



Supplemental Materials: Disease and health inequalities attributable to air pollutant exposure in Detroit, Michigan

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Supplemental Tables:

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Figure S2. Maps of SES variables used to rank census blocks when calculating the concentration index. Figure S3. Comparison of the distributions of measured daily mean SO₂ concentrations at the Southwest High School monitor (2011–2015) and modeled FRESH-EST receptors within 150 m of the monitor. K-S tests for each receptor are all non-significant ($p > 0.05$)

Figure S4. Daily concentrations of NO₂ (daily mean, ppb), O₃, (daily 8-hour max, ppb), and PM_{2.5} (daily mean, $\mu\text{g}/\text{m}^3$) averaged across monitors in the Detroit, MI area.

Figure S5. Annual diesel particulate matter (DPM) concentrations (A, $\mu\text{g}/\text{m}^3$) and excess cancer risk (B, excess cases per 10⁶) due to DPM exposures measured at the census block level.

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Figure S7. Correlations between block-level demographic and socioeconomic variables in the study area

Supplemental Tables

Table S1. Pollutants, health outcomes, age groups, and concentration-response coefficients used in the health impact functions

Pollutant	Health Outcome	Age group	CR	Form	Reference
O ₃	Non-accidental mortality	30+	0.00041	log-linear	Smith et al. (2009) [1]
	ED visit for asthma	0-17	0.01044	log-linear	Mar and Koenig (2009) [2]
	Asthma symptom day (one or more symptoms)	6-14	0.00194	logistic	Schildcrout et al. (2006) [3]
	Pneumonia hospitalization	65+	0.00521	log-linear	Schwartz (1994) [4]
	COPD hospitalization	65+	0.00549	log-linear	Schwartz (1994) [4]
	Missed school day	6-14	0.00755	log-linear	Gilliland et al. (2001) [5]
	Minor restricted activity day	18-64	0.00260	log-linear	Ostro and Rothschild (1989) [6]
PM _{2.5}	All-cause mortality	30+	0.00545	Log-linear	Krewski et al (2009) [7]
	Infant mortality	0-1	0.00392	logistic	Woodruff et al. (1997) [8]
	Asthma hospitalization	0-64	0.00332	log-linear	Sheppard et al. (2003) [9]
	COPD hospitalization	65+	0.00117	log-linear	Ito et al. (2003) [10]
	CVD hospitalization	65+	0.00158	log-linear	Moolgavkar (2003) [11]
	Pneumonia hospitalization	65+	0.00398	log-linear	Ito et al (2003) [10]
	Non-fatal heart attack	18+	0.00222	logistic	Zanobetti et al (2008) [12]
	ED visit for asthma	0-17	0.00560	log-linear	Mar et al. (2010) [13]
	Asthma symptom day (cough)	6-14	0.01906	logistic	Mar et al. (2004) [14]
	Asthma symptom day (shortness of breath)	6-14	0.00256	logistic	Ostro et al. (2001) [15]
	Asthma symptom day (wheeze)	6-14	0.00194	logistic	Ostro et al. (2001) [15]
	Minor restricted activity day	18-64	0.00741	log-linear	Ostro and Rothschild (1989) [6]
SO ₂	Work loss day	18-64	0.00460	log-linear	Ostro (1987) [16]
	Asthma hospitalization	0-64	0.00203	log-linear	Sheppard (2003) [9]
	COPD hospitalization	65+	0.02081	log-linear	Yang et al. (2005) [17]
	ED visit for asthma	0-17	0.00853	log-linear	Ito et al. (2007) [18]
	ED visit for asthma (Detroit CR)	0-17	0.00976	log-linear	Li et al. (2011) [19]
	Asthma symptom day (one or more symptoms)	6-14	0.00392	logistic	Schildcrout et al. (2006) [3]
NO ₂	Asthma symptom day (one or more symptoms, Detroit CR)	6-14	0.01695	logistic	Batterman et al. (in prep) [20]
	Asthma hospitalization	0-64	0.00140	log-linear	Linn et al. (2000) [21]
	COPD hospitalization	65+	0.0024	log-linear	Moolgavkar (2003) [11]
	ED visit for asthma	0-17	0.00546	log-linear	Ito et al. (2007) [18]
	Asthma symptom day (one or more symptoms)	6-14	0.00431	logistic	Schildcrout et al. (2006) [3]

Table S2. Disability weights, duration, and monetary values used to estimate disability-adjusted life years and monetized impacts

Outcome	Age	DW (--)	D (years)	V (\$)	DW Source	D Source	V Source
Mortality							
All-cause	30-34	1	49.327	9600000		MDHHS, 2015 [22]	US EPA, 2012 [23]
All-cause	35-30	1	44.645	9600000		MDHHS, 2015 [22]	US EPA, 2012 [23]
All-cause	40-44	1	39.978	9600000		MDHHS, 2015 [22]	US EPA, 2012 [23]
All-cause	45-49	1	35.406	9600000		MDHHS, 2015 [22]	US EPA, 2012 [23]
All-cause	50-54	1	30.962	9600000		MDHHS, 2015 [22]	US EPA, 2012 [23]
All-cause	55-59	1	26.726	9600000		MDHHS, 2015 [22]	US EPA, 2012 [23]
All-cause	60-64	1	22.653	9600000		MDHHS, 2015 [22]	US EPA, 2012 [23]
All-cause	65-69	1	18.745	9600000		MDHHS, 2015 [22]	US EPA, 2012 [23]
All-cause	70-74	1	15.056	9600000		MDHHS, 2015 [22]	US EPA, 2012 [23]
All-cause	75-79	1	11.68	9600000		MDHHS, 2015 [22]	US EPA, 2012 [23]
All-cause	80-84	1	8.627	9600000		MDHHS, 2015 [22]	US EPA, 2012 [23]
All-cause	85+	1	5.9	9600000		MDHHS, 2015 [22]	US EPA, 2012 [23]
Infant	0-1	1	77.923	9600000		MDHHS, 2015 [22]	US EPA, 2012 [23]
Hospitalizations							
Asthma	0-64	0.64	0.009	16000	de Hollander 1999 [24]	CDC, 2012 [25]	US EPA, 2012 [23]
COPD	65+	0.64	0.012	36000	de Hollander 1999 [24]	CDC, 2012 [25]	US EPA, 2012 [23]
CVD	65+	0.71	0.0126	41000	de Hollander 1999 [24]	CDC, 2012 [25]	US EPA, 2012 [23]
Pneumonia	65+	0.64	0.014	36000	de Hollander 1999 [24]	CDC, 2012 [25]	US EPA, 2012 [23]
Non-fatal MI	18+	0.42	0.015	143000	de Hollander 1999 [24]	CDC, 2012 [25]	US EPA, 2012 [23]
Asthma outcomes							
ED Visit	0-17	0.51	0.0027	430	de Hollander 1999 [24]		US EPA, 2012 [23]
Cough		0.22	0.005	58	de Hollander 1999 [24]		US EPA, 2012 [23]
SoB		0.22	0.005	58	de Hollander 1999 [24]		US EPA, 2012 [23]
Wheeze		0.22	0.005	58	de Hollander 1999 [24]		US EPA, 2012 [23]
One or more		0.22	0.005	58	de Hollander 1999 [24]		US EPA, 2012 [23]
Restricted activity days							
MRAD		0.092	0.0027	68	Murray, 1994 [26]	Ostro, 1987 [16]	US EPA, 2012 [23]
WLD		0.092	0.0027	150	Murray, 1994 [26]		US EPA, 2012 [23]
SLD		0.092	0.0027	98			US EPA, 2016 [27]

Abbreviations: COPD: chronic obstructive pulmonary disease; CVD: cardiovascular disease; D: duration; DW: disability weight; ED: emergency department; MI: myocardial infarction; MRAD: minor restricted activity day; SLD: school loss day (school absence); WLD: work loss day.

Table S3. Concentration index values ($\times 100$) for annual average exposure concentration attributable to individual ambient air pollutants for the full analysis and the two sensitivity analyses. Percentages in parentheses are the percent difference between the sensitivity analysis values and the “all blocks” analysis.

Pollutant	Source	Concentration index (× 100)						
		% non-white	% Latino	% less than HS	Median income	% HH in poverty	% POC	% FB
All census blocks								
PM _{2.5}	Regional	—	—	—	—	—	—	—
	Point	12.9	−15.4	−8.9	0.8	0.7	10.9	−13.2
	Mobile	−0.5	−2.6	−4.0	−4.4	−4.0	−1.1	0.0
	Area	−1.1	0.9	1.7	−0.2	−0.2	−0.8	1.7
	Total	0.4	−0.7	−0.4	−0.3	−0.2	0.3	−0.4
O ₃	Regional	—	—	—	—	—	—	—
SO ₂	Point	6.8	−10.6	−7.0	−2.7	−2.9	5.7	−7.8
NO ₂	Regional	—	—	—	—	—	—	—
	Point	4.3	−6.6	−4.9	−2.0	−2.3	3.5	−5.2
	Mobile	−2.0	−1.0	−3.6	−4.5	−4.1	−2.6	1.4
	Area	3.4	0.6	6.4	5.9	6.1	4.2	−0.8
	Total	−0.3	−0.8	−1.3	−1.6	−1.4	−0.5	0.2
ZIP codes								
PM _{2.5}	Regional	—	—	—	—	—	—	—
	Point	0.139 (−37)	16 (−23)	−27 (−76)	−14.8 (−66)	1 (−35)	−2.7 (508)	9.7 (11)
	Mobile	0.057 (29)	2.7 (681)	−4.5 (−71)	−2.2 (46)	−9.9 (−126)	−8.4 (−110)	1.2 (208)
	Area	0.019 (73)	−1.8 (−61)	4.9 (−425)	1.6 (10)	−0.1 (55)	−0.8 (−301)	−0.9 (−13)
	Total	0.001 (62)	0.5 (−17)	−1.2 (−72)	0.1 (116)	0.2 (185)	0.5 (295)	0.2 (26)
O ₃	Regional	—	—	—	—	—	—	—
SO ₂	Point	0.055 (13)	9.5 (−40)	−13.7 (−29)	−10.7 (−53)	−4.4 (−60)	−4.8 (−64)	7.7 (−36)
NO ₂	Regional	—	—	—	—	—	—	—
	Point	0.027 (23)	6.9 (−59)	−9.8 (−48)	−7.5 (−54)	−2.6 (−31)	−3.4 (−48)	5.4 (−52)
	Mobile	0.055 (34)	1.1 (152)	−2.5 (−163)	−1.4 (60)	−9.9 (−120)	−8.5 (−109)	−0.1 (95)
	Area	0.101 (22)	−4.8 (239)	8.4 (−1278)	7.9 (−24)	4.2 (28)	4.7 (23)	−3.5 (183)
	Total	0.011 (−18)	1.6 (578)	−3.1 (−291)	−2.1 (−56)	−0.6 (60)	−0.9 (36)	1.2 (315)
Census blocks in the SO ₂ non-attainment area								
PM _{2.5}	Regional	—	—	—	—	—	—	—
	Point	0.107 (−5)	−6.9 (153)	−3.7 (76)	−9.5 (−7)	−9.5 (1328)	−9.1 (1482)	−9.4 (186)
	Mobile	0.128 (−61)	−4.7 (−914)	−7.5 (−186)	−6.4 (−58)	−6 (−37)	−6.3 (−57)	−7.3 (−556)
	Area	0.082 (−18)	3.7 (429)	2.2 (−134)	5.8 (−233)	5.2 (3341)	4 (2091)	5 (719)
	Total	0.003 (−13)	−0.5 (217)	−0.7 (−2)	−0.8 (−110)	−0.7 (−178)	−0.9 (−242)	−0.7 (339)
O ₃	Regional	—	—	—	—	—	—	—
SO ₂	Point	0.043 (33)	−6.4 (193)	−4 (62)	−5.8 (17)	−6 (−118)	−6.5 (−123)	−6.7 (219)
NO ₂	Regional	—	—	—	—	—	—	—
	Point	0.042 (−21)	−6.2 (244)	−3.1 (53)	−5.4 (−12)	−6 (−199)	−6.2 (−173)	−6.7 (290)
	Mobile	0.126 (−50)	−4.8 (−133)	−7.4 (−670)	−6.6 (−82)	−6.1 (−35)	−6.4 (−58)	−7.4 (−190)

Area	0.163 (−26)	6.5 (−91)	14.3 (−2242)	15.7 (−145)	10.8 (−85)	12 (−95)	11.5 (−171)
Total	0.012 (−25)	−2 (−494)	−2.4 (−207)	−2.1 (−55)	−2.2 (−38)	−2.3 (−64)	−2.8 (−412)

Supplemental Figures

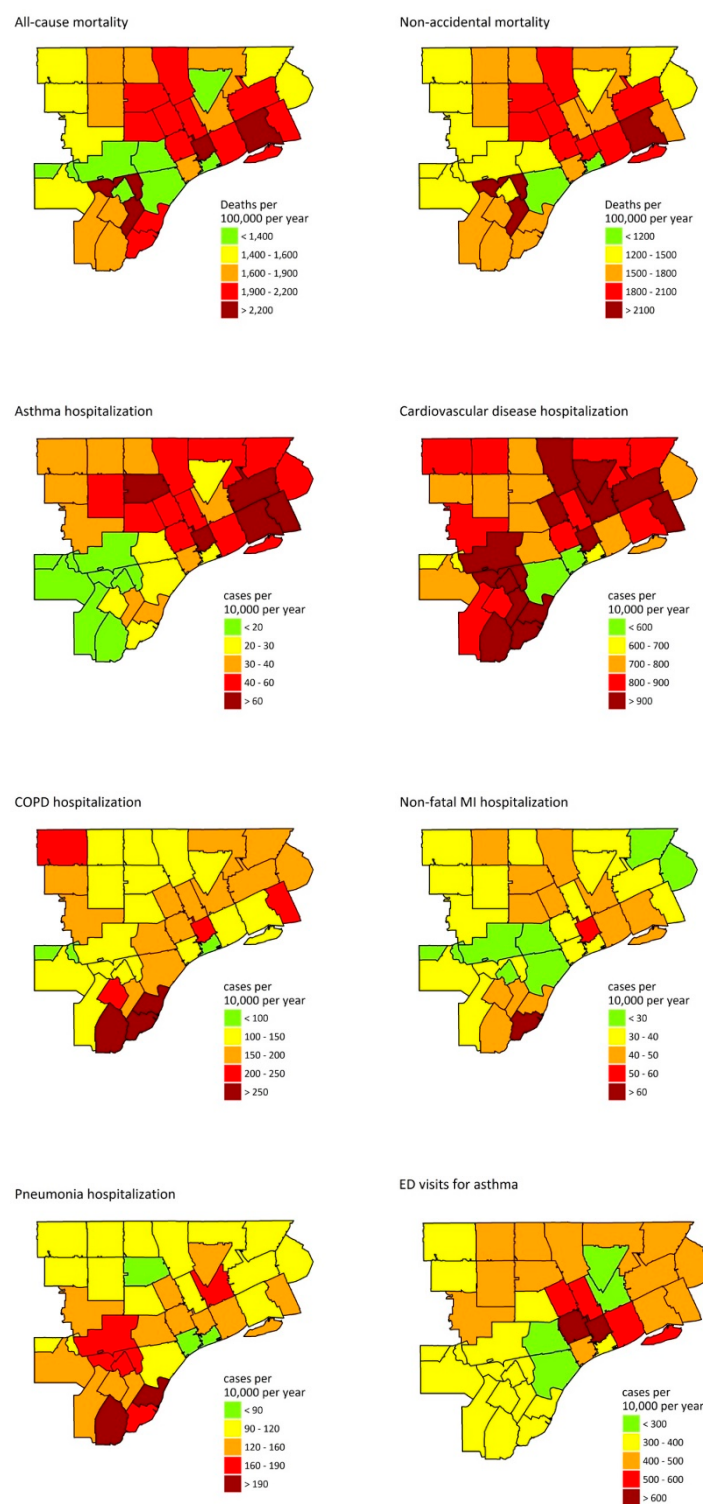


Figure S1. Maps of baseline health rates used in the health impact functions.

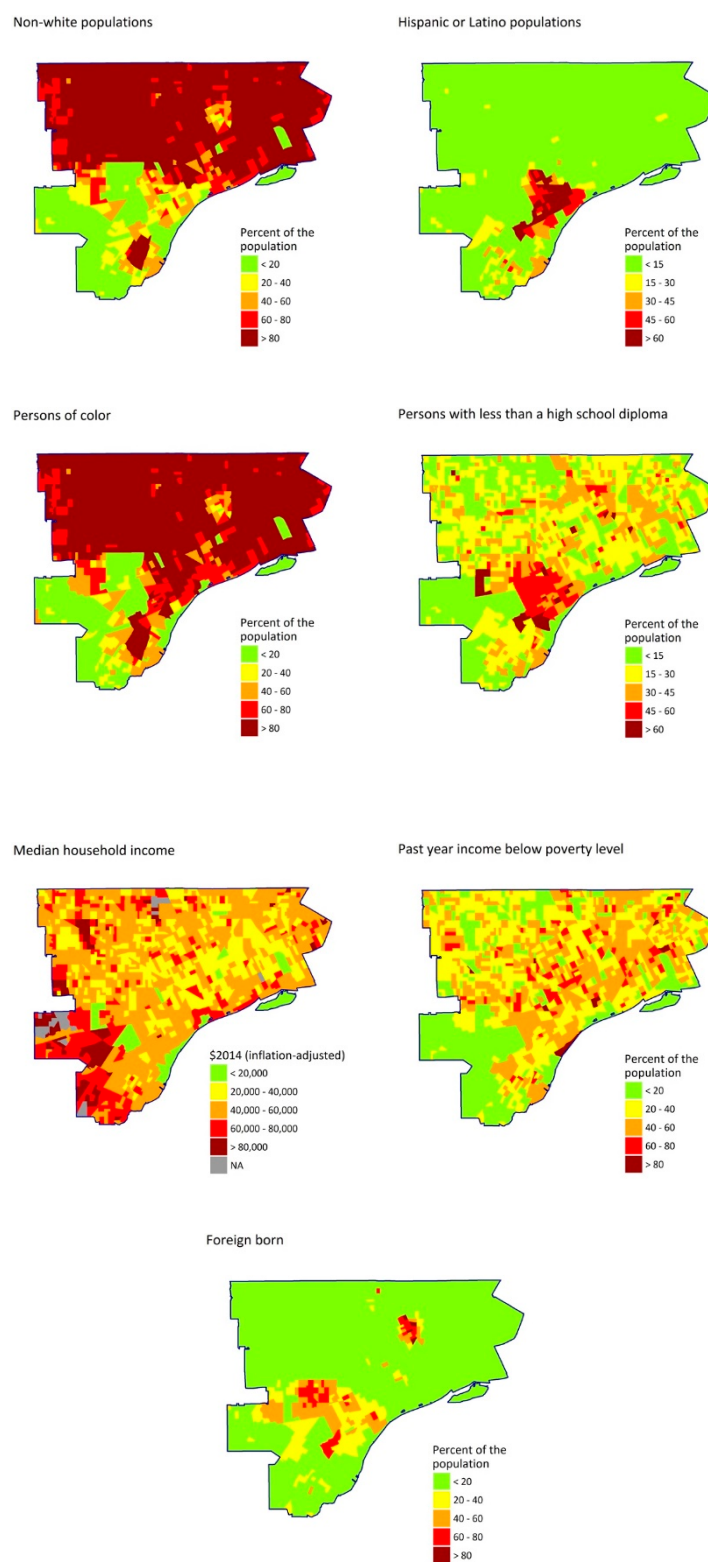


Figure S2. Maps of SES variables used to rank census blocks when calculating the concentration index.

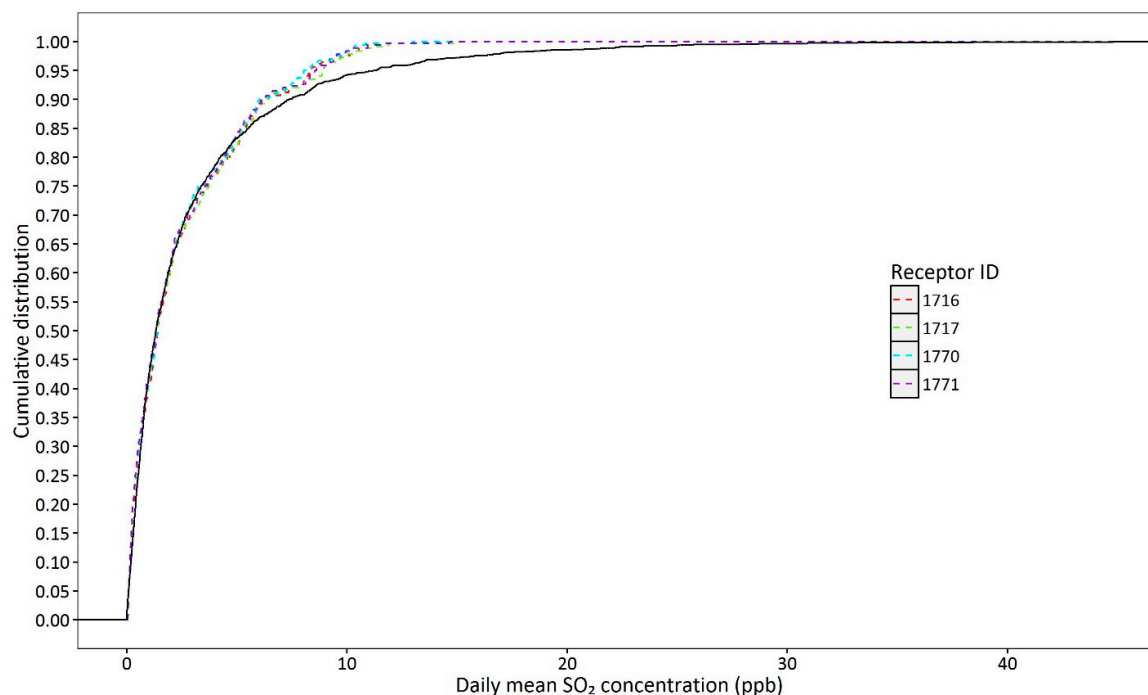


Figure S3. Comparison of the distributions of measured daily mean SO_2 concentrations at the Southwest High School monitor (2011–2015) and modeled FRESH-EST receptors within 150 m of the monitor. K-S tests for each receptor are all non-significant ($p > 0.05$)

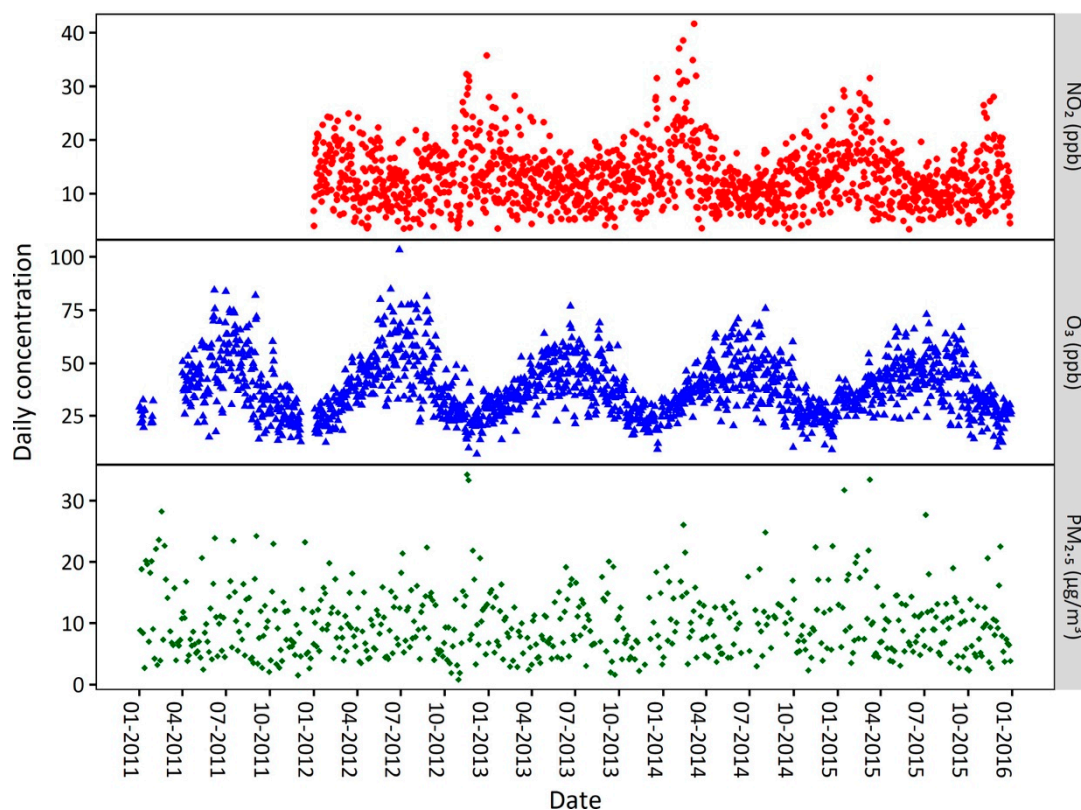


Figure S4. Daily concentrations of NO_2 (daily mean, ppb), O_3 (daily 8-hour max, ppb), and $\text{PM}_{2.5}$ (daily mean, $\mu\text{g}/\text{m}^3$) averaged across monitors in the Detroit, MI area.

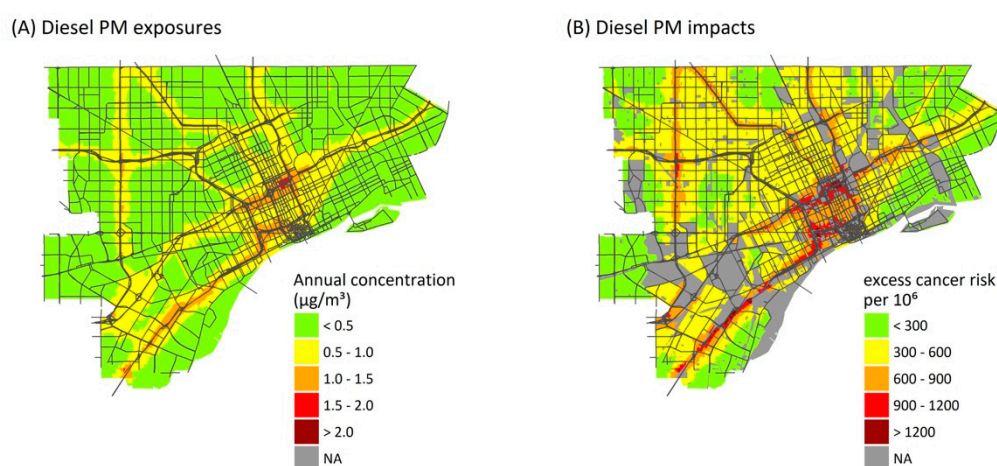


Figure S5. Annual diesel particulate matter (DPM) concentrations (A, $\mu\text{g}/\text{m}^3$) and excess cancer risk (B, excess cases per 10^6) due to DPM exposures measured at the census block level.

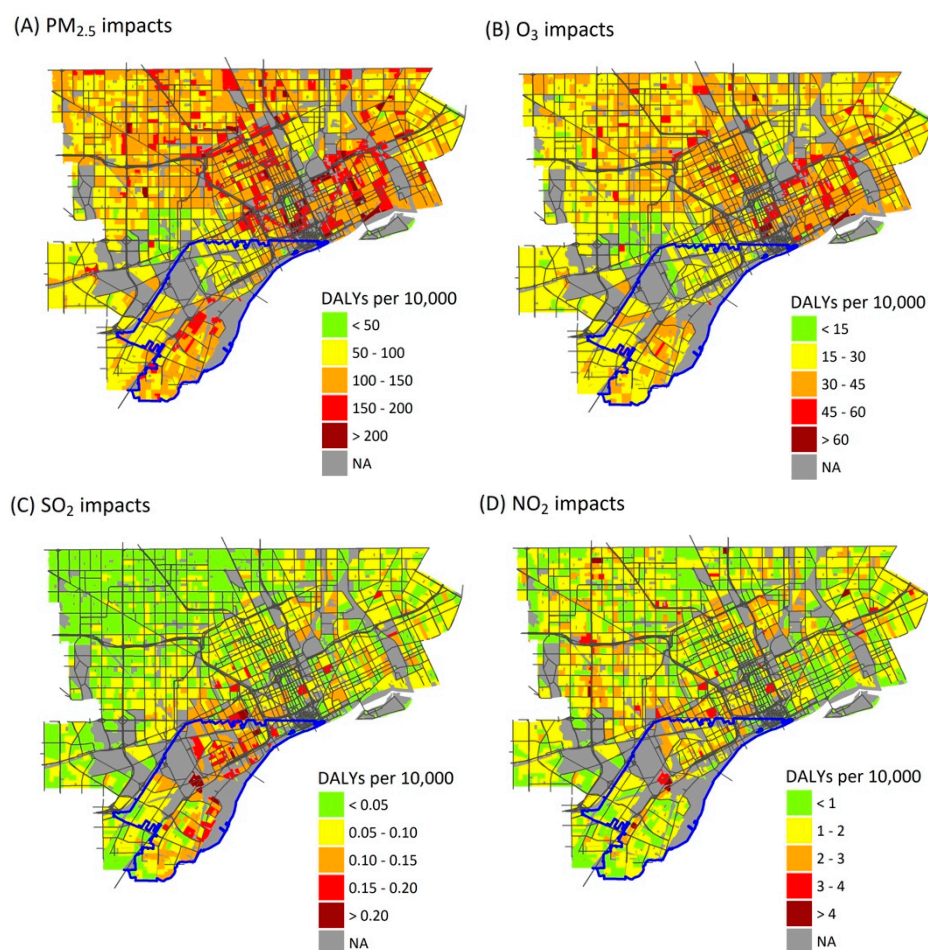


Figure S6. Maps showing the burden of disease (as DALYs per 10,000 per year) attributable to total exposures of (A) $\text{PM}_{2.5}$, (B) ozone, (C) SO_2 , and (D) NO_2 . The sub-region of the study area that is in non-attainment of the SO_2 National Ambient Air Quality Standard is shown (blue polygon).

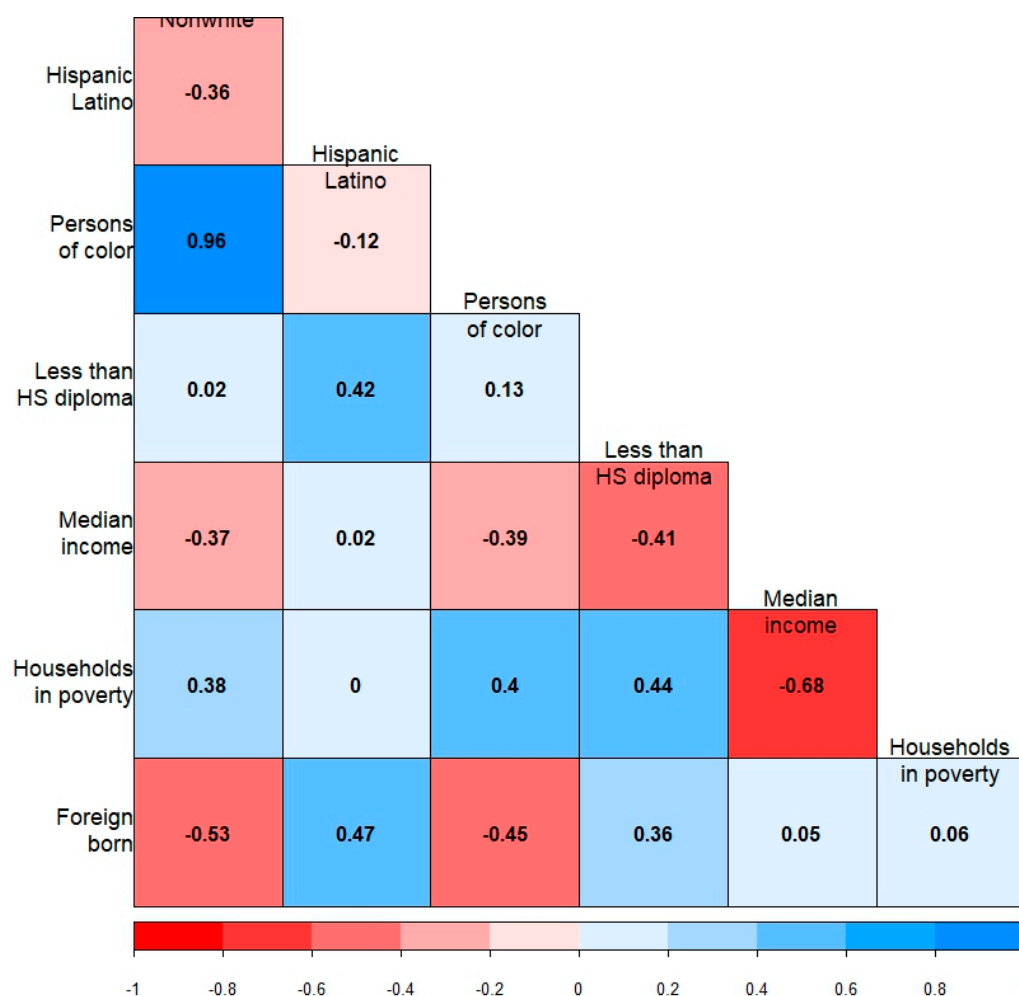


Figure S7. Correlations between block-level demographic and socioeconomic variables in the study area

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