Code Red: Climate Changes Health and Equity

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Natural: everything that is not man-made like the weather, mountains and rivers, and plants and animals.

Social: how we organize ourselves into a society and build communities.

Personal: the lives we to build for ourselves, where we live, what we eat, and behaviors including exercise or smoking.

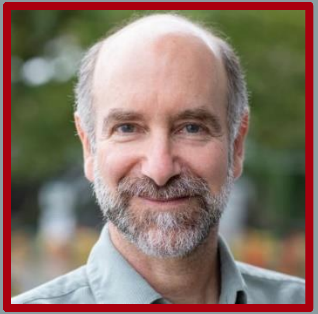
Riggs, DW, Yeager, RA, & Bhatnagar, A. (2018). Defining the human envirome: an omics approach for assessing the environmental risk of cardiovascular disease. Circulation research, 122(9), 1259-1275.

https://**envirome**institute.org

Code Red

Climate change is **the greatest threat** to human health.

Climate Change is Inherently Local



"Impacts are experienced **differently** within segments of the **population** and between **geographic** locations based on **biological**, **social**, and **economic** vulnerabilities as well as the nature of the climate **hazard**." (Patz and Thomson, 2018)

Compounding Global Emergencies

"Across the US, climate change and COVID-19 are playing out in tandem.

The warming planet drives increasingly extreme weather, compounding the pandemic's impacts and complicating disaster response.

At the same time, these dual threats have exposed the profound inequities that divide and weaken us."

Dr. Jalonne White-Newsome, 2020

Source: https://nextcity.org/daily/entry/rethink-resilience-for-the-era-of-covid-19-and-climate-change

COVID-19 Disparities

Ethnicity
- African Americans
- Latinx
- Native Americans

Age
- Older adults

Socioeconomic status
- Low income

Health status
- Heart Disease
- Diabetes
- Other chronic illnesses

Rate ratios compared to Caucasians	American Indian or Alaska Native	Asian	Black or African American	Hispanic or Latino
Cases	**1.8x**	0.6x	1.4x	**1.7x**
Hospitalization	**4.0x**	1.2x	3.7x	**4.1x**
Death	2.6x	1.1x	**2.8x**	**2.8x**

https://www.cdc.gov/coronavirus/2019-ncov/covid-data/investigations-discovery/hospitalization-death-by-race-ethnicity.html

Climate Change Multiplies Health Threats

Climate Change

Climate change **intensifies** health risks for sensitive groups.

- Children
- Older adults
- Impoverished communities
- Communities of color
- Indigenous communities
- People with a disability
- Undocumented residents
- LGBTQ+

Climate Justice

Children are Uniquely Vulnerable

The World Health Organization estimates that **88%** of the global burden of climate change falls on children **younger than 5 years old**.

(Ahdoot and Pacheco 2015)

Children are Uniquely Vulnerable

Children aren't just little adults, they:

- Have immature and developing organ systems
- Breathe in more air and take in more water per body weight
- Are completely dependent on adults to make decisions for them
- Have unique behaviors: hand-to-mouth and crawling activities
- Can be exposed via breastmilk or the placental barrier

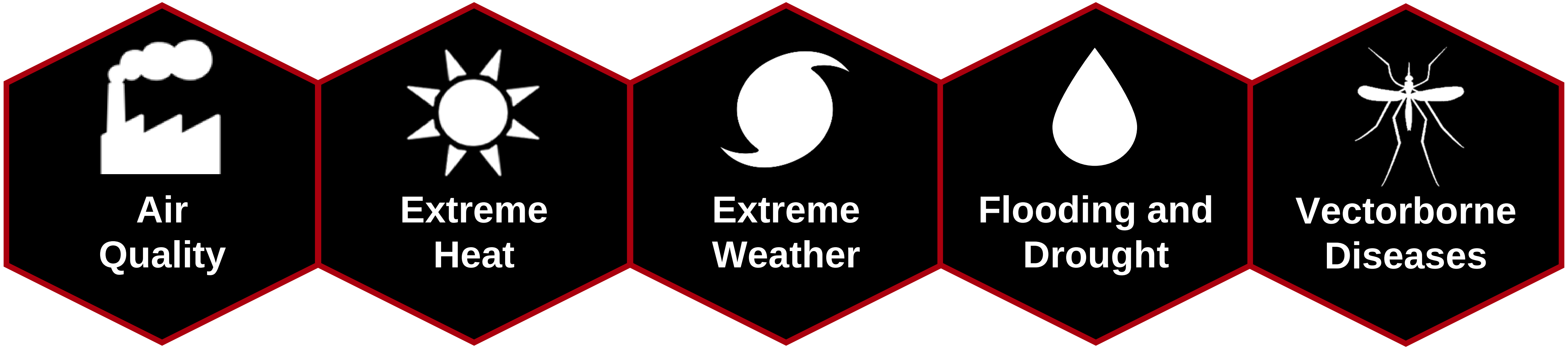
Image source: https://bit.ly/2Fk3uth

It's Not *Just* Physical Health

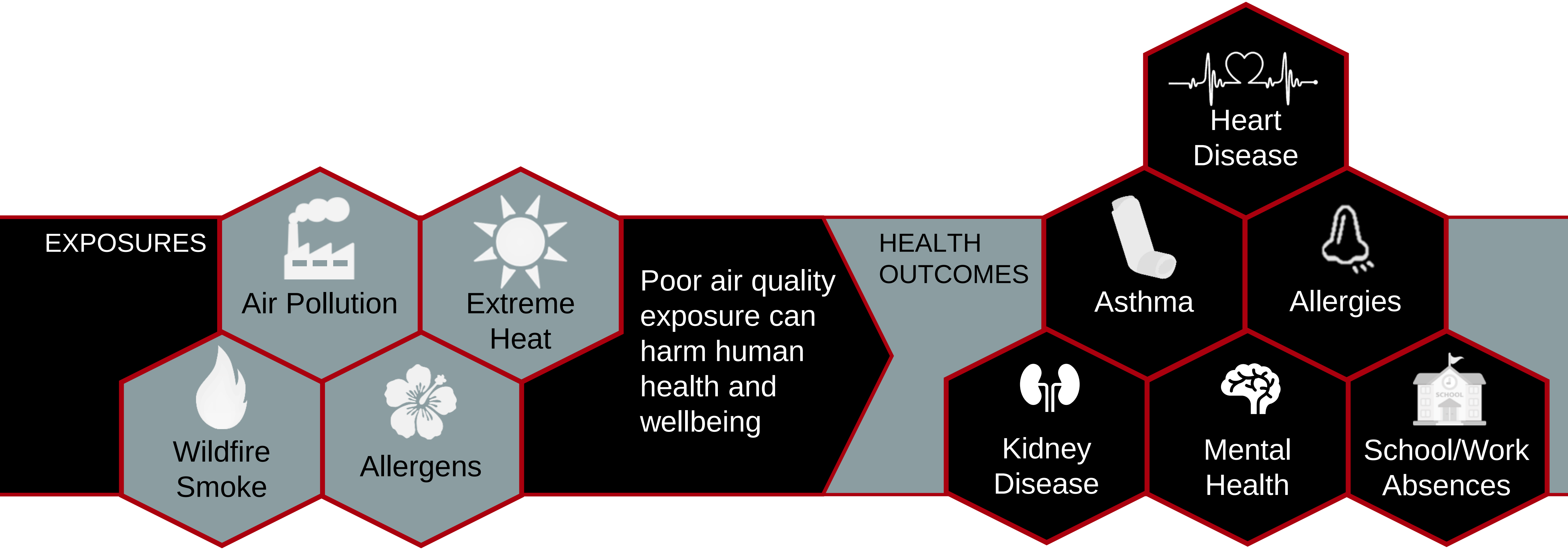
Climate change threatens mental wellness:

Stress
Anxiety
PTSD
Depression
Violence
Suicide
Medication interaction

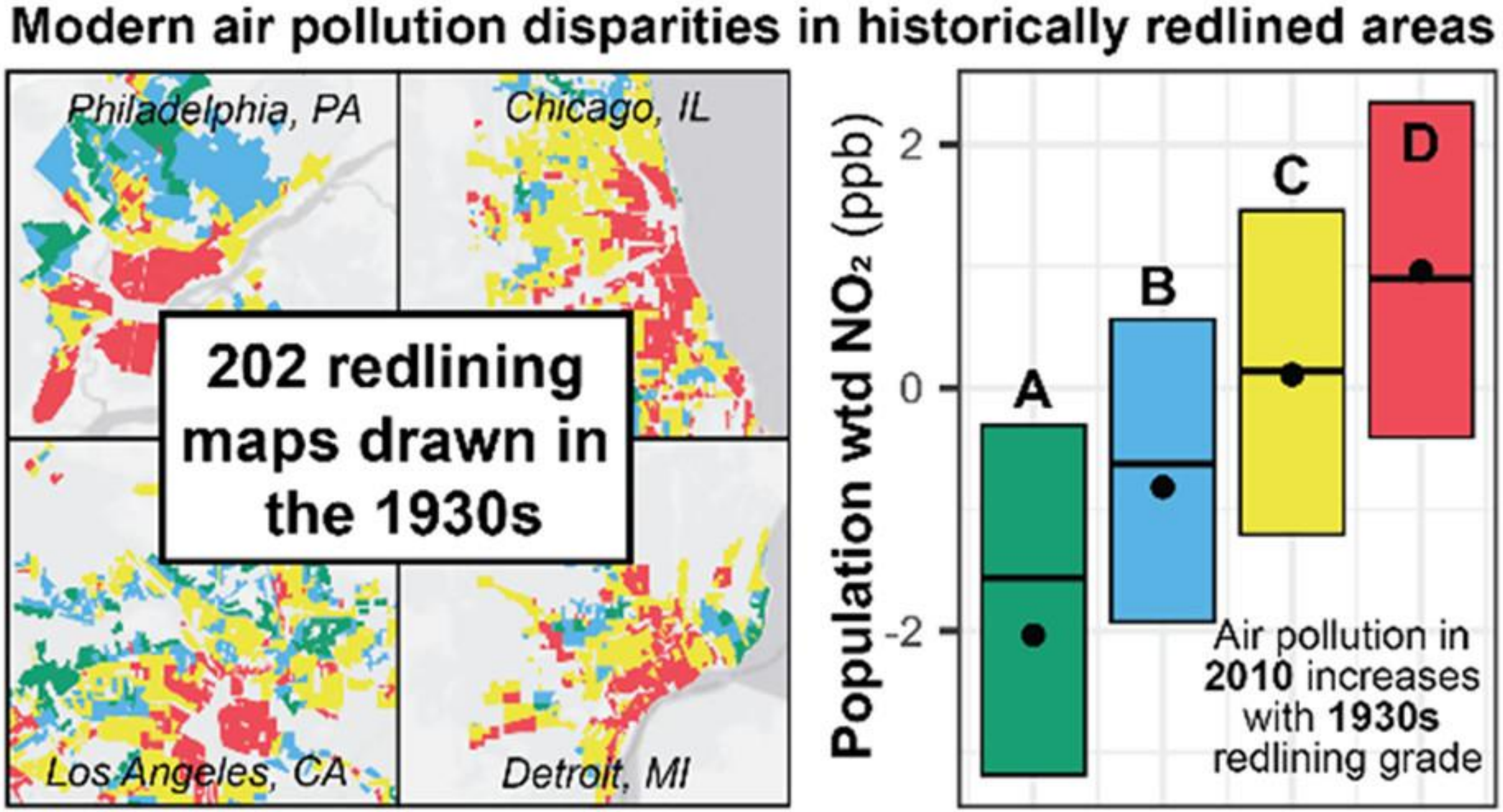
Climate Threats to Health and Equity



Air Quality

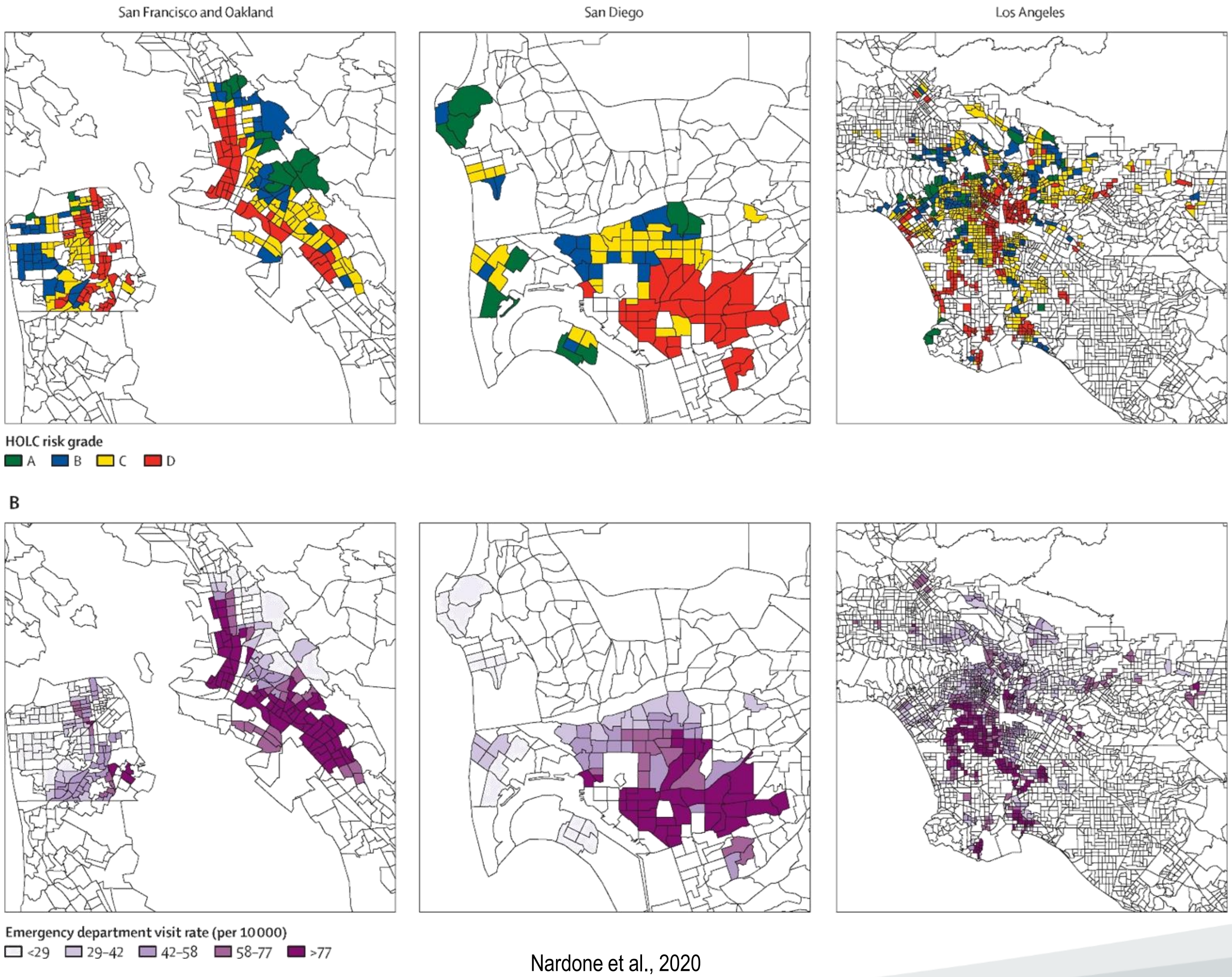

EXPOSURES
Air Pollution
Extreme Heat
Wildfire Smoke
Allergens
Poor air quality exposure can harm human health and wellbeing
HEALTH OUTCOMES
Heart Disease
Asthma
Allergies
Kidney Disease
Mental Health
School/Work Absences

Redlining and Air Quality



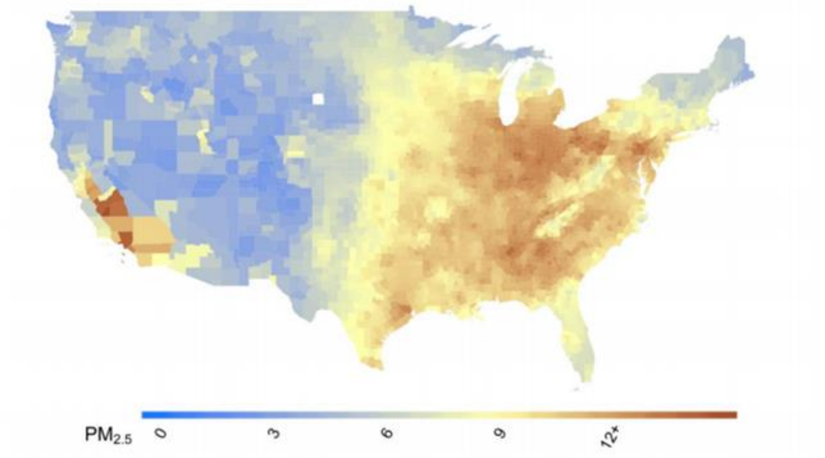
Lane et al. 2022

Redlining and Air Quality



Nardone et al., 2020

COVID-19 and Air Quality



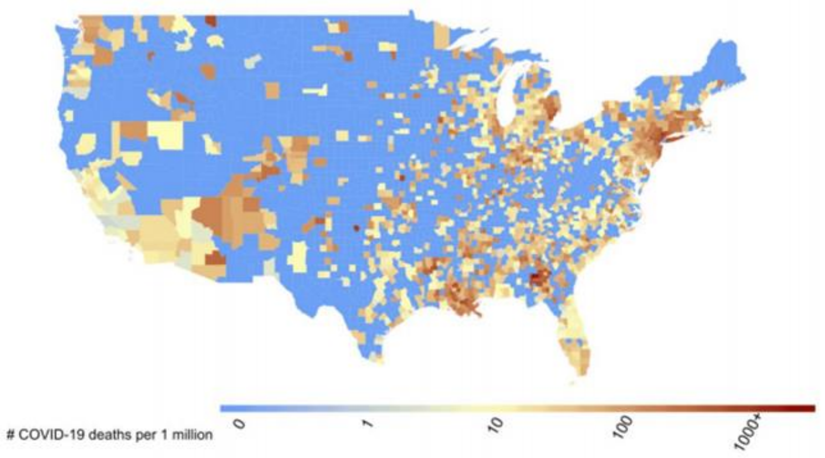
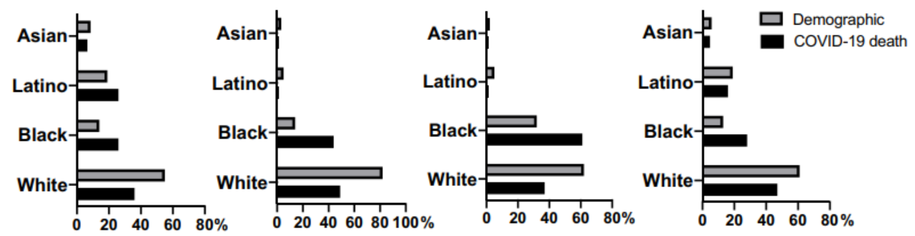


Fig 1: Maps show **(a)** county-level 17-year long-term average of $PM_{2.5}$ concentrations (2000–2016)

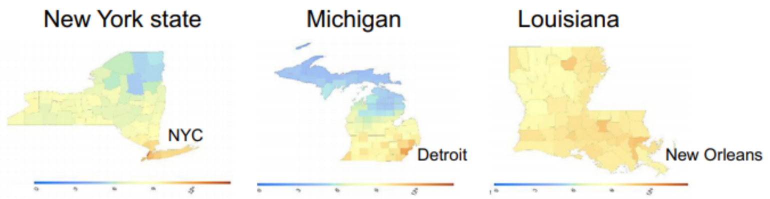
Wu et al., 2020

COVID-19 fatality rates

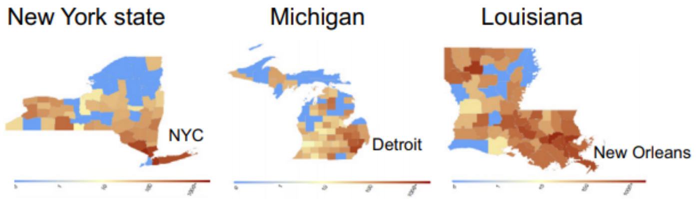


Contributing socioeconomic, racial & environmental factors:

- Structural racism
- Crowded living conditions, multi-generational homes
- Limited access to health care and healthy foods
- Working in low paying "essential" jobs
- Chronic exposure to air pollution



Yearly average $PM_{2.5}$ (g/m^3) levels



# of COVID-19 deaths per 1 million

Brandt, Beck, Mersha, 2020

COVID-19 risk factors

- Age > 65
  - Living in nursing home
- Sex (male)
- Severe obesity
- Diabetes
- Serious heart conditions
  - pulmonary hypertension
- Immunocompromise (cancer…)
- Chronic kidney disease
- Chronic liver disease
- Chronic lung disease
  - COPD
  - Severe Asthma

Regulatory Pause

EPA United States Environmental Protection Agency

Environmental Topics | Laws & Regulations | About EPA | Search EPA.gov

CONTACT US SHARE

News Releases

News Releases from Headquarters > Enforcement and Compliance Assurance (OECA)

EPA Announces Enforcement Discretion Policy for COVID-19 Pandemic

03/26/2020

Contact Information:
Press Office (press@epa.gov)

WASHINGTON (March 26, 2020) - The U.S. Environmental Protection Agency (EPA) is mindful of the health and safety of the public, as well as our staff, and those of Federal Agencies, State and Local Governments, Tribes, Regulated Entities, Contractors, and Non-governmental Organizations during the COVID-19 pandemic. The agency is taking these important considerations into account as we all continue our work to protect human health and the environment. Accordingly, EPA is announcing a temporary policy regarding EPA enforcement of environmental legal obligations during the COVID-19 pandemic.

EPA's temporary enforcement discretion policy applies to civil violations during the COVID-19 outbreak. The policy addresses different categories of noncompliance differently. For example, under the policy EPA does not expect to seek penalties for noncompliance with routine monitoring and reporting obligations that are the result of the COVID-19 pandemic but does expect operators of public water systems to continue to ensure the safety of our drinking water supplies. The policy also describes the steps that regulated facilities should

Source: https://www.epa.gov/newsreleases/epa-announces-enforcement-discretion-policy-covid-19-pandemic

Regulatory Pause

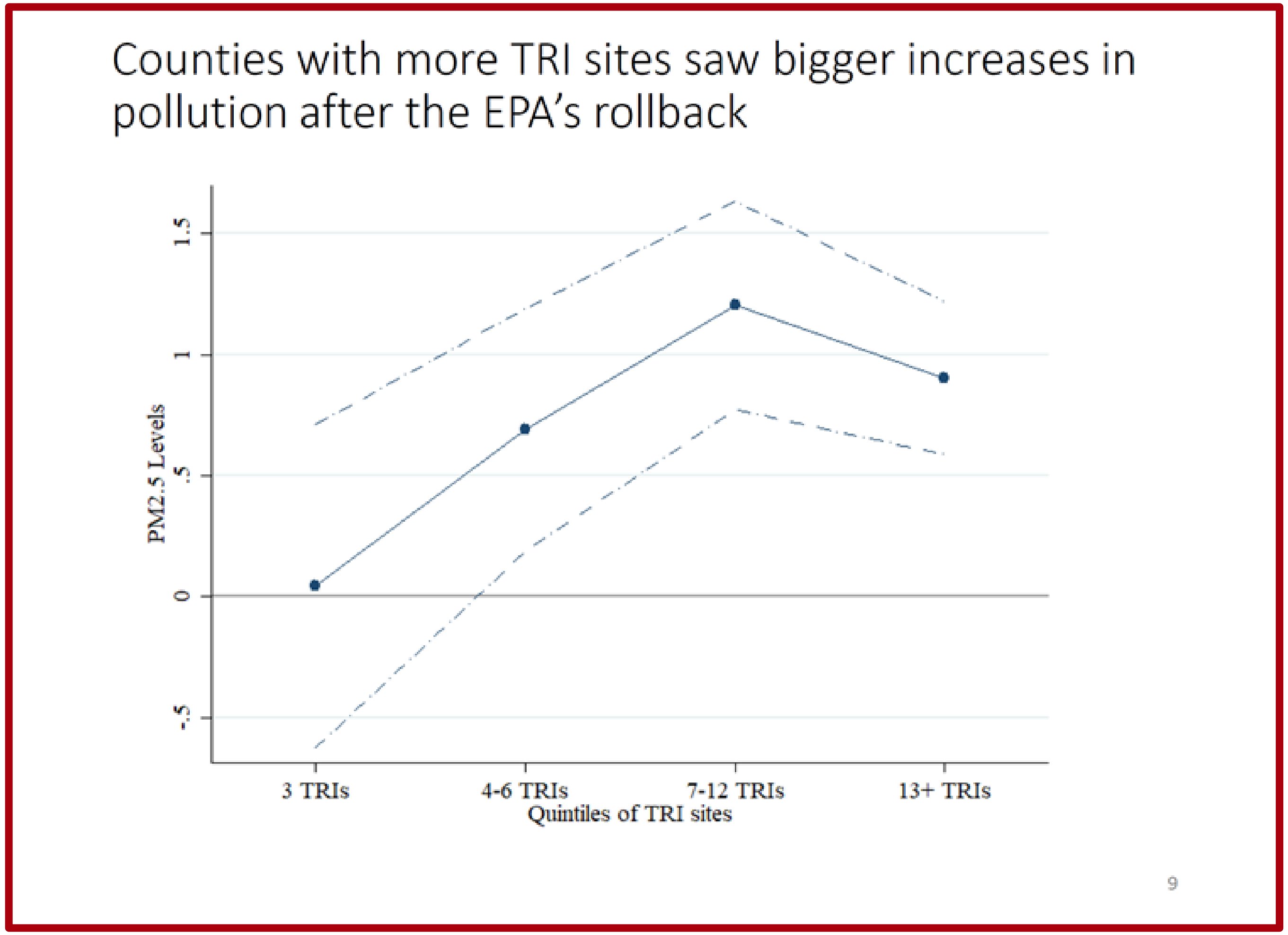
Preview of Results

- Being in a county with 6 or more TRI sites after the EPA's rollback (compared to counties with 1 to 5 TRI sites) results in:
  - 13 percent more PM2.5 pollution (about 0.8 ug/m3)
  - Increases in ozone (5% increase) and PM10 (15% increase) as well
  - A 38.8 percent increase in daily cases of COVID-19
  - A 19.1 percent increase in deaths from COVID-19
  - The effects of air pollution on COVID-19 cases and deaths are worse in counties with a higher percentage of Black individuals (a 26.1 percent increase in daily deaths vs a 4.4 percent increase).
    - This suggests that the burden of pollution exposure is unequal and might underly the racial disparities in COVID outcomes.

8

TRI = Toxic Release Inventory
Courtesy: Persico, American Lung Association Webinar July 2020

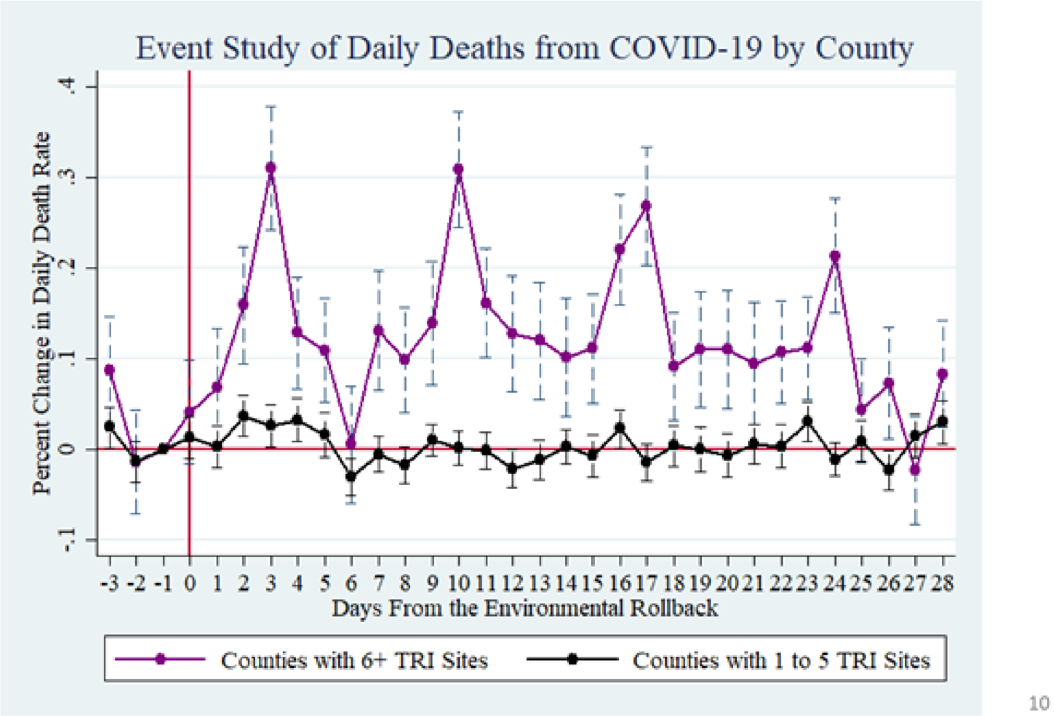
Regulatory Pause



TRI = Toxic Release Inventory
Courtesy: Persico, American Lung Association Webinar July 2020

Regulatory Pause

Counties with 6 or more TRI sites saw bigger increases in deaths than counties with fewer TRI sites after the rollback



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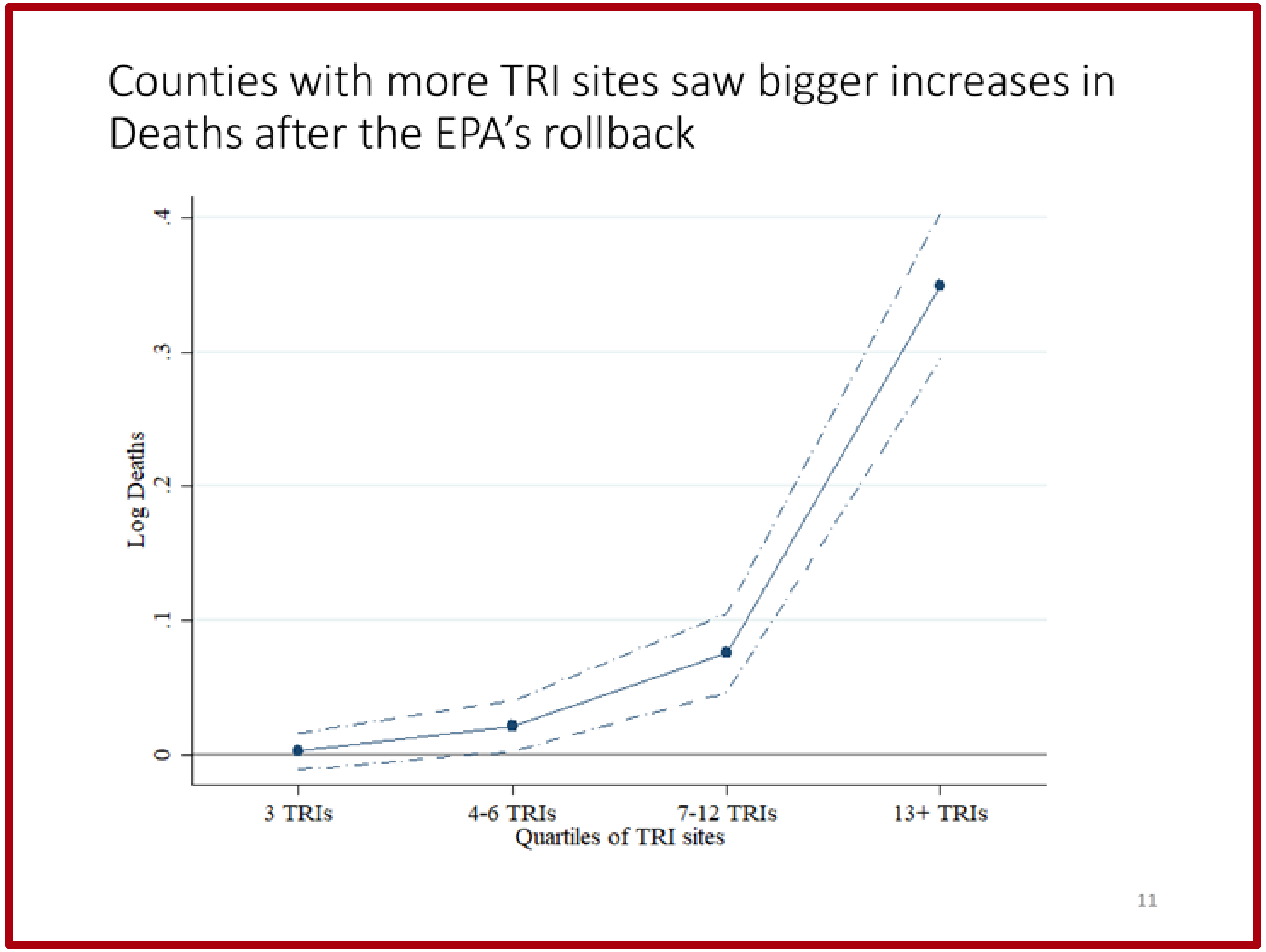
Regulatory Pause



TRI = Toxic Release Inventory
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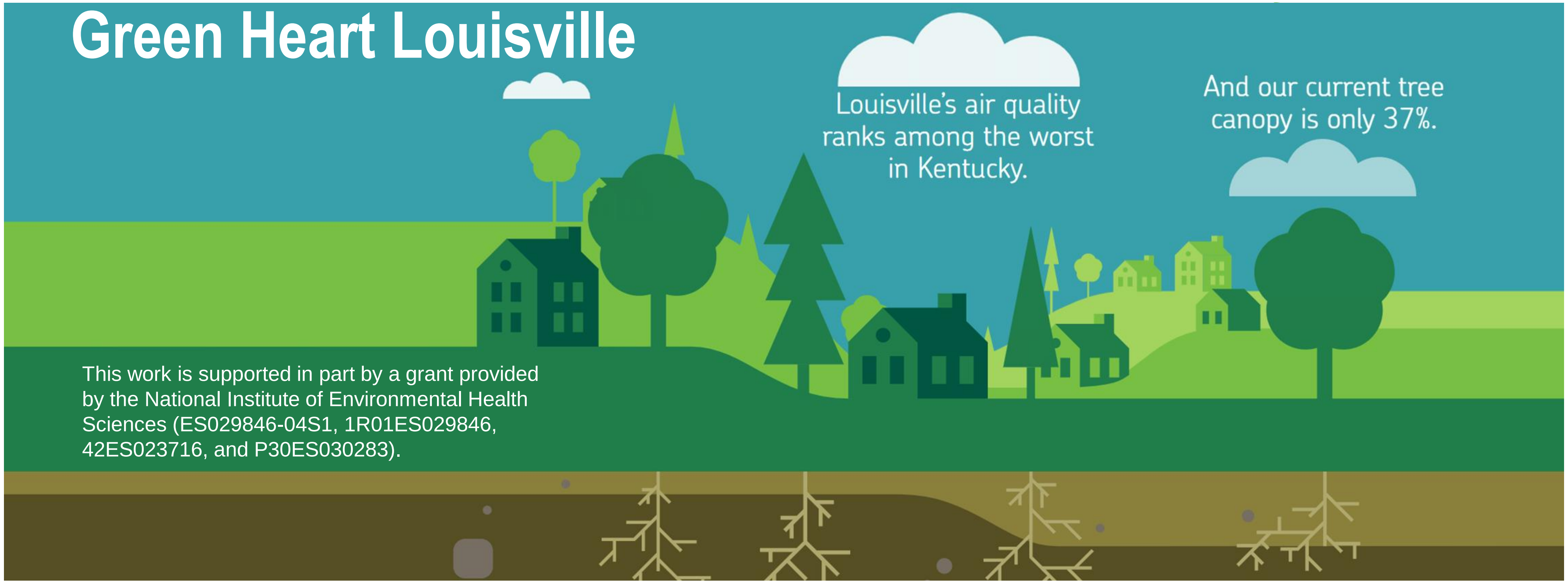
Climate Adaptation

Green Heart Louisville



This work is supported in part by a grant provided by the National Institute of Environmental Health Sciences (ES029846-04S1, 1R01ES029846, 42ES023716, and P30ES030283).

Air Quality

- Test air quality
- Disseminate alerts
- Enforce air quality regulations

Source: https://louisville.edu/**greenheart**

Extreme Heat

Heat is the **top cause** of natural weather-related death in the US. (NOAA 2017)

Climate change increases the frequency and severity of heat waves.

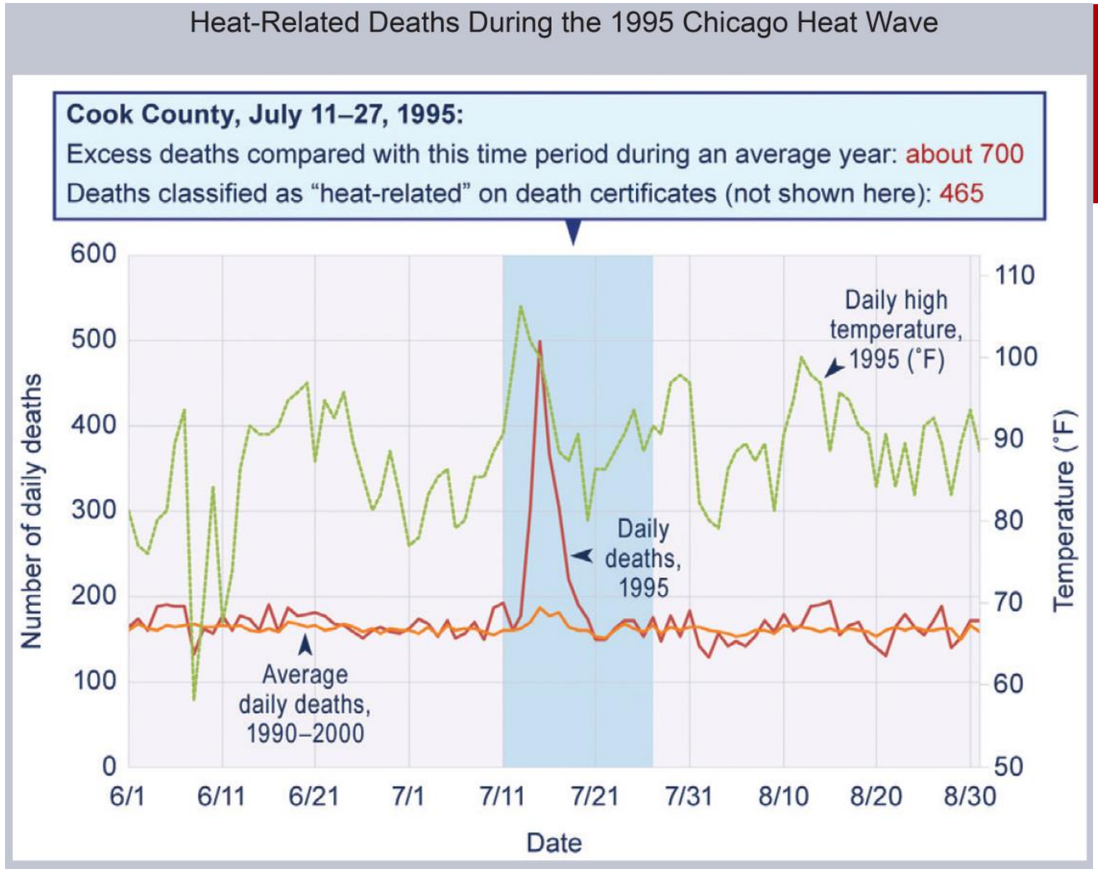
Image sources: https://bit.ly/3wqTIx9, https://bit.ly/3oBkTCo, https://bit.ly/3f4U72p

1995 Chicago Heat Wave

Source: https://www.chicagonow.com/chicago-weather-watch/2015/07/heat-wave-1995/

Source: https://static.abcotvs.com/wls/images/cms/071519-wls-cooked-4p-thumb-img.jpg

1995 Chicago Heat Wave



USGCRP, 2016

Heat waves **increase** risk of death.

Heat waves **exacerbate** inequities.

TABLE 1—Age-Specific and Age-Adjusted Heat-Related Death Rates per 100 000 Population, by Race/Ethnicity: Chicago Residents, Mid-July Heat Wave, 1995

	Non-Hispanic White		Non-Hispanic Black		Total		
Age, y	No.	Rate	No.	Rate	No.	Rate	Ratio[a]
<55	27	4	42	5	73	3	1.3
55–64	19	31	44	57	69	38	1.8
65–74	62	75	62	83	125	68	1.1
75–84	87	119	63	176	153	126	1.5
>84	47	222	45	429	94	258	1.9
Total[b]	242	11	256	17	514	12	1.5

[a]Non-Hispanic Black to non-Hispanic White ratio.
[b]Standardized to the 1940 US population.

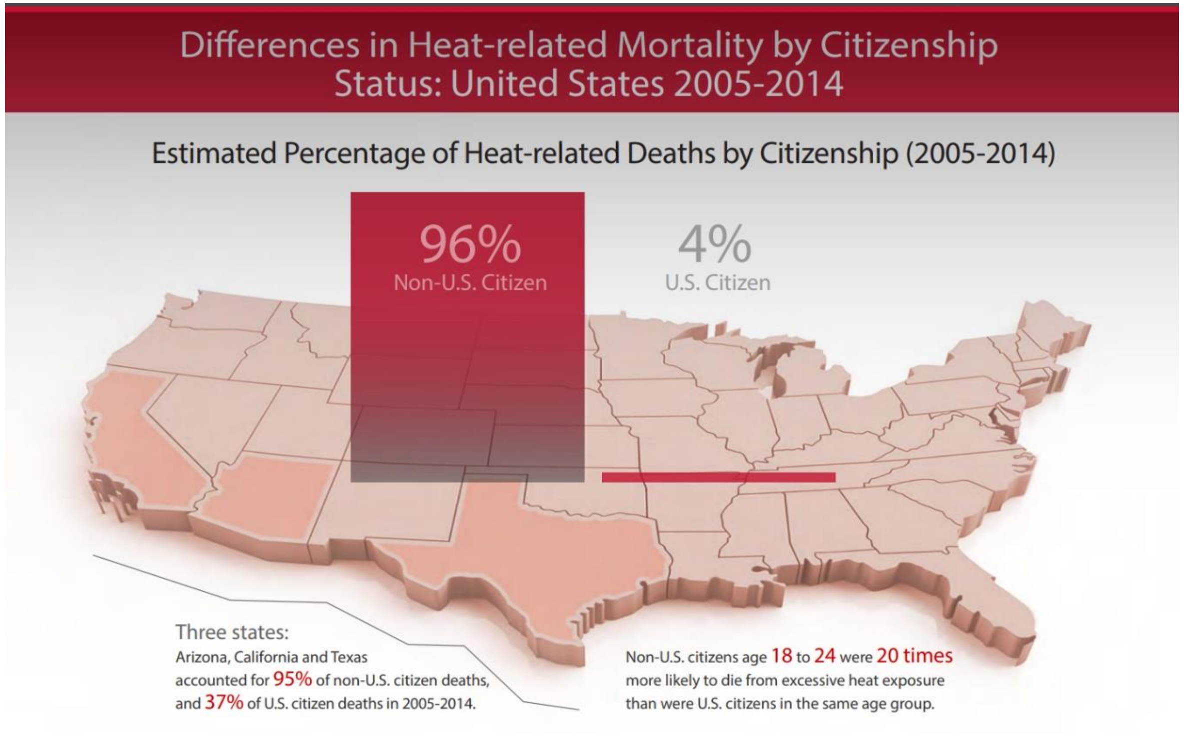
Whitman et al., 1997

Extreme Heat

TABLE 2. Number and rate of heat-related deaths,* by race/ethnicity and level of urbanization — United States, 2004–2018†

Characteristic	No. of deaths (rate)§
Race/Ethnicity¶	
Hispanic	1,349 (0.2)
American Indian/Alaska Native, non-Hispanic	241 (0.6)
Asian/Pacific Islander, non-Hispanic	194 (0.1)
Black, non-Hispanic	1,965 (0.3)
White, non-Hispanic	6,602 (0.2)
Not stated**	176 (N/A)
Level of urbanization††	
Large central metro	4,402 (0.3)
Large fringe metro	1,607 (0.1)
Medium metro	1,764 (0.2)
Small metro	990 (0.2)
Micropolitan	879 (0.2)
Noncore	885 (0.3)
Total	**10,527 (0.2)**

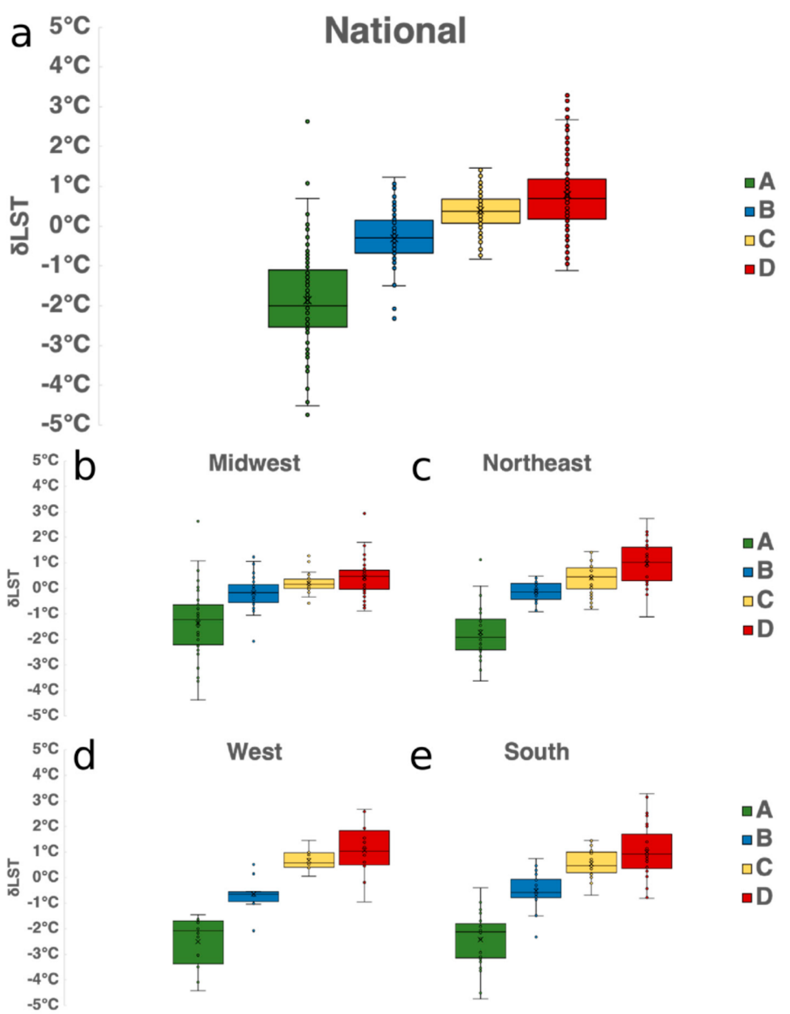
Vaidyanathan et al., 2020



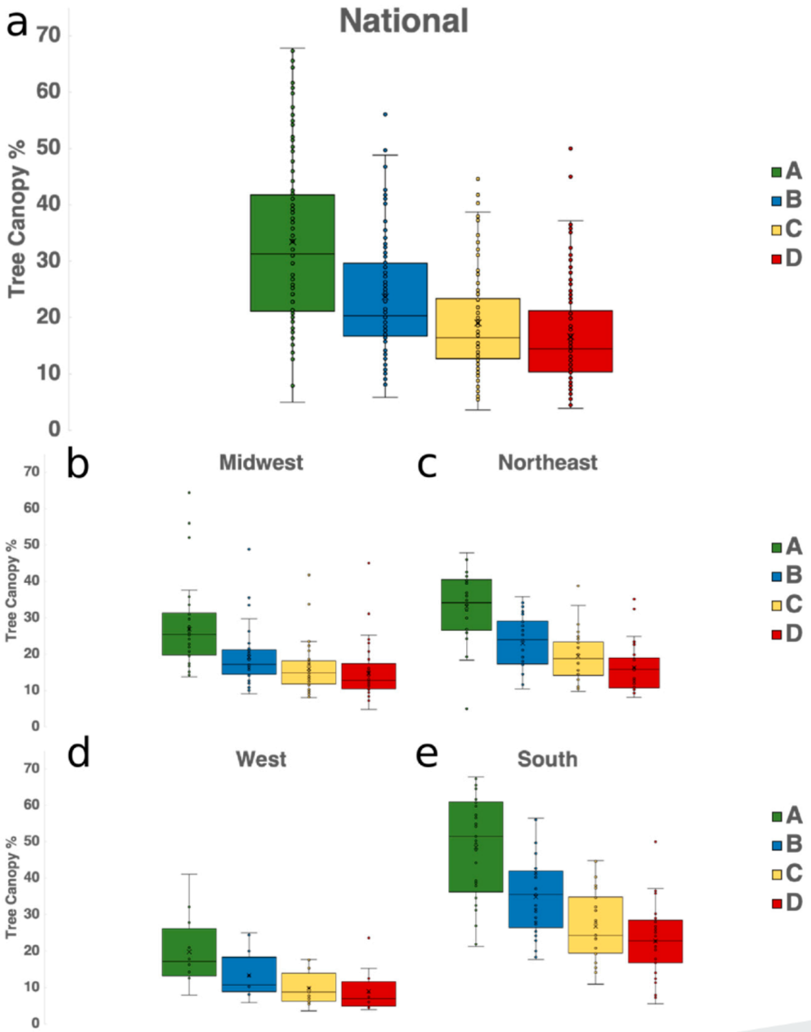
APHA, 2018
Taylor et al., 2018

Redlining and Heat

LAND SURFACE TEMPERATURE ANOMALIES



TREE CANOPY



HOLC security rating
- Green = “Best,” A;
- Blue = “Still Desirable,” B
- Yellow = “Declining,” C
- Red = “Hazardous,” D

Hoffman et al, 2020

Urban Heat Island

High thermal mass – concrete and blacktop roads

Low ventilation – urban canyons, tall buildings

Point source – vehicle and air conditioner heat

Heat absorption – higher night temperatures

Luber and McGeehin, 2008

Socioeconomic Status

Social Determinants of Health

+

CLIMATE CHANGE

Urban Heat Island Effect in Louisville

TOP 10:
Most intense urban heat islands (2004-2013)

- Las Vegas (7.3°F)
- Albuquerque (5.9°F)
- Denver (4.9°F)
- Portland (4.8°F)
- Louisville (4.8°F) ← **#5**
- Washington, DC (4.7°F)
- Kansas City (4.6°F)
- Columbus (4.4°F)
- Minneapolis (4.3°F)
- Seattle (4.1°F)

TOP 10:
Most intense overnight urban heat islands (2004-2013)

- Las Vegas (10.3°F)
- Albuquerque (9.7°F)
- Portland (8.9°F)
- Washington, D.C. (7.1°F)
- San Diego (7.1°F)
- Louisville (7.0°F) ← **#6**
- Phoenix (6.8°F)
- Buffalo (6.4°F)
- Minneapolis (6.1°F)
- Philadelphia (6.0°F)

TOP 10:
Most days above 90°F compared to nearby rural areas

- Dallas (39 more days above 90°F)
- Baton Rouge (26 more days above 90°F)
- Denver (26 more days above 90°F)
- Albuquerque (25 more days above 90°F)
- Nashville (25 more days above 90°F)
- Louisville (23 more days above 90°F) ← **#6**
- Las Vegas (22 more days above 90°F)
- Austin (22 more days above 90°F)
- Oklahoma City (22 more days above 90°F)
- Dayton (21 more days above 90°F)

TOP 10:
Cities with fastest-growing urban heat islands

- Columbus (0.84°F per decade)
- Minneapolis (0.77°F per decade)
- Baltimore (0.66°F per decade)
- Louisville (0.65°F per decade) ← **#4**
- St. Louis (0.64°F per decade
- Wichita (0.60°F per decade)
- Birmingham (0.58°F per decade)
- New Orleans (0.56°F per decade)
- Des Moines (0.56°F per decade)
- Oklahoma (0.55°F per decade)

TOP 10:
Cities with fastest-growing overnight urban heat islands

- Las Vegas (0.95°F per decade)
- Albuquerque (0.93°F per decade)
- New Orleans (0.82°F per decade)
- Minneapolis (0.81°F per decade)
- Norfolk (0.78°F per decade
- Birmingham (0.66°F per decade)
- Jacksonville (0.65°F per decade)
- Philadelphia (0.64°F per decade)
- Louisville (0.61°F per decade) ← **#9**
- St. Louis (0.61°F per decade)

Climate Central, 2014

Extreme Heat Adaptation

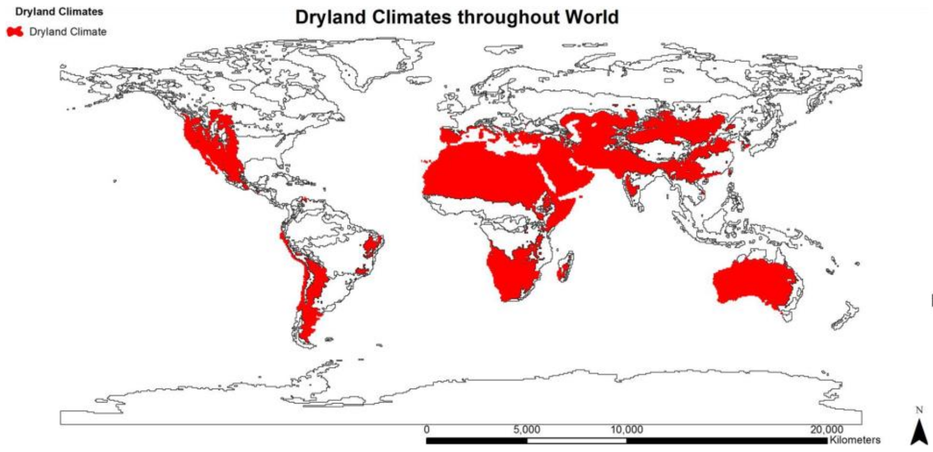


Table 1. Research Findings Related to Strategies to Cool Dryland Cities.

Category	Finding (Study Cities in Parentheses)	Authors
Vegetation	Trees have greater daytime cooling benefit than lawns (Phoenix)	Wang et al. (2016)
	Lawns can increase daytime air temperatures and humidity compared to surrounding urban areas (Tel Aviv)	Potchter, Cohen, and Bitan (2006)
	Irrigated turf leads to lower air temperatures than desert vegetation (Phoenix)	Hall et al. (2016)
	Tree canopy has strong cooling benefits in daytime but not at night (Tel Aviv and Cairo)	Cohen, Potchter, and Matzarakis (2012); Mahmoud (2011); and AboElata (2017)
	Tree canopy has only small air cooling benefit on very hot days (Athens)	Tsiros (2010)
	At night dense, low tree canopies decrease wind and increase air temperatures and humidity (Tel Aviv)	Potchter, Cohen, and Bitan (2006)
	Tree canopies that leave sky view can increase nighttime cooling (Cairo)	AboElata (2017)
	Total area of vegetation matters more than distribution (Denver)	Rhee, Park, and Lu (2014)
	Clustered vegetation cools surface temperatures more than dispersed vegetation (Phoenix and Las Vegas)	Fan, Myint, and Zheng (2015) and Myint et al. (2015)
	Parks in dryland cities typically produce park cool island effects	Bowler et al. (2010)
	The cooling impact of parks extends well beyond their borders	Dimoudi and Nikolopoulou (2003) and Akbari et al. (2016)
Built form	Shade-producing built form (close buildings with narrow streets) can cool dryland cities	Emmanuel and Fernando (2007) and Nassar et al. (2016, 2017)
	Street canyons (narrow streets and tall buildings) reduce daytime air temperatures through shade and reduced sky view	Johansson (2006)
	Street canyons lead to warmer nighttime temperatures since heat escapes more slowly with reduced sky view	Nassar, Blackburn, and Whyatt (2016, 2017) and Jamei et al. (2016)
	Replacing pavement with buildings leads to lower nighttime temperature (Phoenix)	Gober et al. (2012)
	The roughness of urban landscapes leads to less wind and more heating	Golden (2004)
	Tall buildings and straight streets can promote air flow and redirect wind	Golany (1996)
Materials	Cool roof materials reduce urban heating in all climate zones	Roman et al. (2015) and Santamouris (2014)
	Phase change materials can spread heating out through the daily cycle	Roman et al. (2015)
	Highly reflective surfaces may heat other spaces nearby	Vardoulakis, Karamanis, and Mihalakakou (2014)

Extreme Heat

- Educate
- Disseminate alerts
- Assure cooling center access

Wheeler et al. 2019

Extreme Weather

Extreme Weather

- Water contamination
- Property Loss
- Infrastructure Damage

- Gastrointestinal illness
- Cardiovascular disease
- Respiratory illness
- Injuries
- Stress
- Displacement
- Death

Extreme Weather

Image sources: http://www.realclearlife.com/nature/striking-images-hurricane-harvey-devastates-gulf-coast/#1, https://images.fatherly.com/wp-content/uploads/2017/08/hurricane-harvey-1.jpg

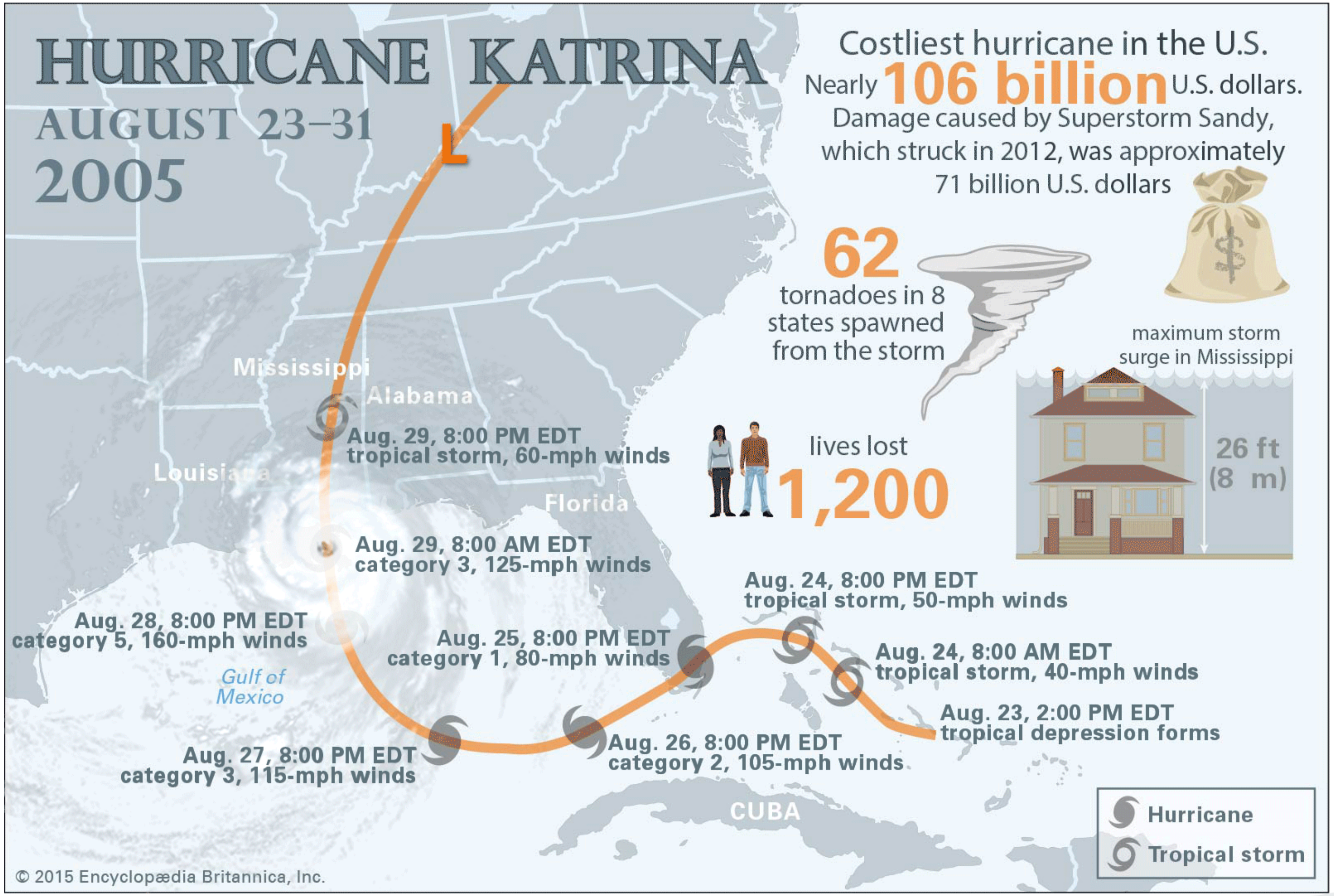
Extreme Weather

Hurricane Harvey

Displacement	Property Loss	Infrastructure Damage	Water contamination
Over 30,000 evacuated	At least 88 deaths	Loss of access to health services	Gastrointestinal illness and skin rash increased

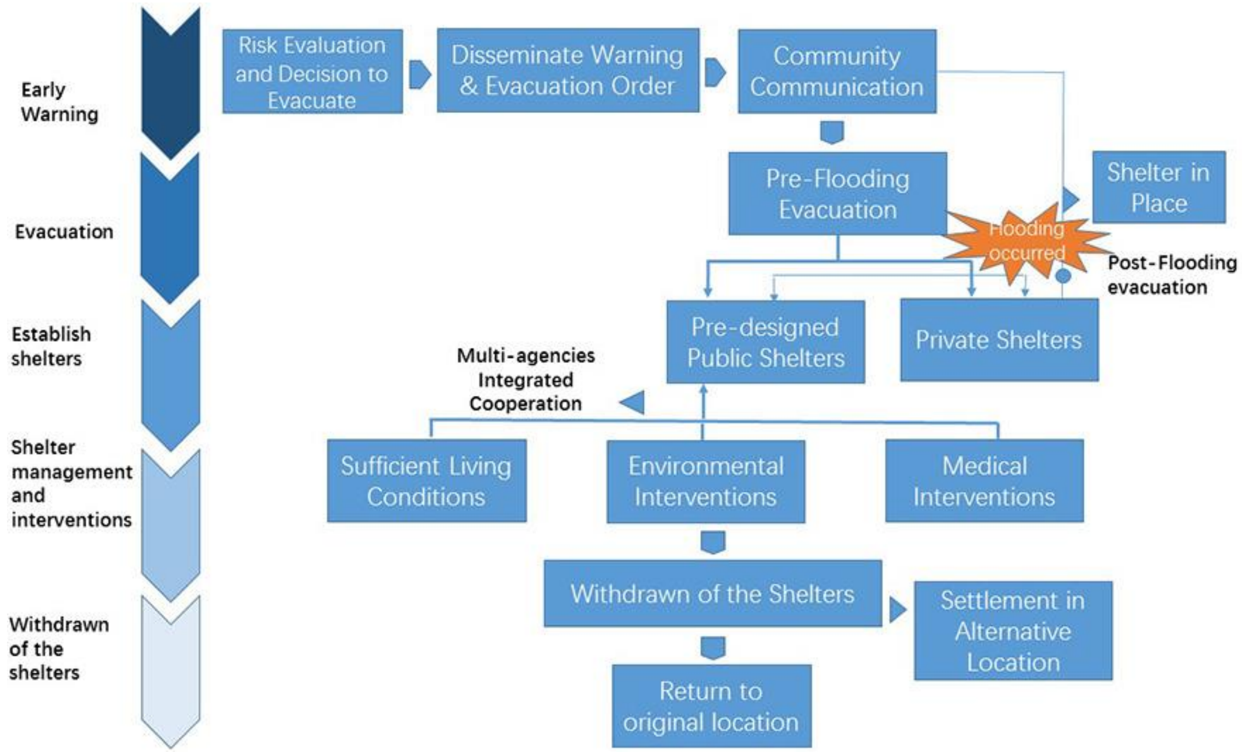
USGCRP, 2018

Extreme Weather



Source: https://www.britannica.com/event/Hurricane-Katrina

Extreme Weather Adaptation



Extreme Weather

- Disseminate alerts
- Ensure evacuation access

Wu et al., 2019

Extreme Precipitation

FLOODING

- Water contamination → Gastrointestinal illness
- Community destruction → Injury, death

Precipitation extremes harms **physical and mental health**, community infrastructure, and the economy.

DROUGHT

- Decreased crop yield → Malnutrition
- Wildfires → Asthma, heart disease

Extreme Precipitation - Drought

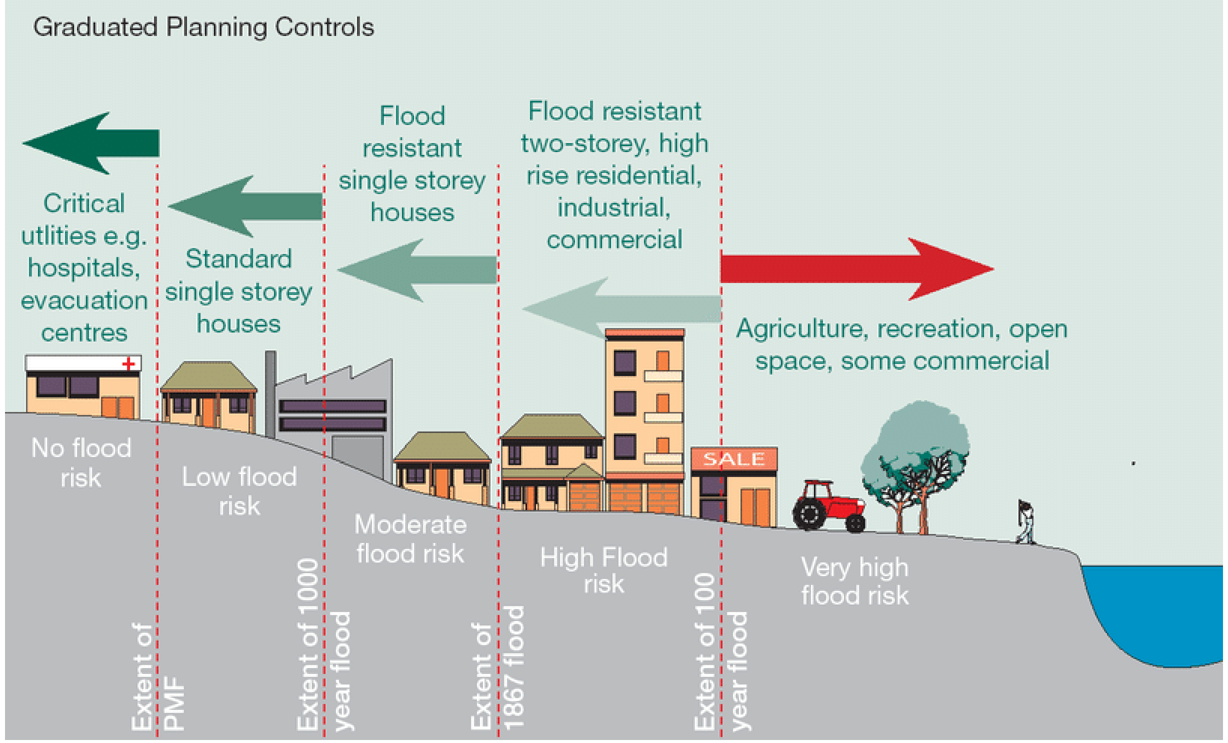
Drought and Health Equity	Impoverished	Food and water insecurity
	Agricultural Workers	Economic and mental health impacts
	Rural Communities	Reliant on small or private drinking water systems
	Tribal Communities	Close ties to land and some communities lack running water
	Chronic Illness	Exacerbate kidney disease, diabetes, and hypertension
	Race and Ethnicity	Heightened economic threat

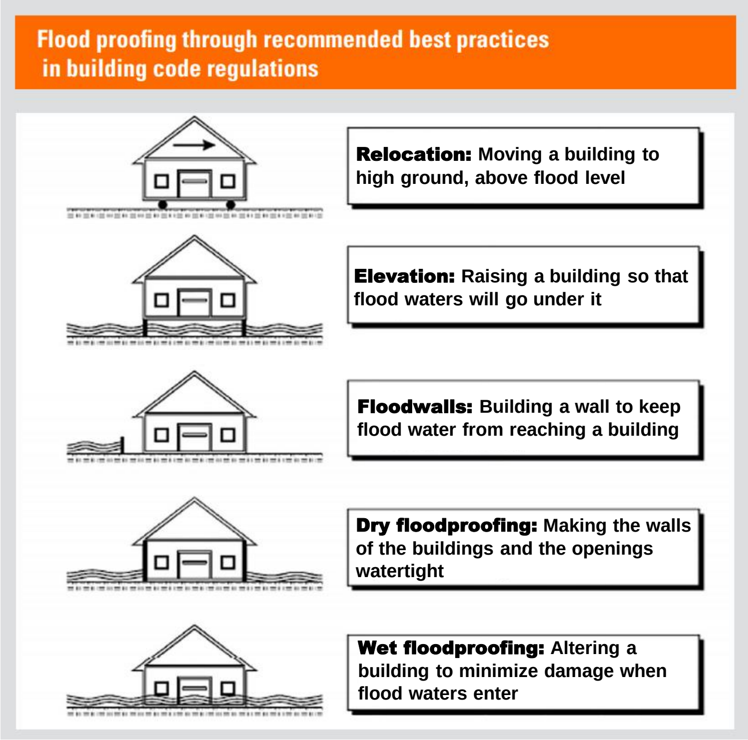
APHA, PHI, CDPH, 2018

Extreme Precipitation - Flooding

Image sources: https://www.wkyt.com/content/news/Summer-storms-down-trees-flood-roads-in-parts-of-central-Kentucky-384184001.html

Extreme Precipitation





Extreme Precipitation

- Assess water and soil quality
- Issue water advisories

Hawkesbury City Council, 2012; UFCOP, 2017

Vectorborne Disease

Climate change increases the **amount and geographic distribution** of disease-carrying mosquitos and ticks.

Vectorborne diseases

Lyme disease

West Nile virus

Zika virus

Image sources: https://bit.ly/3f4XF4L, https://bit.ly/2RqWBPL, https://bit.ly/3bEMQ7q

Vectorborne Disease

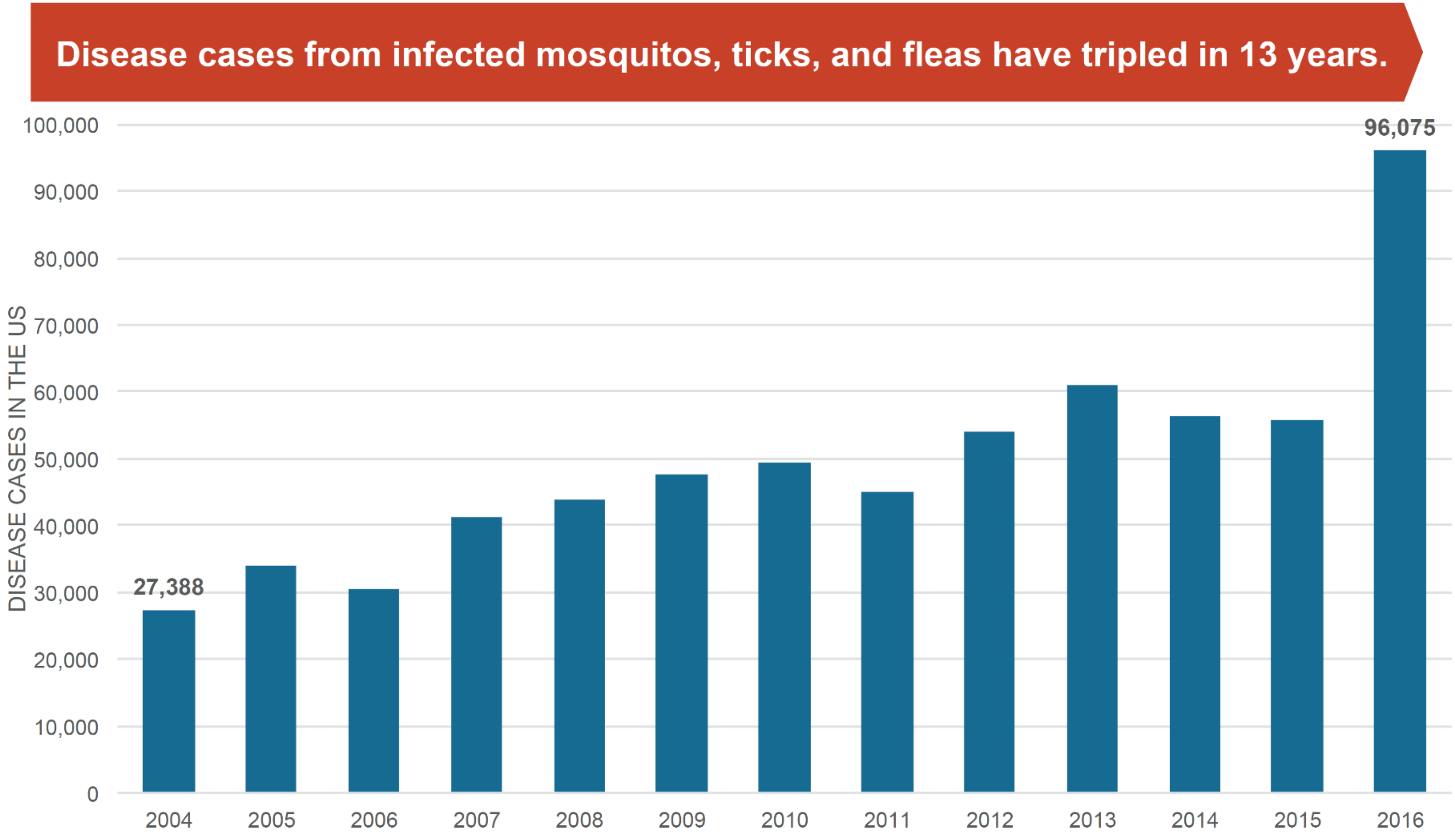


Figure Source: Center for Disease Control and Prevention, 2018.

Salas, Knappenberger, Hess, 2018

Vectorborne Disease Adaptation

Integrated Pest Management

PREVENT the build-up of pests

MONITOR environmental and health status

INTERVENE when control measures are needed

Vectorborne Diseases

- Educate
- Vector control
- Eradicate vector-prone areas

Thank You!

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