

## WEB MATERIAL

### Causal Effects of Air Pollution on Mortality Rate in Massachusetts

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**Web Table 1.** Results of main analysis. Values are the number of deaths (95% CI) per 10 million person-days for each 1- $\mu\text{g}/\text{m}^3$  increase in  $\text{PM}_{2.5}$ , 1-ppb increase in ozone, and 1-ppb increase in nitrogen dioxide.

	Long-Term		Short-Term	
$\text{PM}_{2.5}$ ( $\mu\text{g}/\text{m}^3$ )	< $\infty$	35.38 (33.41, 37.57)	< $\infty$	3.04 (2.17, 3.94)
	<14	35.53 (33.44, 37.75)	<35	3.33 (2.41, 4.11)
	<13	36.75 (34.4, 38.94)	<30	3.35 (2.35, 4.42)
	<12	40.45 (38.00, 42.67)	<25	3.69 (2.73, 4.65)
	<11	45.37 (42.00, 48.35)	<20	4.97 (4.05, 5.97)
	<10	47.11 (43.57, 50.76)	<15	6.11 (4.81, 7.29)
	<9	43.98 (39.21, 49.14)	<10	7.24 (4.99, 9.64)
	<8	59.34 (50.22, 68.84)	<5	14.56 (3.96, 24.59)
Ozone (ppb)	< $\infty$	2.35 (1.08, 3.61)	< $\infty$	2.41 (1.81, 2.91)
	<42	1.89 (0.33, 3.29)	<100	2.44 (1.91, 2.98)
	<41	2.61 (0.94, 3.96)	<90	2.43 (1.91, 2.84)
	<40	4.99 (3.28, 6.64)	<80	2.36 (1.79, 2.83)
	<39	7.10 (5.34, 9.07)	<70	2.47 (1.96, 2.95)
	<38	8.13 (5.53, 10.4)	<60	2.31 (1.75, 2.93)
	<37	12.42 (9.87, 15.67)	<50	3.45 (2.5, 4.36)
	<36	20.52 (16.95, 24.00)	<45	5.56 (4.28, 6.61)
	<35	32.18 (27.22, 36.01)	<40	5.34 (3.28, 6.77)
	<34	41.82 (34.68, 48.51)	<35	3.72 (1.16, 6.79)
	<33	42.09 (29.91, 51.84)	<30	-3.07 (-9.16, 3.21)
Nitrogen dioxide (ppb)	< $\infty$	3.24 (2.75, 3.77)	< $\infty$	5.60 (5.24, 5.98)
	<60	3.24 (2.69, 3.78)	<100	5.60 (5.26, 6.00)
	<55	3.24 (2.75, 3.82)	<90	5.60 (5.26, 5.99)
	<50	3.24 (2.66, 3.81)	<80	5.59 (5.26, 5.95)
	<45	3.25 (2.75, 3.77)	<70	5.59 (5.24, 5.96)
	<40	3.15 (2.63, 3.68)	<60	5.64 (5.26, 5.90)
	<35	3.30 (2.76, 3.95)	<50	5.81 (5.47, 6.20)
	<30	6.44 (5.65, 7.20)	<40	6.14 (5.74, 6.59)
	<25	9.59 (8.53, 10.61)	<30	6.65 (6.07, 7.19)
<20	9.42 (7.60, 11.13)	<20	6.70 (5.37, 7.85)	

Abbreviations: CI, confidence interval;  $\text{PM}_{2.5}$ , particulate matter with an aerodynamic diameter less than or equal to 2.5  $\mu\text{m}$ ; ppb, parts per billion.

**Web Table 2.** Results of sensitivity analysis for adjusting short-term air and dew point temperatures at lag 0-1 only. Values are the number of deaths (95% CI) per 10 million person-days for each 1- $\mu\text{g}/\text{m}^3$  increase in  $\text{PM}_{2.5}$ , 1-ppb increase in ozone, and 1-ppb increase in nitrogen dioxide.

	Long-Term		Short-Term	
PM <sub>2.5</sub> ( $\mu\text{g}/\text{m}^3$ )	< $\infty$	35.37 (33.41, 37.42)	< $\infty$	3.05 (2.19, 3.93)
	<14	35.52 (33.43, 37.75)	<35	3.35 (2.44, 4.13)
	<13	36.73 (34.39, 38.92)	<30	3.35 (2.33, 4.41)
	<12	40.43 (37.98, 42.65)	<25	3.69 (2.77, 4.61)
	<11	45.37 (42.02, 48.35)	<20	5.00 (4.07, 5.98)
	<10	47.13 (43.58, 50.79)	<15	6.17 (4.87, 7.35)
	<9	43.99 (39.20, 49.14)	<10	7.30 (5.06, 9.69)
	<8	59.28 (50.52, 68.84)	<5	14.34 (4.00, 24.21)
Ozone (ppb)	< $\infty$	2.35 (1.09, 3.61)	< $\infty$	2.40 (1.79, 2.90)
	<42	1.86 (0.30, 3.25)	<100	2.43 (1.89, 2.95)
	<41	2.54 (0.84, 3.90)	<90	2.42 (1.89, 2.84)
	<40	4.88 (3.18, 6.51)	<80	2.35 (1.77, 2.84)
	<39	6.97 (5.20, 8.94)	<70	2.47 (1.96, 2.95)
	<38	7.93 (5.33, 10.21)	<60	2.31 (1.74, 2.93)
	<37	12.2 (9.72, 15.44)	<50	3.43 (2.51, 4.33)
	<36	20.35 (16.79, 23.81)	<45	5.55 (4.27, 6.58)
	<35	31.98 (27.03, 35.82)	<40	5.30 (3.24, 6.780)
	<34	41.27 (34.33, 47.79)	<35	3.74 (1.19, 6.79)
	<33	41.11 (28.95, 50.90)	<30	-2.98 (-9.07, 3.37)
Nitrogen dioxide (ppb)	< $\infty$	3.24 (2.72, 3.75)	< $\infty$	5.62 (5.27, 6.00)
	<60	3.23 (2.69, 3.76)	<100	5.63 (5.28, 6.01)
	<55	3.23 (2.75, 3.84)	<90	5.63 (5.29, 6.01)
	<50	3.23 (2.66, 3.72)	<80	5.62 (5.29, 5.96)
	<45	3.24 (2.75, 3.72)	<70	5.61 (5.26, 5.99)
	<40	3.14 (2.57, 3.65)	<60	5.66 (5.29, 5.93)
	<35	3.31 (2.79, 3.90)	<50	5.84 (5.49, 6.22)
	<30	6.45 (5.68, 7.19)	<40	6.16 (5.76, 6.60)
	<25	9.60 (8.72, 10.76)	<30	6.66 (6.08, 7.20)
	<20	9.32 (7.35, 11.30)	<20	6.69 (5.36, 7.84)

Abbreviations: CI, confidence interval;  $\text{PM}_{2.5}$ , particulate matter with an aerodynamic diameter less than or equal to 2.5  $\mu\text{m}$ ; ppb, parts per billion.

**Web Table 3.** Results of sensitivity analysis for adjusting prior history of hospitalizations for chronic obstructive pulmonary disease (*International Classification of Diseases, Ninth Revision*, codes 490 and 491), coronary atherosclerosis (411 and 414), hypertension (401-404), cardiac arrest (427), heart failure (428), cardiac dysrhythmias (427), peripheral artery disease (440-444), and stroke (434) among Medicare fee-for-service beneficiaries. Values are the number of deaths (95% CI) per 10 million person-days for each 1- $\mu\text{g}/\text{m}^3$  increase in  $\text{PM}_{2.5}$ , 1-ppb increase in ozone, and 1-ppb increase in nitrogen dioxide.

	Long-Term		Short-Term	
PM <sub>2.5</sub> ( $\mu\text{g}/\text{m}^3$ )	< $\infty$	35.38 (33.42, 37.57)	< $\infty$	3.04 (2.17, 3.94)
	<14	35.53 (33.44, 37.75)	<35	3.33 (2.41, 4.10)
	<13	36.75 (34.40, 38.94)	<30	3.34 (2.34, 4.42)
	<12	40.45 (38.00, 42.67)	<25	3.69 (2.73, 4.65)
	<11	45.37 (42.00, 48.35)	<20	4.97 (4.05, 5.97)
	<10	47.11 (43.57, 50.76)	<15	6.11 (4.81, 7.28)
	<9	43.99 (39.21, 49.15)	<10	7.24 (5.00, 9.63)
	<8	59.38 (50.26, 68.88)	<5	14.55 (3.96, 24.58)
Ozone (ppb)	< $\infty$	2.36 (1.09, 3.61)	< $\infty$	2.41 (1.81, 2.91)
	<42	1.90 (0.33, 3.29)	<100	2.44 (1.91, 2.98)
	<41	2.63 (0.97, 3.99)	<90	2.43 (1.91, 2.84)
	<40	5.07 (3.35, 6.71)	<80	2.36 (1.79, 2.83)
	<39	7.27 (5.51, 9.23)	<70	2.47 (1.97, 2.95)
	<38	8.43 (5.83, 10.69)	<60	2.31 (1.75, 2.93)
	<37	12.82 (10.27, 16.07)	<50	3.44 (2.49, 4.35)
	<36	20.92 (17.35, 24.40)	<45	5.54 (4.27, 6.59)
	<35	32.58 (27.61, 36.42)	<40	5.30 (3.24, 6.73)
	<34	42.19 (35.05, 48.88)	<35	3.64 (1.08, 6.72)
	<33	42.62 (30.45, 52.35)	<30	-3.19 (-9.28, 3.09)
Nitrogen dioxide (ppb)	< $\infty$	3.24 (2.75, 3.77)	< $\infty$	5.60 (5.24, 5.98)
	<60	3.24 (2.69, 3.78)	<100	5.60 (5.26, 6.00)
	<55	3.24 (2.75, 3.82)	<90	5.60 (5.26, 5.99)
	<50	3.24 (2.66, 3.81)	<80	5.59 (5.26, 5.95)
	<45	3.25 (2.76, 3.77)	<70	5.59 (5.24, 5.96)
	<40	3.15 (2.63, 3.67)	<60	5.64 (5.26, 5.91)
	<35	3.30 (2.76, 3.95)	<50	5.81 (5.47, 6.20)
	<30	6.44 (5.66, 7.20)	<40	6.14 (5.74, 6.59)
	<25	9.59 (8.53, 10.60)	<30	6.65 (6.07, 7.19)
<20	9.40 (7.58, 11.11)	<20	6.70 (5.37, 7.86)	

Abbreviations: CI, confidence interval; PM<sub>2.5</sub>, particulate matter with an aerodynamic diameter less than or equal to 2.5  $\mu\text{m}$ ; ppb, parts per billion.

**Web Table 4.** Results of sensitivity analysis for modeling generalized propensity score with cubic polynomial to allow potential nonlinearity in the outcome regression. Values are the number of deaths (95% CI) per 10 million person-days for each 1- $\mu\text{g}/\text{m}^3$  increase in  $\text{PM}_{2.5}$ , 1-ppb increase in ozone, and 1-ppb increase in nitrogen dioxide.

	Long-Term		Short-Term	
$\text{PM}_{2.5}$ ( $\mu\text{g}/\text{m}^3$ )	< $\infty$	35.47 (33.44, 37.61)	< $\infty$	3.70 (2.80, 4.67)
	<14	35.65 (33.53, 37.88)	<35	3.89 (2.96, 4.67)
	<13	36.93 (34.60, 39.19)	<30	3.84 (2.78, 4.88)
	<12	40.73 (38.25, 42.77)	<25	4.06 (3.10, 4.97)
	<11	45.54 (42.16, 48.51)	<20	5.13 (4.20, 6.12)
	<10	47.29 (43.75, 50.86)	<15	6.07 (4.76, 7.24)
	<9	44.04 (39.16, 49.23)	<10	7.11 (4.87, 9.53)
	<8	59.35 (50.16, 68.91)	<5	14.16 (3.96, 24.22)
Ozone (ppb)	< $\infty$	2.44 (1.18, 3.69)	< $\infty$	2.41 (1.83, 2.91)
	<42	2.17 (0.68, 3.58)	<100	2.44 (1.88, 2.96)
	<41	2.88 (1.13, 4.22)	<90	2.43 (1.91, 2.85)
	<40	5.38 (3.70, 6.96)	<80	2.37 (1.81, 2.83)
	<39	7.70 (5.82, 9.68)	<70	2.48 (1.98, 2.96)
	<38	8.94 (6.27, 11.35)	<60	2.34 (1.77, 2.98)
	<37	13.49 (11.00, 16.80)	<50	3.47 (2.53, 4.38)
	<36	21.78 (17.95, 25.32)	<45	5.55 (4.26, 6.59)
	<35	33.23 (28.14, 37.26)	<40	5.27 (3.20, 6.69)
	<34	42.03 (34.78, 48.81)	<35	3.61 (1.04, 6.67)
	<33	42.19 (29.96, 51.20)	<30	-3.14 (-9.27, 3.20)
	Nitrogen dioxide (ppb)	< $\infty$	3.25 (2.76, 3.78)	< $\infty$
<60		3.24 (2.70, 3.78)	<100	5.69 (5.35, 6.08)
<55		3.25 (2.76, 3.83)	<90	5.69 (5.33, 6.05)
<50		3.24 (2.67, 3.82)	<80	5.68 (5.33, 6.02)
<45		3.26 (2.75, 3.78)	<70	5.68 (5.31, 6.04)
<40		3.16 (2.64, 3.68)	<60	5.71 (5.33, 5.99)
<35		3.32 (2.77, 3.95)	<50	5.84 (5.47, 6.23)
<30		6.46 (5.68, 7.23)	<40	6.14 (5.74, 6.59)
<25		9.67 (8.59, 10.65)	<30	6.67 (6.11, 7.22)
<20		9.44 (7.62, 11.15)	<20	6.72 (5.39, 7.87)

Abbreviations: CI, confidence interval;  $\text{PM}_{2.5}$ , particulate matter with an aerodynamic diameter less than or equal to 2.5  $\mu\text{m}$ ; ppb, parts per billion.

**Web Table 5.** Results of single-pollutant analysis. Values are the number of deaths (95% CI) per 10 million person-days for each 1- $\mu\text{g}/\text{m}^3$  increase in  $\text{PM}_{2.5}$ , 1-ppb increase in ozone, and 1-ppb increase in nitrogen dioxide.

	Long-Term		Short-Term	
$\text{PM}_{2.5}$ ( $\mu\text{g}/\text{m}^3$ )	< $\infty$	35.29 (33.34, 37.49)	< $\infty$	2.96 (2.13, 3.90)
	<14	35.44 (33.35, 37.69)	<35	3.26 (2.29, 3.99)
	<13	36.66 (34.31, 38.84)	<30	3.29 (2.32, 4.32)
	<12	40.40 (37.95, 42.63)	<25	3.69 (2.79, 4.52)
	<11	45.79 (42.26, 48.80)	<20	5.12 (4.23, 5.96)
	<10	48.23 (44.56, 51.97)	<15	6.71 (5.48, 7.90)
	<9	44.81 (40.12, 49.98)	<10	9.87 (7.66, 12.26)
	<8	60.42 (50.97, 69.59)	<5	25.41 (14.64, 35.77)
Ozone (ppb)	< $\infty$	2.27 (1.01, 3.54)	< $\infty$	2.63 (2.06, 3.11)
	<42	1.84 (0.30, 3.24)	<100	2.65 (2.12, 3.20)
	<41	2.60 (0.93, 4.04)	<90	2.63 (2.14, 3.04)
	<40	5.15 (3.52, 6.79)	<80	2.54 (1.98, 3.03)
	<39	7.42 (5.38, 9.41)	<70	2.59 (2.07, 3.04)
	<38	8.66 (6.18, 10.78)	<60	2.23 (1.65, 2.84)
	<37	13.61 (10.93, 16.90)	<50	3.21 (2.27, 3.99)
	<36	21.84 (18.00, 25.30)	<45	5.43 (4.01, 6.57)
	<35	34.06 (29.69, 38.04)	<40	5.19 (3.12, 6.88)
	<34	44.97 (37.92, 51.96)	<35	3.84 (0.63, 7.22)
	<33	47.40 (36.12, 56.14)	<30	-3.22 (-9.36, 2.91)
Nitrogen dioxide (ppb)	< $\infty$	3.32 (2.82, 3.86)	< $\infty$	5.52 (5.14, 5.91)
	<60	3.32 (2.78, 3.85)	<100	5.52 (5.18, 5.88)
	<55	3.32 (2.83, 3.90)	<90	5.53 (5.17, 5.92)
	<50	3.31 (2.75, 3.89)	<80	5.52 (5.18, 5.86)
	<45	3.32 (2.82, 3.84)	<70	5.51 (5.13, 5.91)
	<40	3.22 (2.71, 3.72)	<60	5.57 (5.20, 5.83)
	<35	3.39 (2.85, 4.04)	<50	5.77 (5.42, 6.18)
	<30	6.75 (5.86, 7.56)	<40	6.28 (5.87, 6.72)
	<25	10.78 (9.56, 11.73)	<30	7.59 (7.02, 8.16)
	<20	12.05 (10.16, 13.87)	<20	5.52 (5.14, 5.91)

Abbreviations: CI, confidence interval;  $\text{PM}_{2.5}$ , particulate matter with an aerodynamic diameter less than or equal to 2.5  $\mu\text{m}$ ; ppb, parts per billion.