HEI

SUPPLEMENTARY APPENDIX

Research Report 219

Birth Cohort Studies of Long-Term Exposure to Ambient Air Pollution in Early Life and Development of Asthma in Children and Adolescents from Denmark

Marie Pedersen et al.

Appendix A: Supplementary Figures and Tables

This Appendix was reviewed solely for spelling, grammar, and
cross-references to the main text. It has not been formatted or fully edited by HEI. This document was reviewed
by the HEI Review Committee.

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Contents

Figure A1. Directed Acyclic Graph (DAG) of the relationship between air pollution and asthma. The minimum set of covariates that should be controlled for are those marked with red. However, because some of the variables available may not perfectly capture the underlying factors that we aim to control for, we tested different levels of adjustment and potential effect modification whenever possible. Please note that the DAG is simplified. There are many more plausible arrows. For instance, maternal asthma may influence area of living; ambient air pollution may also determinate maternal asthma. Asthma refers to all asthma outcomes investigated. Year and season of birth refer to the child. Home environment refers to indoor home environment (e.g., mold, gas cooking, wood stoves). Although some of these could be determinants of the modeled ambient air pollution (e.g., wood stoves) others are not (e.g., mold and dampness). Furthermore, grouping all of the air pollutants together in one DAG makes confounding of a specific pollutant–asthma association by copollutants difficult to specify on the DAG. Ideally, each specific pollutant–outcome association would have its own DAG.
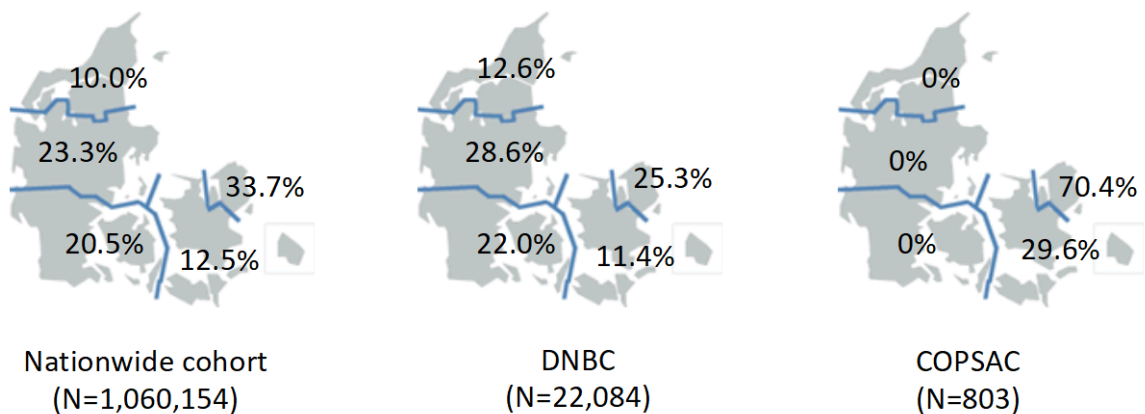
Figure A2. Geographical locations of the home residences of the included children participating in the Birth Cohort Studies of Long-Term Exposure to Ambient Air Pollution in Early Life and Development of Asthma in Children and Adolescents Born in Denmark.
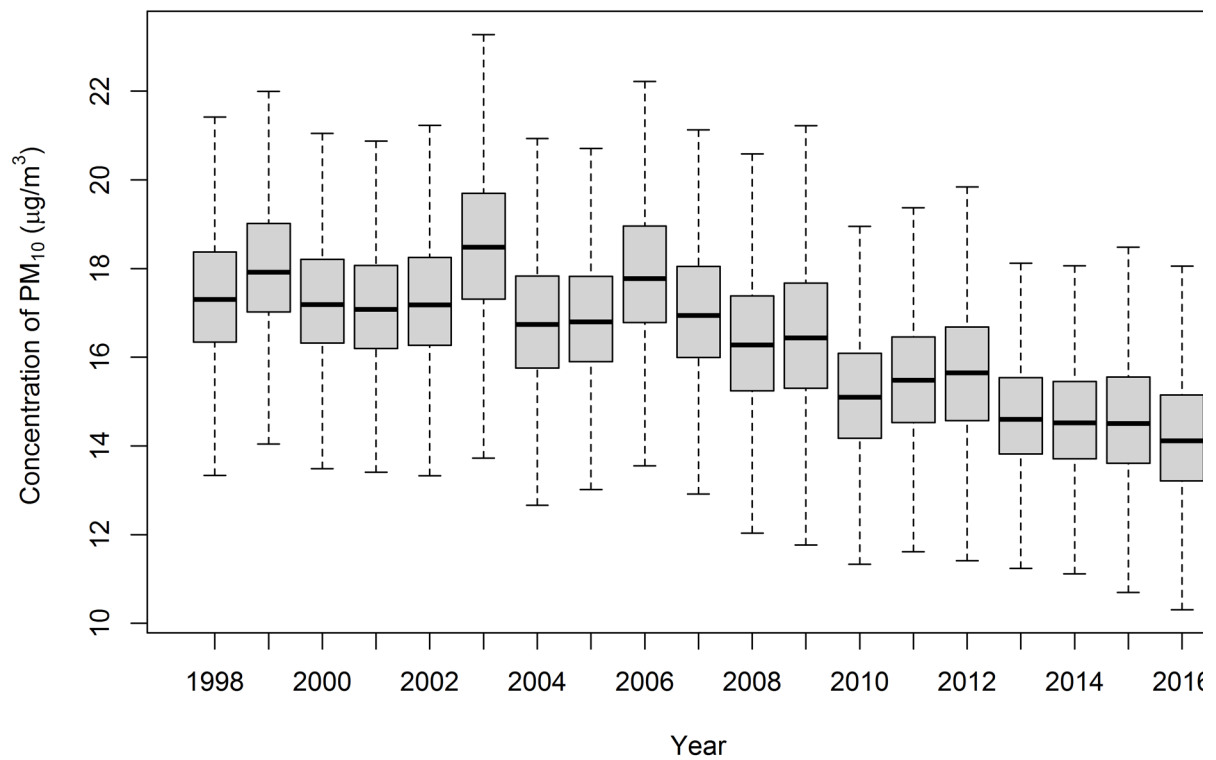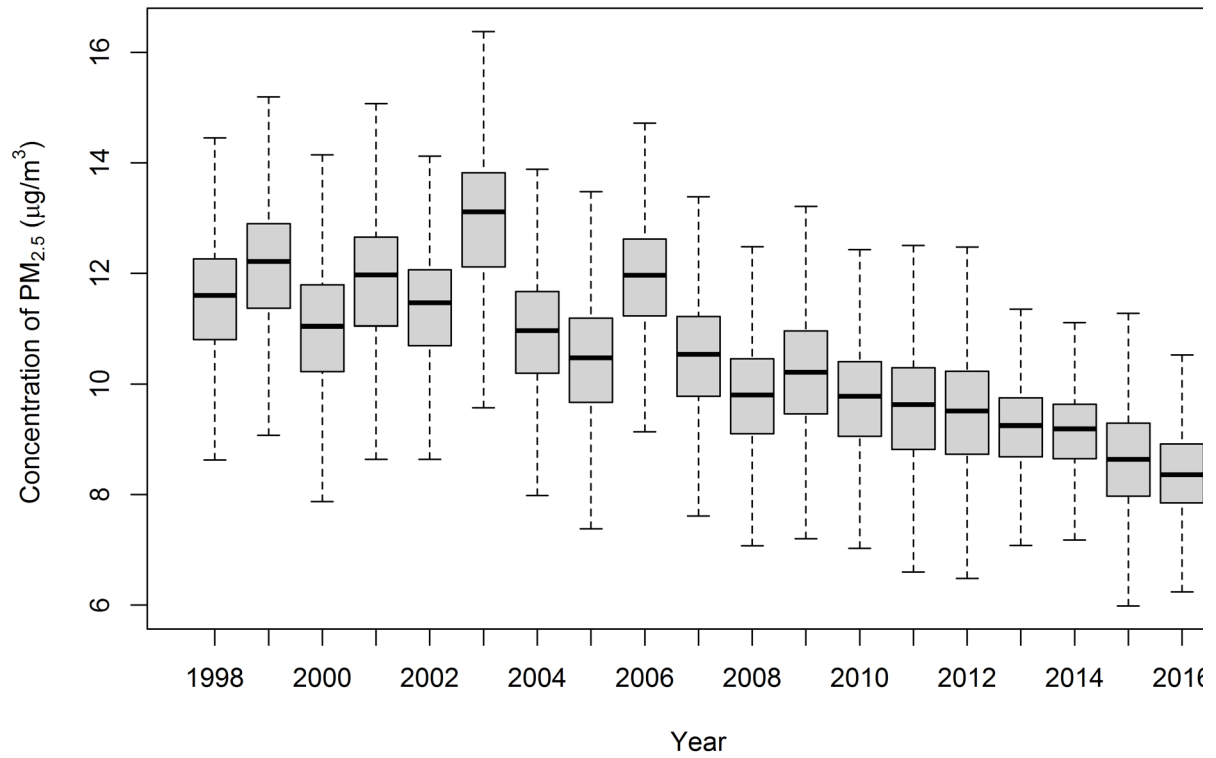
Figure A3. Annual ambient air pollution exposure concentration (μg/m3) distribution over time in the nationwide cohort of 1,060,154 children born in Denmark, 1998–2016. *Figure continues next 5 pages.*
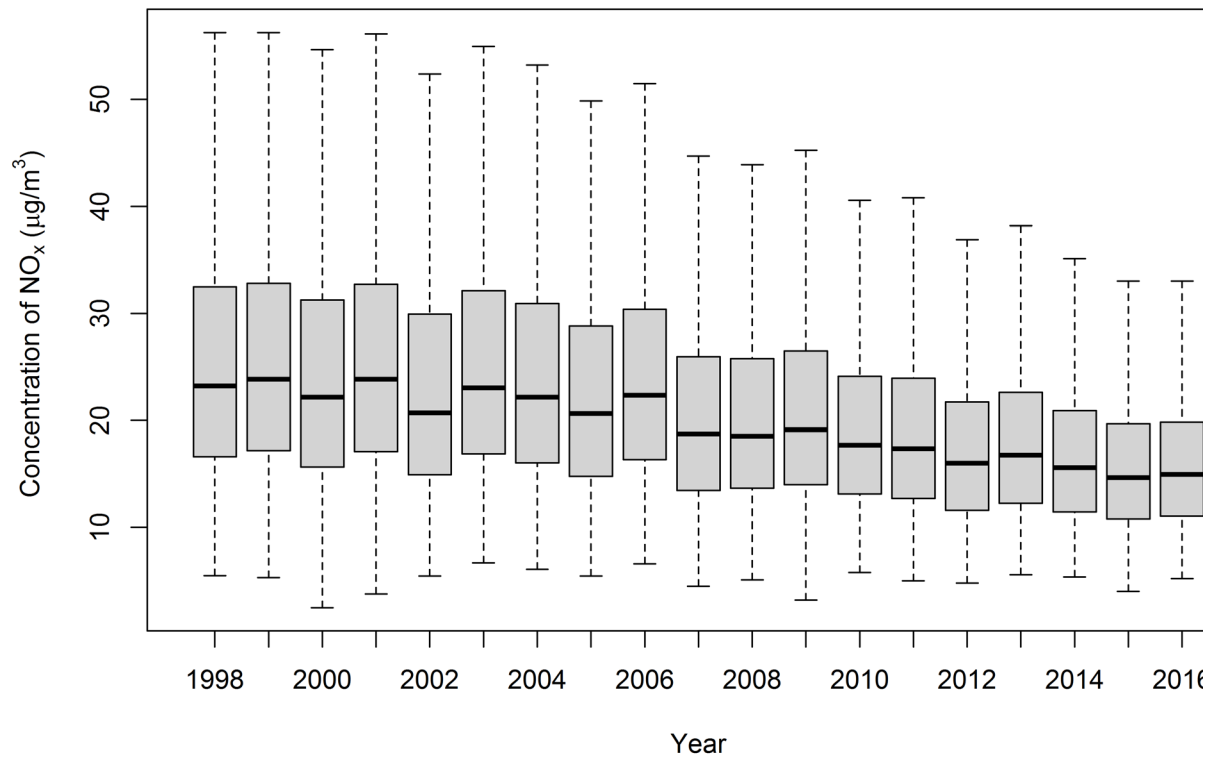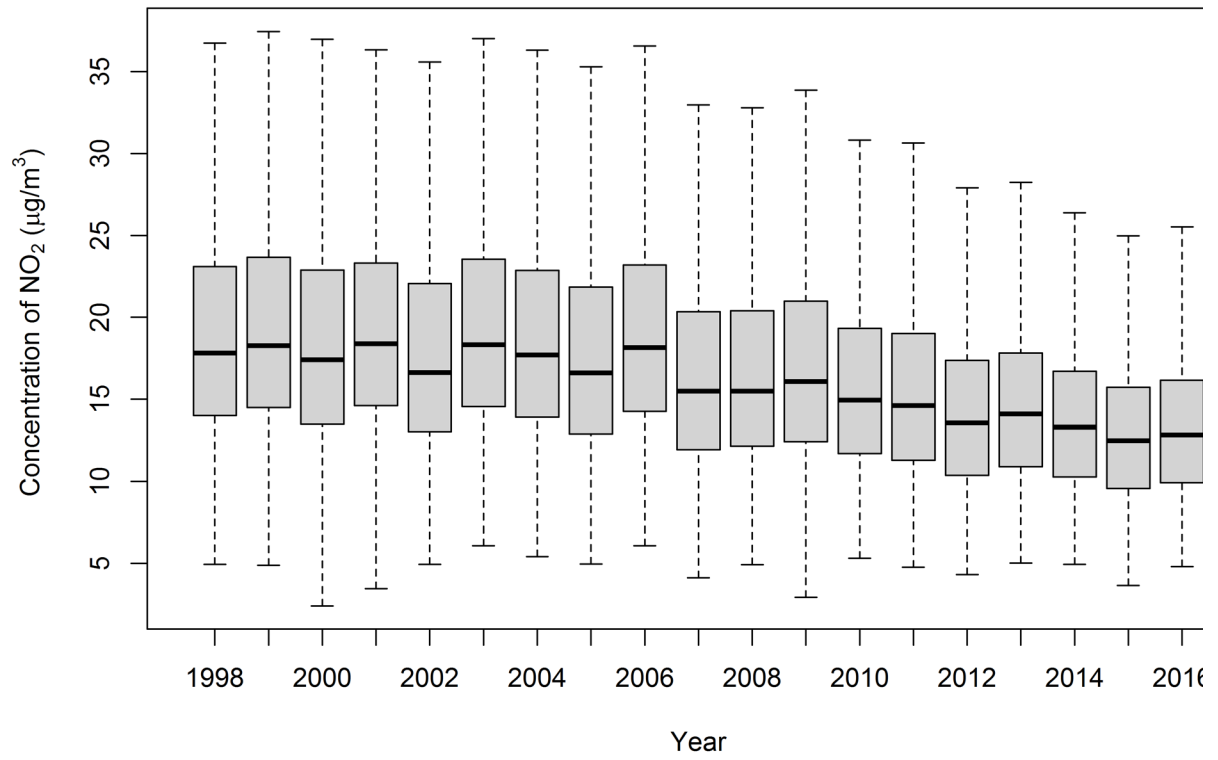
Figure A3. *(Continued).*

Figure A3. *(Continued).*

6
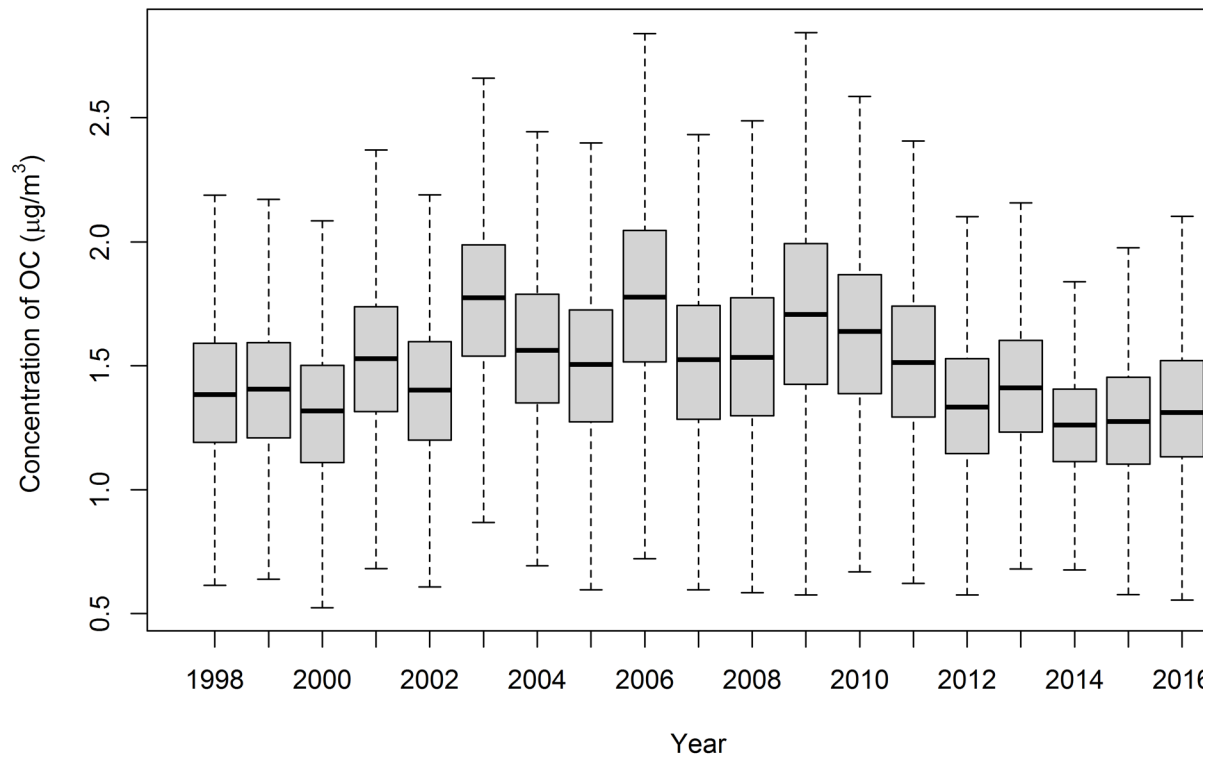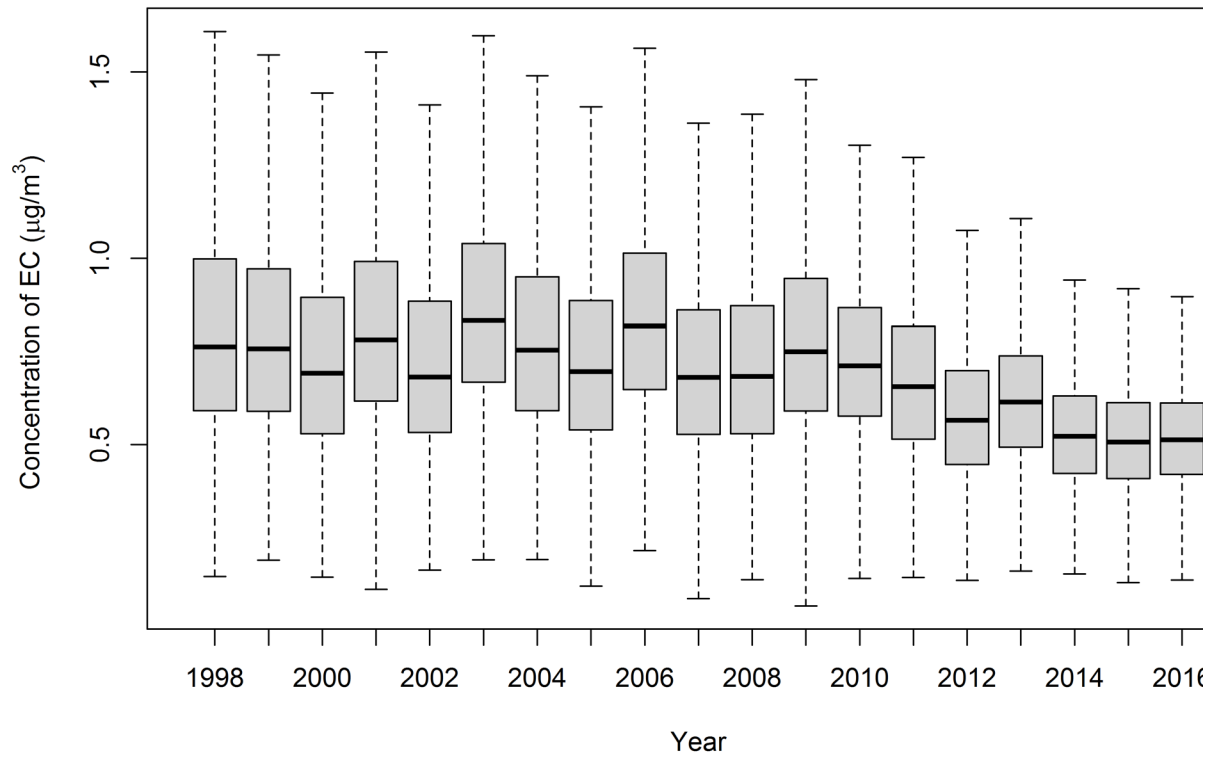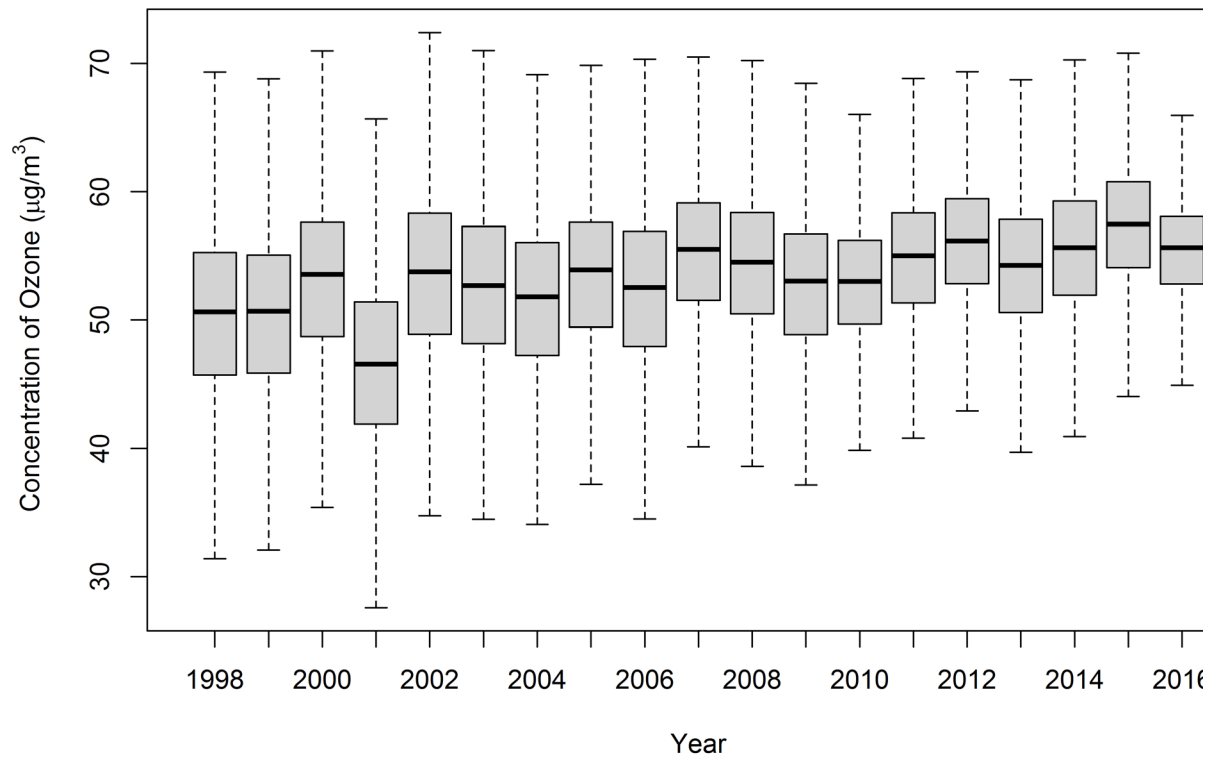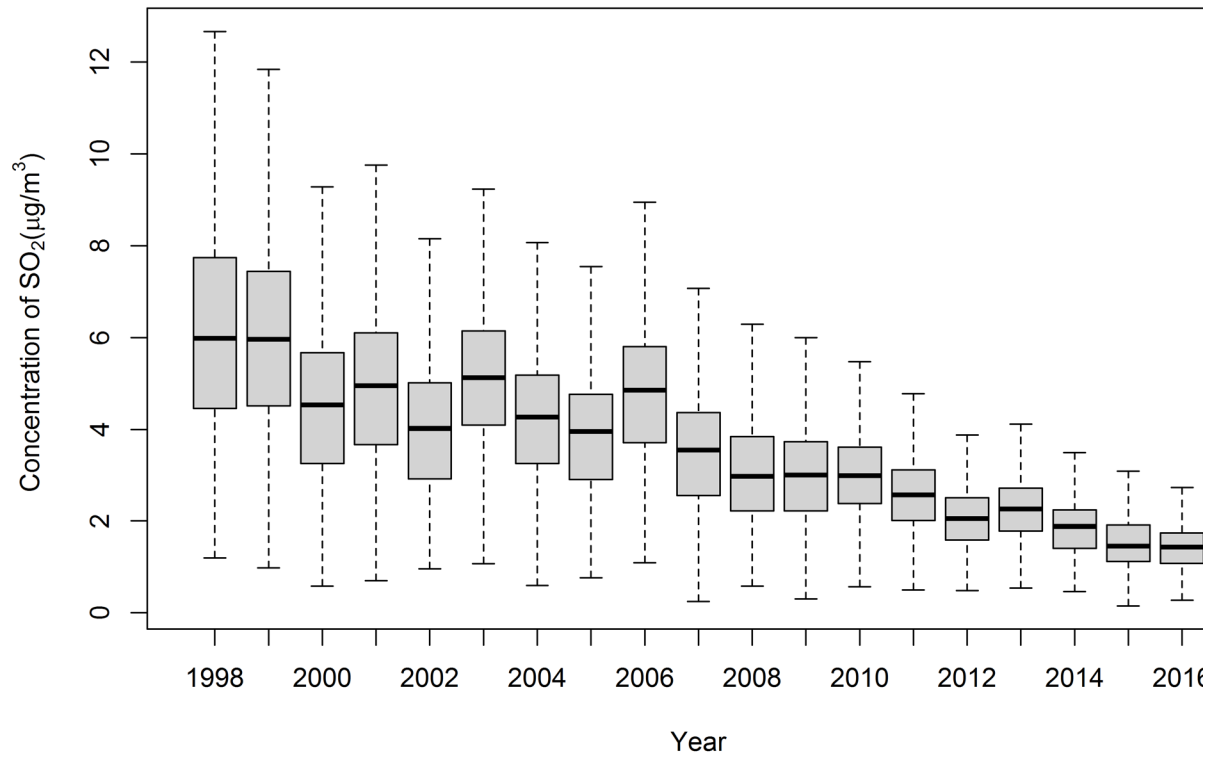
Figure A3. *(Continued).*
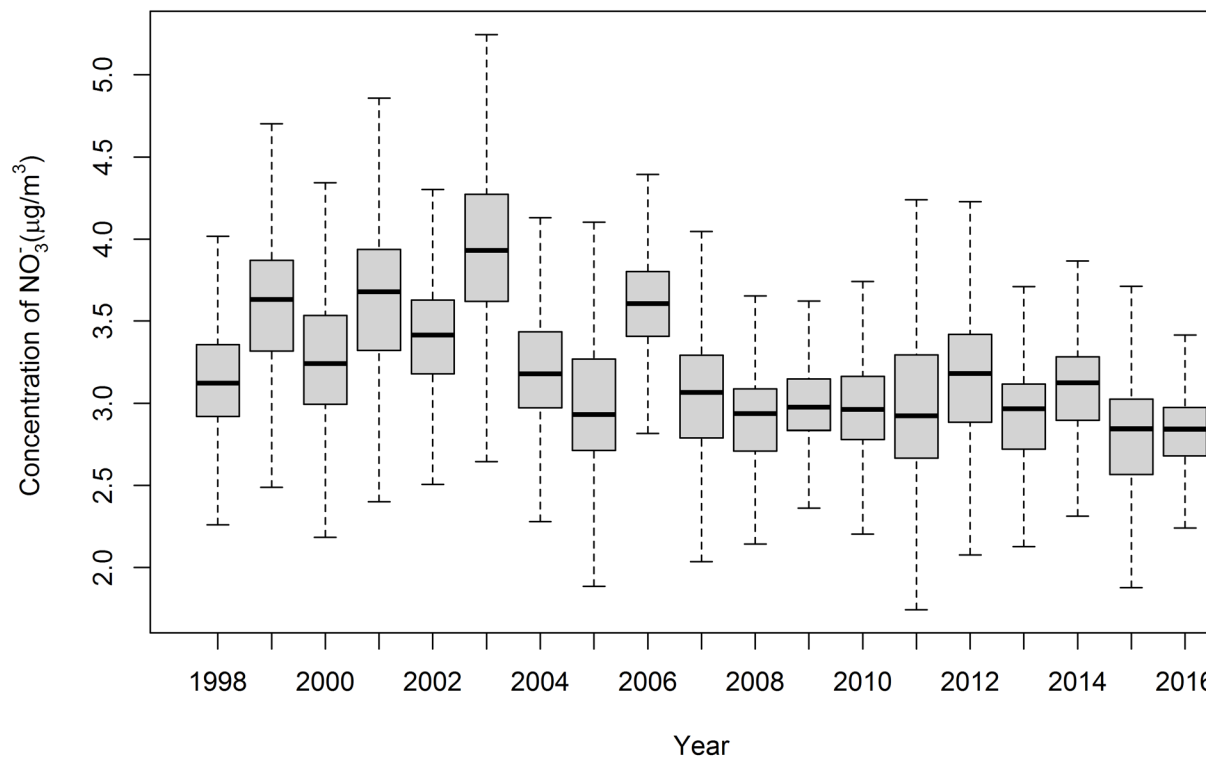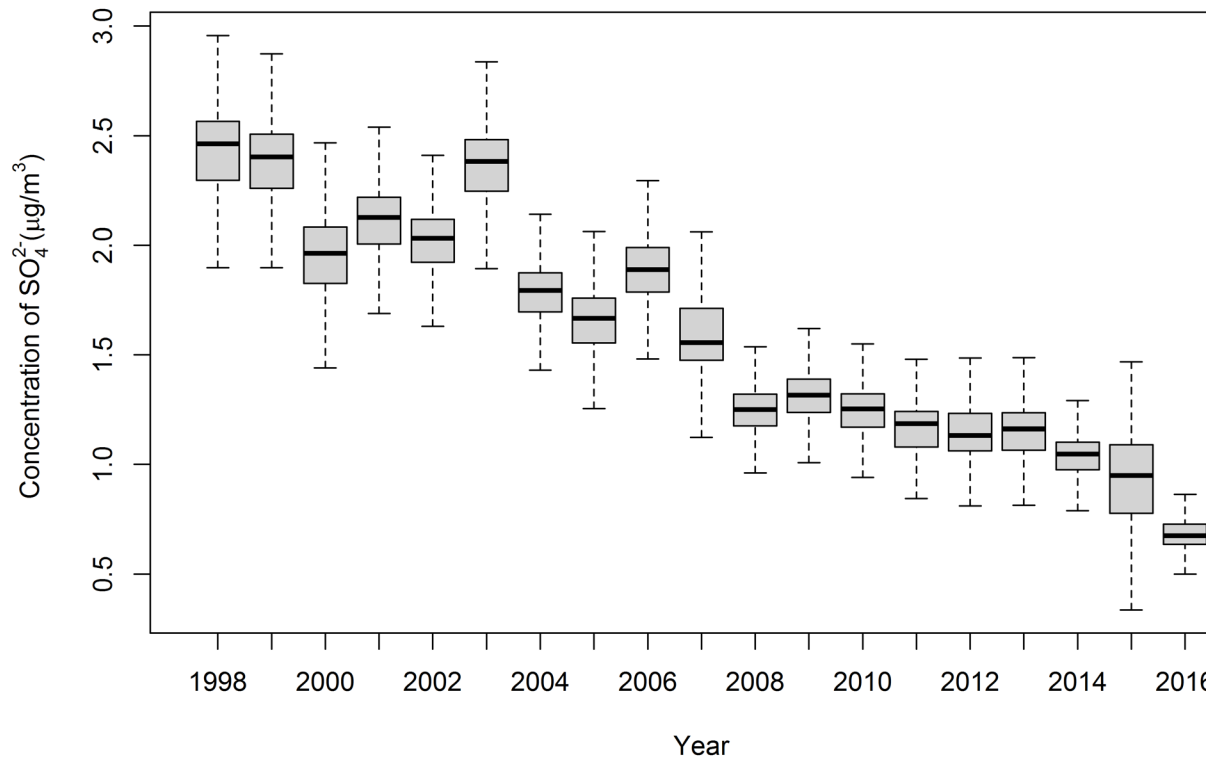
Figure A3. *(Continued).*
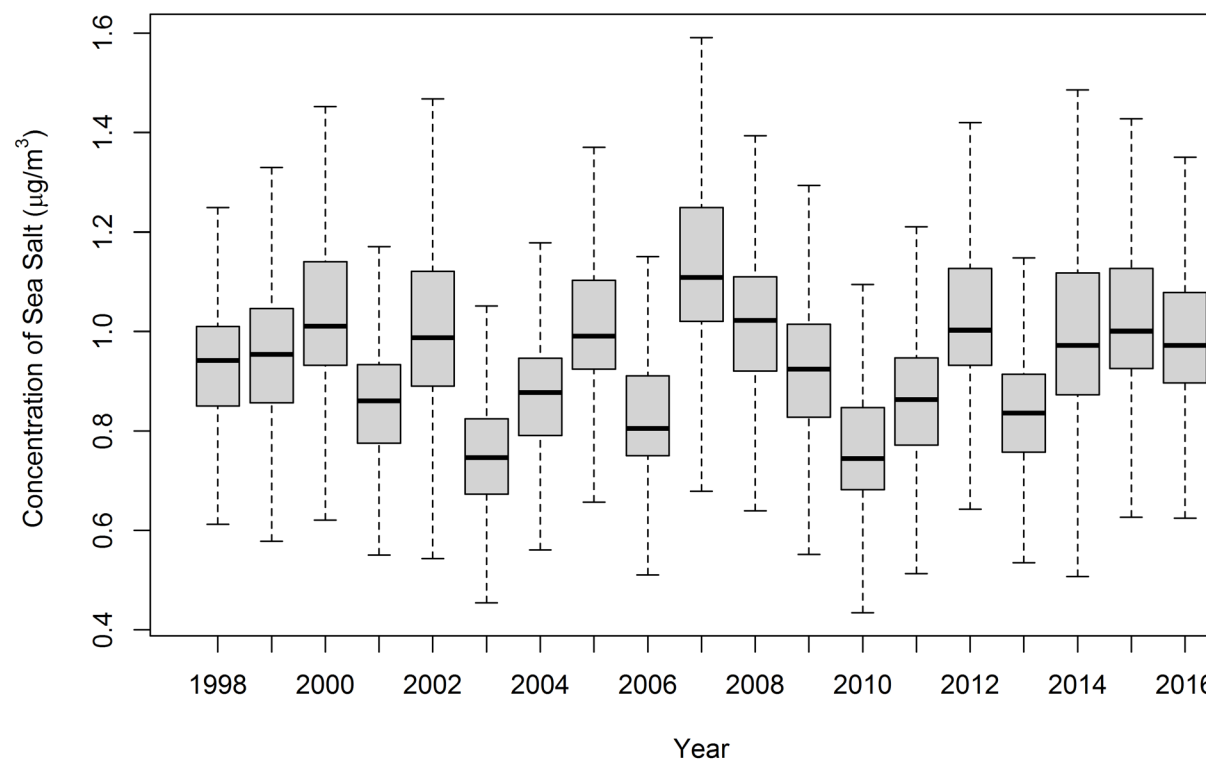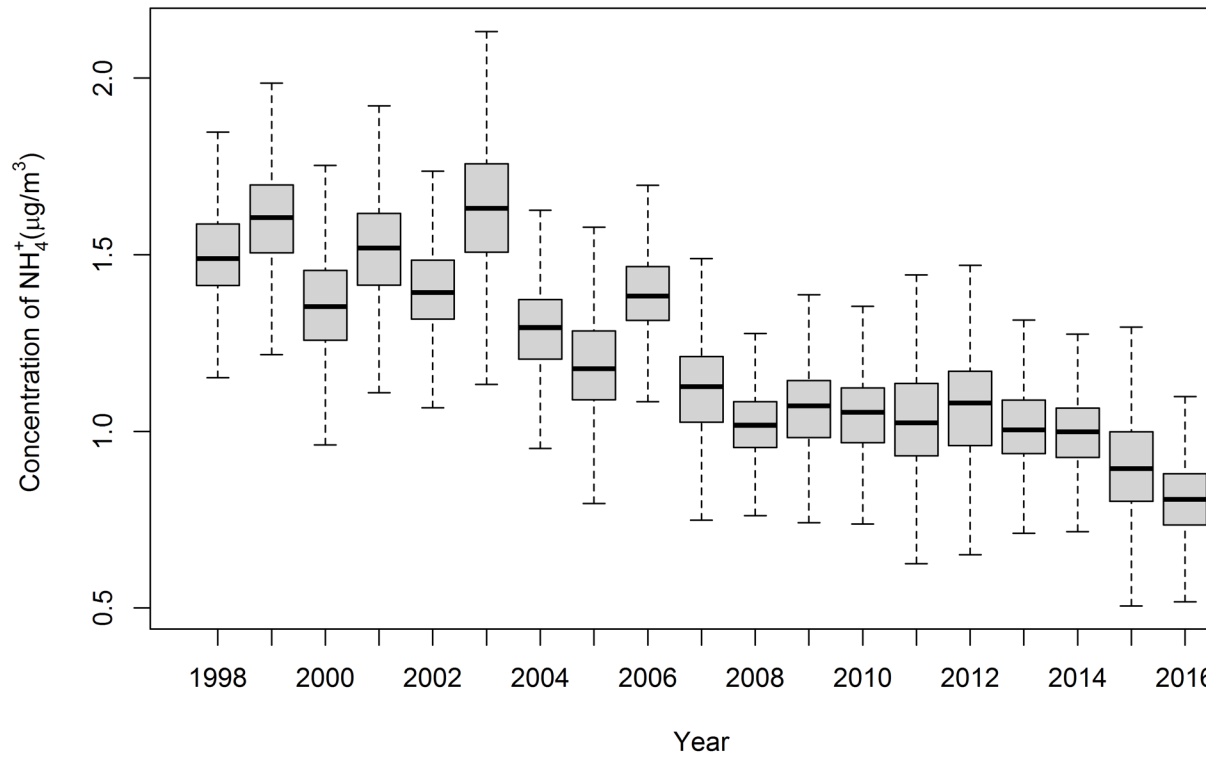
Figure A3. *(Continued).*

DNBC study population flow-chart

Liveborn singletons born 1997-2003 with prenatal exposure (N= 459,791)

↓

Complete covariates* (N=395,185)

↓

Participation in DNBC interview 1 during pregnancy (N=79,885)

↓

Information on breastfeeding 6 and 18 months follow-up (N=62,638)

↓

7-years follow-up information on doctor-diagnosed asthma (N=38,667)

↓

11-years follow-up information on home characteristics (N=22,084)

↓

Non-movers from birth to 11-years follow-up (N=9,507)

* Maternal smoking, education, and income.

Figure A4. Study population flow-chart of the Danish National Birth Cohort (DNBC).

Table A1. Correlation Coefficients between Modeled and Measured Pollutants in Ambient Air in Denmark [a]

Pollutant	Yearly *R*-Pearson (*N*)	Monthly *R*-Pearson (*N*)
$PM_{2.5}$ (LVS)	0.92 (47)	0.89 (514)
PM_{10} (LVS)	0.88 (33)	0.77 (361)
NO_2	0.94 (294)	0.91 (3,400)
NO_x	0.96 (294)	0.93 (3,404)
EC	0.99 (27)	0.89 (302)
OC		0.62 (202)
O_3	0.93 (185)	0.93 (2,105)
SO_4^{2-}		0.80 (760) [b]
NO_3^-		0.67 (158) [b]
NH_4^+		0.74 (482) [b]
Sea salt		0.88 (674) [b]

LVS stands for Low Volume Sampler and refers to the method used for these PM measurements in the Danish Air Quality Monitoring Programme. The LVS method is considered to be in accordance with the current EU-reference standard for PM measurements.

[a] For all available measurements from the Danish monitoring stations
[b] Measurements from EMEP stations within the DEHM domain covering Denmark and nearest surroundings for the period 2006–2015.

Table A2. Study Population Characteristics of the Participants of the Birth Cohort Studies of Long-term Exposure to Ambient Air Pollution in Early Life and Development of Asthma in Children and Adolescents Born in Denmark, 1998–2016

	Nationwide cohort (N = 1,060,154) n (%)	DNBC (N = 22,084) n (%)	COPSAC (N = 803) n (%)
Sex			
Boy	544,044 (51.3)	11,028 (49.9)	389 (48.4)
Girl	516,110 (48.7)	11,056 (50.1)	414 (51.6)
Season of birth			
Winter (Jan, Feb, Dec)	264,511 (25.0)	5,434 (24.6)	223 (27.8)
Spring (March, April, May)	285,516 (26.9)	6,389 (28.9)	200 (24.9)
Summer (June, July, August)	268,332 (25.3)	5,452 (24.7)	190 (23.7)
Fall (Sept, Oct, Nov)	241,795 (22.8)	4,809 (21.8)	190 (23.7)
Year of birth			
1998–2002	281,150 (26.5)	21,564 (97.6)	272 (33.9)
2003–2008	352,394 (33.2)	520 (2.4)	0
2009–2016	370,414 (34.9)	0	531 (66.1)
Maternal education			
Low	216,145 (20.4)	1,878 (8.5)	61 (7.6)
Middle	439,372 (41.4)	10,619 (48.1)	296 (36.9)
High	404,637 (38.2)	9,587 (43.4)	446 (55.5)
Household income			
Low	333,308 (31.4)	2,991 (13.5)	108 (13.4)
Middle	407,931 (38.5)	9,211 (41.7)	271 (33.7)
High	318,915 (30.1)	9,882 (44.7)	424 (52.8)
Older siblings			
No	482,150 (45.2)	10,059 (45.5)	372 (46.3)
Yes	583,152 (54.8)	12,025 (54.5)	431 (53.7)
Maternal smoking during early pregnancy			
No	912,930 (86.1)	17,852 (80.8)	711 (88.5)
Yes	147,224 (13.9)	4,232 (19.2)	92 (11.5)
Maternal asthma			
No	915,292 (86.3)	20,283 (91.8)	427 (53.2)
Yes	144,862 (13.7)	1,801 (8.2)	376 (46.8)
Child asthma (ICD-10)			
No	995,011 (93.9)	20,609 (93.3)	597 (74.3)
Yes	65,143 (6.1)	1,475 (6.7)	206 (25.7)
Pets in the home			
No	NA	12,932 (58.6)	7 (0.9)
Yes		9,152 (41.4)	796 (99.1)
Breast feeding			
No	NA	5,706 (25.8)	6 (0.7)
Yes		16,378 (74.2)	797 (99.3)
Daycare attendance			
No	NA	19,525 (88.4)	NA
Yes		2,559 (11.6)	
Postnatal exposure to ETS			
No	NA	18,306 (82.9)	99 (12.3)
Yes		3,778 (17.1)	704 (87.7)
Mold or dampness in the home			
No	NA	9,116 (41.3)	NA
Yes		12,968 (58.7)	
Gas stove in the home			
No	NA	20,434 (92.5)	424 (52.8)
Yes		1,650 (7.5)	177 (22.0)
Wood stove in the home			
No	NA	12,597 (57.0)	394 (49.1)
Yes		9,487 (43.0)	409 (50.9)

NA refers to not available. ETS refers to environmental tobacco smoke.

Table A3. Prenatal Exposure to Ambient Air Pollution Concentrations (μg/m³) of the Children Born in Denmark, 1998–2016[a]

Pollutant	Nationwide Cohort ($N = 1,060,154$)	DNBC ($N = 22,084$)	COPSAC ($N = 803$)
$PM_{2.5}$	10.5 ± 1.8	11.5 ± 1.4	10.8 ± 1.5
PM_{10}	16.6 ± 2.2	17.6 ± 1.8	16.0 ± 2.1
NO_2	17.5 ± 7.4	18.6 ± 7.3	20.4 ± 6.9
NO_x	24.1 ± 17.3	26.9 ± 19.4	28.2 ± 16.9
EC	0.7 ± 0.3	0.8 ± 0.4	0.9 ± 0.3
OC	1.5 ± 0.3	1.4 ± 0.3	1.7 ± 0.3
SO_2	3.8 ± 2.3	5.0 ± 2.3	3.9 ± 1.5
O_3	53.1 ± 6.7	51.1 ± 7.2	49.9 ± 6.6
SO_4^{2-}	1.6 ± 0.5	2.1 ± 0.2	1.6 ± 0.4
NO_3^-	3.2 ± 0.5	3.4 ± 0.5	3.2 ± 0.4
NH_4^+	1.2 ± 0.3	1.8 ± 0.9	1.2 ± 0.3
SOA	0.3 ± 0.1	0.3 ± 0.1	0.3 ± 0.1
Sea salt	0.9 ± 0.2	1.0 ± 0.2	0.8 ± 0.1

[a] Values are mean ± standard deviation.

Table A4. Spearman Correlation Coefficients between Ambient Air Pollutant Concentrations During the Prenatal Periods for the Children Born in Denmark, 1998–2016

Nationwide cohort ($N = 1{,}060{,}154$)

Pollutant	$PM_{2.5}$	PM_{10}	NO_2	NO_x	OC	EC	SO_2	O_3	SO_4^{2-}	NO_3^-	NH_4^+	SOA
PM_{10}	0.82	1.00										
NO_2	0.71	0.59	1.00									
NO_x	0.69	0.60	0.98	1.00								
EC	0.74	0.68	0.91	0.90	1.00							
OC	0.58	0.49	0.63	0.58	0.77	1.00						
SO_2	0.79	0.67	0.66	0.63	0.69	0.52	1.00					
O_3	-0.59	-0.54	-0.81	-0.79	-0.82	-0.64	-0.59	1.00				
SO_4^{2-}	0.83	0.63	0.41	0.40	0.42	0.23	0.77	-0.32	1.00			
NO_3^-	0.72	0.44	0.29	0.27	0.24	0.19	0.41	-0.17	0.63	1.00		
NH_4^+	0.83	0.64	0.31	0.30	0.34	0.24	0.66	-0.27	0.91	0.81	1.00	
SOA	0.17	-0.05	0.22	0.19	0.07	-0.07	0.09	0.14	0.18	0.27	0.04	1.00
Sea salt	-0.34	0.07	-0.44	-0.39	-0.40	-0.42	-0.27	0.28	-0.23	-0.32	-0.17	-0.38

DNBC ($N = 22{,}084$)

Pollutant	$PM_{2.5}$	PM_{10}	NO_2	NO_x	OC	EC	SO_2	O_3	SO_4^{2-}	NO_3^-	NH_4^+	SOA
PM_{10}	0.78	1.00										
NO_2	0.84	0.74	1.00									
NO_x	0.80	0.81	0.93	1.00								
OC	0.67	0.43	0.64	0.46	1.00							
EC	0.82	0.82	0.94	0.97	0.57	1.00						
SO_2	0.50	0.46	0.52	0.39	0.56	0.46	1.00					
O_3	-0.72	-0.60	-0.83	-0.74	-0.75	-0.80	-0.54	1.00				
SO_4^{2-}	0.62	0.28	0.36	0.25	0.35	0.28	0.42	-0.30	1.00			
NO_3^-	0.62	0.24	0.21	0.12	0.27	0.11	0.14	-0.16	0.55	1.00		
NH_4^+	0.61	0.29	0.15	0.08	0.32	0.11	0.24	-0.21	0.72	0.87	1.00	
SOA	0.13	-0.08	0.15	0.09	-0.13	0.02	-0.07	0.23	0.12	0.24	-0.08	1.00
Sea salt	-0.49	0.08	-0.42	-0.28	-0.51	-0.31	-0.22	0.38	-0.51	-0.45	0.41	-0.39

COPSAC ($N = 803$)

Pollutant	$PM_{2.5}$	PM_{10}	NO_2	NO_x	OC	EC	SO_2	O_3	SO_4^{2-}	NO_3^-	NH_4^+	SOA
PM_{10}	0.94	1.00										
NO_2	0.62	0.71	1.00									
NO_x	0.63	0.72	0.98	1.00								
EC	0.67	0.78	0.92	0.91	1.00							
OC	0.38	0.47	0.29	0.25	0.57	1.00						
SO_2	0.77	0.71	0.55	0.53	0.51	0.22	1.00					
O_3	-0.63	-0.70	-0.80	-0.77	-0.85	-0.48	-0.57	1.00				
SO_4^{2-}	0.85	0.69	0.32	0.32	0.31	0.14	0.77	-0.34	1.00			
NO_3^-	0.64	0.44	0.03	0.06	0.01	-0.07	0.50	-0.07	0.79	1.00		
NH_4^+	0.80	0.63	0.15	0.17	0.18	0.12	0.68	-0.28	0.91	0.89	1.00	
SOA	-0.24	-0.25	0.09	0.09	-0.11	-0.52	-0.16	0.31	-0.20	-0.15	-0.38	1.00
Sea salt	0.39	0.44	0.01	0.02	0.01	-0.02	0.33	-0.10	0.49	0.29	0.47	-0.21

Table A5. Spearman Correlation Coefficients between Prenatal and Postnatal Exposure Concentrations for the Children Born in Denmark, 1998–2016

Nationwide cohort ($N = 1,060,154$) — Postnatal exposure as annual mean concentration during the first year of life

Prenatal exposure	$PM_{2.5}$	PM_{10}	NO_2	NO_x	EC	OC	SO_2	O_3	SO_4^{2-}	NO_3^-	NH_4^+	SOA	Sea salt
$PM_{2.5}$	0.76	0.62	0.63	0.61	0.59	0.34	0.68	-0.50	0.74	0.46	0.65	0.15	-0.22
PM_{10}	0.63	0.73	0.50	0.51	0.51	0.24	0.61	-0.40	0.59	0.30	0.52	0.08	0.03
NO_2	0.64	0.51	0.91	0.89	0.81	0.54	0.62	-0.69	0.41	0.25	0.28	0.24	-0.37
NO_x	0.62	0.52	0.90	0.90	0.80	0.50	0.60	-0.68	0.39	0.24	0.27	0.22	-0.34
EC	0.63	0.56	0.83	0.81	0.83	0.57	0.60	-0.64	0.42	0.28	0.24	0.23	-0.29
OC	0.45	0.35	0.61	0.56	0.61	0.62	0.45	-0.45	0.24	0.12	0.13	0.27	-0.28
SO_2	0.70	0.59	0.61	0.58	0.59	0.38	0.90	-0.48	0.74	0.35	0.60	0.15	-0.16
O_3	-0.46	-0.39	-0.76	-0.73	-0.67	-0.5	-0.54	0.62	-0.23	-0.13	-0.2	-0.22	0.26
SO_4^{2-}	0.70	0.55	0.39	0.38	0.37	0.14	0.71	-0.32	0.89	0.49	0.79	0.11	-0.11
NO_3^-	0.49	0.31	0.26	0.25	0.20	0.08	0.39	-0.20	0.51	0.53	0.57	0.03	-0.16
NH_4^+	0.62	0.49	0.27	0.27	0.26	0.08	0.59	-0.24	0.80	0.52	0.78	0.04	-0.07
SOA	0.28	0.13	0.34	0.32	0.28	0.23	0.26	-0.28	0.25	0.16	0.16	0.09	-0.17
Sea salt	-0.23	0.00	-0.39	-0.36	-0.33	-0.30	-0.18	0.28	-0.14	-0.13	-0.05	-0.16	0.32

DNBC ($N = 22,084$) — Postnatal exposure as annual mean concentration during the first year of life

Prenatal exposure	$PM_{2.5}$	PM_{10}	NO_2	NO_x	EC	OC	SO_2	O_3	SO_4^{2-}	NO_3^-	NH_4^+	SOA	Sea salt
$PM_{2.5}$	0.61	0.53	0.65	0.61	0.46	0.61	0.25	-0.43	0.18	0.25	-0.38	0.25	-0.24
PM_{10}	0.61	0.76	0.62	0.67	0.32	0.67	0.32	-0.44	0.19	0.14	-0.17	0.12	0.00
NO_2	0.74	0.65	0.91	0.84	0.57	0.84	0.46	-0.71	0.30	0.14	-0.54	0.19	-0.37
NO_x	0.70	0.71	0.85	0.90	0.41	0.87	0.34	-0.64	0.21	0.08	-0.40	0.13	-0.26
EC	0.40	0.24	0.50	0.35	0.62	0.39	0.27	-0.35	0.02	0.12	-0.43	0.32	-0.34
OC	0.69	0.69	0.85	0.85	0.47	0.87	0.37	-0.63	0.17	0.07	-0.43	0.17	-0.27
SO_2	0.37	0.36	0.46	0.35	0.44	0.39	0.79	-0.37	0.21	0.03	-0.42	0.09	-0.16
O_3	-0.55	-0.52	-0.79	-0.71	-0.49	-0.71	-0.40	0.60	-0.07	-0.03	0.43	-0.14	0.24
SO_4^{2-}	0.24	0.13	0.24	0.17	0.25	0.17	0.09	-0.11	0.20	0.12	-0.35	0.10	-0.12
NO_3^-	0.25	0.11	0.11	0.06	0.13	0.04	-0.03	0.03	0.11	0.42	-0.12	0.27	-0.10
NH_4^+	0.13	0.07	0.01	-0.01	0.05	0.03	-0.07	0.10	0.02	0.26	0.05	0.17	0.16
SOA	0.23	0.07	0.22	0.16	0.28	0.18	0.09	-0.18	0.20	0.11	-0.30	0.01	-0.21
Sea salt	-0.17	0.06	-0.31	-0.21	-0.32	-0.20	0.00	0.12	0.10	-0.05	0.44	-0.34	0.31

DNBC ($N = 22,084$) — Postnatal exposure as the mean concentration during the first seven years of life

Prenatal exposure	$PM_{2.5}$	PM_{10}	NO_2	NO_x	EC	OC	SO_2	O_3	SO_4^{2-}	NO_3^-	NH_4^+	SOA	Sea salt
$PM_{2.5}$	0.74	0.57	0.68	0.58	0.57	0.60	0.45	-0.57	0.44	0.46	-0.42	0.09	-0.31
PM_{10}	0.50	0.70	0.49	0.50	0.29	0.52	0.35	-0.39	0.15	0.18	-0.07	-0.02	0.11
NO_2	0.68	0.53	0.82	0.70	0.60	0.72	0.47	-0.67	0.35	0.20	-0.54	0.16	-0.41
NO_x	0.65	0.58	0.77	0.75	0.45	0.74	0.37	-0.60	0.27	0.13	-0.43	0.12	-0.30
EC	0.53	0.29	0.58	0.40	0.76	0.46	0.42	-0.52	0.21	0.24	-0.48	0.20	-0.46
OC	0.66	0.58	0.78	0.71	0.57	0.76	0.44	-0.63	0.26	0.14	-0.47	0.15	-0.35
SO_2	0.39	0.35	0.46	0.33	0.45	0.38	0.76	-0.40	0.25	0.11	-0.41	0.05	-0.20
O_3	-0.64	-0.49	-0.79	-0.65	-0.63	-0.68	-0.50	0.66	-0.33	-0.16	0.48	-0.15	0.39
SO_4^{2-}	0.41	0.29	0.33	0.22	0.21	0.24	0.38	-0.28	0.58	0.34	-0.36	-0.12	-0.11
NO_3^-	0.43	0.23	0.17	0.10	0.16	0.09	0.15	-0.13	0.41	0.66	-0.09	0.04	-0.11
NH_4^+	0.31	0.23	0.06	0.02	0.05	0.02	0.02	-0.07	0.39	0.51	0.12	0.59	-0.11
SOA	0.47	0.08	0.55	0.38	0.57	0.40	0.26	-0.47	0.28	0.31	-0.68	0.19	-0.63
Sea salt	-0.46	-0.02	-0.51	-0.34	-0.56	-0.36	-0.30	0.42	-0.38	-0.28	0.63	-0.23	0.66

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Table A5 *(continued)*. Spearman Correlation Coefficients between Prenatal and Postnatal Exposure Concentrations for the Children Born in Denmark, 1998–2016

COPSAC (N = 803)	**Postnatal exposure as the mean concentration during the first six years of life**
Prenatal exposure	$PM_{2.5}$	PM_{10}	NO_2	NO_x	EC	OC	SO_2	O_3	SO_4^{2-}	NO_3^-	NH_4^+	SOA	Sea salt
$PM_{2.5}$	0.79	0.75	0.61	0.61	0.68	0.63	0.71	-0.58	0.72	0.40	0.60	0.71	-0.50
PM_{10}	0.75	0.75	0.64	0.65	0.70	0.61	0.64	-0.61	0.64	0.27	0.46	0.6	-0.47
NO_2	0.63	0.65	0.85	0.85	0.83	0.59	0.5	-0.83	0.31	-0.10	0.06	0.59	-0.40
NO_x	0.64	0.67	0.84	0.85	0.81	0.57	0.49	-0.8	0.31	-0.06	0.09	0.57	-0.37
EC	0.54	0.57	0.74	0.74	0.75	0.55	0.39	-0.71	0.23	-0.17	-0.01	0.52	-0.34
OC	0.05	0.07	0.16	0.15	0.20	0.24	0.00	-0.14	-0.07	-0.33	-0.22	0.15	-0.10
SO_2	0.71	0.68	0.61	0.58	0.63	0.61	0.88	-0.59	0.71	0.33	0.52	0.69	-0.45
O_3	-0.52	-0.53	-0.66	-0.65	-0.66	-0.49	-0.44	0.62	-0.33	0.04	-0.11	-0.54	0.31
SO_4^{2-}	0.69	0.6	0.42	0.39	0.47	0.51	0.74	-0.4	0.85	0.57	0.75	0.66	-0.52
NO_3^-	0.49	0.43	0.14	0.13	0.19	0.25	0.51	-0.13	0.64	0.77	0.80	0.40	-0.20
NH_4^+	0.62	0.53	0.27	0.25	0.33	0.41	0.65	-0.24	0.79	0.71	0.84	0.58	-0.4
SOA	0.04	0.07	0.13	0.13	0.12	0.11	0.02	-0.18	-0.1	-0.14	-0.13	-0.07	-0.02
Sea salt	0.41	0.33	0.11	0.10	0.17	0.24	0.46	-0.11	0.73	0.43	0.58	0.18	-0.51
COPSAC (N = 803)	**Postnatal exposure as the annual mean concentration during the year before lung function measurement**
Prenatal exposure	$PM_{2.5}$	PM_{10}	NO_2	NO_x	EC	OC	SO_2	O_3	SO_4^{2-}	NO_3^-	NH_4^+	SOA	Sea salt
$PM_{2.5}$	0.74	0.69	0.49	0.51	0.41	0.01	0.66	-0.42	0.71	0.51	0.64	0.00	0.50
PM_{10}	0.67	0.65	0.52	0.54	0.42	-0.03	0.64	-0.42	0.60	0.45	0.54	0.11	0.41
NO_2	0.55	0.55	0.69	0.68	0.58	0.09	0.58	-0.52	0.42	0.17	0.29	0.13	0.13
NO_x	0.53	0.54	0.67	0.67	0.57	0.09	0.54	-0.50	0.40	0.15	0.27	0.13	0.13
EC	0.61	0.59	0.68	0.67	0.57	0.07	0.61	-0.53	0.49	0.23	0.37	0.13	0.20
OC	0.50	0.46	0.52	0.52	0.41	0.01	0.54	-0.40	0.43	0.20	0.34	0.17	0.17
SO_2	0.68	0.60	0.50	0.49	0.39	0.00	0.77	-0.42	0.70	0.47	0.61	0.01	0.39
O_3	-0.30	-0.29	-0.59	-0.56	-0.42	0.08	-0.36	0.29	-0.20	-0.06	-0.06	-0.34	0.12
SO_4^{2-}	0.70	0.62	0.27	0.28	0.21	-0.06	0.64	-0.30	0.80	0.63	0.77	-0.11	0.73
NO_3^-	0.42	0.31	-0.06	-0.04	-0.1	-0.17	0.32	0.03	0.55	0.69	0.66	-0.19	0.42
NH_4^+	0.64	0.53	0.13	0.15	0.07	-0.14	0.56	-0.17	0.78	0.73	0.81	-0.13	0.67
SOA	0.61	0.52	0.31	0.30	0.34	0.3	0.48	-0.35	0.57	0.47	0.62	-0.42	0.20
Sea salt	-0.05	-0.08	-0.07	-0.06	-0.05	-0.04	-0.01	-0.03	-0.06	0.09	-0.04	0.17	-0.12

Table A6. Associations between Prenatal Exposure to Ambient Air Pollution and Asthma Incidence After Age 4 in the Nationwide Cohort of Children Born in Denmark, 1998–2016[a]

Pollutant	Asthma at any age Same study population as the right column HR (95% CI)	Asthma after 4 years of age HR (95% CI)
$PM_{2.5}$	1.05 (1.03–1.07)	1.03 (1.00–1.05)
PM_{10}	1.05 (1.03–1.06)	1.03 (1.01–1.05)
NO_2	1.04 (1.02–1.05)	1.02 (1.00–1.04)
NO_x	1.01 (1.01–1.02)	1.01 (1.00–1.02)
EC	1.02 (1.01–1.03)	1.02 (1.00–1.03)
OC	1.08 (1.06–1.09)	1.05 (1.02–1.08)
SO_2	1.02 (1.01–1.03)	1.02 (1.00–1.04)
O_3	0.98 (0.96–0.99)	0.98 (0.95–1.00)
SO_4^{2-}	1.03 (1.00–1.07)	0.99 (0.94–1.04)
NO_3^-	1.01 (1.00–1.03)	1.00 (0.98–1.03)
NH_4^+	1.01 (0.98–1.03)	0.99 (0.96–1.02)
SOA	1.02 (1.01–1.04)	1.03 (1.01–1.05)
Sea salt	0.99 (0.97–1.00)	1.00 (0.98–1.03)

[a] Restricted to infants born between 1998 and 2012.

Hazard ratio (HR) and 95% confidence intervals (CI) from Cox regression models per fixed increments of the interquartile range ($\mu g/m^3$) of the time-weighted average exposures to ambient air pollutants for the full prenatal period of 2.4 for $PM_{2.5}$, 2.7 for PM_{10}, 8.7 for NO_2, 13.4 for NO_x, 0.3 for EC, 0.5 for OC, 2.7 for SO_2, 8.5 for O_3, 0.9 for SO_4^{2-}, 0.6 for NO_3^-, 0.4 for NH_4^+, 0.1 for SOA and 0.2 for sea salt with age as the time dimension adjusted for year, sex, household income, maternal education, parity, season of birth, smoking during pregnancy and municipality.

The total number of children is 829,851 and the number of asthma cases is 25,739.

Table A7. Sensitivity Analyses of Associations between Air Pollution and Asthma Incidence in the Nationwide Cohort of Children Born in Denmark, 1998–2016 [a]

Pollutant	Restricted to infants born in Greater Copenhagen HR (95% CI)	Additional adjustment for area-level SES HR (95% CI)	Additional adjustment for population density (strata) HR (95% CI)
$PM_{2.5}$	1.08 (1.04–1.12)	1.05 (1.03–1.07)	1.06 (1.04–1.07)
PM_{10}	1.05 (1.03–1.07)	1.05 (1.03–1.06)	1.05 (1.03–1.06)
NO_2	1.03 (1.01–1.06)	1.04 (1.02–1.05)	1.04 (1.02–1.05)
NO_x	1.01 (1.00–1.02)	1.01 (1.01–1.02)	1.01 (1.01–1.02)
EC	1.03 (1.01–1.04)	1.02 (1.01–1.03)	1.02 (1.02–1.03)
OC	1.14 (1.09–1.18)	1.08 (1.06–1.10)	1.08 (1.06–1.10)
SO_2	1.03 (1.00–1.06)	1.02 (1.01–1.03)	1.02 (1.01–1.03)
O_3	0.95 (0.93–0.98)	0.98 (0.96–0.99)	0.98 (0.96–1.00)
SO_4^{2-}	1.18 (1.09–1.28)	1.03 (1.00–1.07)	1.04 (1.01–1.08)
NO_3^-	1.03 (1.00–1.07)	1.01 (1.00–1.03)	1.02 (1.00–1.03)
NH_4^+	1.07 (1.02–1.13)	1.01 (0.98–1.03)	1.01 (0.99–1.03)
SOA	1.02 (0.99–1.05)	1.02 (1.01–1.04)	1.02 (1.01–1.04)
Sea salt	0.96 (0.92–1.00)	0.99 (0.97–1.00)	0.99 (0.97–1.00)

[a] Hazard ratio (HR) and 95% confidence intervals (CI) from Cox regression models per fixed increments of the interquartile range ($\mu g/m^3$) of the time-weighted average exposures to ambient air pollutants for the full prenatal period of 2.4 for $PM_{2.5}$, 2.7 for PM_{10}, 8.7 for NO_2, 13.4 for NO_x, 0.3 for EC, 0.5 for OC, 2.7 for SO_2, 8.5 for O_3, 0.9 for SO_4^{2-}, 0.6 for NO_3^-, 0.4 for NH_4^+, 0.1 for SOA, and 0.2 for sea salt with age as the time dimension adjusted for year, sex, household income, maternal education, parity, season of birth, smoking during pregnancy and municipality.

The total number of children is 276,773 and the number of asthma cases is 12,270 in models restricted to Greater Copenhagen. Greater Copenhagen refers to municipality of Copenhagen, Frederiksberg, Dragør, Tårnby, Albertslund, Ballerup, Brøndby, Gentofte, Gladsaxe, Glostrup, Herlev, Hvidovre, Høje-Taastrup, Ishøj, Lyngby-Taarbæk, Rødovre, and Vallensbæk.

The total number of children is 985,760 and the number of asthma cases is 65,143 in models with additional adjustment for area-level SES.

The total number of children is 1,059,987 and the number of asthma cases is 65,143 in models with additional adjustment for population density.

Table A8. Associations between Prenatal Exposure to Air Pollution and Asthma Incidence by Sex in the Nationwide Cohort of Children Born in Denmark, 1998–2016 [a]

Pollutant	Boys (N = 554,044; n = 40,861) HR (95% CI)	Girls (N = 516,110; n = 24,282) HR (95% CI)	P value
$PM_{2.5}$	1.04 (1.02–1.06)	1.08 (1.06–1.11)	<0.001
PM_{10}	1.04 (1.02–1.05)	1.07 (1.05–1.09)	0.01
NO_2	1.03 (1.01–1.05)	1.05 (1.03–1.07)	0.12
NO_x	1.01 (1.00–1.02)	1.02 (1.01–1.03)	0.06
EC	1.02 (1.01–1.03)	1.03 (1.02–1.04)	0.17
OC	1.09 (1.07–1.10)	1.07 (1.05–1.10)	0.35
SO_2	1.01 (1.00–1.02)	1.04 (1.02–1.05)	0.001
O_3	0.98 (0.97–1.00)	0.97 (0.95–0.98)	0.09
SO_4^{2-}	1.01 (0.98–1.05)	1.09 (1.05–1.13)	<0.001
NO_3^-	1.01 (0.99–1.02)	1.03 (1.01–1.05)	0.03
NH_4^+	0.99 (0.97–1.01)	1.04 (1.02–1.07)	<0.001
SOA	1.02 (1.01–1.04)	1.03 (1.01–1.05)	0.66
Sea salt	0.99 (0.97–1.00)	0.99 (0.97–1.01)	0.59

[a] Hazard ratio (HR) and 95% confidence intervals (CI) from Cox regression models per fixed increments of the interquartile range ($\mu g/m^3$) of the time-weighted average exposures to ambient air pollutants for the full prenatal period of 2.4 for $PM_{2.5}$, 2.7 for PM_{10}, 8.7 for NO_2, 13.4 for NO_x, 0.3 for EC, 0.5 for OC, 2.7 for SO_2, 8.5 for O_3, 0.9 for SO_4^{2-}, 0.6 for NO_3^-, 0.4 for NH_4^+, 0.1 for SOA, and 0.2 for sea salt with age as the time dimension adjusted for year, household income, maternal education, parity, season of birth, smoking during pregnancy and municipality.

Table A9. Study Population Characteristics of Excluded vs. Included and Nonmovers vs. Movers of the Danish National Birth Cohort (DNBC)

	% Excluded (N = 57,084)	% Included (N = 22,084)	P value[a]	% Nonmovers (N = 9,507)	% Movers (N = 12, 577)	P value[b]
Sex			<0.001			0.25
Boy	51.8	49.9		50.4	49.6	
Girl	48.2	50.1		49.6	50.4	
Season of delivery			<0.001			0.06
Winter (Jan, Feb, Dec)	25.9	24.6		24.6	24.6	
Spring (March, April, May)	25.1	28.9		29.8	28.2	
Summer (June, July, August)	25.8	24.7		24.4	24.9	
Fall (Sept, Oct, Nov)	23.1	21.8		21.2	22.2	
Year of delivery			<0.001			0.09
1998–2002	94.9	97.6		97.9	97.4	
2003–2008	5.1	2.4		2.1	2.6	
Maternal education			<0.001			<0.001
Low	16.6	8.5		7.3	9.4	
Middle	51.2	48.1		46.8	49.1	
High	32.2	43.4		45.9	41.5	
Household income			<0.001			<0.001
Low	20.3	13.5		8.5	17.4	
Middle	41.6	41.7		43.4	40.4	
High	38.1	44.7		48.1	42.2	
Older siblings			<0.001			<0.001
No	47.0	45.5		32.5	55.4	
Yes	53.0	54.5		67.5	44.6	
Maternal smoking during pregnancy			<0.001			<0.001
No	71.7	80.8		83.9	78.5	
Yes	28.2	19.2		16.1	21.5	
Maternal asthma			<0.001			0.08
No	91.0	91.8		92.2	91.6	
Yes	9.0	8.2		7.8	8.4	
Child asthma (ICD-10)			<0.001			0.51
No	91.6	93.3		93.4	93.2	
Yes	8.4	6.7		6.6	6.8	
Pets in the home			<0.001			<0.001
No	54.9	58.6		52.1	63.4	
Yes	45.0	41.4		47.9	36.6	
Missing	0.1					
Breast fed			0.16			<0.001
No	18.7	25.8		23.8	27.4	
Yes	52.3	74.2		76.2	72.6	
Missing	29.0					
Daycare			<0.001			<0.001
No	62.1	88.4		87.4	89.2	
Yes	8.7	11.6		12.6	10.8	
Missing	29.2					
Postnatal exposure to ETS			<0.001			0.003
No	24.4	82.9		83.8	82.2	
Yes	6.6	17.1		16.2	17.8	
Missing	69.0					
Mold or dampness in the home			<0.001			<0.001
No	12.9	41.3		38.9	43.1	
Yes	16.8	58.7		61.1	56.9	
Missing	70.3					
Gas stove in the home			<0.001			0.05
No	27.7	92.5		92.9	92.2	
Yes	3.1	7.5		7.1	7.8	
Missing	69.2					
Wood stove in the home			<0.001			<0.001
No	18.3	57.0		53.2	60.0	
Yes	12.5	43.0		46.8	40.0	
Missing	69.2					

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[a] Comparing included vs. excluded study population.
[b] Comparing nonmovers vs. movers.
ETS refers to environmental tobacco smoke

Table A9 *(continued)*. Study Population Characteristics of Excluded vs. Included and Nonmovers vs. Movers of the Danish National Birth Cohort (DNBC)

Pollutant	% Excluded ($N = 57{,}801$)	% Included ($N = 22{,}084$)	P value[a]	% Nonmovers ($N = 9{,}507$)	% Movers ($N = 12{,}577$)	P value[b]
$PM_{2.5}$	11.5 ± 1.5	11.5 ± 1.4	0.004	11.2 ± 1.3	11.7 ± 1.5	<0.001
PM_{10}	17.5 ± 1.9	17.6 ± 1.8	<0.001	17.2 ± 1.4	17.9 ± 2.0	<0.001
NO_2	18.8 ± 7.5	18.6 ± 7.3	0.002	16.5 ± 5.4	20.3 ± 8.0	<0.001
NO_x	27.5 ± 20.3	26.9 ± 19.4	<0.001	21.9 ± 12.7	30.7 ± 22.5	<0.001
EC	0.8 ± 0.4	0.8 ± 0.4	0.54	0.7 ± 0.3	0.9 ± 0.4	<0.001
OC	1.4 ± 0.3	0.8 ± 0.4	<0.001	1.4 ± 0.3	1.4 ± 0.3	<0.001
SO_2	5.0 ± 2.3	5.0 ± 2.3	0.08	4.6 ± 1.5	5.3 ± 2.4	<0.001
O_3	51.0 ± 7.4	51.1 ± 7.2	<0.001	52.8 ± 6.3	49.8 ± 7.6	<0.001
SO_4^{2-}	2.1 ± 0.2	2.1 ± 0.2	<0.001	2.1 ± 0.2	2.1 ± 0.2	<0.001
NO_3^-	3.4 ± 0.5	3.4 ± 0.5	<0.001	3.4 ± 0.5	3.4 ± 0.5	0.02
NH_4^+	1.8 ± 0.9	1.8 ± 0.9	<0.001	2.0 ± 0.9	1.7 ± 0.8	<0.001
SOA	0.3 ± 0.1	0.3 ± 0.1	<0.001	0.3 ± 0.1	0.3 ± 0.1	<0.001
Sea salt	1.0 ± 0.2	1.0 ± 0.2	<0.001	1.0 ± 0.2	1.0 ± 0.2	<0.001

[a] Comparing included vs. excluded study population.
[b] Comparing nonmovers vs. movers.

Table A10. Sensitivity Analysis Restricted to Nonmovers of the Danish National Birth Cohort (DNBC)

| | Incidence [a] (ICD-10) | Prevalence [b] (Parental Recall) | |
| | Asthma Ever ($N = 9{,}507$; $n = 623$) | Asthma Ever ($N = 9{,}507$; $n = 883$) | Active Asthma ($N = 9{,}507$; $n = 396$) |
Pollutant	HR (95% CI)	OR (95% CI)	OR (95% CI)
$PM_{2.5}$	1.12 (0.89–1.41)	1.05 (0.74–1.49)	1.22 (0.73–2.02)
PM_{10}	1.21 (1.01–1.45)	1.12 (0.66–1.89)	1.20 (0.56–2.58)
NO_2	1.18 (0.98–1.44)	1.10 (0.93–1.29)	1.03 (0.80–1.31)
NO_x	1.08 (0.98–1.18)	1.07 (0.95–1.21)	0.98 (0.81–1.19)
EC	1.07 (0.95–1.21)	1.11 (0.83–1.49)	0.96 (0.62–1.48)
OC	0.97 (0.76–1.25)	1.05 (0.75–1.47)	1.14 (0.70–1.85)
SO_2	1.07 (0.95–1.20)	0.99 (0.95–1.03)	0.92 (0.75–1.14)
O_3	0.92 (0.79–1.08)	0.91 (0.79–1.06)	0.99 (0.94–1.05)
SO_4^{2-}	1.10 (0.71–1.71)	1.02 (0.67–1.57)	1.23 (0.66–2.31)
NO_3^-	0.99 (0.83–1.18)	0.73 (0.30–1.77)	1.84 (0.51–6.68)
NH_4^+	0.97 (0.74–1.26)	0.93 (0.59–1.45)	1.44 (0.75–2.76)
SOA	0.98 (0.85–1.13)	0.64 (0.24–1.69)	0.68 (0.17–2.72)
Sea salt	1.22 (1.01–1.47)	1.23 (0.68–2.22)	1.44 (0.61–3.40)

[a] Hazard ratio (HR) and 95% confidence intervals (CI) from Cox regression models per fixed increments of the time-weighted average exposures to ambient air pollutants for the full prenatal period of 2.4 for $PM_{2.5}$, 2.7 for PM_{10}, 8.7 for NO_2, 13.4 for NO_x, 0.3 for EC, 0.5 for OC, 2.7 for SO_2, 8.5 for O_3, 0.9 for SO_4^{2-}, 0.6 for NO_3^-, 0.4 for NH_4^+, 0.1 for SOA and 0.2 for sea salt with age as the time dimension adjusted for year, household income, maternal education, parity, season of birth, smoking during pregnancy, municipality, maternal and paternal asthma, pets during pregnancy, house size at birth, breastfeeding, daycare, mold, dampness, environmental tobacco smoke, presence of gas stove, presence of wood stove, and candlelight burning in the home at age 11.

[b] Odds ratios (OR) and the 95% confidence intervals (CI) from logistic regression models with GEE for fixed increments ($\mu g/m^3$) of the time-weighted average exposures to ambient air pollutants for the full prenatal period of 5 for $PM_{2.5}$, 10 for PM_{10}, 10 for NO_2, 20 for NO_x, 1 for EC, 1 for OC, 1 for SO_2, 10 for O_3, 1 for SO_4^{2-}, 5 for NO_3^-, 1 for NH_4^+, 1 for SOA and 1 for sea salt with adjustment for sex, birth year, maternal education, income, parity, delivery season, maternal smoking during pregnancy, municipality, maternal and paternal asthma, pets during pregnancy, house size at birth, breastfeeding, daycare, mold, dampness, environmental tobacco smoke, presence of gas stove, presence of wood stove, and candlelight burning in the home at age 11.

Table A11. Sensitivity Analysis Estimating Relative Risks and their 95% Confidence Intervals for the Associations between Prenatal and Postnatal Exposure to Air Pollution and Asthma (Parental Recall) Prevalence in the Danish National Birth Cohort (DNBC) [a]

	Asthma ever from birth to 7 years of age ($n = 2{,}188$)			Active asthma at 7 years of age ($n = 978$)		
	Prenatal exposure	Postnatal exposure of the first year of life	Postnatal exposure from birth to age 7	Prenatal exposure	Postnatal exposure of the first year of life	Postnatal exposure from birth to age 7
Pollutants	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)
$PM_{2.5}$	0.87 (0.73–1.04)	1.05 (0.89–1.26)	0.89 (0.68–1.15)	0.93 (0.70–1.23)	1.03 (0.80–1.34)	0.90 (0.62–1.32)
NO_2	0.95 (0.89–1.03)	0.95 (0.89–1.03)	0.95 (0.87–1.05)	0.97 (0.87–1.08)	0.94 (0.84–1.05)	0.86 (0.75–0.98)

[a] Relative risks (RR) and the 95% confidence intervals (CI) from Poisson regression models with a robust error variance per 5-μg/m^3 increment for $PM_{2.5}$ and 10-μg/m^3 increment for NO_2 with adjustment for year, sex, household income, maternal education, parity, season of birth, smoking during pregnancy, municipality, maternal and paternal asthma, pets during pregnancy, house size at birth, breastfeeding, daycare, mold, dampness, environmental tobacco smoke, presence of gas stove, presence of wood stove, and candlelight burning in the home at age 11.