PM_{2.5}$, (d) NO_2, (e) NOx, and (f) Ozone; annual and daily estimates adjusted for time spent at residential, occupational or both address/es

Boxes: blue = annual estimates at residential address; red = daily estimates at residential address, proportioned as time spent at residential during each three-day period preceding health testing; green = daily estimates at residential and work address, summed as a proportion of time (hours) spent at each during each three-day period preceding health testing.

(a)



(b)

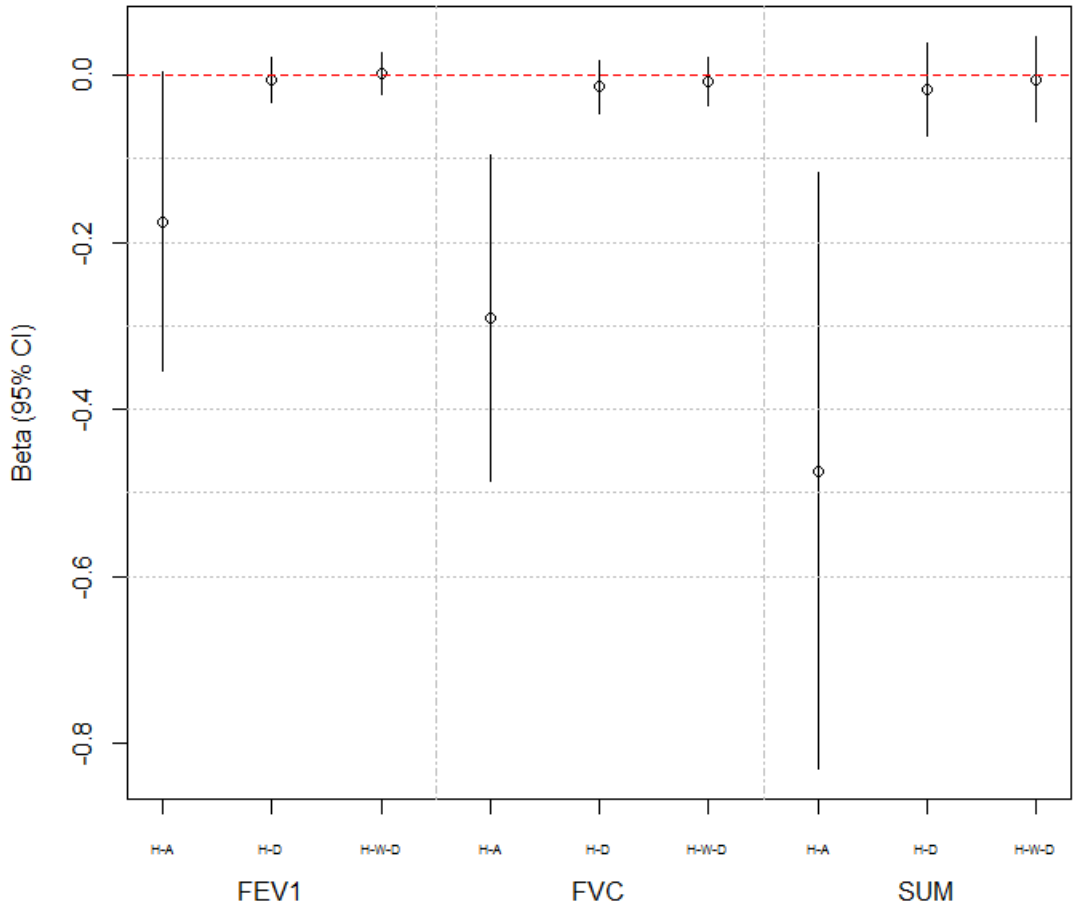
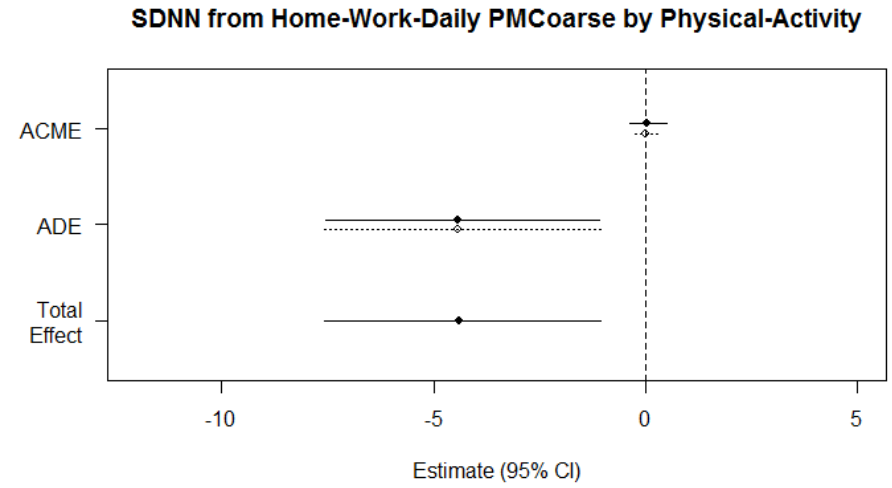
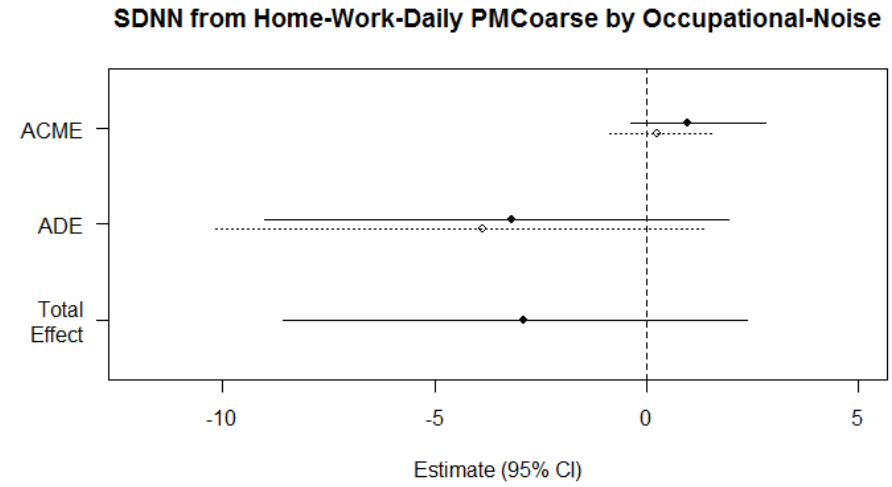


Figure S4 – Comparison of (a) cardiovascular and (b) pulmonary outcomes from exposure attributions: single-pollutant [(a) O_3, (b) PM_{10}] models (spatially and spatiotemporally) adjusted for age, sex, height, season

H-A = annual estimate at residential address; H-D = three-day average estimate for time at residential address prior to outcome measurement; H-W-D = three-day average-summed estimate for time at residential and work address prior to outcome measurement. HR = heart rate; DBP = diastolic blood pressure; SBP = systolic blood pressure; FEV1 = forced expiratory volume in first second of spirometric manuevre; FVC = forced vital capacity; SUM = highest sum of FEV1 plus FVC.



(a)

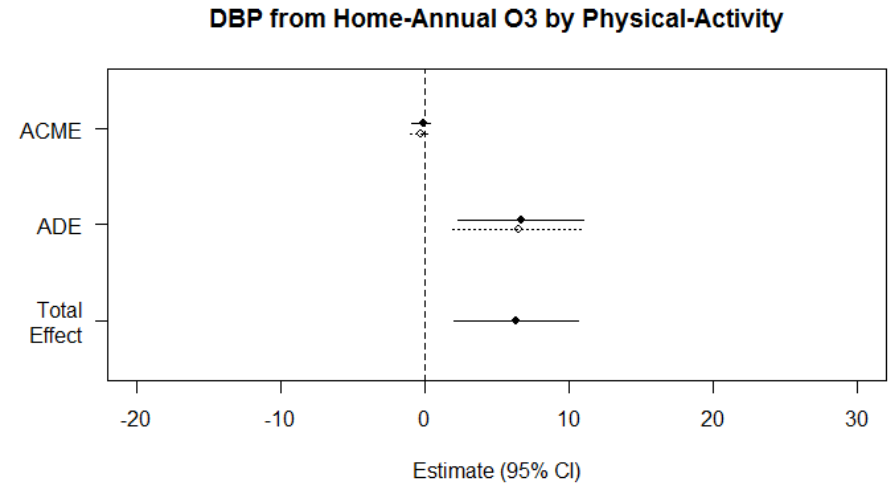


(b)

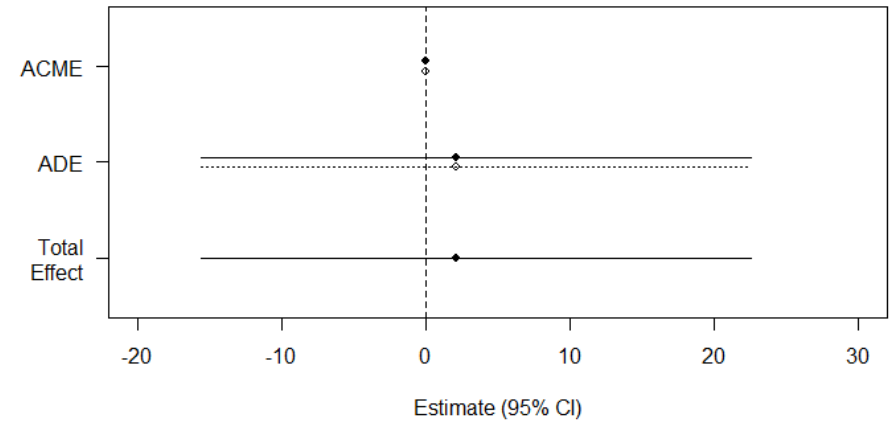
Figure S5 - Proportion mediated effect by (a) daily physical activity level and (b) occupational-address noise level on SDNN from PM_{Coarse} exposure

ACME = average causal mediation effect; ADE = Average direct effect; Total Effect = ACME (average) + ADE (average).

Output Based on Overall Averages Across Groups.
Controlled for age, height, sex and season.
Quasi-Bayesian Confidence Intervals are given.
Sample Size Used: 223.
Simulations: 1000.
Solid line = mediated; dotted line = control.



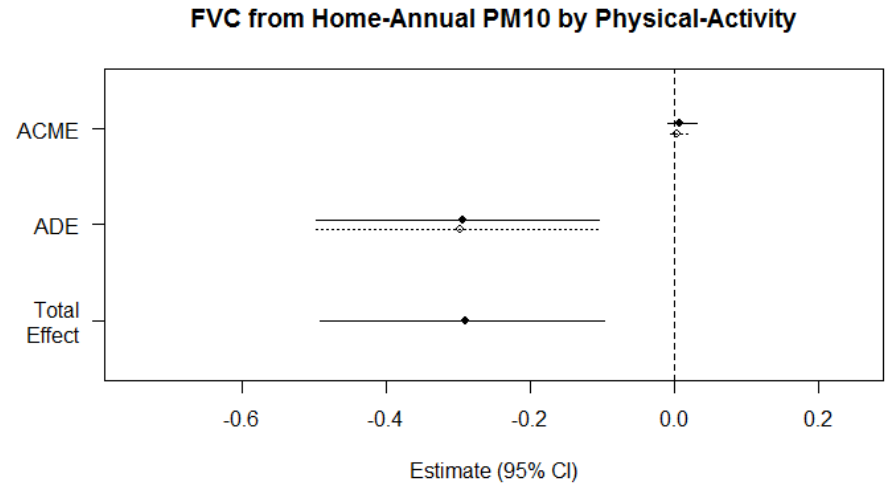
(a)



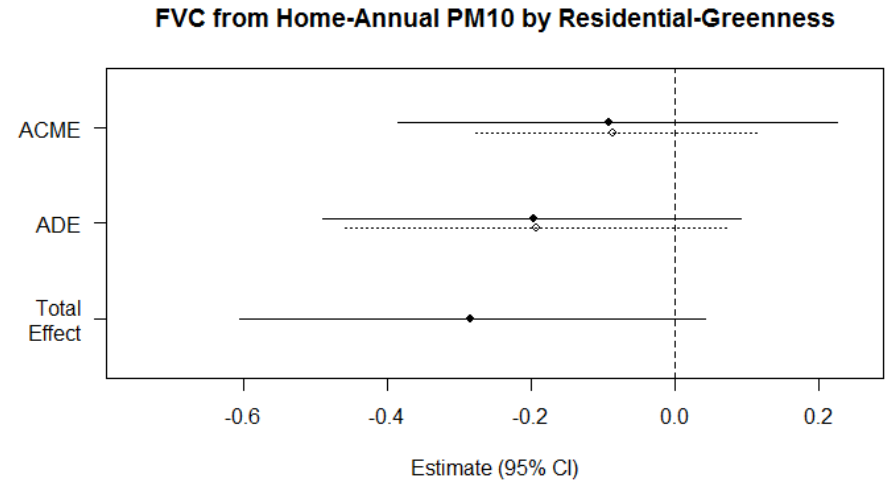
(b)

Figure S6 – Proportion mediated effect by (a) daily physical activity level and (b) occupational-address noise level on DBP from Ozone (O_3) exposure

ACME = average causal mediation effect; ADE = Average direct effect; Total Effect = ACME (average) + ADE (average).
Output Based on Overall Averages Across Groups.
Controlled for age, height, sex and season.
Quasi-Bayesian Confidence Intervals are given.
Sample Size Used: 84.
Simulations: 1000.
Solid line = mediated; dotted line = control.



(a)



(b)

Figure S7 – Proportion mediated effect by (a) daily physical activity level (b) residential-neighborhood greenness on FVC from PM10

ACME = average causal mediation effect; ADE = Average direct effect; Total Effect = ACME (average) + ADE (average).
Output Based on Overall Averages Across Groups.
Controlled for age, height, sex and season.
Quasi-Bayesian Confidence Intervals are given.
Sample Size Used: 227.
Simulations: 1000.
Solid line = mediated; dotted line = control.

TABLES

Table S1 – Correlation of all exposure estimates to single-pollutant exposure estimates of PM_{10} and Ozone

	PM_{10}			**Ozone**		
	Residential -Annual	Residential -3day	Residential -Work -3day	Residential -Annual	Residential -3day	Residential -Work -3day
PM_{10}						
Residential-Annual	1.00	0.50	0.52	-0.56	-0.02	0.06
Residential-3day	0.50	1.00	0.92	-0.36	0.34	0.30
Residential-Work-3day	0.52	0.92	1.00	-0.42	0.21	0.32
PM_{Coarse}						
Residential-Annual	0.90	0.42	0.47	-0.56	-0.09	-0.01
Residential-3day	0.46	0.89	0.84	-0.35	0.22	0.19
Residential-Work-3day	0.47	0.80	0.89	-0.40	0.09	0.20
$PM_{2.5}$						
Residential-Annual	0.73	0.33	0.38	-0.40	-0.15	-0.08
Residential-3day	0.45	0.91	0.81	-0.31	0.32	0.25
Residential-Work-3day	0.51	0.81	0.90	-0.39	0.16	0.27
$PM_{2.5Absorbance}$						
Residential-Annual	0.83	0.35	0.42	-0.40	-0.09	0.01
Residential-3day	0.35	0.46	0.36	-0.03	-0.24	-0.35
Residential-Work-3day	0.38	0.40	0.44	-0.12	-0.38	-0.37
Ozone						
Residential-Annual	-0.56	-0.36	-0.42	1.00	0.21	0.10
Residential-3day	-0.02	0.34	0.21	0.21	1.00	0.90
Residential-Work-3day	0.06	0.30	0.32	0.10	0.90	1.00
NO_2						
Residential-Annual	0.73	0.13	0.12	-0.21	-0.14	-0.13
Residential-3day	0.56	0.54	0.44	-0.16	-0.15	-0.25
Residential-Work-3day	0.56	0.40	0.45	-0.17	-0.28	-0.23
NOx						
Residential-Annual	0.84	0.34	0.40	-0.37	-0.06	0.03
Residential-3day	0.49	0.46	0.39	-0.10	-0.22	-0.30
Residential-Work-3day	0.52	0.41	0.46	-0.17	-0.33	-0.30

Table S2a – Outcomes of mixed effects models for cardiovascular health parameters and air pollution estimates [see also Figure S3b]

Outcome	Exposure	Adjustment	n	estimate	p-value	min95	max95
HR	O3_10ppb	Home-Annual	227	3.948	0.102	-0.789	8.686
HR	O3_10ppb	Home-Daily	216	0.478	0.186	-0.231	1.186
HR	O3_10ppb	Home-Work-Daily	216	0.275	0.453	-0.442	0.991
DBP	O3_10ppb	Home-Annual	227	6.416	0.003	2.145	10.687
DBP	O3_10ppb	Home-Daily	216	-0.132	0.643	-0.692	0.427
DBP	O3_10ppb	Home-Work-Daily	216	-0.316	0.273	-0.881	0.249
SBP	O3_10ppb	Home-Annual	227	4.125	0.124	-1.132	9.382
SBP	O3_10ppb	Home-Daily	216	-0.346	0.406	-1.163	0.47
SBP	O3_10ppb	Home-Work-Daily	216	-0.57	0.174	-1.391	0.251

HR = heart rate (pulse); DBP = diastolic blood pressure; SBP = systolic blood pressure

Table S2b – Outcomes of mixed effects models for pulmonary health parameters and air pollution estimates [see also Figure S3a]

Outcome	Exposure	Adjustment	n	estimate	p-value	min95	max95
FEV_1	pm10_10ug	Home-Annual	227	-0.175	0.055	-0.353	0.004
FEV_1	pm10_10ug	Home-Daily	227	-0.005	0.71	-0.032	0.022
FEV_1	pm10_10ug	Home-Work-Daily	227	0.002	0.867	-0.023	0.027
FVC	pm10_10ug	Home-Annual	227	-0.291	0.003	-0.486	-0.096
FVC	pm10_10ug	Home-Daily	227	-0.014	0.386	-0.045	0.018
FVC	pm10_10ug	Home-Work-Daily	227	-0.008	0.59	-0.037	0.021
SUM	pm10_10ug	Home-Annual	226	-0.474	0.009	-0.831	-0.117
SUM	pm10_10ug	Home-Daily	226	-0.017	0.536	-0.072	0.038
SUM	pm10_10ug	Home-Work-Daily	226	-0.005	0.861	-0.056	0.047

FEV_1 = forced expiratory volume in first second; FVC = forced vital capacity; SUM = largest sum of FEV_1 and FVC.

Table S3 – Estimates for PM_{Coarse} (5 µg/m^3) models, adjusted for PM_{10} (10 µg/m^3), greenness, time-activities, and noise [Figure 3 of manuscript]

Outcome	Exposure	Adjustment	n	estimate	p-value	min95	max95
SDNN	Home-Annual	unadjusted	223	-6.13	0.091	-13.246	0.986
SDNN	Home-Annual	PM10	223	-3.807	0.402	-12.714	5.1
SDNN	Home-Annual	H_nqlow_5	223	-13.259	0.008	-23.067	-3.45
SDNN	Home-Annual	met	223	-6.146	0.093	-13.326	1.034
SDNN	Home-Annual	tvlden_w	82	1.867	0.74	-9.159	12.894
SDNN	Home-Daily	unadjusted	223	-4.346	0.022	-8.073	-0.618
SDNN	Home-Daily	PM10	223	-3.68	0.067	-7.616	0.256
SDNN	Home-Daily	H_nqlow_5	223	-4.737	0.016	-8.58	-0.895
SDNN	Home-Daily	met	223	-4.346	0.023	-8.082	-0.61
SDNN	Home-Daily	tvlden_w	82	-3.207	0.22	-8.332	1.918
SDNN	Home-Work-Daily	unadjusted	223	-4.143	0.011	-7.335	-0.952
SDNN	Home-Work-Daily	PM10	223	-3.62	0.037	-7.02	-0.22
SDNN	Home-Work-Daily	H_nqlow_5	223	-4.51	0.007	-7.799	-1.22
SDNN	Home-Work-Daily	met	223	-4.145	0.011	-7.344	-0.947
SDNN	Home-Work-Daily	tvlden_w	82	-2.746	0.2	-6.95	1.457

Table S4a – Estimates for O_3 (annual-residential, 10 ppb) models, adjusted for PM_{10} (annual-residential, 10 µg/m^3), greenness, time-activities, and noise [Figure 4a of manuscript]

Outcome	Exposure	Adjustment	n	estimate	p-value	min95	max95
pulse	O3_home_annual_10ppb	unadjusted	227	3.948	0.102	-0.789	8.686
pulse	O3_home_annual_10ppb	PM10	227	5.23	0.065	-0.317	10.777
pulse	O3_home_annual_10ppb	H_nqlow_5	227	3.703	0.146	-1.285	8.691
pulse	O3_home_annual_10ppb	met	227	4.278	0.076	-0.439	8.995
pulse	O3_home_annual_10ppb	tvlden_w	84	4.345	0.446	-6.838	15.528
diastole	O3_home_annual_10ppb	unadjusted	227	6.416	0.003	2.145	10.687
diastole	O3_home_annual_10ppb	PM10	227	7.595	0.003	2.637	12.554
diastole	O3_home_annual_10ppb	H_nqlow_5	227	7.109	0.002	2.642	11.575
diastole	O3_home_annual_10ppb	met	227	6.766	0.002	2.499	11.032
diastole	O3_home_annual_10ppb	tvlden_w	84	0.289	0.962	-11.501	12.08
systole	O3_home_annual_10ppb	unadjusted	227	4.125	0.124	-1.132	9.382
systole	O3_home_annual_10ppb	PM10	227	4.87	0.126	-1.362	11.102
systole	O3_home_annual_10ppb	H_nqlow_5	227	4.469	0.115	-1.094	10.033
systole	O3_home_annual_10ppb	met	227	4.469	0.115	-1.094	10.033
systole	O3_home_annual_10ppb	tvlden_w	84	1	0.897	-14.102	16.102

Table S4b – Estimates for PM_{10} (annual-residential, 10 µg/m^3) models, adjusted for O_3 (annual-residential), greenness, time-activities, and noise [Figure 4b of manuscript]

Outcome	Exposure	Adjustment	n	estimate	p-value	min95	max95
fev1_0	pm10_annual_home_10ug	unadjusted	227	-0.175	0.055	-0.353	0.004
fev1_0	pm10_annual_home_10ug	O3	227	-0.159	0.107	-0.353	0.035
fev1_0	pm10_annual_home_10ug	H_nqlow_5	227	-0.097	0.404	-0.326	0.131
fev1_0	pm10_annual_home_10ug	met	227	-0.181	0.047	-0.36	-0.002
fev1_0	pm10_annual_home_10ug	total_pollen_tot	223	-0.182	0.046	-0.36	-0.004
fvc_0	pm10_annual_home_10ug	unadjusted	227	-0.291	0.003	-0.486	-0.096
fvc_0	pm10_annual_home_10ug	O3	227	-0.244	0.025	-0.456	-0.031
fvc_0	pm10_annual_home_10ug	H_nqlow_5	227	-0.219	0.088	-0.471	0.033
fvc_0	pm10_annual_home_10ug	met	227	-0.296	0.003	-0.491	-0.1
fvc_0	pm10_annual_home_10ug	total_pollen_tot	223	-0.294	0.003	-0.488	-0.099
sum_0	pm10_annual_home_10ug	unadjusted	226	-0.474	0.009	-0.831	-0.117
sum_0	pm10_annual_home_10ug	O3	226	-0.408	0.039	-0.796	-0.021
sum_0	pm10_annual_home_10ug	H_nqlow_5	226	-0.338	0.148	-0.797	0.12
sum_0	pm10_annual_home_10ug	met	226	-0.485	0.008	-0.842	-0.128
sum_0	pm10_annual_home_10ug	total_pollen_tot	222	-0.482	0.008	-0.839	-0.126