GeoHealth

Supporting Information for

Estimating the Health-Related Costs of Ten Climate-Sensitive US Events During 2012

Vijay S. Limaye[1*], Wendy Max[2], Juanita Constible[1], Kim Knowlton[1,3]

[1]Natural Resources Defense Council, New York, NY 10011, USA; jconstible@nrdc.org, ORCiD 0000-0002-2642-4608 (J.C.); kknowlton@nrdc.org, ORCiD 0000-0002-8075-7817 (K.K.)

[2]Institute for Health & Aging, University of California San Francisco, San Francisco, CA 94118, USA; wendy.max@ucsf.edu, ORCiD 0000-0002-4040-1592

[3]Mailman School of Public Health, Columbia University, New York, NY 10032, USA

*Corresponding author: vlimaye@nrdc.org, ORCiD 0000-0003-3118-6912, Tel.: +1-212-727-4683, Fax: +1-212-727-1773

Contents of this file

Directly Reported and Estimated Health Impacts for Case Study Events

Event	State	# Deaths (Reported)	Source	# Imputed Deaths (HCUP)	ICD-9 Code(s)	Diagnosis	# HA (red if imputed)	# ED (red if imputed)	Source

Lyme disease	MI	0		0.0	322.9	Meningitis	1.6	0.8	CDC (2017)
Lyme disease	MI				695.9	Erythema migrans rash	56.8	1.6	CDC (2017)
Lyme disease	MI				351	Facial palsy	72	5.1	CDC (2017)
Lyme disease	MI				357	Radiculonerupathy	3.2	0.4	CDC (2017)
Lyme disease	MI				422	Carditis	0.8	0.1	CDC (2017)
Lyme disease	MI				714	Arthritis	22.4	3.1	CDC (2017)
Lyme disease	MI TOTAL	0.0		0.0			156.8	11.1	
All. Pollen	NC	0		3.5	493.XX	ED Visit, Asthma	183.1	1149.0	Anenberg et al. (2017), Sun et al. (2016)
All. Pollen	NC TOTAL	0.0		3.5			183.1	1,149.0	
Extr. weather	OH	8	NOAA HazStat (2012), Ohio State Emergency Operations Center (2012)		493.XX	Asthma	18.0	113.0	Brokamp et al. (2017)
Extr. Weather	OH				001-009	Gastrointestinal Illness	8.3	147.0	Brokamp et al. (2017)
Extr. Weather	OH				686.9	Skin and Soft Tissue Infection	8.9	83.0	Brokamp et al. (2017)
Extr. Weather	OH				460–465, 466.0	Acute Respiratory Infection	2.0	0.0	Beer et al. (2015)
Extr. weather	OH TOTAL	8.0		0.0			37.2	342.9	
Extr. heat	WI	27	Christenson et al. (2013)	0.0	992.0	Heat Stroke and Sunstroke	29.1	17.9	CDC Environmental Public Health Tracking (2012)
Extr. heat	WI				992.1	Heat Syncope	1.5	17.9	CDC Environmental Public Health Tracking (2012)
Extr. heat	WI				992.2	Heat Cramps	1.5	17.9	CDC Environmental Public Health Tracking (2012)
Extr. heat	WI				992.3	Heat Exhaustion, Anhydrotic	1.5	17.9	CDC Environmental Public Health Tracking (2012)
Extr. heat	WI				992.4	Heat Exhaustion, Salt Depletion	1.5	17.9	CDC Environmental Public Health Tracking (2012)
Extr. heat	WI				992.5	Heat Exhaustion, Unspecified	52.4	722.8	CDC Environmental Public Health Tracking (2012)
Extr. heat	WI				992.6	Heat Fatigue, Transient	1.5	17.9	CDC Environmental Public Health Tracking (2012)
Extr. heat	WI				992.7	Heat Edema	1.5	17.9	CDC Environmental Public Health Tracking (2012)

Extr. heat	WI				992.8	Other Specified Heat Effects	1.5	17.9	CDC Environmental Public Health Tracking (2012)
Extr. heat	WI				992.9	Unspecified Effects Heat and Light	1.5	17.9	CDC Environmental Public Health Tracking (2012)
Extr. heat	WI				E900	Excessive Heat: Weather	52.4	582.8	CDC Environmental Public Health Tracking (2012)
Extr. heat	WI				E900.9	Exposure to excessive natural heat	9.1	153.6	CDC Environmental Public Health Tracking (2012)
Extr. heat	WI TOTAL	27.0		0.0			155.0	1,620.0	
Ozone	NV	97.0	Cromar et al. (2016)	0.0	518.81	HA Respiratory	26.1	95.7	Cromar et al. (2016)
Ozone	NV				518.89	HA Chronic Lung Disease	72.2	26.1	Cromar et al. (2016)
Ozone	NV				493.XX	ED Visit, Asthma	15.3	72.2	Cromar et al. (2016)
Ozone	NV TOTAL	97.0		0.0			113.6	194.0	
WNV	TX	89.0	CDC (2012)		66.4	Fever	1,057.2	1868.0	Chung et al. (2013)
WNV	TX				322.9	Meningitis	182.9	361.4	Chung et al. (2013)
WNV	TX				66.41	Encephalitis	377.9	431.8	Chung et al. (2013)
WNV	TX				344.89	Acute flaccid paralysis	3.3	4.7	Chung et al. (2013)
WNV	TX				378.52	Cranial nerve palsy	6.2	14.1	Chung et al. (2013)
WNV	TX TOTAL	89.0		0.0			1,627.5	2,680.0	
Wildfires	CO	3.0	NOAA (2012), Munich RE (2017)	0.04	493–786.07	Asthma & Wheeze (all ages)	156.1	838.3	Alman et al. (2016), Fann et al. (2018)
Wildfires	CO	170.6	Fann et al. (2018)	0.01	460–465, 466.0	Upper Respiratory Infection	5.7	316.6	Alman et al. (2016), Fann et al. (2018)
Wildfires	CO			0.08	480–486	Pneumonia	56.7	126.7	Alman et al. (2016), Fann et al. (2018)
Wildfires	CO				490	Bronchitis	0.9	62.1	Alman et al. (2016), Fann et al. (2018)
Wildfires	CO			0.03	491, 492, 496	COPD	1.1	15.5	Alman et al. (2016), Fann et al. (2018)
Wildfires	CO				460–465, 466.0, 466.1, 466.11, 466.19, 480–486, 487, 488, 490, 491, 492, 496,	Respiratory Disease (all ages)	0.7	3.9	Alman et al. (2016), Fann et al. (2018)

					493–786.07				
Wildfires	CO			0.2	410	Acute myocardial infarction	35.1	68.5	Alman et al. (2016), Fann et al. (2018)
Wildfires	CO TOTAL	173.6		0.3			256.4	1,431.7	
HABs	FL	0		0.0	460–465, 466.0, 466.1, 466.11, 466.19, 480–486, 487, 488, 490, 491, 492, 496, 493–786.07	Respiratory Disease fall ages)	4,973.0	1,858.8	Hoagland et al. (2014)
HABs	FL				520-579.9	Digestive System Disease	6,092.8	1,998.6	Hoagland et al. (2014)
HABs	FL TOTAL	0.0		0.0			11,065.8	3,857.4	
Wildfires	WA	1	Nat'l Interagency Fire Center (2012)	0.02	493–786.07	Asthma & Wheeze (all ages)	67.3	361.6	Gan et al. (2017), Fann et al. (2018)
Wildfires	WA	243.2	Fann et al. (2018)	0.01	460-519	Respiratory	16.3	905.6	Gan et al. (2017), Fann et al. (2018)
Wildfires	WA				490	Bronchitis	0.1	5.3	Gan et al. (2017), Fann et al. (2018)
Wildfires	WA			0.09	491, 492, 496	COPD	3.1	42.1	Gan et al. (2017), Fann et al. (2018)
Wildfires	WA			0.32	410	Acute myocardial infarction	75.7	147.6	Gan et al. (2017), Fann et al. (2018)
Wildfires	WA			0.26	480-486	Pneumonia	187.9	420.0	Gan et al. (2017), Fann et al. (2018)
Wildfires	WA				410–414, 427, 428, 433–437, 440, 443, 444, 451–453	Cardiovascular disease	16.6		Gan et al. (2017), Fann et al. (2018)
Wildfires	WA				437.9	Cerebrovascular disease	1.8	4.1	Gan et al. (2017), Fann et al. (2018)
Wildfires	WA TOTAL	244.2		0.7			370.7	1897.3	
Hurricane Sandy	NJ	159 (Sandy USA total)	Diakakis et al. (2015)	0.0	410.XX	Myocardial infarction	3,546.0	0.0	Swerdel et al. (2014)

Hurricane Sandy	NJ	69.0	Swerdel et al. (2014)		362.3; 430.X; 431.X; 432.9; 433.01; 433.11; 433.21; 433.31; 433.81; 433.91; 434.01; 434.11; 434.9; 436.X; 435.X; 997.02	Stroke	1,465.0	0.0	Swerdel et al. (2014)
Hurricane Sandy	NJ				250.x0 or 250.x2	Type II Diabetes ER visits	132.0	0.0	Velez-Valle et al. (2016)
Hurricane Sandy	NJ				E877	Open Wounds (ED visits) 65+	189.0	197.0	McQuade et al. (2018)
Hurricane Sandy	NJ				800–829	Fractures (ED visits) 65+	14.3	193.0	McQuade et al. (2018)
Hurricane Sandy	NJ				E916–E928	Injury Other (Ed visits) 65+	1.3	178.0	McQuade et al. (2018)
Hurricane Sandy	NJ				300.9	Mental illness (ED visits) 65+	2.4	169.0	McQuade et al. (2018)
Hurricane Sandy	NJ				924.9	Contusions (ED visits) 65+	0.2	163.0	McQuade et al. (2018)
Hurricane Sandy	NJ				840–848	Sprains and Strains (ED visits) 65+	0.2	149.0	McQuade et al. (2018)
Hurricane Sandy	NJ				V51.89	Unspecified and Aftercare (ED visits) 65+	0	134.0	McQuade et al. (2018)
Hurricane Sandy	NJ				V89	Suspected Conditions (ED visits) 65+	0	109.0	McQuade et al. (2018)
Hurricane Sandy	NJ				536.9	Functional Digestive Issues (ED visits) 65+	22.7	103.0	McQuade et al. (2018)
Hurricane Sandy	NJ				466.19	Bronchitis (Unspecified) (ED visits) 65+	9.7	82.0	McQuade et al. (2018)
Hurricane Sandy	NJ				250	Diabetes (ED visits) 65+	2.1	65.0	McQuade et al. (2018)
Hurricane Sandy	NJ				465.9	Acute Upper Respiratory Illness (ED visits) 65+	0.4	46.0	McQuade et al. (2018)
Hurricane Sandy	NJ				276.9	Fluid Imbalance (ED visits) 65+	11.9	45.0	McQuade et al. (2018)
Hurricane Sandy	NJ				592	Calculus of Kidney and Ureter (ED visits) 65+	2.2	41.0	McQuade et al. (2018)
Hurricane Sandy	NJ				715.09	Osteoarthritis and Allied Disorders (ED visits) 65+	3.3	31.0	McQuade et al. (2018)
Hurricane Sandy	NJ				E880–E888	Falls (in 2013) ED and Hospital discharge	7.6	78.0	Marshall et al. (2016)
Hurricane Sandy	NJ				E920	Cut/pierce injury ED and hospital discharge	3.4	34.0	Marshall et al. (2016)
Hurricane Sandy	NJ				E916, E917	Struck by/against ED and Hospital discharge	0.3	17.0	Marshall et al. (2016)

Hurricane Sandy	NJ				E927	Overexertion ED and Hospital discharge	0.3	31.0	Marshall et al. (2016)
Hurricane Sandy	NJ				CM 585.6	ED visit for end-stage renal disease	99.5	155.0	Kelmen et al. (2015)
Hurricane Sandy	NJ				39.95	Dialysis rec'd in ED		24.0	Kelmen et al. (2015)
Hurricane Sandy	NJ	23.0	Kelmen et al. (2015)		CM 585.6	Hospital visit for end-stage renal disease	79.0	0.0	Kelmen et al. (2015)
Hurricane Sandy	NJ				276.51, 276.50, 276.52	Dehydration HA	119.0	0.0	Swerdel et al. (2016)
Hurricane Sandy	NJ				Gen Con 5	Mental health counseling	27.0	0.0	Boscarino et al. (2013)
Hurricane Sandy	NJ				F43.10	Mental health treatment	41.0	0.0	Boscarino et al. (2013)
Hurricane Sandy	NJ				986	CO exposures to ED	14.6	164.3	Schnall et al. (2017)
Hurricane Sandy	NJ				W20.8	Tree-related injury ED visits	0.2	39.0	Marshall et al. (2018)
Hurricane Sandy	NJ TOTAL	251		0.0			5,794.7	2,247.3	
Hurricane Sandy	NY	(NY deaths counted in NJ)	Diakakis et al. (2015)		300	Anxiety (ED)	0.9	56.7	Lin et al. (2016)
Hurricane Sandy	NY				309	Adjustment	12.0	57.6	Lin et al. (2016)
Hurricane Sandy	NY				297.9	Psychosis (ED)	3.6	50.7	Lin et al. (2016)
Hurricane Sandy	NY				F30	Mood disorder (ED)	0.0	74.1	Lin et al. (2016)
Hurricane Sandy	NY				305.9	Substance abuse (ED)	4.6	266.4	Lin et al. (2016)
Hurricane Sandy	NY				V62.84	Suicide counseling (ED)	0.1	7.5	Lin et al. (2016)
Hurricane Sandy	NY				460-519	Respiratory health (ED)	16.8	303.3	Kim et al. (2016)
Hurricane Sandy	NY				991	Hypothermia	0.0	80.4	Lee et al. (2016)
Hurricane Sandy	NY				V56	Dialysis	107.2	347	Lin et al. (2014)
Hurricane Sandy	NY				V60	Homeless	0.3	55.8	Lee et al. (2016)
Hurricane Sandy	NY				V46	Ventilator	0.0	52.1	Lee et al. (2016)
Hurricane Sandy	NY				585	Kidney disease (ED)	27.9	39.0	Lee et al. (2016)
Hurricane Sandy	NY				496	COPD (ED)	1.4	23.3	Lee et al. (2016)
Hurricane Sandy	NY				V68	Admin Encounter (ED)	0.0	22.5	Lee et al. (2016)
Hurricane Sandy	NY				304	Drug Dependence (ED)	2.0	19.8	Lee et al. (2016)
Hurricane Sandy	NY				403	Hypertensive Kidney Disease (ED)	12.0	13.6	Lee et al. (2016)
Hurricane Sandy	NY				515	Pulmonary Fibrosis	9.8	13.1	Lee et al. (2016)
Hurricane Sandy	NY				994	External Exposure (ED)	1.6	10.5	Lee et al. (2016)
Hurricane Sandy	NY				276	Electrolyte Abnormality (ED)	4.3	5.4	Lee et al. (2016)

Hurricane Sandy	NY				250	Diabetes (ED)	0.8	4.7	Lee et al. (2016)
Hurricane Sandy	NY				All	Elderly ED visits	0.0	10.3	Gotanda et al. (2015)
Hurricane Sandy	NY				CM 585.6	ED visit for end-stage renal disease	90.8	141.4	Kelmen et al. (2015)
Hurricane Sandy	NY				39.95	Dialysis rec'd in ED	0.0	21.5	Kelmen et al. (2015)
Hurricane Sandy	NY	21.4	Kelmen et al. (2015)		CM 585.6	Hospital visit for end-stage renal disease	72.5	0.0	Kelmen et al. (2015)
Hurricane Sandy	NY				986	CO Exposure ED	22.0	248.0	Schnall et al. (2017)
Hurricane Sandy	NY				482.84	Legionellosis	0.0	1.0	Greene et al. (2013)
Hurricane Sandy	NY				V60.0, 60.1	ED for homelessness	1.7	133.0	Doran et al. (2016)
Hurricane Sandy	NY				250.00-250.93	ED for Diabetes	6.6	190.3	Lee et al. (2016)
Hurricane Sandy	NY				881	Nonfatal injuries	0.4	58.0	Brackbill et al. (2014)
Hurricane Sandy	NY				388.7	ENT HAs	15.7	15.7	Mongin et al. (2017)
Hurricane Sandy	NY				518.81	Respiratory HAs	379.4	0.0	Mongin et al. (2017)
Hurricane Sandy	NY				238.79	Myeloproliferative /neoplasm HAs	10.3	0.0	Mongin et al. (2017)
Hurricane Sandy	NY				309.81	Mental disorder HAs	0.6	0.0	Mongin et al. (2017)
Hurricane Sandy	NY				634, 640	Threatened or spontaneous aborton	0.1	9.9	Xiao et al. (2019)
Hurricane Sandy	NY				644	Threatened or early delivery	1.3	10.5	Xiao et al. (2019)
Hurricane Sandy	NY TOTAL	21.4 (in addition to NY deaths already counted in NJ)		0.0			806.8	2,426.3	

Table S1. Health incidence data and corresponding sources for valuation analysis. Red text indicates imputed counts, "XX" indicates all numeric values between 0 and 99. Column totals may not equal component sums due to rounding.

Sensitivity Analysis Methods

For each case study, we also conducted a sensitivity analysis of morbidity and mortality impacts to illuminate uncertainty in our estimates (see Supplemental Table S2). For mortality cost estimates, we considered low and high estimates within the range of labor market values ($1.05-24.4 million in 2018 dollars) from willingness to pay-derived estimates for the VSL (U.S. Environmental Protection Agency, 2010). While a central VSL estimate is commonly employed in regulatory impact analyses conducted by the US government (U.S. Environmental Protection Agency, 2015), alternate VSL methods provide a more dynamic estimate of an individual's willingness to experience a change in the risk of premature death depending on baseline health status and age.

For sensitivity analyses of our cost estimates of human morbidity, we considered alternate estimation approaches. For all case studies, we considered an alternate average estimate of the number of days of work missed due to illness from the National Health Interview Survey (U.S. Centers for Disease Control and Prevention, 2013), and applied this hospital LOS estimate to all HAs and EDs before calculating lost wages, rather than the diagnosis-specific LOS values derived from HCUP. For a subset of health studies in New Jersey and Ohio that included upper and lower 95% confidence intervals for excess HA and ED incidence, we used these values in alternate incidence estimates. For Nevada, our sensitivity analysis considered health-related costs in counties exceeding the less health-protective, current NAAQS 8-hour standard for ozone (70 parts per billion, ppb), instead of the threshold applied in the main analysis (60 ppb). For Florida, we substituted HA and ED cost estimates from the original study (Hoagland et al., 2014) for HCUP-estimated costs. For Michigan, we considered probable Lyme disease cases as determined by the state, in addition to confirmed ones (Michigan Department of Community Health, 2013). See Supplemental Table S2 for the full results of the sensitivity analyses.

Sensitivity Analysis Results

Although some of the health incidence data we utilized provided estimates of uncertainty, we were unable to calculate 95% confidence intervals for our cost estimates because of our combination of data from epidemiologic studies and the range of data sources identified in Figure 2; rather, the ranges listed in Supplemental Table S2 are driven by alternate approaches to estimating incidence, VSL and LOS (see Sensitivity Analysis Methods above). Our estimate of lost wages (Table 4 in the main text) may be too high because we included all HAs and EDs (rather than a fraction representing the working-age population) in this calculation. However, we only included lost wages for individuals who sought medical care and for conditions that HCUP provided LOS information for; many more people not included in these estimates may have lost wages from climate change-induced illnesses, for example working adult caregivers who stayed home from work to care for sick children or older adults.

(A) State	(B) Event	(C) Deaths	(D) Mortality (Lower Bound)	(E) Mortality (Upper Bound)	(F) Wage Sensitivity	(G) Morbidity Sensitivity	(H) Total (Lower Bound)	(I) Total (Higher Bound)
		(millions of 2018 dollars)						
MI	Lyme Disease	0	$0	$0	$0.003	$7.9	$7.9	$9.7
NC	Allergenic Pollen	4	$4.2	$97.7	$3.6	$5.8	$13.6	$107.1

OH	Extreme Weather	8	$8.3	$195.3	$0.09	$13.4	$21.8	$208.8
WI	Extreme Heat	27	$28.3	$659.2	$0.4	$4.8	$61.5	$664.4
FL	Harmful Algal Blooms	0	$0	$0	$3.6	$233.1	$236.7	$557.0
NV	Ground-level Ozone	97	$101.9	$2,373.0	$0.1	$3.6	$105.6	$2,376.7
TX	West Nile Virus	89	$93.3	$2,172.8	$1.0	$274.3	$368.6	$2,448.2
CO	Wildfires	174	$182.3	$4,246.8	$0.4	$22.5	$205.2	$4,269.7
WA	Wildfires	245	$256.7	$5,979.8	$0.5	$54.6	$311.9	$6,035.0
NJ	Hurricane Sandy	273*	$286.1	$6,664.9	1.9	$1,033.3	$1,321.3	$7,700.1
NY			$0	$0	$0.8	$109.2	$110.0	$222.3
ALL		**917**	**$961.2**	**$22,389.4**	**$12.6**	**$1,762.6**	**$2,736.3**	**$24,599.0**

Table S2. Sensitivity analysis for estimated health-related costs of 2012 case studies (millions of 2018 dollars). Columns D and E represent mortality valuation using alternate value of a statistical life (VSL) estimates. Column F represents alternate approach to estimating hospital length of stay (LOS) and associated lost wages. Column G represents alternate approach to estimating HA and ED incidence. Column H equals sum of columns D, F, and G. Column I equals sum of columns E, F, and G. For more information on sensitivity analysis methods, see supplemental text. Row and column totals may not equal component sums due to rounding. *Hurricane Sandy mortality estimate includes deaths reported from Pennsylvania, West Virginia, Connecticut, Maryland, and those not classified by state (Diakakis et al., 2015).

Discussion Notes

While the costs associated with ED visits dominated morbidity costs in most states, all events involved hospitalizations and outpatient medical needs (outpatient care, home health visits, and prescribed medications) that, in cost terms, greatly exceeded the more immediate lost wages related to HAs and ED visits (Table 4 and Figure 3 in the main text). This effect may be due to the limited subset of health outcomes considered; given the variety of climate-sensitive health risks we face and the paucity of linkages between existing HA and ED data and climate change-related environmental exposure data, fuller consideration of human morbidity risks and costs over the months following such exposures remains an important area for future study. Interestingly, the relative shares of morbidity cost components are more comparable in the two states experiencing widespread wildfires (Colorado and Washington, see Figure 3 in the main text) than the two states for which we analyzed the effects of Hurricane Sandy. This distinction appears to stem from the close alignment in the overall range of health effects examined between Colorado and Washington as compared to cost divergence between New Jersey and New York.

Although weather conditions in any particular year may fluctuate, the long-term trends in climate-driven extreme weather events and the underreporting of certain health conditions are not in question. For example, beyond extreme heat impacts in Wisconsin (Table 3 in the main text), 24 other states had at least ten times more record high temperatures than record lows in

2012 (Climate Central, 2012), and at least 722 heat-related deaths and 35,123 heat-related ED visits occurred nationwide (U.S. Centers for Disease Control and Prevention, n.d.). Moreover, (Hess et al., 2014), analyzing data from 2006-2010, estimated about 65,299 ED annual visits for acute heat illness nationally.

This work further illuminates the urgency of actions to respond to climate change and highlights the need for robust public health preparedness and surveillance and tracking efforts to monitor climate-sensitive health conditions.

State vs. National Health Impacts

	State-Level Case Study Estimate	National Estimate	State-Level Case Study Share of National Estimate
Lyme Disease (cases)	80	22,014	0.4%
Allergenic Oak Pollen (ED visits)	1,149	21,200	5.4%
Extreme Weather (deaths)	8	79	10.1%
Extreme Heat (deaths)	27	722	3.7%
Ozone (deaths)	97	6,410	1.5%
West Nile Virus (deaths)	89	286	31.1%
Wildfires (deaths)	419	12,810	3.3%
Hurricanes (deaths)	273	281	97.2%

Table S3. Comparison of state-level case study health impacts to national estimates (data used for Figure 4 in main text).

References for Supplemental Material

Bandala, E. R., Kebede, K., Jonsson, N., Murray, R., Green, D., Mejia, J. F., & Martinez-Austria, P. F. (2019). Extreme heat and mortality rates in Las Vegas, Nevada: inter-annual variations and thresholds. *International Journal of Environmental Science and Technology*. https://doi.org/10.1007/s13762-019-02357-9

Brackbill, R. M., Caramanica, K., Maliniak, M., Stellman, S. D., Fairclough, M. A., Farfel, M. R., et al. (2014). Nonfatal Injuries 1 Week After Hurricane Sandy — New York City Metropolitan Area, October 2012, *63*(42), 5.

120 Chakraborty, J., Collins, T. W., Montgomery, M. C., & Grineski, S. E. (2014). Social and Spatial
121 Inequities in Exposure to Flood Risk in Miami, Florida. *Natural Hazards Review*, *15*(3),
122 04014006. https://doi.org/10.1061/(ASCE)NH.1527-6996.0000140
123 Chakraborty, J., Collins, T. W., & Grineski, S. E. (2019). Exploring the Environmental Justice
124 Implications of Hurricane Harvey Flooding in Greater Houston, Texas. *American Journal*
125 *of Public Health*, *109*(2), 244–250. https://doi.org/10.2105/AJPH.2018.304846
126 Climate Central. (2012, September 12). 2012 Record Temperatures: Which States Led the
127 Nation. Retrieved June 26, 2019, from https://www.climatecentral.org/news/2012-
128 record-temperatures-which-states-led-the-nation-14951
129 Davies, B. W., Smith, J. M., Hink, E. M., & Durairaj, V. D. (2017). Increased Incidence of Rhino-
130 Orbital-Cerebral Mucormycosis After Colorado Flooding. *Ophthalmic Plastic and*
131 *Reconstructive Surgery*, *33*, S148–S151.
132 https://doi.org/10.1097/IOP.0000000000000448
133 Declet-Barreto, J., Knowlton, K., Jenerette, G. D., & Buyantuev, A. (2016). Effects of Urban
134 Vegetation on Mitigating Exposure of Vulnerable Populations to Excessive Heat in
135 Cleveland, Ohio. *Weather, Climate, and Society*, *8*(4), 507–524.
136 https://doi.org/10.1175/WCAS-D-15-0026.1
137 Diakakis, M., Deligiannakis, G., Katsetsiadou, K., & Lekkas, E. (2015). Hurricane Sandy mortality
138 in the Caribbean and continental North America. *Disaster Prevention and Management:*
139 *An International Journal*, *24*(1), 132–148. https://doi.org/10.1108/DPM-05-2014-0082

Greenstone, M., Kopits, E., & Wolverton, A. (2013). Developing a Social Cost of Carbon for US Regulatory Analysis: A Methodology and Interpretation. *Review of Environmental Economics and Policy*, *7*(1), 23–46. https://doi.org/10.1093/reep/res015

Hess, J. J., Saha, S., & Luber, G. (2014). Summertime Acute Heat Illness in U.S. Emergency Departments from 2006 through 2010: Analysis of a Nationally Representative Sample. *Environmental Health Perspectives*, *122*(11), 1209–1215. https://doi.org/10.1289/ehp.1306796

Hoagland, Jin, D., Beet, A., Kirkpatrick, B., Reich, A., Ullmann, S., et al. (2014). The human health effects of Florida Red Tide (FRT) blooms: An expanded analysis. *Environment International*, *68*, 144–153. https://doi.org/10.1016/j.envint.2014.03.016

Isaksen, T. B., Yost, M., Hom, E., & Fenske, R. (2014). Projected health impacts of heat events in Washington State associated with climate change. *Reviews on Environmental Health*, *29*(1–2), 119–123. https://doi.org/10.1515/reveh-2014-0029

Keim, M. E. (2008). Building Human Resilience. *American Journal of Preventive Medicine*, *35*(5), 508–516. https://doi.org/10.1016/j.amepre.2008.08.022

Kishore, N., Marqués, D., Mahmud, A., Kiang, M. V., Rodriguez, I., Fuller, A., et al. (2018). Mortality in Puerto Rico after Hurricane Maria. *New England Journal of Medicine*, *379*(2), 162–170. https://doi.org/10.1056/NEJMsa1803972

Kornhuber, K., Osprey, S., Coumou, D., Petri, S., Petoukhov, V., Rahmstorf, S., & Gray, L. (2019). Extreme weather events in early summer 2018 connected by a recurrent hemispheric wave-7 pattern. *Environmental Research Letters*, *14*(5), 054002. https://doi.org/10.1088/1748-9326/ab13bf

Kovach, M. M., Konrad, C. E., & Fuhrmann, C. M. (2015). Area-level risk factors for heat-related illness in rural and urban locations across North Carolina, USA. *Applied Geography*, *60*, 175–183. https://doi.org/10.1016/j.apgeog.2015.03.012

McQuade, L., Merriman, B., Lyford, M., Nadler, B., Desai, S., Miller, R., & Mallette, S. (2018). Emergency Department and Inpatient Health Care Services Utilization by the Elderly Population: Hurricane Sandy in The State of New Jersey. *Disaster Medicine and Public Health Preparedness*, 1–9. https://doi.org/10.1017/dmp.2018.1

Michigan Department of Community Health. (2013, June). Michigan Zoonotic & Vector-Borne Disease Surveillance Summary. Retrieved June 26, 2019, from https://www.michigan.gov/documents/emergingdiseases/LD_2012_summary_432339_7.pdf

Mora, C., Spirandelli, D., Franklin, E. C., Lynham, J., Kantar, M. B., Miles, W., et al. (2018). Broad threat to humanity from cumulative climate hazards intensified by greenhouse gas emissions. *Nature Climate Change*. https://doi.org/10.1038/s41558-018-0315-6

Ricke, K., Drouet, L., Caldeira, K., & Tavoni, M. (2018). Country-level social cost of carbon. *Nature Climate Change*, *8*(10), 895–900. https://doi.org/10.1038/s41558-018-0282-y

Salas, R. N., Jacobs, W., & Perera, F. (2019). The Case of Juliana v. U.S. — Children and the Health Burdens of Climate Change. *N Engl j Med*, 3.

Santos-Burgoa, C., Sandberg, J., Suárez, E., Goldman-Hawes, A., Zeger, S., Garcia-Meza, A., et al. (2018). Differential and persistent risk of excess mortality from Hurricane Maria in Puerto Rico: a time-series analysis. *The Lancet Planetary Health*, *2*(11), e478–e488. https://doi.org/10.1016/S2542-5196(18)30209-2

Santos-Lozada, A. R., & Howard, J. T. (2018). Use of Death Counts From Vital Statistics to Calculate Excess Deaths in Puerto Rico Following Hurricane Maria. *JAMA*, *320*(14), 1491–1493. https://doi.org/10.1001/jama.2018.10929

Schatz, J., & Kucharik, C. J. (2015). Urban climate effects on extreme temperatures in Madison, Wisconsin, USA. *Environmental Research Letters*, *10*(9), 094024. https://doi.org/10.1088/1748-9326/10/9/094024

Spangler, K. R., Manjourides, J., Lynch, A. H., & Wellenius, G. A. (2019). Characterizing Spatial Variability of Climate-Relevant Hazards and Vulnerabilities in the New England Region of the United States. *GeoHealth*, *3*(4), 104–120. https://doi.org/10.1029/2018GH000179

U.S. Centers for Disease Control and Prevention. (2013). National Health Interview Survey (NHIS), 2012 Episode Public Use File (injpoiep). Retrieved June 25, 2019, from ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2012/Injpoiep_freq.pdf

U.S. Centers for Disease Control and Prevention. (n.d.). National Environmental Public Health Tracking. Retrieved June 20, 2019, from https://www.cdc.gov/nceh/tracking/default.htm

U.S. Environmental Protection Agency. (2010). *Guidelines for Preparing Economic Analyses: Mortality Risk Valuation Estimates (Appendix B)*. Retrieved from https://www.epa.gov/sites/production/files/2017-09/documents/ee-0568-22.pdf

U.S. Environmental Protection Agency. (2015). *Regulatory Impact Analysis for the Clean Power Plan Final Rule (No. EPA-452/R-15-003)*. Retrieved from

https://www3.epa.gov/ttnecas1/docs/ria/utilities_ria_final-clean-power-plan-existing-units_2015-08.pdf

U.S. Global Change Research Program. (2018). *Fourth National Climate Assessment, Volume II: Impacts, Risks, and Adaptation in the United States* (p. 1515). Washington, D.C.: US Global Change Research Program. Retrieved from https://nca2018.globalchange.gov/