Ambient air pollution and risk of respiratory infection among adults: Evidence from the Multi-Ethnic Study of Atherosclerosis

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Online Supplementary Data

Table S1. Baseline characteristics of study participants followed-up in the Multi-Ethnic Study of Atherosclerosis (MESA), by contribution to all study visits.*

Characteristic	Participants contributing to analysis at all visits *n* = 4,197	Participants who dropped out during follow-up or were ineligible for analysis on at least one examination *n* = 2,339
Age (years), mean (SD)	60.3 (9.6)	65.1 (10.7)
Study region		
Winston-Salem	698 (16.6)	318 (13.6)
New York City	743 (17.7)	323 (13.8)
Baltimore	567 (13.5)	455 (19.5)
St. Paul	688 (16.4)	345 (14.7)
Chicago	812 (19.3)	318 (13.6)
Los Angeles	689 (16.4)	580 (24.8)
Race		
White	1,717 (40.9)	799 (34.2)
Chinese-American	498 (11.9)	289 (12.4)
African-American	1,099 (26.2)	687 (29.4)
Hispanic	883 (21.0)	564 (24.1)
Sex		
Female	2,197 (52.3)	1,248 (53.4)
Male	2,000 (47.7)	1,091 (46.6)
Education level		

Less than high school	579 (13.8)	590 (25.2)
High school	725 (17.3)	462 (19.8)
Some college or technical certificate	1,215 (28.9)	643 (27.5)
College or graduate degree	1,678 (40.0)	644 (27.5)
Married/living with a partner	2,644 (63.0)	1,303 (55.7)
Body mass index, mean (SD)	28.3 (5.3)	28.4 (5.7)
Ever smoked	2,222 (52.9)	1,263 (54.0)
Current smoker	420 (10.0)	321 (13.9)
Employed	2,055 (49.0)	783 (33.5)
Annual family income, US dollars		
<20,000	801 (19.2)	796 (34.4)
20,000-39,999	1,083 (26.0)	673 (29.1)
40,000-74,999	1,150 (27.6)	503 (21.8)
≥75,000	1,134 (27.2)	340 (14.7)
Own home or pay mortgage (not rent)	2,968 (70.9)	1,445 (62.1)
Excellent self-reported general health status	906 (53.5)	559 (39.0)
No health insurance	241 (5.8)	223 (9.7)
On Medicaid	322 (7.7)	294 (12.8)
Diabetic per ADA 2003 criteria	599 (14.3)	453 (19.4)
Has metabolic syndrome	1,504 (35.9)	981 (42.0)

Moderate and vigorous physical activity, Met Mins/Week, median (IQR)	4,219 (2,160–7,410)	3,330 (1,508–6,375)
Intentional physical activity, Met Mins/Week, median (IQR)	840 (210–2,062)	712 (0–1,800)
Self-reported emphysema	23 (0.5)	50 (2.1)
Self-reported asthma	136 (3.2)	117 (5.0)

* Units are *n* (%) unless otherwise specified. ADA – American Diabetic Association, IQR – Interquartile range, SD – Standard Deviation

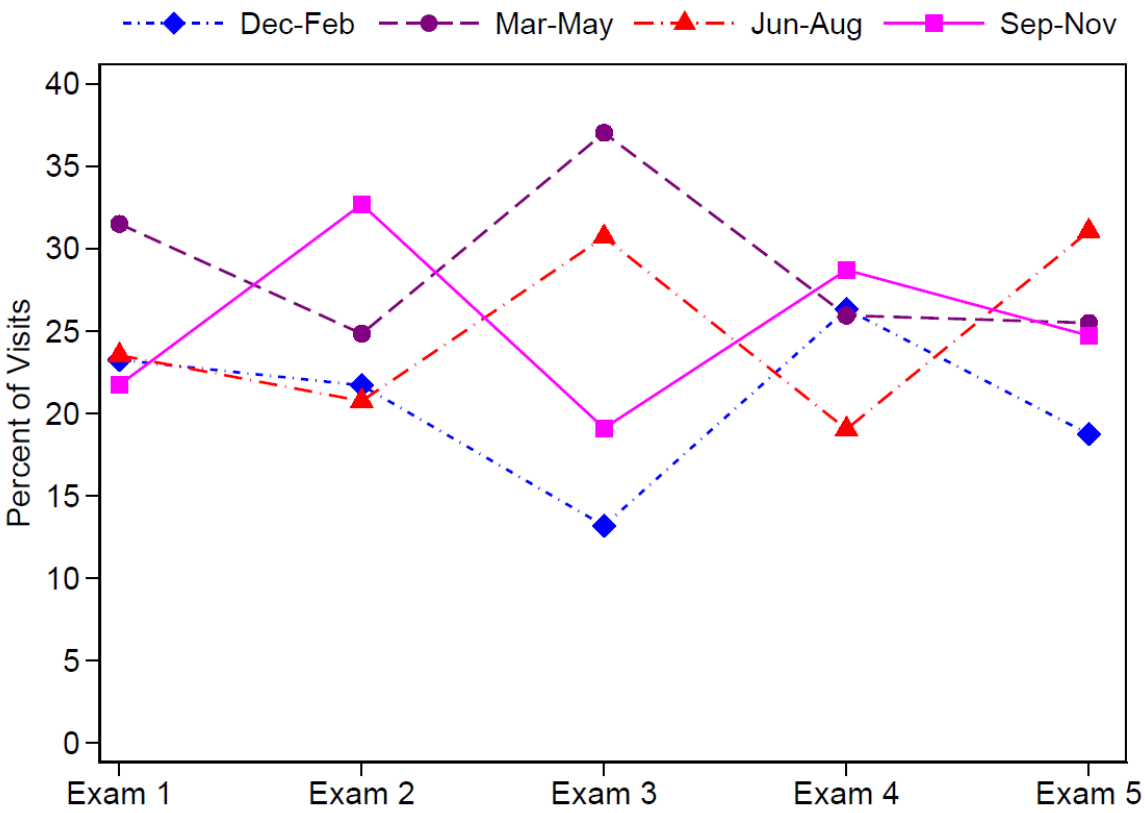

Figure S1. Distribution of study examinations per season in MESA.

Table S2. Risk ratios (95% CIs) for associations between respiratory infection and average exposure to $PM_{2.5}$, NO_x, and NO_2 among MESA participants, for entire study duration and per study exam.

Pollutant	Examination	Annual average		28-day average		14-day average	
		RR (95% CI)	*p*-value	RR (95% CI)	*p*-value	RR (95% CI)	*p*-value
$PM_{2.5}$	Overall (1–5)	1.00 (0.94, 1.07)	0.980	1.04 (1.00, 1.09)	0.078	1.03 (0.99, 1.08)	0.102
	1	1.13 (1.01, 1.28)	0.038	1.09 (0.99, 1.19)	0.075	1.05 (0.97, 1.14)	0.220
	2	1.00 (0.86, 1.15)	0.957	1.01 (0.90, 1.12)	0.926	1.00 (0.92, 1.10)	0.925
	3	0.89 (0.80, 1.00)	0.047	0.99 (0.89, 1.10)	0.878	0.98 (0.89, 1.07)	0.620
	4	1.12 (0.99, 1.27)	0.074	1.09 (0.96, 1.23)	0.195	1.10 (0.99, 1.24)	0.087
	5	1.03 (0.91, 1.17)	0.666	1.00 (0.85, 1.18)	0.997	1.00 (0.86, 1.16)	0.979
NO_x	Overall (1–5)	1.04 (0.95, 1.14)	0.405	1.15 (1.10, 1.20)	0.000	1.12 (1.08, 1.16)	0.000
	1	1.05 (0.88, 1.27)	0.578	1.11 (1.02, 1.20)	0.012	1.08 (1.00, 1.17)	0.046
	2	1.17 (0.96, 1.42)	0.126	1.17 (1.06, 1.30)	0.003	1.12 (1.02, 1.23)	0.022
	3	0.90 (0.75, 1.09)	0.278	1.06 (0.94, 1.20)	0.314	1.05 (0.95, 1.17)	0.338
	4	1.20 (0.98, 1.47)	0.076	1.12 (1.00, 1.24)	0.048	1.10 (0.99, 1.22)	0.073
	5	1.10 (0.88, 1.38)	0.404	1.02 (0.85, 1.22)	0.843	1.02 (0.86, 1.21)	0.816
NO_2	Overall (1–5)	1.07 (0.94, 1.22)	0.301	1.21 (1.10, 1.33)	0.000	1.15 (1.05, 1.25)	0.002
	1	1.08 (0.84, 1.39)	0.567	1.09 (0.90, 1.31)	0.394	1.03 (0.87, 1.22)	0.761
	2	1.31 (0.98, 1.73)	0.064	1.21 (1.00, 1.47)	0.051	1.12 (0.93, 1.34)	0.226
	3	0.95 (0.75, 1.21)	0.694	1.07 (0.88, 1.31)	0.490	1.04 (0.87, 1.25)	0.650
	4	1.19 (0.92, 1.52)	0.180	1.21 (0.99, 1.48)	0.066	1.15 (0.95, 1.40)	0.154
	5	1.04 (0.78, 1.40)	0.769	1.07 (0.81, 1.42)	0.610	1.07 (0.82, 1.39)	0.626

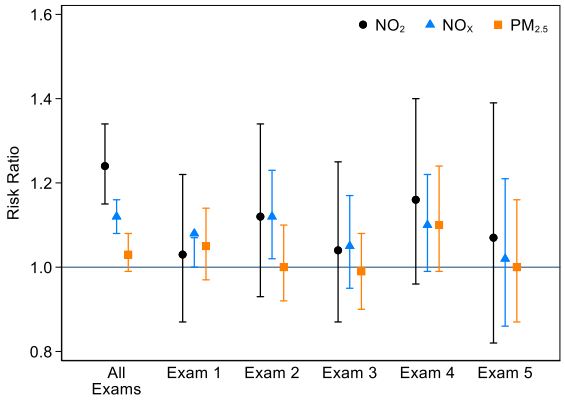

Figure S2. Risk ratios and 95% confidence intervals for associations between respiratory infection and pollutant exposure in the two to four week period before a study examination, for an interquartile range increase in average pollutant exposure. Results are from a model adjusted for study site, race/ethnicity, sex, age, body mass index, marital status, education level, smoking status (ever/never smoked), employment status, annual income, neighborhood level socio-economic index, home ownership, number of household members, having health insurance, whether on Medicaid, diabetes diagnosis based on ADA criteria and natural cubic splines of temperature and relative humidity (four degrees of freedom).

Table S3. Risk ratios (95% CIs) of respiratory infection for an interquartile range increase in average air pollutant exposure in the two-to-six week period before interview among participants in the MESA study, stratified by select characteristics.

Characteristic	$PM_{2.5}$		NO_x		NO_2	
	Risk ratio (95% CI)	p-value	Risk ratio (95% CI)	p-value	Risk ratio (95% CI)	p-value
Age (years)		0.522		0.428		0.494
Less than 65	1.03 (0.97, 1.10)		1.13 (1.06, 1.20)		1.16 (1.02, 1.32)	
65 or more	1.05 (0.99, 1.12)		1.18 (1.11, 1.24)		1.26 (1.11, 1.44)	
Race/ethnicity		0.853		0.141		0.431
White	1.01 (0.93, 1.10)		1.19 (1.08, 1.32)		1.14 (0.98, 1.33)	
Chinese American	1.16 (0.94, 1.43)		1.25 (1.07, 1.46)		1.37 (1.04, 1.80)	
African American	1.01 (0.94, 1.08)		1.10 (1.01, 1.20)		1.16 (0.98, 1.38)	
Hispanic	1.06 (0.97, 1.17)		1.14 (1.04, 1.24)		1.13 (0.93, 1.36)	
Sex		0.148		0.688		0.861
Female	1.05 (0.99, 1.11)		1.13 (1.07, 1.19)		1.16 (1.03, 1.31)	
Male	1.03 (0.95, 1.10)		1.18 (1.10, 1.26)		1.26 (1.09, 1.46)	
Ever smoked		0.494		0.893		0.370
No	1.06 (0.99, 1.13)		1.16 (1.09, 1.23)		1.16 (1.01, 1.33)	
Yes	1.03 (0.97, 1.09)		1.14 (1.08, 1.21)		1.25 (1.10, 1.42)	
Diabetic		0.137		0.133		0.283
No	1.05 (1.00, 1.11)		1.17 (1.12, 1.23)		1.23 (1.11, 1.36)	
Yes	1.00 (0.90, 1.11)		1.07 (0.96, 1.19)		1.14 (0.89, 1.45)	
Metabolic syndrome		0.161		0.279		0.695
No	1.07 (1.01, 1.13)		1.18 (1.12, 1.24)		1.21 (1.08, 1.36)	
Yes	1.01 (0.94, 1.08)		1.12 (1.05, 1.19)		1.19 (1.03, 1.38)	
Neighborhood SES index at baseline		0.997		0.237		0.378
≤0	1.02 (0.94, 1.10)		1.16 (1.06, 1.27)		1.15 (0.99, 1.32)	
>0	1.05 (0.99, 1.11)		1.15 (1.10, 1.21)		1.25 (1.11, 1.42)	
Education level		0.715		0.212		0.843
Less than high school	1.06 (0.96, 1.16)		1.10 (1.01, 1.20)		1.04 (0.87, 1.26)	
High school	1.02 (0.92, 1.14)		1.23 (1.11, 1.36)		1.23 (0.96, 1.56)	
Some college	1.03 (0.94, 1.12)		1.12 (1.04, 1.21)		1.23 (1.03, 1.47)	
College or graduate	1.05 (0.97, 1.14)		1.21 (1.11, 1.32)		1.27 (1.09, 1.47)	
Household income, US dollars		0.418		0.175		0.419
< 20,000	1.06 (0.97, 1.15)		1.10 (1.03, 1.18)		1.12 (0.95, 1.32)	
20,000 – 39,999	1.08 (0.98, 1.17)		1.20 (1.10, 1.31)		1.19 (0.97, 1.46)	
40,000 – 74,999	0.96 (0.88, 1.05)		1.14 (1.04, 1.26)		1.22 (1.02, 1.46)	
≥ 75,000	1.05 (0.94, 1.16)		1.19 (1.06, 1.34)		1.18 (0.99, 1.42)	

Table S4. Risk ratios and 95% CIs of respiratory infection for an interquartile range increase in pollutant exposure, stratified by influenza activity-week threshold, based on data from the Los Angeles study area*

Characteristic	Number of participants	Number of visits	Risk ratio (95% CI)	*p*-value
Long-term (1-year) exposure				
$PM_{2.5}$				0.412
Flu week	607	702	1.03 (0.83, 1.28)	
Non-flu week	607	702	1.13 (0.49, 2.62)	
NO_x				0.479
Flu week	607	702	1.11 (0.90, 1.38)	
Non-flu week	607	702	1.26 (0.79, 2.02)	
NO_2				0.472
Flu week	607	702	1.06 (0.88, 1.28)	
Non-flu week	607	702	1.12 (0.80, 1.57)	
Short-term (4-week) exposure				
$PM_{2.5}$				0.088
Flu week	608	703	1.01 (0.93, 1.10)	
Non-flu week	608	703	1.05 (0.78, 1.41)	
NO_x				0.137
Flu week	608	703	1.08 (0.94, 1.24)	
Non-flu week	608	703	1.11 (0.92, 1.35)	
NO_2				0.161
Flu week	608	703	1.09 (0.95, 1.25)	
Non-flu week	608	703	1.18 (0.90, 1.55)	
Short-term (2-week) exposure				
$PM_{2.5}$				0.135
Flu week	608	703	1.01 (0.88, 1.15)	
Non-flu week	608	703	1.02 (0.80, 1.30)	
NO_x				0.161
Flu week	608	703	1.06 (0.95, 1.19)	
Non-flu week	608	703	1.10 (0.91, 1.33)	
NO_2				0.149
Flu week	608	703	1.07 (0.94, 1.22)	
Non-flu week	608	703	1.15 (0.88, 1.49)	

* Flu week is defined as periods of two or more consecutive weeks in which each week accounted for more than 2% of the season's total number of specimens that tested positive for influenza in public health laboratories.

Table S5. Risk ratios and 95% CIs of respiratory infection during high versus low influenza activity weeks, stratified by exposure to lower or higher than median pollutant levels in the two-to-six weeks prior to study examination, based on data from the Los Angeles study area*

Characteristic	Risk ratio (95% CI)	*p*-value
$PM_{2.5}$		0.263
Above median	3.76 (1.56, 9.10)	
Below median	0.91 (0.15, 5.57)	
NO_2		0.298
Above median	3.31 (1.39, 7.89)	
Below median	0.79 (0.12, 5.28)	

* Median pollutant concentrations for the period when influenza activity data were available were 11.4 $\mu g/m^3$ for $PM_{2.5}$ and 24.9 ppb for NO_2 in Los Angeles. Model convergence was not achieved for NOx. Periods meeting influenza activity thresholds are defined by the Centers for Disease Control as two or more consecutive weeks in which each week accounted for more than 2% of the season's total number of specimens that tested positive for influenza in public health laboratories. P-value corresponds to a joint Wald test of equality of coefficients across strata of variable.

Table S6. Risk ratios (95% CIs) for associations between respiratory infection and average exposure to $PM_{2.5}$, NO_x, and NO_2 among 4,197 MESA participants who were evaluated at all five study examinations, for entire study duration and per study exam.

Pollutant	Examination	Annual average		28-day average		14-day average	
		RR (95% CI)	*p*-value	RR (95% CI)	*p*-value	RR (95% CI)	*p*-value
$PM_{2.5}$	Overall (1–5)	0.99 (0.91, 1.08)	0.844	1.03 (0.97, 1.09)	0.342	1.03 (0.98, 1.09)	0.190
	1	1.12 (0.98, 1.28)	0.088	1.07 (0.94, 1.21)	0.300	1.07 (0.96, 1.19)	0.240
	2	0.94 (0.80, 1.11)	0.486	0.98 (0.86, 1.12)	0.803	0.99 (0.89, 1.11)	0.865
	3	0.92 (0.81, 1.05)	0.226	1.01 (0.89, 1.15)	0.862	1.00 (0.89, 1.12)	0.989
	4	1.17 (1.02, 1.34)	0.029	1.09 (0.95, 1.26)	0.229	1.13 (1.00, 1.29)	0.054
	5	1.01 (0.89, 1.15)	0.860	0.97 (0.82, 1.15)	0.753	0.97 (0.83, 1.13)	0.660
NO_x	Overall (1–5)	1.03 (0.93, 1.15)	0.555	1.13 (1.08, 1.20)	0.000	1.11 (1.05, 1.16)	0.000
	1	1.10 (0.87, 1.38)	0.426	1.11 (0.99, 1.24)	0.073	1.12 (1.02, 1.24)	0.024
	2	1.11 (0.86, 1.43)	0.414	1.14 (1.00, 1.30)	0.053	1.06 (0.93, 1.19)	0.396
	3	0.93 (0.74, 1.16)	0.506	1.07 (0.93, 1.24)	0.354	1.03 (0.91, 1.18)	0.618
	4	1.27 (1.02, 1.58)	0.035	1.10 (0.97, 1.25)	0.143	1.08 (0.95, 1.22)	0.222
	5	1.08 (0.85, 1.37)	0.515	1.03 (0.85, 1.24)	0.780	1.02 (0.85, 1.22)	0.847
NO_2	Overall (1–5)	1.08 (0.93, 1.26)	0.319	1.20 (1.07, 1.34)	0.002	1.14 (1.02, 1.26)	0.016
	1	1.07 (0.78, 1.47)	0.671	1.05 (0.82, 1.34)	0.698	1.09 (0.87, 1.35)	0.466
	2	1.30 (0.91, 1.86)	0.154	1.20 (0.93, 1.54)	0.155	1.06 (0.84, 1.33)	0.645
	3	1.02 (0.77, 1.36)	0.888	1.12 (0.88, 1.42)	0.360	1.05 (0.84, 1.30)	0.679
	4	1.34 (1.02, 1.76)	0.034	1.28 (1.02, 1.60)	0.030	1.20 (0.97, 1.48)	0.091
	5	1.01 (0.74, 1.37)	0.961	1.07 (0.80, 1.43)	0.658	1.04 (0.78, 1.37)	0.798

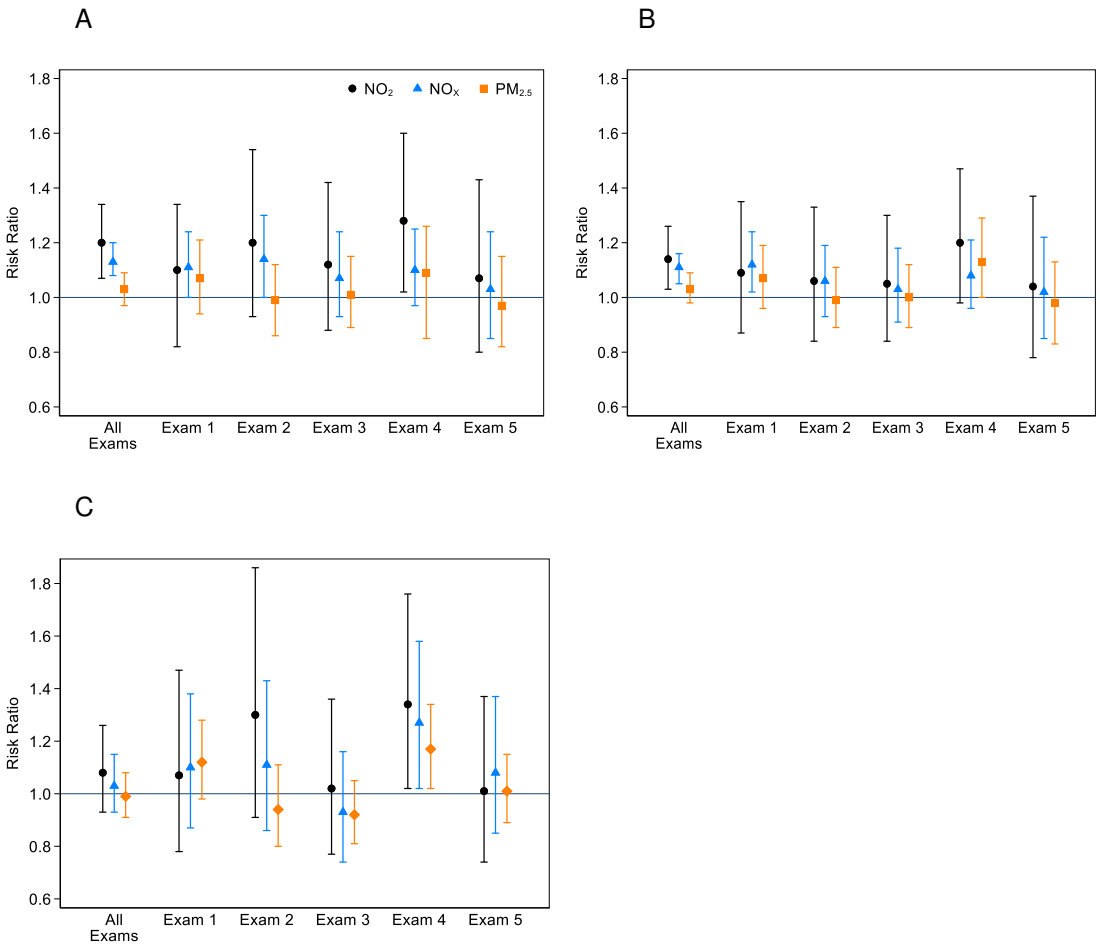

Figure S3. Risk ratios and 95% confidence intervals for associations between respiratory infection and pollutant exposure among 4,197 MESA participants who were evaluated at all five study examinations, in the two-to-six weeks (A), two-to-four weeks (B), and year (C) prior to study visit, for an interquartile range increase in average pollutant exposure.

Table S7. Risk ratios and 95% confidence intervals for associations between respiratory infection and pollutant exposure in the two-to-six weeks before study examination when excluding report of febrile illness from the outcome definition, for an interquartile range increase in average pollutant exposure.

Pollutant	Risk ratio (95% CI)	
	Main result in Figure 4	Excluding febrile illness
$PM_{2.5}$	1.04 (1.00, 1.09)	1.04 (0.99, 1.09)
NO_x	1.15 (1.10, 1.20)	1.15 (1.10, 1.20)
NO_2	1.21 (1.10, 1.33)	1.21 (1.10, 1.33)