

# Supporting information to “Estimating intra-urban inequities in PM<sub>2.5</sub>-attributable health impacts: A case study for Washington, DC.”

**Maria D. Castillo<sup>a</sup>, Patrick L. Kinney<sup>b</sup>, Veronica Southerland<sup>a</sup>, C. Anneta Arno<sup>c</sup>, Kelly Crawford<sup>d</sup>, Aaron van Donkelaar<sup>e,f</sup>, Melanie Hammer<sup>f</sup>, Randall V. Martin<sup>f,e</sup>, Susan C. Anenberg<sup>a,\*</sup>**

<sup>a</sup> George Washington University Milken Institute School of Public Health, Department of Environmental and Occupational Health, 950 New Hampshire Ave NW, Washington, DC, USA, 20052

<sup>b</sup> Boston University School of Public Health, Department of Environmental Health, 715 Albany Street, Talbot 4W, Boston, Massachusetts, USA, 02118

<sup>c</sup> District of Columbia Department of Health, Office of Health Equity, 899 North Capitol Street NE, Washington, DC, USA 20002

<sup>d</sup> District of Columbia Department of Energy & Environment, Air Quality Division, 1200 First Street NE, Washington, DC, USA, 20002

<sup>e</sup> Department of Physics and Atmospheric Science, Dalhousie University, Halifax, NS B3H 4R2, Canada

<sup>f</sup> Center for Aerosol Science and Engineering, Department of Energy, Environmental and Chemical Engineering, Washington University in St. Louis, St. Louis, MO, USA, 63130

\*Corresponding author: S. C. Anenberg, 950 New Hampshire Ave NW, Washington, DC 20052, [sanenberg@gwu.edu](mailto:sanenberg@gwu.edu), 1-202-994-2392

**Table S1:** Annual average PM<sub>2.5</sub> concentrations (µg/m<sup>3</sup>) derived from high spatial resolution satellite data (Hammer et al., 2020; van Donkelaar et al., 2019) in each of the eight wards in Washington, DC as well as the District-wide mean, standard deviation (SD), minimum (Min), and maximum (Max) values for each year from 2000 to 2018.

	Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Ward	1	16.0	15.9	15.0	14.1	14.4	15.1	13.5	13.6	12.0	10.5	11.1	10.7	10.4	9.2	9.5	9.8	8.7	8.3	8.0
	2	16.7	16.6	15.5	14.6	14.8	15.3	13.8	13.9	12.3	10.7	11.3	10.9	10.6	9.6	9.6	10.0	9.1	8.9	8.9
	3	16.5	16.3	15.5	14.4	14.7	15.1	13.7	13.7	12.1	10.5	11.2	10.8	10.6	9.6	9.6	10.0	9.0	8.9	9.3
	4	16.1	15.9	14.9	14.2	14.4	15.2	13.4	13.6	12.2	10.6	11.3	10.8	10.4	9.2	9.6	9.9	8.7	8.3	8.3
	5	16.4	16.0	15.1	14.4	14.5	15.0	13.4	13.6	12.1	10.4	11.1	11.0	10.4	9.6	9.6	9.7	8.9	8.6	9.0
	6	16.5	16.2	15.4	14.4	14.6	15.2	13.6	13.7	12.1	10.4	11.2	11.0	10.6	9.7	9.6	10.0	9.0	8.8	9.1
	7	15.6	15.3	14.5	13.8	13.9	14.5	12.8	13.2	11.8	10.1	10.9	10.8	10.1	9.3	9.4	9.5	8.6	8.1	8.7
	8	15.6	15.2	14.6	13.7	13.9	14.5	13.0	13.1	11.8	10.1	11.0	11.1	10.4	9.4	9.6	9.7	8.7	8.1	8.7
DC	Year	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
	Mean	17.0	16.9	17.6	18.1	15.8	16.6	13.8	14.3	11.4	10.8	11.6	12.8	11.8	10.6	10.9	12.6	10.2	8.5	8.7
	SD	0.93	0.91	0.86	0.96	0.83	0.90	0.78	0.77	0.69	0.70	0.69	0.76	0.71	0.66	0.68	0.68	0.60	0.53	0.70
	Min	14.5	15	15.5	16	14	14.3	12	12.3	10	9	10	11	10	9	9.5	11	9	7	6.3
	Max	19	19	19.8	20.3	17.8	18.8	15.5	16	13	12	13	14.3	13	12	12	14	11.5	9.2	9.5

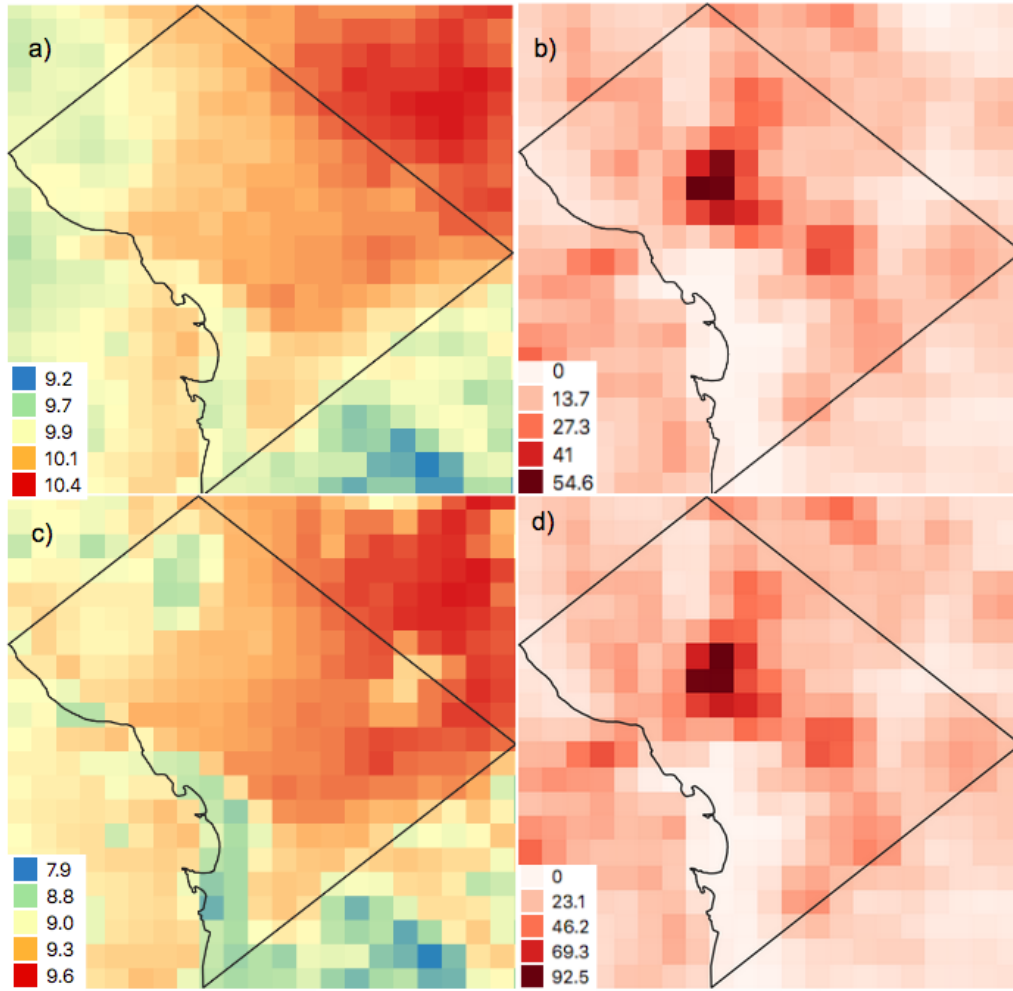
**Table S2:** PM<sub>2.5</sub>-attributable deaths and asthma ED visits throughout Washington, DC that would have been avoided if each year's PM<sub>2.5</sub> concentrations were set at 2018 levels (District-wide average PM<sub>2.5</sub> = 8.7 µg/m<sup>3</sup>). a) PM<sub>2.5</sub>-attributable all-cause mortality deaths that would have been avoided annually; and b) total cumulative PM<sub>2.5</sub>-attributable cases for each health endpoint that would have been avoided between 2000 and 2015 (2014-2018 for asthma ED visits).

a)	Year	Avoided Deaths	b)	Health Endpoint	Avoided Cases
	2000	279		COPD	58
	2001	210		IHD	538
	2002	183		LC	110
	2003	121		Stroke	48
	2004	135		All-Cause	1,617
	2005	166		Asthma	5
	2006	118			
	2007	122			
	2008	79			
	2009	28			
	2010	50			
	2011	44			
	2012	33			
	2013	15			
	2014	14			
	2015	21			

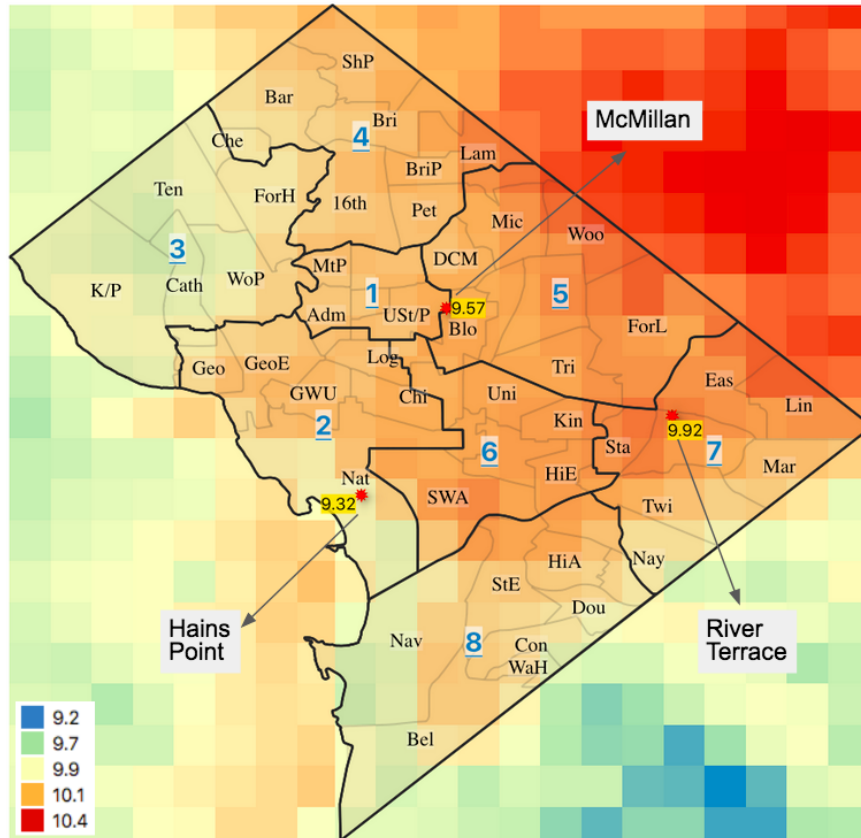
**Table S3:** Five-year (2011-2015) mean PM<sub>2.5</sub>-attributable mortality rates (per 100,000) and asthma ED visit rates (per 10,000) and selected social determinants of health in each statistical neighborhood in the District. Four neighborhoods (Georgetown, National Mall, Naval Station & Air Force, and Stadium Armory) were omitted given their low population counts and/or had suppressed values in the nine key drivers of health. Table is sorted in ascending order for estimated PM<sub>2.5</sub>-attributable all-cause mortality rate.

Neighborhood	Attributable Rates (per 100,000 people)							Socio-Economic indicators			Life Expectancy at Birth (years)	Race and Ethnicity			
	All-Cause	Asthma ED Visits	COPD	IHD	Lung Cancer	Stroke	Education (%)	Employment (%)	Median Household Income (\$)	Residents Living in Poverty (%)		% White	% Black	% Hispanic/Latino	% Asian
WOODLEY PARK	17	1	3	7	3.1	2.3	98	3	139,744	7	89	71	8	12	6
GEORGETOWN EAST	17	1	2	11	2.8	0.7	99	3	132,021	10	87	73	5	11	8
GWU	18	1	2	20	2.8	0.7	NA	NA	NA	NA	NA	69	6	11	11
ADAMS MORGAN	20	3	2	9	3.9	1.1	96	5	96,194	7	85	63	12	16	6
U ST/PLEASANT	21	5	2	12	4.1	1.2	89	7	94,614	12	82	45	34	13	5
KENT/PALISADES	22	1	3	13	3.1	2.3	98	6	161,252	9	88	71	7	11	8
CAPITOL HILL	23	4	3	12	5.1	1.8	98	3	121,668	6	86	65	21	7	3
LOGAN CIRCLE/SHAW	28	4	2	19	3.4	1.0	91	4	94,043	11	81	54	24	11	8
SHEPHERD PARK	28	2	3	16	4.9	2.2	93	12	102,053	11	83	29	46	21	2
TENLEYTOWN	28	1	3	16	3.1	2.3	99	2	136,641	5	87	71	7	11	7
Lowest attributable rates (10-neighborhood mean)	22	2	2	14	4	2	95	5	119,803	9	86	61	17	12	6
CATHEDRAL HEIGHTS	30	1	3	19	3.0	2.1	97	4	90,124	16	89	71	7	11	7
SOUTH COLUMBIA HEIGHTS	30	3	2	17	4.1	1.2	90	8	82,241	14	79	45	28	18	6
FOREST HILLS	31	1	3	18	3.1	2.3	99	4	113,269	9	87	67	11	14	5
MOUNT PLEASANT	32	6	2	30	4.1	1.2	89	5	71,837	12	79	45	21	26	4
UNION STATION	32	7	3	16	5.1	1.8	95	5	110,907	10	78	51	36	6	5
16th ST HEIGHTS	33	6	3	18	4.8	2.2	83	8	75,848	13	80	32	38	24	4
SAINT ELIZABETHS	33	14	5	17	8.8	2.9	NA	18	25,311	40	68	15	78	5	1
CHINATOWN	38	4	2	24	3.8	1.2	89	5	82,789	18	78	52	24	11	10
COLUMBIA HEIGHTS	41	6	2	24	4.2	1.2	79	7	70,554	17	80	37	32	23	5
HILL EAST	41	3	3	26	5.1	1.8	92	9	92,617	14	78	47	41	6	2
DC MEDICAL CENTER	44	6	4	57	6.3	3.1	NA	NA	NA	NA	NA	30	49	15	3
BARNABY WOODS	44	1	3	22	4.8	2.2	99	3	200,031	2	87	53	26	14	5
BLOOMINGDALE	46	6	4	33	6.4	3.1	91	9	87,146	12	76	37	47	7	5
DOUGLASS	47	13	5	34	8.7	2.8	82	23	31,319	37	72	2	92	3	0
KINGMAN PARK	48	7	3	31	5.3	2.0	92	8	91,073	12	77	39	49	6	2
HISTORIC ANACOSTIA	50	13	5	27	8.9	2.9	83	15	28,790	37	70	3	92	3	0
EASTLAND GARDENS	52	14	4	27	7.5	3.6	79	21	31,333	34	73	3	91	4	0
LAMOND RIGGS	52	6	4	27	5.3	2.5	89	15	67,745	9	81	17	62	17	2
TWINING	52	13	4	25	8.0	3.3	88	16	47,486	21	75	4	90	3	1
PETWORTH	52	6	3	29	4.8	2.2	86	12	77,020	13	79	22	51	22	3
BRENTWOOD	52	9	4	33	6.4	3.2	87	15	61,739	19	77	20	67	8	3
BRIGHTWOOD	53	5	3	28	4.9	2.2	84	9	66,395	13	81	25	50	19	2
SW/WATERFRONT	57	7	3	33	5.1	1.8	94	7	76,429	14	78	50	35	8	4
BELLEVUE	57	15	5	38	8.8	2.9	83	30	32,562	40	74	8	86	3	0
CONGRESS HEIGHTS/SHIPLEY	59	16	5	58	8.8	2.9	82	27	28,711	39	72	2	93	3	0
EDGEWOOD	60	7	4	46	6.4	3.2	84	20	41,171	29	79	31	52	11	4
NAYLOR/HILLCREST	61	13	4	39	7.8	3.3	84	17	37,771	35	73	3	91	3	1

MICHIGAN PARK	62	6	4	38	6.4	3.2	86	16	57,943	12	82	24	56	15	2
TRINIDAD	66	7	4	36	6.4	3.2	80	18	36,655	29	71	27	62	6	3
FORT LINCOLN/GATEWAY	66	9	4	55	6.4	3.2	81	14	51,454	19	76	9	82	6	1
BRIGHTWOOD PARK	66	6	3	40	4.9	2.2	87	10	61,476	16	77	16	60	19	2
WOODRIDGE	66	9	4	42	6.5	3.2	93	14	85,947	11	79	17	69	9	2
CHEVY CHASE	68	1	3	40	3.8	2.3	94	4	115,697	9	83	73	8	10	6
LINCOLN HEIGHTS	72	14	4	38	7.6	3.6	81	21	36,577	26	73	1	93	4	0
WASHINGTON HIGHLANDS	74	16	5	46	8.7	2.8	NA	NA	28,468	39	72	1	95	2	0
MARSHALL HEIGHTS	74	14	4	38	7.4	3.5	84	20	43,043	29	72	1	94	3	0
FORT DUPONT	90	13	4	46	7.5	3.6	82	24	35,545	31	75	1	93	4	1
Highest attributable rates (10-neighborhood mean)	70	9	4	42	7	3	85	16	55,281	22	76	17	71	8	2
District of Columbia means	46	7	4	29	6	2	89%	10	\$70,848	40%	79	36%	46%	11%	4%

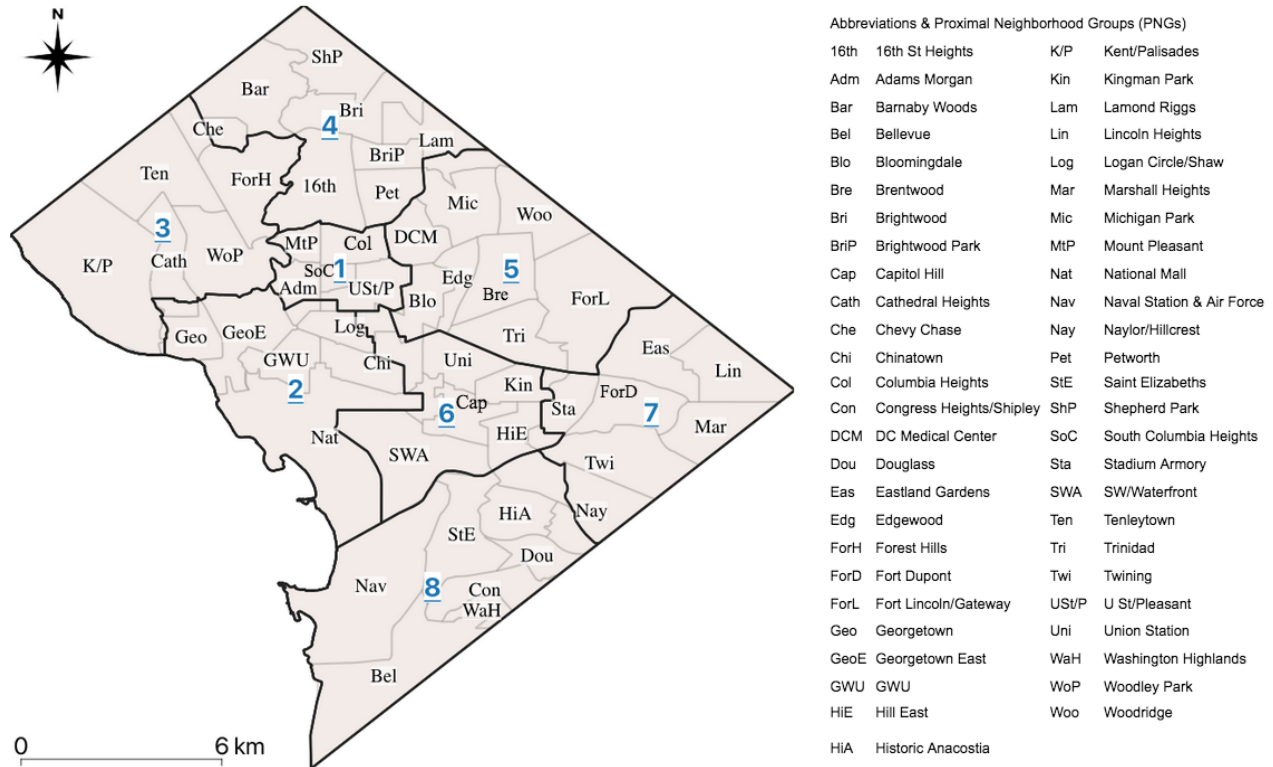


**Fig S1:** Five-year mean PM<sub>2.5</sub> concentrations (µg/m<sup>3</sup>) for a) 2011-2015 and c) 2014-2018 (van Donkelaar et al., 2019); and Socioeconomic Data and Applications Center (SEDAC) 2010 population count estimates from the Gridded Population of the World (GPW), Version 4, by the Center for International Earth Science Information Network (Center For International Earth Science Information Network-CIESIN-Columbia University, 2018) for b) 30-99 years of age and d) all ages. Estimates are displayed on a 100 m x 100 m resolution grid overlaid on the outline of the District of Columbia.



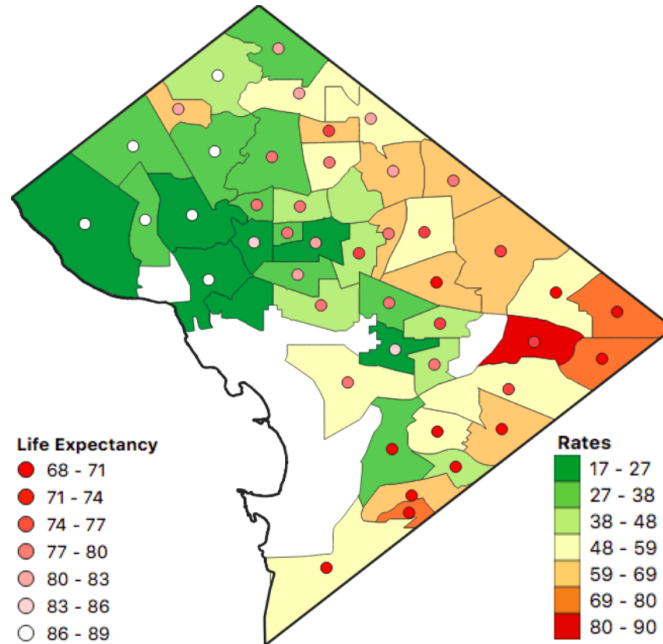
Station	River Terrace		Hains Point		McMillan	
Year	Satellite	Monitor	Satellite	Monitor	Satellite	Monitor
2011	10.9	10.4	10.7	10.2	11.1	10.3
2012	10.7	9.8	10.5	9.8	10.4	9.6
2013	9.7	9.3	8.4	8.3	9.7	9.1
2014	9.7	10.2	9.6	9.1	9.6	9.4
2015	10.1	NA	10.0	9.2	9.8	8.9
2011-2015	10.2	9.9	9.8	9.3	10.1	9.6

**Fig S2:** Comparison of PM<sub>2.5</sub> concentrations (µg/m<sup>3</sup>) derived from high spatial resolution satellite data (Hammer et al., 2020; van Donkelaar et al., 2019) and ground-based monitors (Federal Reference and Equivalent Methods - FRM/FEM). Top: Five-year (2011 - 2015) average concentrations (µg/m<sup>3</sup>) from satellite data (raster layer at ~1 x 1km) and three ground-based monitors (located in Wards 1, 2 and 7, in PNGs U St/Pleasant, National Mall, and Fort Dupont, respectively). Bottom: Annual comparisons of PM<sub>2.5</sub> concentrations (µg/m<sup>3</sup>) between 2011 and 2015, as well as 5-year average comparison for each of the three monitoring stations that were available for these years. Satellite data values correspond to the grid cells where the ground-based monitors are located.

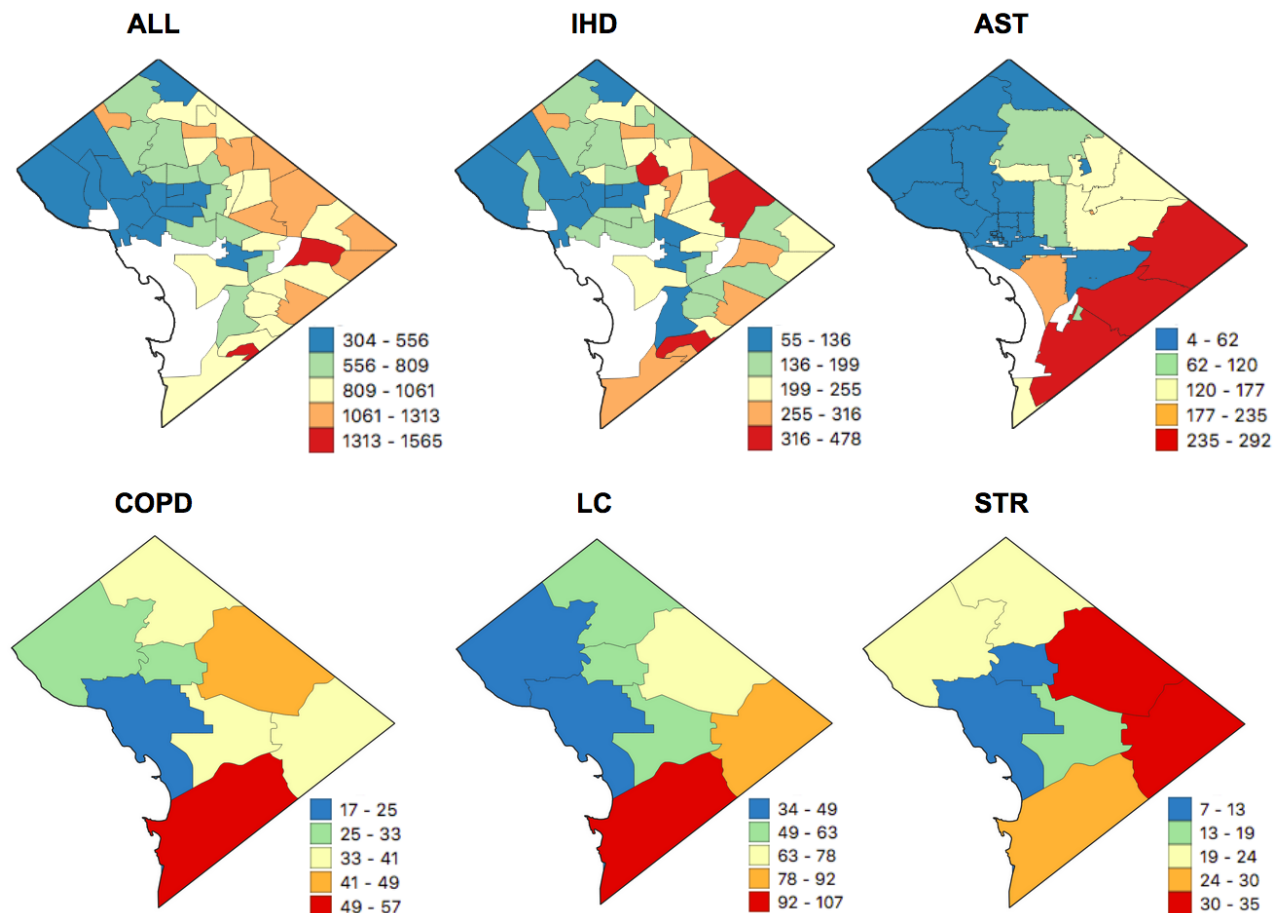


**Fig S3:** District of Columbia's 51 Proximal Neighborhood Groups (PNGs) defined by the District of Columbia Department of Health (DOH) and Ward overlays (1-8), and a list of PNGs abbreviations and names. Shapefiles retrieved from Open Data DC (<https://opendata.dc.gov/>) and Figure produced in Quantum Geographic Information System (QGIS 3.6.2).





**Figure S4:** PM<sub>2.5</sub>-attributable all-cause mortality rates (per 100,000 people) and life expectancy at birth (in years) from the District of Columbia Department of Health (DOH) Center for Policy, Planning and Evaluation. Data represent 2011-2015 means.



**Fig S5:** Five-year mean baseline disease rates (cases per 100,000 people for all mortality outcomes and per 10,000 people for asthma ED visits) from the District of Columbia Department of Health between 2011 and 2015 for all mortality outcomes, and between 2014 to 2018 for asthma ED visits. Data resolution is at the neighborhood-level for all-cause mortality (ALL) and ischaemic heart disease (IHD); zip code-level for asthma ED visits (AST); and ward-level for chronic obstructive pulmonary disease (COPD), lung cancer (LC), and stroke (STR). Colors represent five equal intervals for each health outcome of interest.

## Supplementary Material References:

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