

**Ozone, fine particulate matter and chronic lower respiratory disease mortality in the United States**

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**ONLINE DATA SUPPLEMENT**

**SUPPLEMENTARY TABLE 1. PEARSON CORRELATION COEFFICIENTS MATRIX OF MODEL COVARIATES**

	Adults aged ≥65 years, %	Poverty, %	Lifetime smoking, %	Obesity, %	Extreme hot days, ≥90oF	Ozone, ppb	PM <sub>2.5</sub> , µg/m <sup>3</sup>
Adults aged ≥65 years, %	1.00						
Poverty, %	-0.06	1.00					
Lifetime smoking, %	0.16	0.15	1.00				
Obesity, %	-0.13	0.70	0.07	1.00			
Extreme hot days, ≥90°F	-0.09	0.34	-0.21	0.42	1.00		
Ozone, ppb	-0.11	0.19	0.00	0.09	0.19	1.00	
PM <sub>2.5</sub> , µg/m <sup>3</sup>	-0.29	0.02	0.14	0.26	0.10	0.07	1.00

*Definition of abbreviations:* PM<sub>2.5</sub> = particulate matter with aerodynamic diameter of 2.5 µm or less.

**SUPPLEMENTARY TABLE 2. ADJUSTED RATE RATIOS (95%CLS) OF PREDICTORS ASSOCIATED WITH CLRD DEATHS MEASURED BY PER FIVE-UNIT INCREMENT FOR ALL VARIABLES**

Model	1	2	3	4	5
Adults aged ≥65 years, %	1.09(1.07, 1.11)	1.09(1.07, 1.11)	1.09(1.07, 1.11)	1.09(1.08, 1.11)	1.10(1.08, 1.12)
Poverty, %	1.07(1.06, 1.09)	1.07(1.06, 1.09)	1.06(1.04, 1.08)	1.06(1.04, 1.08)	1.06(1.05, 1.08)
Lifetime smoking, %	1.15(1.13, 1.18)	1.15(1.13, 1.18)	1.13(1.10, 1.15)	1.13(1.10, 1.15)	1.13(1.10, 1.16)
Obesity, %	1.02(0.99, 1.04)	1.02(0.99, 1.04)	1.03(1.01, 1.05)	1.03(1.01, 1.05)	1.03(1.00, 1.05)
Extreme hot days, ≥90°F	1.00(1.00, 1.00)	1.00(1.00, 1.00)	1.01(1.00, 1.01)	1.01(1.00, 1.01)	1.01(1.00, 1.01)
Ozone, ppb	1.10(1.08, 1.13)	1.10(1.08, 1.13)	1.05(1.01, 1.09)	1.05(1.01, 1.09)	1.06(1.02, 1.10)
PM <sub>2.5</sub> , µg/m <sup>3</sup>	1.03(0.99, 1.08)	1.03(0.99, 1.08)	1.07(0.99, 1.14)	1.06(0.99, 1.13)	1.08(1.01, 1.15)

**Note:**

Model 1, state unstructured random effects only:  $\log[y_i] = \log[E_i] + \alpha + X_i\beta + ST_{j|i}$

Model 2, state unstructured and county unstructured random effects:  $\log[y_i] = \log[E_i] + \alpha + X_i\beta + ST_{j|i} + U_i$ ,

Model 3, state unstructured and county spatially structured random effects:  $\log[y_i] = \log[E_i] + \alpha + X_i\beta + ST_{j|i} + S_i$ ,

Model 4, state unstructured, county unstructured, and county spatially structured random effects:  $\log[y_i] = \log[E_i] + \alpha + X_i\beta + ST_{j|i} + U_i + S_i$ ,

Model 5, Model 4 with a mixture parameter embedded between county unstructured and county spatially structured random effects:

$$\log[y_i] = \log[E_i] + \alpha + X_i\beta + ST_{j|i} + \rho_i U_i + (1 - \rho_i) S_i$$

where  $y_i$  is the number of deaths for county  $i$  ( $i = 1, \dots, 3109$ ),  $E_i$  the population ( $\geq 45$  years),  $\alpha$  the intercept,  $X_i$  the vector of seven predictors ( $X_{1,i}, \dots, X_{7,i}$ ),  $\beta_{[1,\dots,7]}$  the corresponding regression coefficients,  $ST_{j|i}$  ( $j = 1, \dots, 49$ ) state unstructured random effects,  $U_i$  county unstructured random effects,  $S_i$  county spatially structured random effects, and  $\rho$  the mixture parameter ( $0 \leq \rho \leq 1$ ). County spatially structured random

effects are formulated as  $S_i | S_j \sim Normal(\bar{S}_i, \tau_i^2)$  ( $i \neq j$ ) (20), where  $\bar{S}_i = \frac{1}{\sum_j w_{ij}} \sum_j S_j w_{ij}$ ,  $\tau_i^2 = \frac{\tau_s^2}{\sum_j w_{ij}}$ ,  $w_{ij} = 1$ , if  $i, j$  are adjacent counties,

otherwise  $w_{ij} = 0$ . The state unstructured and county unstructured random effects are formulated as  $ST_{j[i]} \sim Normal(0, \tau_{ST}^2)$  and

$U_i \sim Normal(0, \tau_u^2)$ .  $\tau_{ST}^2$ ,  $\tau_s^2$ , and  $\tau_u^2$  are the variance parameters of  $ST_{j[i]}$ ,  $S_i$  and  $U_i$ .

**SUPPLEMENTARY TABLE 3. ADJUSTED RATE RATIOS (95%CLS) OF PREDICTORS ASSOCIATED WITH CLRD DEATHS MEASURED BY PER FIVE-UNIT INCREMENT FOR ALL VARIABLES**

Model	I	II	III	IV	V	VI
Adults aged ≥65 years, %				1.09(1.07, 1.11)	1.09(1.07, 1.11)	1.09(1.07, 1.11)
Poverty, %				1.06(1.04, 1.07)	1.06(1.04, 1.07)	1.06(1.04, 1.07)
Lifetime smoking, %				1.12(1.10, 1.15)	1.13(1.11, 1.15)	1.13(1.11, 1.15)
Obesity, %				1.03(1.01, 1.05)	1.03(1.01, 1.05)	1.03(1.01, 1.05)
Extreme hot days, ≥90°F				1.01(1.00, 1.01)	1.01(1.00, 1.01)	1.01(1.00, 1.01)
Ozone, ppb	1.12(1.07, 1.17)		1.09(1.05, 1.15)	1.04(1.01, 1.08)		1.05(1.01, 1.09)
PM <sub>2.5</sub> , µg/m <sup>3</sup>		0.77(0.71, 0.83)	0.79(0.74, 0.86)		1.05(0.99, 1.13)	1.07(1.01, 1.13)

**Note:** Models I to VI include state unstructured and county spatially structured random effects:  $\log[y_i] = \log[E_i] + \alpha + X_i\beta + ST_{j(i)} + S_i$ ; Model I includes only ozone as covariate; Model II includes only PM<sub>2.5</sub> as covariate; Model III includes both ozone and PM<sub>2.5</sub> as covariates; Model IV includes all other covariates plus ozone; Model V includes all other covariates plus PM<sub>2.5</sub>; Model VI is the Model 3 showed in Table 3 as well as in Supplementary Table 2.

**SUPPLEMENTARY TABLE 4. ADJUSTED RATE RATIOS OF PREDICTORS ASSOCIATED WITH CLRD DEATHS MEASURED BY PER FIVE-UNIT INCREMENT FOR ALL VARIABLES USING OZONE AND PM<sub>2.5</sub> EXPOSURE AVERAGED DURING EARLY TWO YEARS (2001-2002)**

Variable	Rate Ratio	95% CI
Adults aged ≥65 years, %	1.092	1.073 to 1.111
Poverty, %	1.060	1.044 to 1.076
Lifetime smoking, %	1.126	1.104 to 1.151
Obesity, %	1.028	1.005 to 1.050
Extreme hot days, ≥90°F	1.006	1.003 to 1.010
Ozone, ppb	1.043	1.012 to 1.074
PM <sub>2.5</sub> , µg/m <sup>3</sup>	1.045	0.980 to 1.109

*Definition of abbreviations:* PM<sub>2.5</sub> = particulate matter with aerodynamic diameter of 2.5 µm or less;

CI = credible interval.

**SUPPLEMENTARY TABLE 5. DISTRIBUTION OF COUNTY-LEVEL OZONE AND PM<sub>2.5</sub> AMONG 3109 CONTIGUOUS U.S. COUNTIES: MEAN, STANDARD ERROR (SE), AND COEFFICIENT OF VARIATION (CV)**

Air Pollutants	Statistics	N	Mean	Minimum	Q1	Median	Q3	Maximum
Ozone	Mean	3109	40.9	27.8	39.0	41.2	42.9	52.0
	SE	3109	0.056	0.002	0.031	0.050	0.073	0.165
	CV	3109	0.0014	0.0001	0.0008	0.0012	0.0018	0.0041
PM <sub>2.5</sub>	Mean	3109	10.7	4.8	8.7	10.9	12.5	16.8
	SE	3109	0.031	0.002	0.020	0.030	0.042	0.083
	CV	3109	0.0032	0.0001	0.0018	0.0028	0.0041	0.0107

*Definition of abbreviations:* Q1 = First Quartile; Q3 = Third Quartile; SE = standard error; CV = coefficient of variation.

**SUPPLEMENTARY TABLE 6. ADJUSTED RATE RATIOS OF PREDICTORS ASSOCIATED WITH COPD DEATHS MEASURED BY PER FIVE-UNIT INCREMENT FOR ALL VARIABLES BASED ON MODEL 3**

Variable	Rate Ratio	95% CI
Adults aged ≥65 years, %	1.09	1.07 to 1.11
Poverty, %	1.06	1.04 to 1.07
Lifetime smoking, %	1.14	1.11 to 1.16
Obesity, %	1.03	1.01 to 1.05
Extreme hot days, ≥90°F	1.01	1.00 to 1.01
Ozone, ppb	1.05	1.01 to 1.09
PM <sub>2.5</sub> , µg/m <sup>3</sup>	1.06	0.98 to 1.34

*Definition of abbreviations:* PM<sub>2.5</sub> = particulate matter with aerodynamic diameter of 2.5 µm or less;

CI = credible interval.