

Supplementary Information

Table S1. Exposure distribution in individual cohorts and the pooled cohort

Pollutant	Mean	SD	P5	P25	Median	P75	P95
CEANS-SDPP							
PM _{2.5}	7.62	0.93	5.91	7.35	7.77	8.11	8.67
NO ₂	15.42	4.27	7.81	12.78	15.54	18.13	22.39
BC	0.56	0.19	0.3	0.41	0.52	0.71	0.92
O ₃	77.57	1.91	74.44	76.39	77.5	78.97	80.62
Cu	0.02	0.2	0	0	0	0	0
Fe	26.21	16.32	0	15.51	24.86	36.36	53.62
K	89.16	11.66	71.47	80.69	93.91	98.39	102.96
Ni	0.4	0.12	0.19	0.32	0.39	0.49	0.57
S	500.21	27.61	469.54	477.94	494.23	517.27	552.29
Si	84.18	11.04	69.62	75.64	83.13	90.5	103.65
V	1.02	0.19	0.7	0.88	1.02	1.16	1.33
Zn	9	1.63	6.43	7.47	9.42	10.37	11.18
CEANS-SIXTY							
PM _{2.5}	8.3	0.92	6.82	7.94	8.41	8.83	9.44
NO ₂	20.63	6.11	10.74	17	20.48	23.85	31.19
BC	0.8	0.25	0.39	0.64	0.81	0.96	1.17
O ₃	76.71	2.52	72.58	75.4	76.85	78.26	80.72
Cu	1.23	1.65	0	0	0.31	2.11	4.57
Fe	65.19	38.79	11.27	37.5	58.43	85.94	140.17
K	83.54	12.11	62.47	75.82	83.23	92.7	101.41
Ni	0.58	0.22	0.3	0.42	0.54	0.69	0.97
S	521.12	36.59	467.17	495.54	518.51	543.66	583.94
Si	103.75	24.4	73.59	86.19	98.16	114.79	157.97
V	0.94	0.47	0.27	0.62	0.92	1.16	1.7
Zn	10.74	2.27	7.46	9.32	10.52	11.86	15.19
CEANS-SALT							
PM _{2.5}	8.37	0.86	7.08	7.99	8.47	8.87	9.52
NO ₂	21.22	6.22	11.04	17.51	20.99	24.78	31.88
BC	0.83	0.25	0.41	0.67	0.83	0.98	1.19
O ₃	76.59	2.73	72.13	75.28	76.8	78.15	80.84
Cu	1.44	1.73	0	0	0.76	2.46	4.7
Fe	69.66	39.72	13.76	41.42	63.93	90.66	143.2
K	82.7	11.8	62.88	75.3	81.92	91.54	101
Ni	0.59	0.23	0.3	0.42	0.55	0.72	0.98
S	523.3	37.38	469.27	496.62	519.65	546.02	588.21
Si	105.25	25.09	73.23	86.93	99.79	117.39	159.22
V	0.89	0.49	0.21	0.55	0.89	1.11	1.72
Zn	10.79	2.28	7.56	9.36	10.51	11.86	16.15
CEANS-SNACK							
PM _{2.5}	8.57	0.83	7.17	8.36	8.62	8.97	9.61
NO ₂	27.42	5.07	18.29	23.73	28.6	30.95	33.95
BC	1.08	0.15	0.92	0.98	1.05	1.13	1.33
O ₃	75.1	2.66	70.18	73.99	75.44	76.88	78.18
Cu	3.98	0.93	2.34	3.46	4.03	4.52	5.25
Fe	122.69	24.04	79.98	106.83	125.51	139.41	157.85
K	72.79	7.58	48.71	73.73	74.89	75.93	76.77
Ni	0.83	0.13	0.58	0.79	0.84	0.91	0.97
S	526.1	40.2	482.02	502.75	516.01	537.88	612.35
Si	144.16	20.54	102.79	132	148.77	157.12	174.19
V	1.09	0.61	0	0.57	1.2	1.67	1.72
Zn	13.78	2.46	9.6	11.95	14	16.27	16.42
DCH							

PM _{2.5}	13.18	1.43	11.31	12.3	12.89	13.79	15.93
NO ₂	28.09	6.88	16.51	23.22	28.46	33.36	38.25
BC	1.35	0.35	0.73	1.12	1.36	1.6	1.88
O ₃	77.41	5.07	67.5	74.24	79	81.42	83.38
Cu	2.66	1.78	0	1.11	2.55	3.97	5.58
Fe	76.68	34.73	22.96	51.9	75.59	98.46	138.05
K	113.92	13.35	93.47	103.37	115.56	124.56	132.77
Ni	1.25	0.69	0.41	0.79	1.04	1.72	2.43
S	732.28	58.52	642.58	689.91	724.87	774.2	833.25
Si	99.56	19.75	69.19	84.68	98.64	112.86	135.19
V	2.26	1.81	0.47	0.91	1.72	2.63	6.13
Zn	16.16	4.99	9.35	12.33	15.21	19	25.68
DNC-1993							
PM _{2.5}	12.73	1.53	10.36	11.7	12.64	13.57	15.59
NO ₂	21.8	7.96	10.17	16.27	20.28	26.75	36.95
BC	1.09	0.37	0.59	0.8	1.03	1.31	1.79
O ₃	80.44	3.98	72.65	78.94	81.22	82.87	85.25
Cu	0.91	1.44	0	0	0.18	1.18	4.39
Fe	40.01	31.26	2.93	18.74	31.53	52.7	106.77
K	123.52	19.67	92.64	110.3	123.19	135.89	155.07
Ni	0.88	0.48	0.47	0.65	0.76	0.92	2.01
S	699.5	54	618.12	662.63	696.45	731.25	796.71
Si	84.43	17.47	62.31	71.1	81.21	95.03	116.84
V	1.85	1.04	0.72	1.48	1.69	1.9	3.85
Zn	12.84	3.95	8.09	10.39	12.4	14.29	21.42
DNC-1999							
PM _{2.5}	13.8	1.51	11.36	12.75	13.6	15.08	16.31
NO ₂	25.84	8.49	13.67	19.42	23.71	33.27	38.95
BC	1.3	0.38	0.72	1.02	1.26	1.58	1.9
O ₃	80.64	3.81	73.39	79.12	81.38	82.98	85.26
Cu	0.83	1.37	0	0	0.14	1.05	4.09
Fe	38	29.78	3.03	17.78	30.14	49.58	100.77
K	123.13	19.38	92.13	110.51	123	135.63	155.01
Ni	0.87	0.42	0.49	0.65	0.76	0.92	1.83
S	696.01	51.84	617.02	661.29	692.71	726.17	789.33
Si	83.14	17.11	62.19	69.95	79.9	93.17	115.69
V	1.83	0.96	0.8	1.5	1.69	1.88	3.47
Zn	12.66	3.59	8.12	10.38	12.27	14.16	19.85
EPIC-NL-Morgen							
PM _{2.5}	17.95	1.01	16.11	17.3	17.92	18.72	19.43
NO ₂	34.54	6.05	26.18	29.97	33.57	38.93	44.89
BC	1.72	0.28	1.36	1.49	1.69	1.92	2.2
O ₃	73.48	7.71	57.67	68.83	76.78	78.49	81.88
Cu	4.98	1.47	3.1	3.81	4.67	5.96	7.58
Fe	113.9	29.86	74.93	90.4	109.5	131.13	170.36
K	174.28	34.48	117.18	134.85	194.08	197.61	207.78
Ni	1.61	0.83	0.94	1.03	1.33	1.82	3.34
S	792.06	37.62	736.87	770.3	789.01	813.26	856.66
Si	99.63	16.49	77.38	87.01	97.5	110.01	129.6
V	3.06	1.78	1.88	2.12	2.26	3.09	7.14
Zn	33.39	18.18	21.03	22.48	25.97	31.5	71.59
EPIC-NL-Prospect							
PM _{2.5}	16.87	0.77	15.65	16.39	16.93	17.35	18.02
NO ₂	35.92	5.41	27.35	32.49	35.43	39.75	44.58
BC	1.66	0.27	1.28	1.46	1.61	1.83	2.13
O ₃	72.68	2.71	67.78	71.26	73.08	74.55	76.35
Cu	5.5	1.56	2.92	4.28	5.63	6.5	7.69
Fe	128.52	32.26	75.49	105.44	128.71	150.38	177.82

K	157.71	12.7	133.08	150.56	158.34	166.55	173.5
Ni	1.24	0.21	1	1.12	1.23	1.36	1.5
S	783.82	36.35	727.22	759.9	783.77	807.13	842.58
Si	106.64	20.47	72.29	91.79	105.69	122.8	138.93
V	2.3	0.23	1.93	2.14	2.3	2.48	2.66
Zn	21.75	2.06	17.96	20.35	22	23.15	24.75
E3N							
PM _{2.5}	17.02	2.92	12.92	15.1	16.46	18.62	22.89
NO ₂	26.33	9.74	13.4	19.3	24.53	31.85	45.56
BC	1.79	0.48	1.2	1.42	1.68	2.07	2.73
O ₃	87.71	7.99	76.09	82.56	87	91.32	103.9
Cu	5.93	3.47	1.8	3.49	5.16	7.44	13.67
Fe	119.39	69.56	43.91	68.8	100.72	148.52	276.24
K	194.35	34.66	140.39	170.72	191.62	214.33	260.84
Ni	1.4	0.65	0.49	0.99	1.31	1.74	2.6
S	848.59	108.12	676.34	780.22	844.59	920.22	1026.93
Si	101.29	33.85	62.19	75.37	92.96	118.91	170.5
V	2.48	1.12	0.82	1.86	2.43	2.97	4.5
Zn	26.63	15.9	12.11	18.1	23.35	30.77	50.88
VHM&PP							
PM _{2.5}	15.73	2.64	10.86	13.95	16.51	17.54	19.16
NO ₂	21.95	5.34	12.28	18.62	22.45	25.62	29.68
BC	1.64	0.26	1.21	1.46	1.65	1.81	2.03
O ₃	92.62	3.63	86.91	89.88	92.8	95.51	97.98
Cu	3.41	2.04	0	1.72	3.48	4.99	6.5
Fe	84.62	31.5	30.13	63.68	84.75	107.14	133.55
K	195.68	45.08	123.52	157.98	196.62	237.37	260.64
Ni	0.3	0.23	0	0	0.34	0.47	0.58
S	552.71	79.81	404.65	503.64	567.05	612.04	662.09
Si	92.74	12.74	71.84	84.2	92.8	100.74	114.65
V	0.35	0.29	0	0	0.39	0.6	0.74
Zn	12.87	6.74	0	7.02	13.22	18.75	22.55
Pooled cohort							
PM _{2.5}	14.94	3.19	8.63	12.77	15.32	17.28	19.23
NO ₂	24.86	7.96	12.8	19.47	24.09	29.46	39.2
BC	1.52	0.42	0.74	1.29	1.55	1.78	2.11
O ₃	85.44	9.03	70.31	78.52	86.99	93.02	97.42
Cu	3.44	2.55	0	1.32	3.43	5.03	7.26
Fe	86.04	45.05	20.7	55.55	83.92	111.21	156.29
K	165.8	52.68	90.4	122.42	162.23	204.81	255.72
Ni	0.77	0.68	0	0.34	0.54	1.09	2.17
S	652.67	137.84	436.53	551.49	643.67	758	875.56
Si	95.88	20.36	68.62	82.29	93.56	105.77	132.82
V	1.34	1.43	0	0.4	0.75	2.07	4.16
Zn	16.54	10.8	3.64	10.8	15.15	21.25	30.28

SD is standard deviation, P5 to P95 are percentiles.

Units for pollutants: PM_{2.5} – µg/m³, NO₂ – µg/m³, BC – 10⁻⁵/m, O₃ – µg/m³; ng/m³ for PM_{2.5} elemental composition

Exposures were estimated with supervised linear regression. Elemental composition exposure estimated with random forest are shown in Figure S1.

Table S2. Spearman correlation between pollutants (N=302,493)

Sub-cohort		PM_{2.5}	NO₂	BC	O₃
Average^a	PM_{2.5}	1	0.59	0.56	-0.36
CEANS-SDPP	PM _{2.5}	1	0.60	0.58	-0.14
CEANS-SIXTY	PM _{2.5}	1	0.63	0.53	-0.42
CEANS-SALT	PM _{2.5}	1	0.63	0.52	-0.46
CEANS-SNACK	PM _{2.5}	1	0.76	0.28	-0.63
DCH	PM _{2.5}	1	0.75	0.72	-0.56
DNC-1993	PM _{2.5}	1	0.58	0.69	-0.27
DNC-1999	PM _{2.5}	1	0.57	0.63	-0.10
EPIC-NL-Morgen	PM _{2.5}	1	0.20	0.43	0.18
EPIC-NL-Prospect	PM _{2.5}	1	0.42	0.39	-0.43
E3N	PM _{2.5}	1	0.77	0.68	-0.45
VHM&PP	PM _{2.5}	1	0.62	0.74	-0.71
Average^a	NO₂	0.59	1	0.81	-0.62
CEANS-SDPP	NO ₂	0.60	1	0.64	-0.67
CEANS-SIXTY	NO ₂	0.63	1	0.81	-0.67
CEANS-SALT	NO ₂	0.63	1	0.81	-0.69
CEANS-SNACK	NO ₂	0.76	1	0.38	-0.72
DCH	NO ₂	0.75	1	0.91	-0.60
DNC-1993	NO ₂	0.58	1	0.90	-0.35
DNC-1999	NO ₂	0.57	1	0.93	-0.16
EPIC-NL-Morgen	NO ₂	0.20	1	0.82	-0.77
EPIC-NL-Prospect	NO ₂	0.42	1	0.89	-0.85
E3N	NO ₂	0.77	1	0.90	-0.52
VHM&PP	NO ₂	0.62	1	0.90	-0.82
Average^a	BC	0.56	0.81	1	-0.53
CEANS-SDPP	BC	0.58	0.64	1	-0.27
CEANS-SIXTY	BC	0.53	0.81	1	-0.66
CEANS-SALT	BC	0.52	0.81	1	-0.69
CEANS-SNACK	BC	0.28	0.38	1	-0.60
DCH	BC	0.72	0.91	1	-0.57
DNC-1993	BC	0.69	0.90	1	-0.38
DNC-1999	BC	0.63	0.93	1	-0.16
EPIC-NL-Morgen	BC	0.43	0.82	1	-0.50
EPIC-NL-Prospect	BC	0.39	0.89	1	-0.81
E3N	BC	0.68	0.90	1	-0.37
VHM&PP	BC	0.74	0.90	1	-0.87

^aAverage of cohort-specific correlation coefficients

Table S3. Spearman Correlation between elemental composition and PM_{2.5} (N=302,493)

Sub-cohort	PM _{2.5} Cu		PM _{2.5} Fe		PM _{2.5} K		PM _{2.5} Ni		PM _{2.5} S		PM _{2.5} Si		PM _{2.5} V		PM _{2.5} Zn	
	SLR	RF	SLR	RF	SLR	RF	SLR	RF	SLR	RF	SLR	RF	SLR	RF	SLR	RF
Average^a	0.46	0.51	0.48	0.44	0.25	0.43	0.24	0.25	0.51	0.46	0.39	0.20	0.13	0.19	0.44	0.46
CEANS-SDPP	0.19	0.60	0.31	0.36	-0.07	0.39	-0.23	0.07	0.55	0.47	0.21	-0.20	-0.23	0.32	-0.18	0.44
CEANS-SIXTY	0.48	0.59	0.53	0.51	0.07	0.54	0.31	0.33	0.47	0.33	0.48	0.36	-0.03	0.25	0.45	0.43
CEANS-SALT	0.49	0.57	0.51	0.51	0.06	0.54	0.30	0.35	0.47	0.31	0.47	0.40	-0.02	0.28	0.42	0.42
CEANS-SNACK	0.50	0.65	0.53	0.65	0.55	0.55	0.18	0.50	0.47	0.25	0.45	0.31	0.43	0.29	0.39	0.57
DCH	0.74	0.72	0.76	0.66	-0.19	0.54	0.52	0.64	0.66	0.65	0.65	0.41	0.32	0.60	0.68	0.67
DNC-1993	0.41	0.40	0.38	0.37	0.17	0.42	0.21	0.27	0.42	0.50	0.35	0.22	0.10	0.28	0.48	0.34
DNC-1999	0.30	0.28	0.27	0.24	0.11	0.36	0.11	0.18	0.30	0.38	0.21	0.12	0.00	0.22	0.36	0.22
EPIC_NL-Morgen	0.22	0.24	0.28	0.24	0.50	0.49	0.14	0.06	0.46	0.61	0.28	0.46	-0.16	-0.52	0.55	0.55
EPIC_NL-Prospect	0.40	0.32	0.37	0.33	0.44	0.43	0.11	0.41	0.63	0.54	0.30	0.23	0.24	0.22	0.34	0.29
E3N	0.62	0.63	0.67	0.56	0.31	-0.12	0.41	0.20	0.43	0.50	0.51	0.08	0.17	0.24	0.64	0.66
VHM&PP	0.72	0.63	0.62	0.39	0.76	0.59	0.54	-0.30	0.79	0.55	0.38	-0.20	0.64	-0.04	0.68	0.44

^aAverage of cohort-specific correlation coefficients

Table S4. Spearman Correlation between elemental composition and NO₂ (N=302,493)

Sub-cohort	PM _{2.5} Cu		PM _{2.5} Fe		PM _{2.5} K		PM _{2.5} Ni		PM _{2.5} S		PM _{2.5} Si		PM _{2.5} V		PM _{2.5} Zn	
	SLR	RF	SLR	RF	SLR	RF	SLR	RF	SLR	RF	SLR	RF	SLR	RF	SLR	RF
Average^a	0.72	0.79	0.79	0.74	0.03	0.45	0.46	0.35	0.43	0.31	0.69	0.33	0.25	0.26	0.52	0.54
CEANS-SDPP	0.29	0.81	0.84	0.69	0.07	0.79	0.16	0.30	0.30	-0.06	0.73	-0.20	0.03	0.33	0.38	0.62
CEANS-SIXTY	0.83	0.89	0.90	0.85	-0.24	0.68	0.52	0.58	0.46	0.30	0.82	0.64	-0.13	0.21	0.58	0.70
CEANS-SALT	0.85	0.89	0.90	0.87	-0.27	0.69	0.53	0.63	0.44	0.32	0.82	0.71	-0.11	0.25	0.56	0.69
CEANS-SNACK	0.74	0.84	0.77	0.88	0.72	0.73	0.27	0.66	0.47	0.35	0.68	0.56	0.63	0.30	0.54	0.70
DCH	0.90	0.88	0.88	0.79	-0.24	0.63	0.55	0.62	0.57	0.58	0.63	0.31	0.36	0.61	0.62	0.68
DNC-1993	0.56	0.60	0.58	0.50	-0.11	0.42	0.27	0.25	0.32	0.28	0.50	0.17	0.01	0.28	0.39	0.51
DNC-1999	0.36	0.36	0.35	0.28	-0.12	0.27	0.12	0.13	0.19	0.18	0.27	0.08	-0.07	0.16	0.23	0.29
EPIC_NL-Morgen	0.88	0.90	0.88	0.88	-0.39	-0.45	0.72	0.71	0.27	-0.30	0.76	0.51	0.65	0.45	0.27	-0.35
EPIC_NL-Prospect	0.86	0.89	0.89	0.88	-0.11	0.71	0.57	0.09	0.41	0.56	0.86	0.77	0.32	-0.21	0.66	0.73
E3N	0.81	0.82	0.86	0.81	0.28	-0.16	0.58	0.36	0.58	0.59	0.76	0.31	0.36	0.43	0.73	0.72
VHM&PP	0.83	0.79	0.88	0.76	0.71	0.67	0.72	-0.52	0.72	0.63	0.80	-0.24	0.75	0.10	0.76	0.65

^aAverage of cohort-specific correlation coefficients

Table S5. Associations of air pollution with bladder cancer incidence in models with increasing control for covariates

Exposure	Exposure model	Model 1 (N=351,644) ^a	Model 1 (N=302,493)	Model 2 (N= 305,734) ^b	Model 2 (N=302,493)	Model 3 (N=302,493) ^c
PM _{2.5}	SLR	1.08 (0.94, 1.25)	1.10 (0.94, 1.28)	1.07 (0.92, 1.24)	1.08 (0.93, 1.26)	1.09 (0.93, 1.27)
NO ₂	SLR	1.02 (0.93, 1.12)	1.03 (0.93, 1.14)	1.00 (0.90, 1.10)	1.00 (0.91, 1.11)	1.01 (0.91, 1.12)
BC	SLR	1.02 (0.92, 1.12)	1.02 (0.92, 1.13)	0.99 (0.89, 1.10)	0.99 (0.89, 1.10)	1.00 (0.90, 1.11)
O ₃	SLR	0.93 (0.82, 1.05)	0.95 (0.83, 1.09)	1.00 (0.87, 1.15)	1.00 (0.87, 1.15)	1.00 (0.87, 1.14)
PM _{2.5} Cu	SLR	1.06 (0.92, 1.23)	1.04 (0.89, 1.22)	0.98 (0.84, 1.16)	0.99 (0.84, 1.16)	0.99 (0.84, 1.17)
PM _{2.5} Cu	RF	1.01 (0.81, 1.28)	0.98 (0.76, 1.27)	0.89 (0.69, 1.16)	0.90 (0.69, 1.16)	0.91 (0.70, 1.17)
PM _{2.5} Fe	SLR	1.05 (0.89, 1.23)	1.04 (0.87, 1.24)	0.96 (0.81, 1.15)	0.97 (0.81, 1.16)	0.98 (0.81, 1.17)
PM _{2.5} Fe	RF	1.07 (0.85, 1.35)	1.09 (0.85, 1.40)	0.98 (0.76, 1.26)	0.99 (0.77, 1.28)	1.00 (0.78, 1.29)
PM _{2.5} K	SLR	1.07 (0.98, 1.17)	1.06 (0.96, 1.17)	1.05 (0.95, 1.16)	1.05 (0.95, 1.16)	1.06 (0.96, 1.16)
PM _{2.5} K	RF	1.10 (1.01, 1.20)	1.08 (0.98, 1.19)	1.08 (0.98, 1.18)	1.07 (0.97, 1.17)	1.08 (0.98, 1.18)
PM _{2.5} Ni	SLR	1.04 (0.92, 1.17)	0.99 (0.87, 1.13)	0.93 (0.81, 1.06)	0.93 (0.81, 1.07)	0.93 (0.81, 1.06)
PM _{2.5} Ni	RF	1.15 (0.91, 1.45)	1.13 (0.88, 1.45)	1.05 (0.81, 1.35)	1.07 (0.83, 1.38)	1.06 (0.82, 1.37)
PM _{2.5} S	SLR	1.12 (0.95, 1.31)	1.11 (0.92, 1.34)	1.03 (0.86, 1.24)	1.06 (0.88, 1.27)	1.06 (0.88, 1.27)
PM _{2.5} S	RF	1.07 (0.83, 1.36)	1.18 (0.87, 1.60)	1.03 (0.78, 1.36)	1.09 (0.80, 1.48)	1.10 (0.81, 1.49)
PM _{2.5} Si	SLR	1.34 (0.98, 1.83)	1.28 (0.91, 1.80)	1.09 (0.77, 1.53)	1.10 (0.78, 1.55)	1.10 (0.77, 1.55)
PM _{2.5} Si	RF	1.16 (0.88, 1.53)	1.26 (0.94, 1.70)	1.17 (0.87, 1.58)	1.19 (0.88, 1.61)	1.18 (0.87, 1.60)
PM _{2.5} V	SLR	1.07 (0.97, 1.18)	1.02 (0.91, 1.13)	0.97 (0.87, 1.08)	0.97 (0.87, 1.09)	0.97 (0.87, 1.09)
PM _{2.5} V	RF	1.17 (0.93, 1.46)	1.09 (0.86, 1.39)	1.02 (0.80, 1.30)	1.04 (0.81, 1.33)	1.03 (0.81, 1.32)
PM _{2.5} Zn	SLR	1.09 (1.02, 1.17)	1.10 (1.02, 1.18)	1.07 (0.99, 1.16)	1.07 (0.99, 1.16)	1.08 (1.00, 1.16)
PM _{2.5} Zn	RF	1.14 (1.01, 1.30)	1.20 (1.04, 1.38)	1.17 (1.01, 1.34)	1.17 (1.01, 1.34)	1.17 (1.02, 1.35)

^a Model 1 population = 351,644, person-years at risk = 6,304,430, incident bladder cancer events = 1,107. We excluded 3348 (0.9%) subjects due to fail in logical checks, 10582 (2.9%) with cancer diagnosis before baseline and 1830 (0.5%) with missing exposure.

^b Model 2 population = 305,734, person-years at risk = 5,556,163, incident bladder cancer events = 974. We further excluded 45,910 (12.5%) subjects from Model 1 population due to missing individual-level covariates.

^c Model 3 population = 302,493, person-years at risk = 5,497,514, incident bladder cancer events = 967. We further excluded 3,241 (0.9%) subjects from Model 2 population due to missing area-level covariates.

Hazard Ratio (95% confidence interval) presented for the following increments: PM_{2.5} – 5 µg/m³, NO₂ – 10 µg/m³, BC – 0.5*10⁻⁵/m, O₃ – 10 µg/m³, PM_{2.5} Cu – 5 ng/m³, PM_{2.5} Fe – 100 ng/m³, PM_{2.5} K – 50 ng/m³, PM_{2.5} Ni – 1 ng/m³, PM_{2.5} S – 200 ng/m³, PM_{2.5} Si – 100 ng/m³, PM_{2.5} V – 2 ng/m³, PM_{2.5} Zn – 10 ng/m³; Model 1 adjusted for age (time axis), sub-cohort (strata), sex (strata) and year of enrollment; Model 2 further adjusted for smoking (status, duration, intensity, intensity²), BMI categories, marital status and employment status; Model 3 further adjusted for 2001 neighborhood-level mean income; SLR = Supervised Linear Regression model, RF = Random Forest model; PM_{2.5}, NO₂, BC and O₃ exposures were only estimated with supervised linear regression

Table S6. Associations of Random Forest-modeled elemental composition with bladder cancer incidence in single- and two-pollutant models

Exposure	Single pollutant HR	HR adjusted for PM _{2.5}	HR adjusted for NO ₂
PM _{2.5} Cu	0.91 (0.70, 1.17)	0.78 (0.57, 1.06)	0.71 (0.46, 1.11)
PM _{2.5} Fe	1.00 (0.78, 1.29)	0.94 (0.72, 1.24)	0.95 (0.64, 1.42)
PM _{2.5} K	1.08 (0.98, 1.18)	1.07 (0.96, 1.19)	1.08 (0.98, 1.20)
PM _{2.5} Ni	1.06 (0.82, 1.37)	1.05 (0.81, 1.36)	1.06 (0.81, 1.39)
PM _{2.5} S	1.10 (0.81, 1.49)	1.02 (0.72, 1.44)	1.10 (0.79, 1.53)
PM _{2.5} Si	1.18 (0.87, 1.60)	1.18 (0.87, 1.60)	1.19 (0.87, 1.62)
PM _{2.5} V	1.03 (0.81, 1.32)	1.01 (0.79, 1.30)	1.03 (0.79, 1.33)
PM _{2.5} Zn	1.17 (1.02, 1.35)	1.17 (1.00, 1.36)	1.19 (1.03, 1.39)

N=302,493; Hazard Ratio (95% confidence interval) presented for the following increments: PM_{2.5} Cu – 5 ng/m³, PM_{2.5} Fe – 100 ng/m³, PM_{2.5} K – 50 ng/m³, PM_{2.5} Ni – 1 ng/m³, PM_{2.5} S – 200 ng/m³, PM_{2.5} Si – 100 ng/m³, PM_{2.5} V – 2 ng/m³, PM_{2.5} Zn – 10 ng/m³; main model adjusted for sub-cohort (strata), age (time axis), sex (strata), year of baseline visit, smoking (status, duration, intensity, intensity²), BMI, marital status, employment status and 2001 neighborhood-level mean income

PM_{2.5} and NO₂ exposures were estimated with supervised linear regression.

Effect estimates for PM_{2.5} and NO₂ in two-pollutant models are shown in Table S6.

Table S7. Effect estimates for PM_{2.5} and NO₂ in two-pollutant models adjusting for elemental components model

Model	HR (95% CI) for PM _{2.5} ^a	HR (95% CI) for NO ₂ ^a
Single-pollutant	1.09 (0.93, 1.27)	1.01 (0.91, 1.12)
+ Cu (SLR-modeled)	1.17 (0.95, 1.44)	1.04 (0.87, 1.24)
+ Cu (RF-modeled)	1.18 (0.98, 1.42)	1.12 (0.95, 1.33)
+ Fe (SLR-modeled)	1.16 (0.96, 1.41)	1.09 (0.89, 1.33)
+ Fe (RF-modeled)	1.10 (0.93, 1.30)	1.03 (0.87, 1.20)
+ K (SLR-modeled)	1.05 (0.86, 1.28)	0.99 (0.89, 1.11)
+ K (RF-modeled)	1.03 (0.86, 1.23)	0.98 (0.88, 1.09)
+ Ni (SLR-modeled)	1.15 (0.97, 1.37)	1.06 (0.94, 1.20)
+ Ni (RF-modeled)	1.08 (0.93, 1.26)	1.00 (0.90, 1.12)
+ S (SLR-modeled)	1.10 (0.89, 1.38)	0.99 (0.87, 1.12)
+ S (RF-modeled)	1.08 (0.91, 1.29)	1.00 (0.89, 1.11)
+ Si (SLR-modeled)	1.08 (0.91, 1.28)	0.98 (0.85, 1.14)
+ Si (RF-modeled)	1.08 (0.93, 1.27)	1.00 (0.89, 1.11)
+ V (SLR-modeled)	1.11 (0.94, 1.31)	1.03 (0.92, 1.15)
+ V (RF-modeled)	1.09 (0.93, 1.27)	1.01 (0.90, 1.12)
+ Zn (SLR-modeled)	1.01 (0.85, 1.21)	0.96 (0.85, 1.07)
+ Zn (RF-modeled)	1.02 (0.86, 1.20)	0.97 (0.87, 1.08)

SLR = Supervised Linear Regression model, RF = Random Forest model

N=302,493; Hazard Ratio (95% confidence interval) presented for the following increments: PM_{2.5} – 5 µg/m³, NO₂ – 10 µg/m³; main model adjusted for sub-cohort (strata), age (time axis), sex (strata), year of baseline visit, smoking (status, duration, intensity, intensity²), BMI, marital status, employment status and 2001 neighborhood-level mean income

^aPM_{2.5} and NO₂ exposure were estimated with SLR.

Table S8. Sensitivity analysis: Associations between air pollution and bladder cancer incidence with additional adjustment for individual level covariates

Exposure	Full population (N=302,493)	w/o VHM&PP (N = 162,404)		w/o VHM&PP (N = 161,276)		w/o DCH (N = 249,714)		w/o VHM&PP (N = 154,075)	
		Main model ^a	Main model + smoking in former smokers	Main model	Main model + educational level	Main model	Main model + occupational status	Main model	Main model + alcohol assumption in tertiles
PM _{2.5}	1.09 (0.93, 1.27)	1.07 (0.81, 1.41)	1.07 (0.81, 1.41)	1.11 (0.84, 1.46)	1.11 (0.84, 1.46)	1.07 (0.91, 1.27)	1.07 (0.91, 1.27)	1.07 (0.81, 1.42)	1.08 (0.81, 1.43)
NO ₂	1.01 (0.91, 1.12)	0.95 (0.84, 1.08)	0.95 (0.84, 1.08)	0.96 (0.85, 1.09)	0.96 (0.85, 1.09)	1.05 (0.92, 1.19)	1.05 (0.92, 1.19)	0.95 (0.84, 1.08)	0.95 (0.84, 1.08)
BC	1.00 (0.90, 1.11)	0.95 (0.83, 1.07)	0.94 (0.83, 1.07)	0.95 (0.84, 1.08)	0.95 (0.84, 1.08)	1.07 (0.93, 1.22)	1.07 (0.93, 1.22)	0.94 (0.83, 1.07)	0.94 (0.83, 1.07)
O ₃	1.00 (0.87, 1.14)	1.08 (0.92, 1.28)	1.09 (0.92, 1.28)	1.07 (0.91, 1.27)	1.07 (0.91, 1.27)	0.96 (0.81, 1.15)	0.96 (0.81, 1.15)	1.08 (0.91, 1.27)	1.08 (0.91, 1.27)
PM _{2.5} Cu	0.99 (0.84, 1.17)	0.93 (0.74, 1.17)	0.92 (0.73, 1.16)	0.94 (0.74, 1.18)	0.94 (0.74, 1.18)	1.03 (0.85, 1.25)	1.03 (0.85, 1.25)	0.92 (0.73, 1.17)	0.93 (0.73, 1.17)
PM _{2.5} Fe	0.98 (0.81, 1.17)	0.90 (0.72, 1.13)	0.89 (0.71, 1.12)	0.91 (0.73, 1.14)	0.91 (0.73, 1.14)	1.01 (0.81, 1.25)	1.01 (0.81, 1.25)	0.89 (0.70, 1.13)	0.89 (0.71, 1.13)
PM _{2.5} K	1.06 (0.96, 1.16)	1.14 (0.92, 1.43)	1.15 (0.92, 1.43)	1.15 (0.92, 1.44)	1.15 (0.92, 1.44)	1.04 (0.94, 1.16)	1.04 (0.94, 1.16)	1.18 (0.94, 1.47)	1.17 (0.94, 1.47)
PM _{2.5} Ni	0.93 (0.81, 1.06)	0.97 (0.83, 1.13)	0.97 (0.83, 1.13)	0.98 (0.84, 1.14)	0.98 (0.84, 1.15)	0.93 (0.75, 1.16)	0.94 (0.75, 1.16)	0.97 (0.83, 1.14)	0.98 (0.83, 1.14)
PM _{2.5} S	1.06 (0.88, 1.27)	0.98 (0.73, 1.30)	0.97 (0.73, 1.29)	1.01 (0.76, 1.35)	1.01 (0.76, 1.35)	1.09 (0.88, 1.35)	1.09 (0.88, 1.35)	0.95 (0.71, 1.28)	0.96 (0.71, 1.28)
PM _{2.5} Si	1.10 (0.77, 1.55)	0.91 (0.61, 1.37)	0.90 (0.60, 1.35)	0.93 (0.62, 1.40)	0.93 (0.62, 1.40)	1.12 (0.72, 1.73)	1.12 (0.72, 1.73)	0.93 (0.61, 1.42)	0.93 (0.61, 1.43)
PM _{2.5} V	0.97 (0.87, 1.09)	1.00 (0.88, 1.13)	1.00 (0.88, 1.13)	1.01 (0.89, 1.14)	1.01 (0.89, 1.14)	0.94 (0.75, 1.19)	0.94 (0.75, 1.19)	1.00 (0.89, 1.14)	1.01 (0.89, 1.14)
PM _{2.5} Zn	1.08 (1.00, 1.16)	1.09 (1.00, 1.19)	1.09 (1.00, 1.19)	1.10 (1.00, 1.20)	1.10 (1.00, 1.20)	1.08 (1.00, 1.17)	1.08 (1.00, 1.17)	1.09 (1.00, 1.19)	1.09 (1.00, 1.19)

^a Main model adjusted for sub-cohort id, age, sex, year of enrollment, smoking (status, duration, intensity, intensity²), BMI categories, marital status, employment status and 2001 neighborhood-level mean income

Hazard Ratio (95% confidence interval) presented for the following increments: PM_{2.5} – 5 µg/m³, NO₂ – 10 µg/m³, BC – 0.5*10⁻⁵/m, O₃ – 10 µg/m³, PM_{2.5} Cu – 5 ng/m³, PM_{2.5} Fe – 100 ng/m³, PM_{2.5} K – 50 ng/m³, PM_{2.5} Ni – 1 ng/m³, PM_{2.5} S – 200 ng/m³, PM_{2.5} Si – 100 ng/m³, PM_{2.5} V – 2 ng/m³, PM_{2.5} Zn – 10 ng/m³

Exposures were estimated with supervised linear regression

Table S9. Subset analyses of associations between air pollutants and bladder cancer incidence

Exposure	Subset	Participants, N	Cases, N	HR (95% CI)
PM _{2.5}	Full dataset	302,493	967	1.09 (0.93, 1.27)
	< 25 µg/m ³	302,467	967	1.09 (0.93, 1.27)
	< 20 µg/m ³	295,691	961	1.14 (0.97, 1.34)
	< 15 µg/m ³	144,236	549	1.33 (0.93, 1.90)
	< 12 µg/m ³	49,746	183	1.10 (0.49, 2.45)
	< 10 µg/m ³	23,525	96	0.73 (0.24, 2.24)
NO ₂	Full dataset	302,493	967	1.01 (0.91, 1.12)
	<40 µg/m ³	289,639	943	1.06 (0.94, 1.18)
	<30 µg/m ³	231,921	740	1.19 (1.02, 1.40)
	<20 µg/m ³	83,020	231	1.13 (0.74, 1.73)
BC	Full dataset	302,493	967	1.00 (0.90, 1.11)
	< 3.0 10 ⁻⁵ /m	301,950	967	1.01 (0.90, 1.12)
	< 2.5 10 ⁻⁵ /m	298,239	963	1.02 (0.91, 1.14)
	< 2.0 10 ⁻⁵ /m	277,154	897	0.98 (0.86, 1.10)
	< 1.5 10 ⁻⁵ /m	132,912	472	1.02 (0.82, 1.28)
	< 1.0 10 ⁻⁵ /m	33,295	148	1.00 (0.58, 1.73)
O ₃	Full dataset	302,493	967	1.00 (0.87, 1.14)
	< 120 µg/m ³	302,493	967	1.00 (0.87, 1.14)
	< 100 µg/m ³	297,948	962	1.02 (0.88, 1.18)
	< 80 µg/m ³	91,522	354	1.01 (0.78, 1.30)

Hazard Ratio (95% confidence interval) presented for the following increments: PM_{2.5} – 5 µg/m³, NO₂ – 10 µg/m³, BC – 0.5*10⁻⁵/m, O₃ – 10 µg/m³; main model adjusted for sub-cohort (strata), age (time axis), sex (strata), year of baseline visit, smoking (status, duration, intensity, intensity²), BMI, marital status, employment status and 2001 neighborhood-level mean income

Table S10. Effect modification analyses by age group, sex and smoking status^a

Exposure	model	Age group			Sex			Smoking status			
		<65 y	≥65 y	P	Female	Male	P	never	former	current	P
		Cases = 823	Cases = 144	-	Cases = 343	Cases = 624	-	Cases = 350	Cases = 213	Cases = 404	-
PM _{2.5}	SLR	1.10 (0.93, 1.30)	1.03 (0.75, 1.41)	0.68	0.92 (0.74, 1.14)	1.19 (1.00, 1.42)	0.02	1.07 (0.88, 1.30)	0.96 (0.75, 1.24)	1.18 (0.95, 1.45)	0.33
PM _{2.5} Zn	SLR	1.08 (1.00, 1.17)	1.04 (0.83, 1.31)	0.77	1.11 (1.01, 1.23)	1.04 (0.94, 1.15)	0.30	1.02 (0.90, 1.15)	1.02 (0.88, 1.19)	1.15 (1.04, 1.27)	0.18
PM _{2.5} Zn	RF	1.17 (1.01, 1.36)	1.18 (0.79, 1.77)	0.97	1.10 (0.90, 1.34)	1.22 (1.04, 1.43)	0.32	1.09 (0.88, 1.35)	1.08 (0.87, 1.35)	1.27 (1.08, 1.50)	0.23

N=302,493; Hazard Ratio (95% confidence interval) presented for the following increments: PM_{2.5} – 5 µg/m³, PM_{2.5} Zn – 10 ng/m³;

^aDifference in hazard ratios between groups tested by Wald test, significance level P<0.1

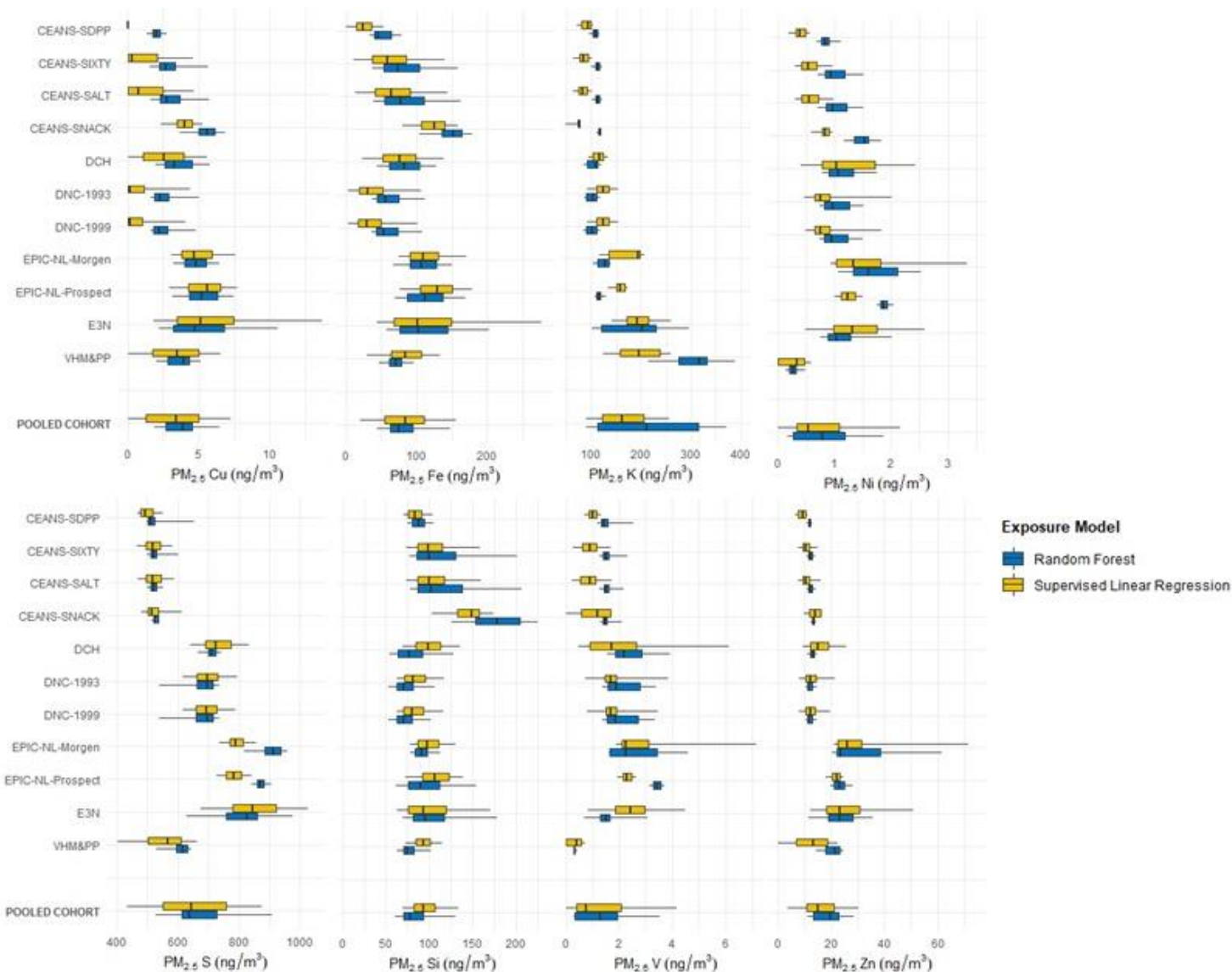


Figure S1. Exposure distribution of PM_{2.5} elemental components

The boundary of the box closest to zero indicates P25; furthest from zero – P75; bold vertical line inside the box – P50; whiskers indicate P5 and P95. Random forest and supervised linear regression both refer to the 2010 exposure. Sub-cohorts are shown from north to south

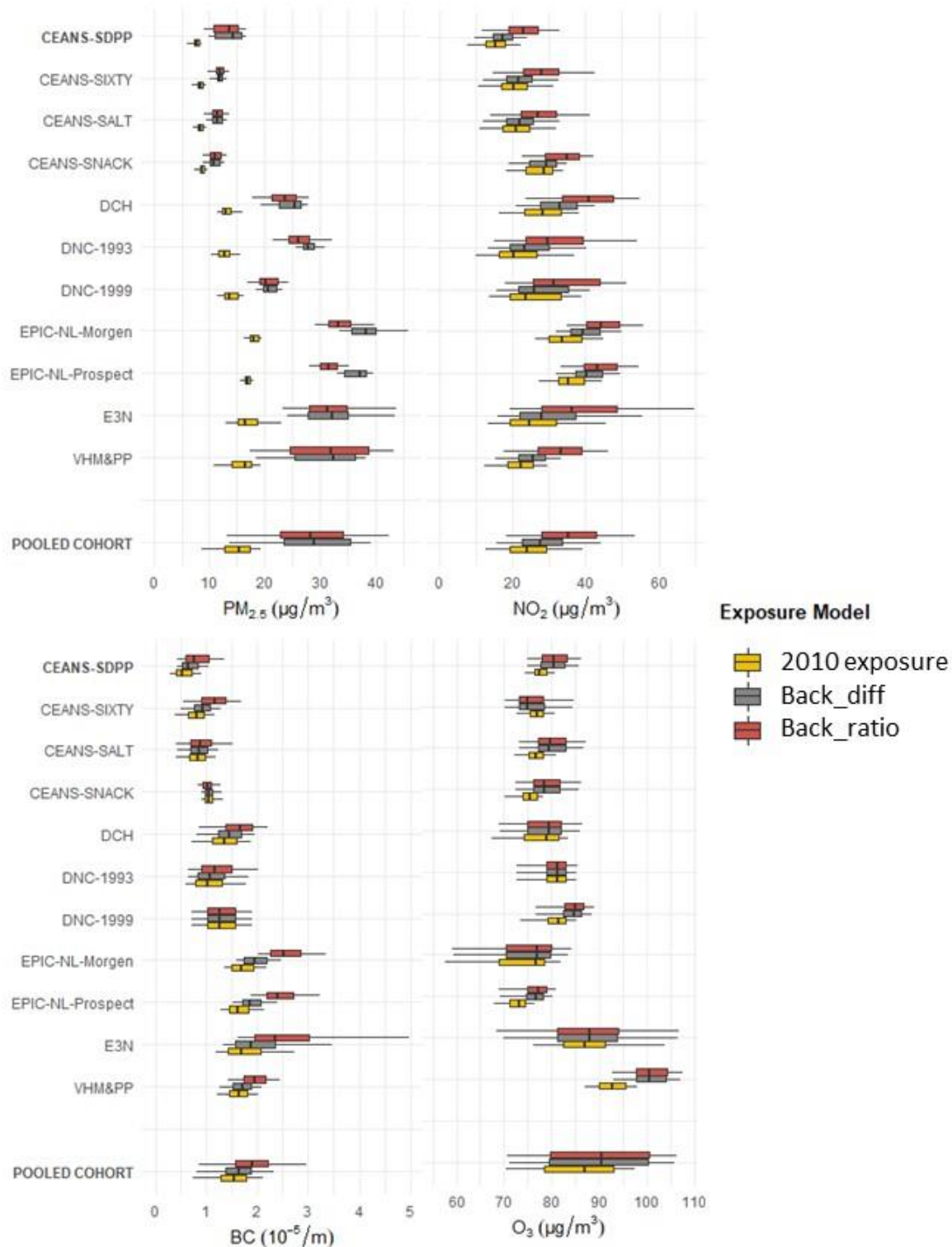


Figure S2. Exposure distribution of air pollutants in year 2010 and at baseline

The boundary of the box closest to zero indicates P25; furthest from zero – P75; bold vertical line inside the box – P50; whiskers indicate P5 and P95. Back refers to concentrations back-extrapolated to baseline using the difference and ratio method. Sub-cohorts are shown from north to south

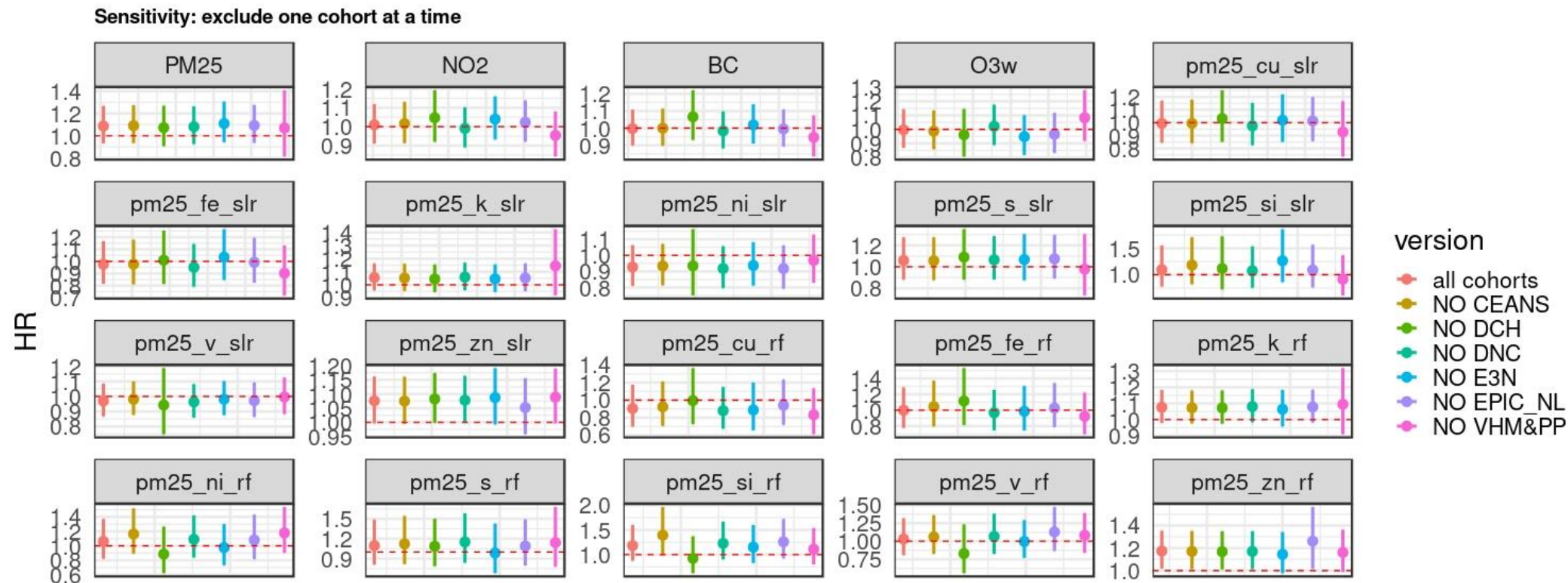


Figure S3. Sensitivity analysis – excluding one cohort at a time

Main model adjusted for sub-cohort (strata), age (time axis), sex (strata), year of enrollment, smoking (status, duration, intensity, intensity²), BMI categories, marital status, employment status and 2001 neighborhood-level mean income

SLR = Supervised Linear Regression model, RF = Random Forest model. Hazard Ratio (95% confidence interval) presented for the following increments: PM_{2.5} – 5 µg/m³, NO₂ – 10 µg/m³, BC – 0.5*10⁻⁵/m, O₃ – 10 µg/m³, PM_{2.5} Cu – 5 ng/m³, PM_{2.5} Fe – 100 ng/m³, PM_{2.5} K – 50 ng/m³, PM_{2.5} Ni – 1 ng/m³, PM_{2.5} S – 200 ng/m³, PM_{2.5} Si – 100 ng/m³, PM_{2.5} V – 2 ng/m³, PM_{2.5} Zn – 10 ng/m³

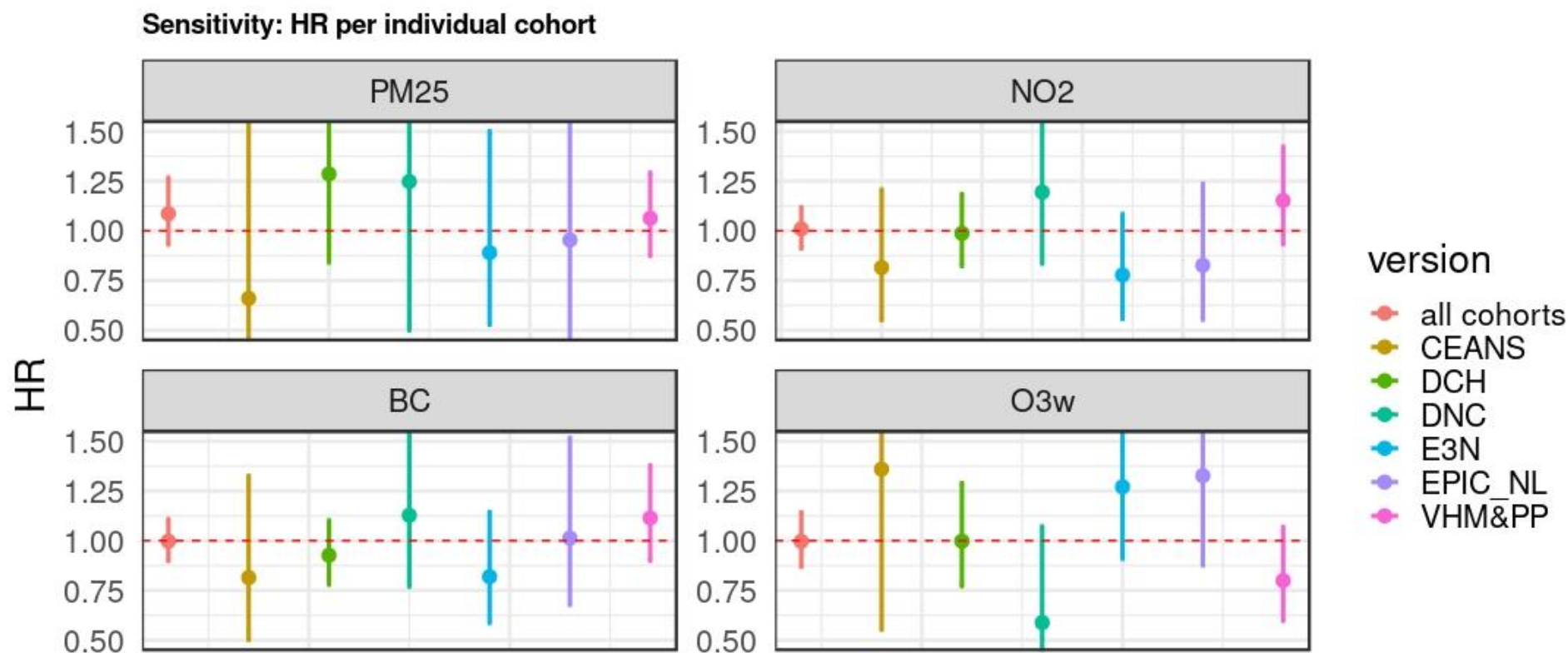


Figure S4. Hazard ratios for associations between main air pollutants and bladder cancer incidence in individual cohorts

Main model adjusted for sub-cohort (strata), age (time axis), sex (strata), year of enrollment, smoking (status, duration, intensity, intensity²), BMI categories, marital status, employment status and 2001 neighborhood-level mean income

Hazard Ratio (95% confidence interval) presented for the following increments: PM_{2.5} – 5 µg/m³, NO₂ – 10 µg/m³, BC – 0.5*10⁻⁵/m, O₃ – 10 µg/m³

Y axis truncated at 0.5 and 1.5

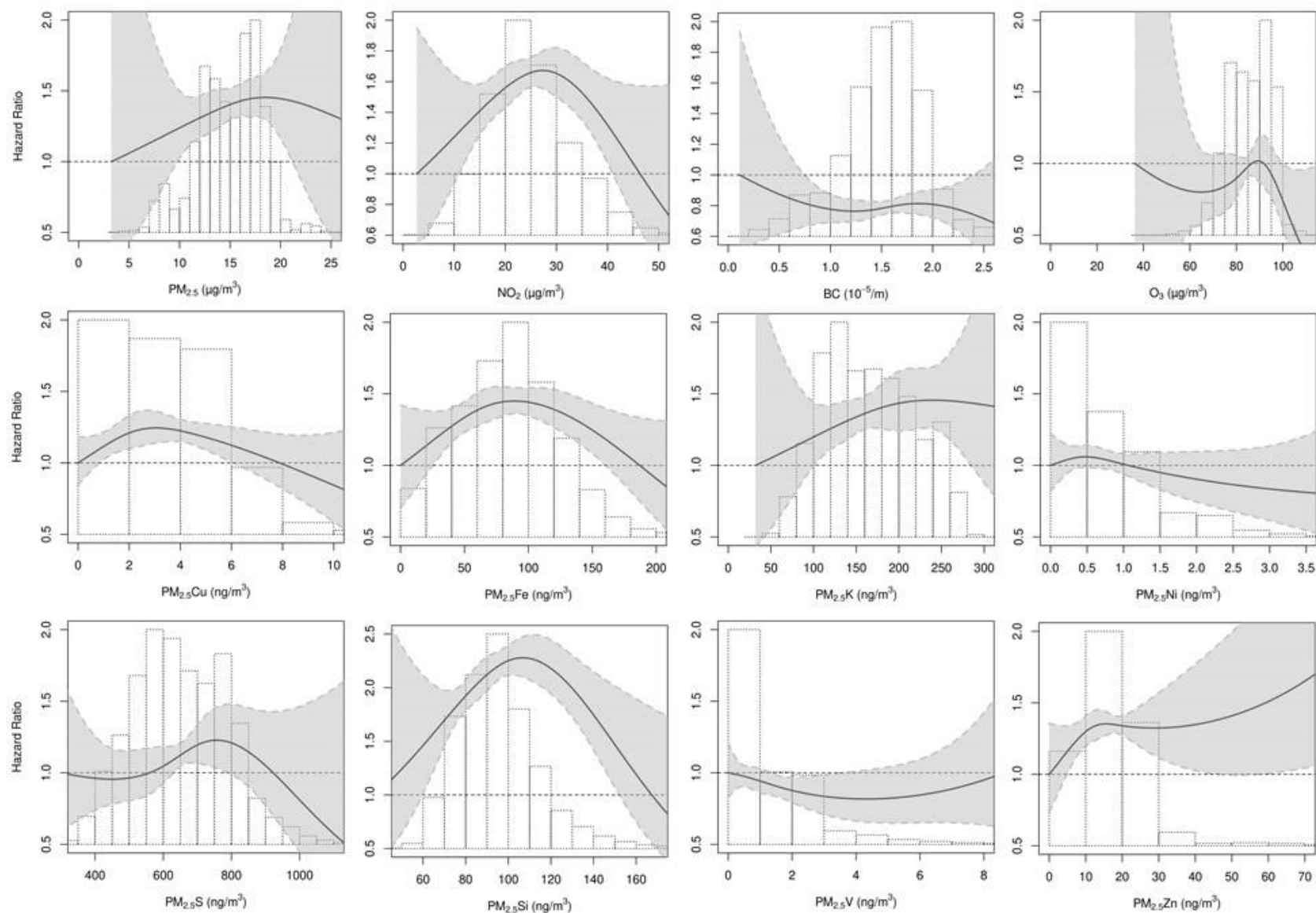


Figure S5. Natural spline (3 degree of freedom) for associations between air pollutants and bladder cancer incidence

Exposures were estimated with supervised linear regression

Histogram shows the exposure distribution of the pooled cohort; Shaded: 95% confidence intervals; Hazard ratios are expressed relative to minimum exposure.