A Green Heart for Healthy Communities

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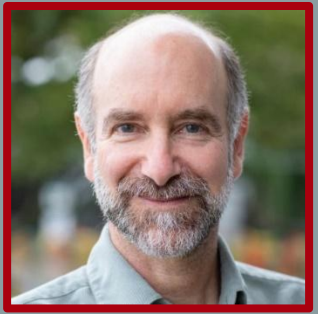
UNIVERSITY OF LOUISVILLE

What's In The Air?

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)

Climate Change Multiplies Health Threats

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+

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

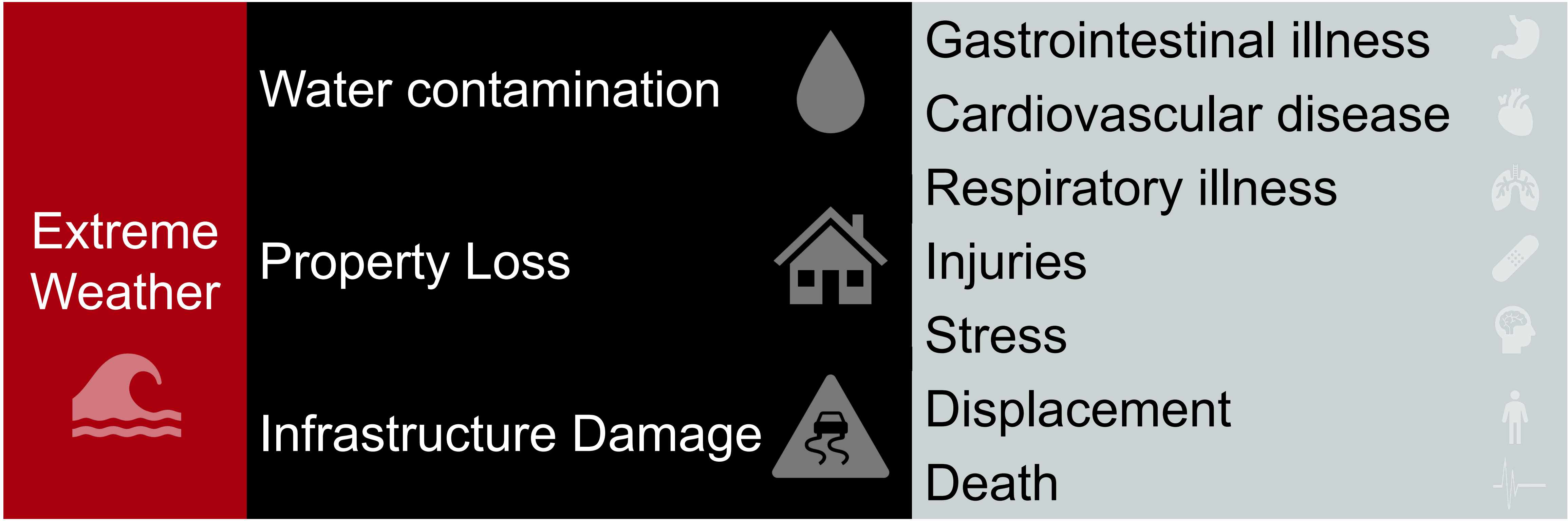
Climate change threatens mental wellness:

- Stress
- Anxiety
- PTSD
- Depression
- Violence
- Suicide
- Medication interaction

Climate Threats to Health and Equity

- Extreme Weather
- Flooding and Drought
- Vectorborne Diseases
- Air Quality
- Extreme Heat

Extreme Weather



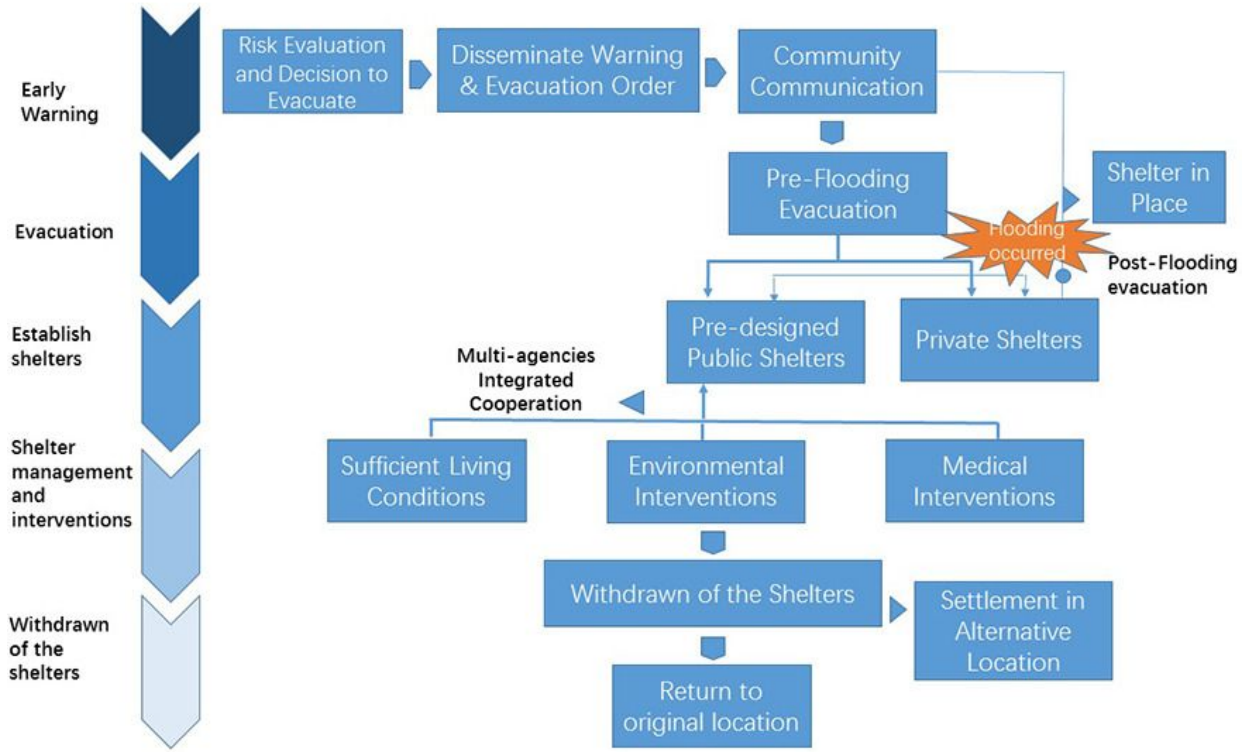
Extreme Weather

Hurricane Harvey

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

USGCRP, 2018

Extreme Weather Adaptation



Wu et al., 2019

Extreme Weather

- Disseminate alerts
- Ensure evacuation access

Extreme Precipitation

FLOODING

Water contamination

Community destruction

Gastrointestinal illness

Injury, death

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

DROUGHT

Decreased crop yield

Wildfires

Malnutrition

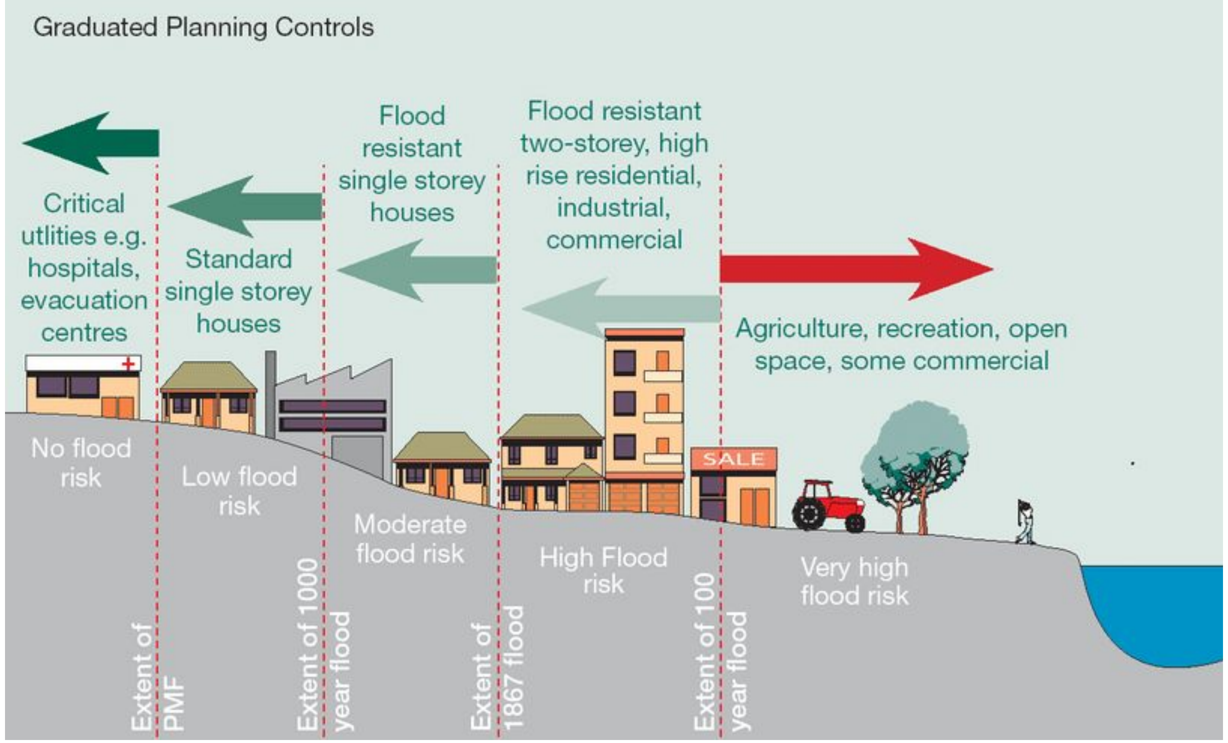
Asthma, heart disease

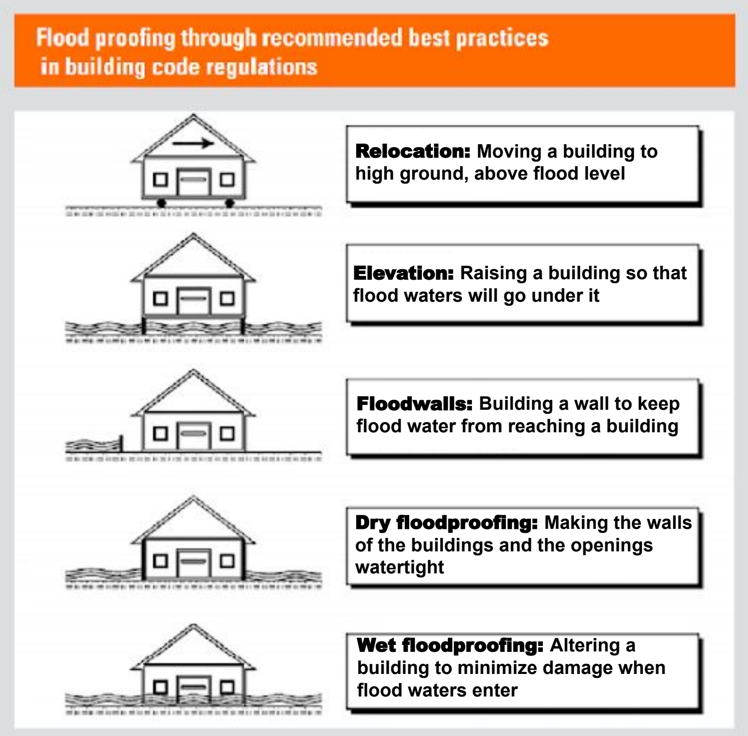
Extreme Precipitation - Drought

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





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

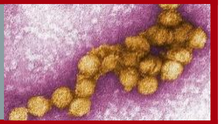
- Lyme disease 
- West Nile virus 
- Zika virus 

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

Vectorborne Disease

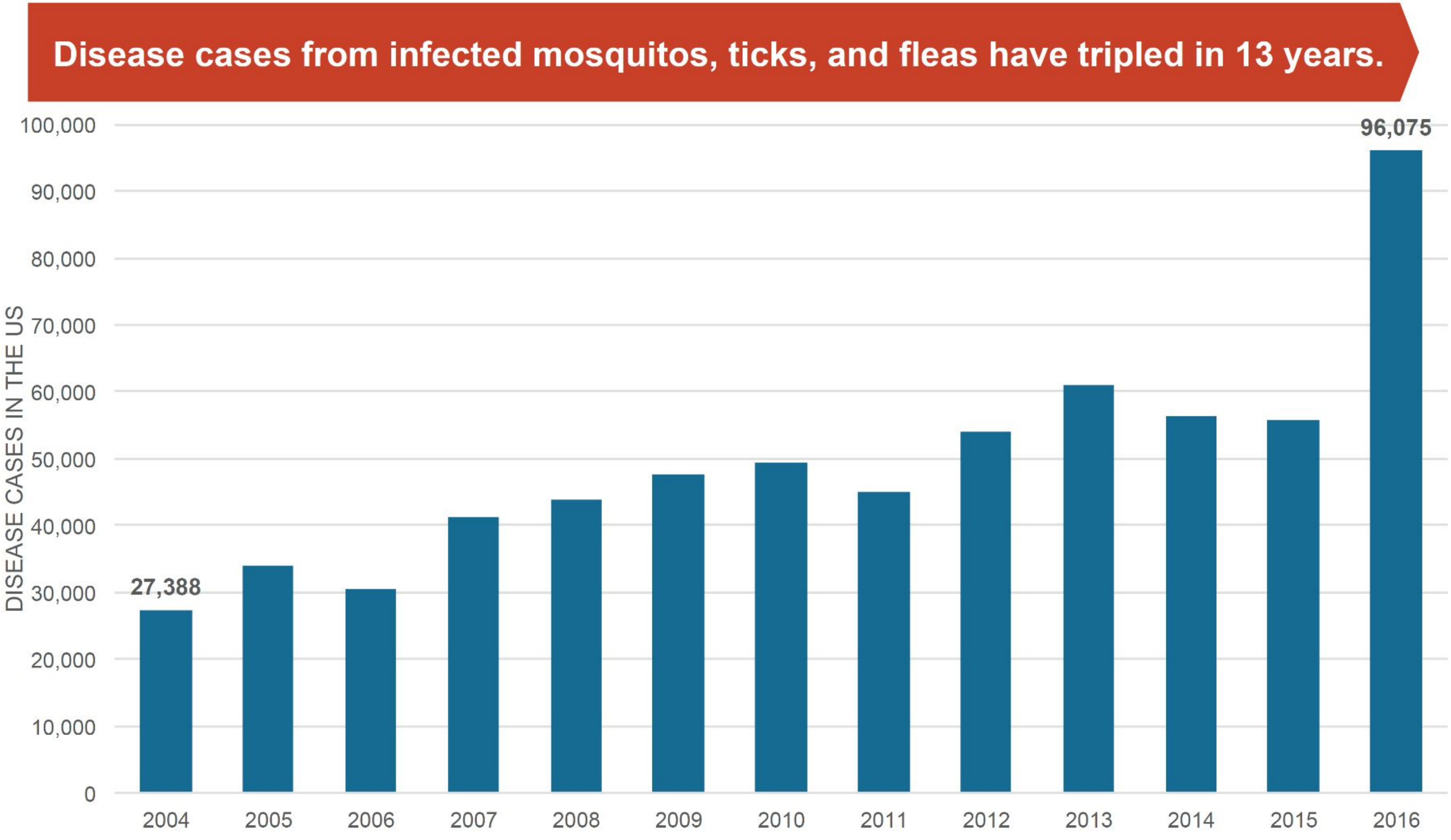


Figure Source: Center for Disease Control and Prevention, 2018.

Salas, Knappenberger, Hess, 2018

Vectorborne Disease Adaptation

Integrated Pest Management

PREVENT the build-up of pests

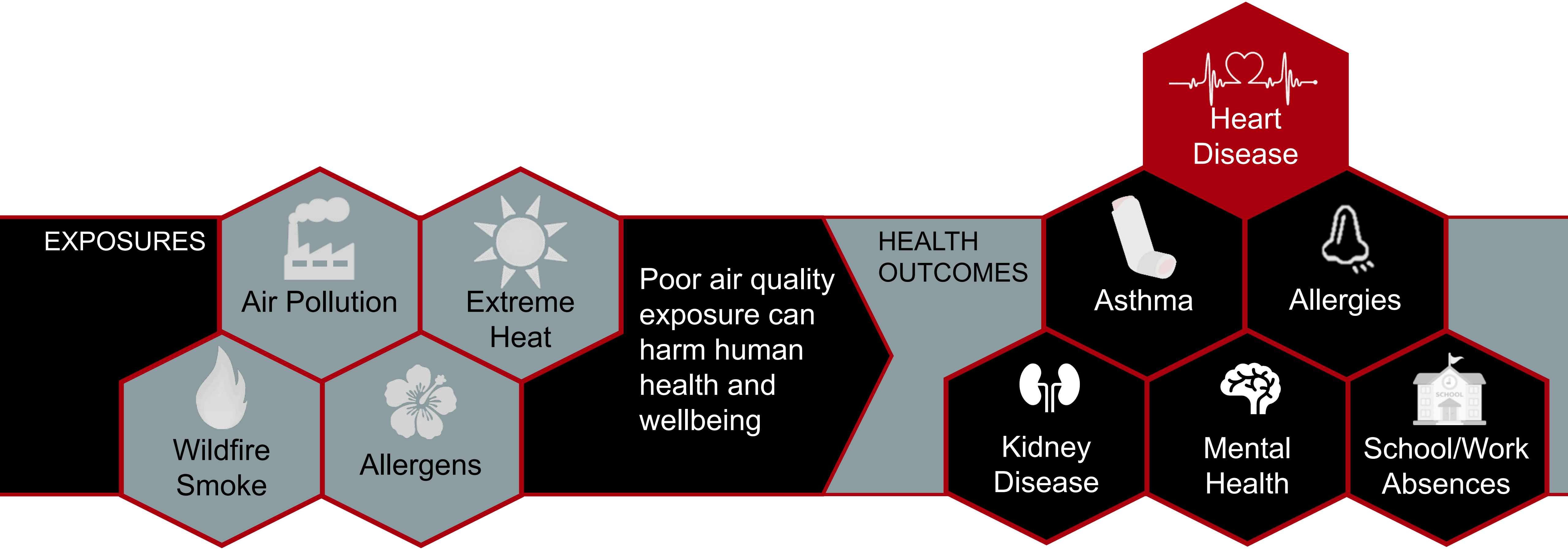
MONITOR environmental and health status

INTERVENE when control measures are needed

Vectorborne Diseases

- Educate
- Vector control
- Eradicate vector-prone areas

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

Risk Factors for Cardiovascular Disease

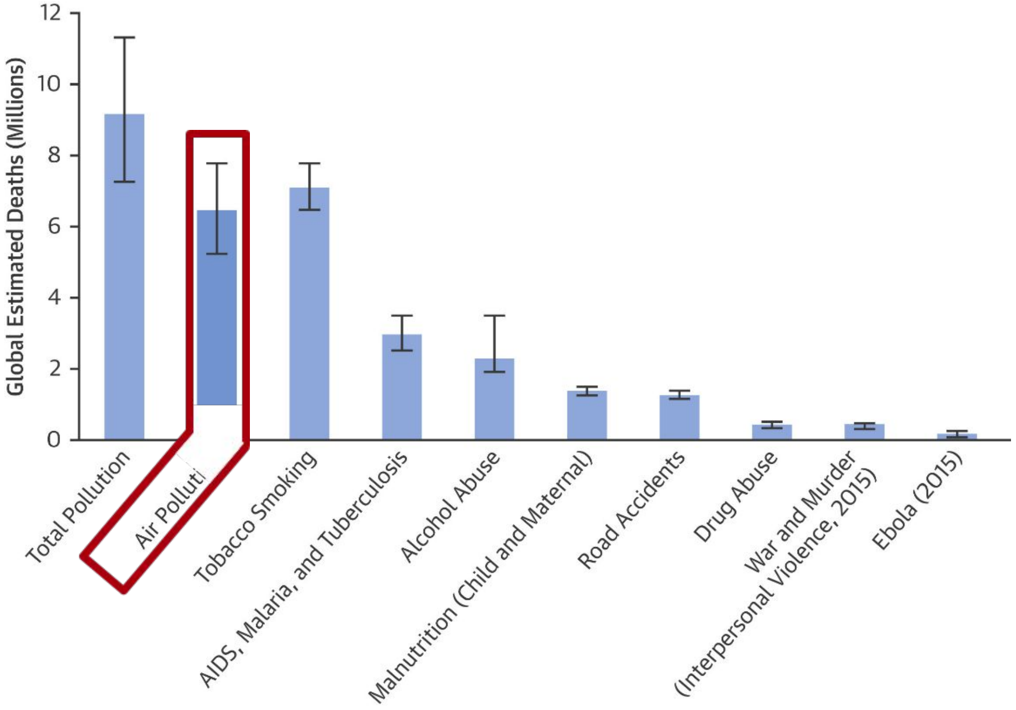
- Age
- Gender
- High Blood Pressure
- Diabetes
- High Cholesterol
- Tobacco
- Overweight & Obesity
- Unhealthy Diet
- Kidney Disease
- Harmful Use of Alcohol
- Physical Inactivity
- Air Pollution

- Traditional risk factors do not fully explain CVD
- **70-80%** of CVD could be due to environmental causes
- Temperatures influence air quality.

Bhatnagar, 2006, 2017

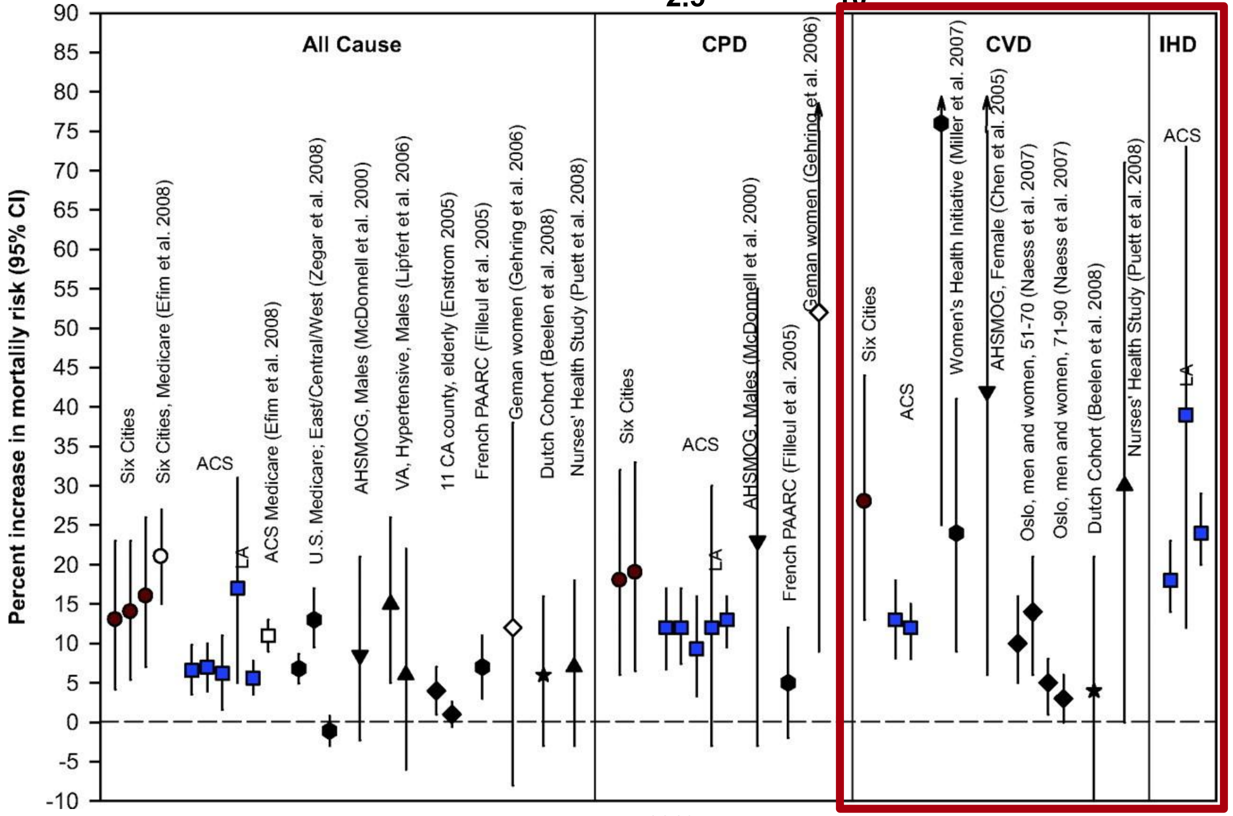
Air Pollution

The Contribution of Air Pollution Versus Other Risk Factors to Global Mortality



Rajagopalan et al. 2018

Risk estimates provided by several cohort studies per increment of 10 µg/m^3 in $PM_{2.5}$ or PM_{10}



Brook et al. 2010

CPD = cardiopulmonary disease
CVD = cardiovascluar disease
IHD = ischemic heart disease

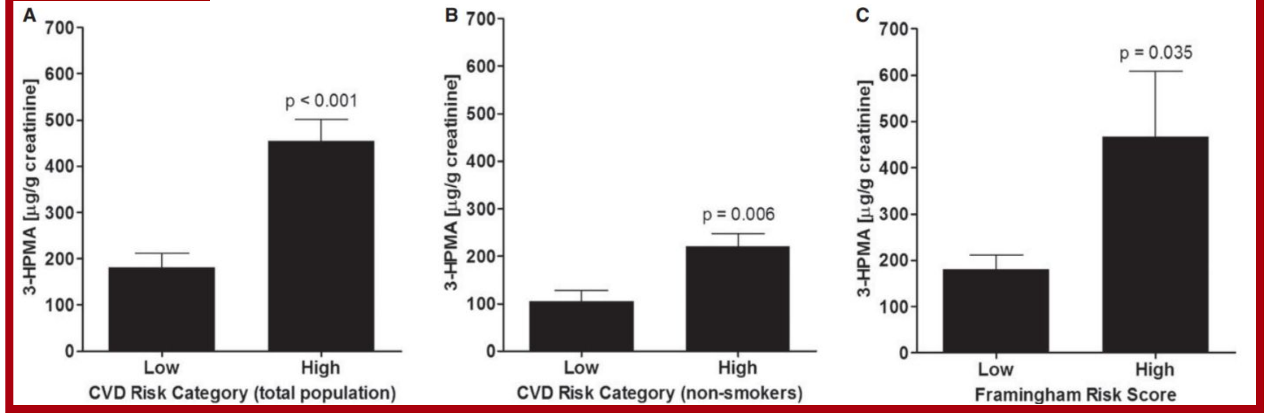
Environmental Health Assessment

Volatile organic compounds (VOCs)

CVD risk outcomes

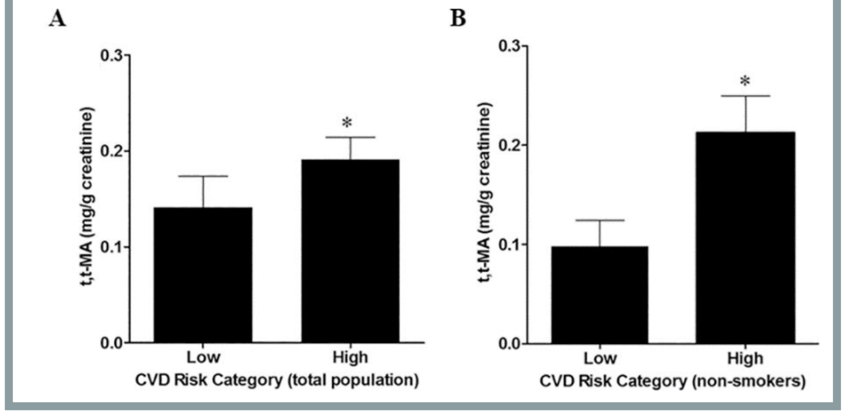
Acrolein and benzene exposures are linked with higher CVD risk.

Acrolein



DeJarnett et al. 2014

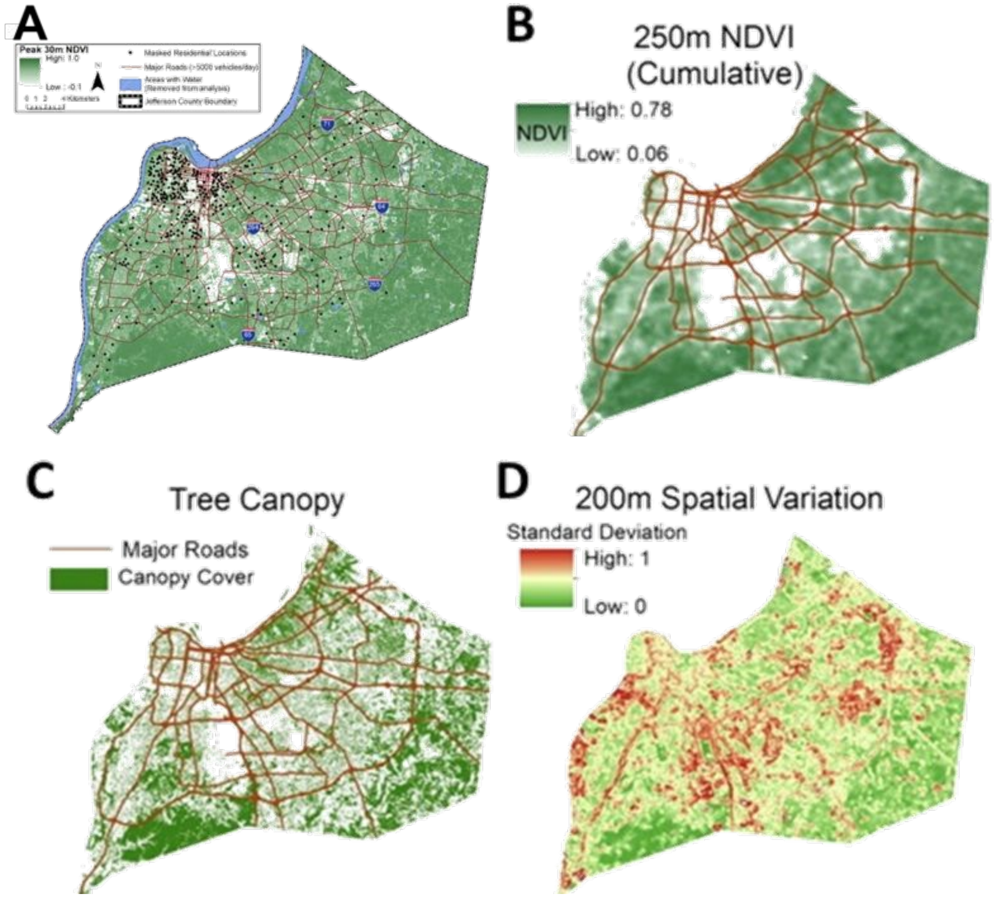
Benzene



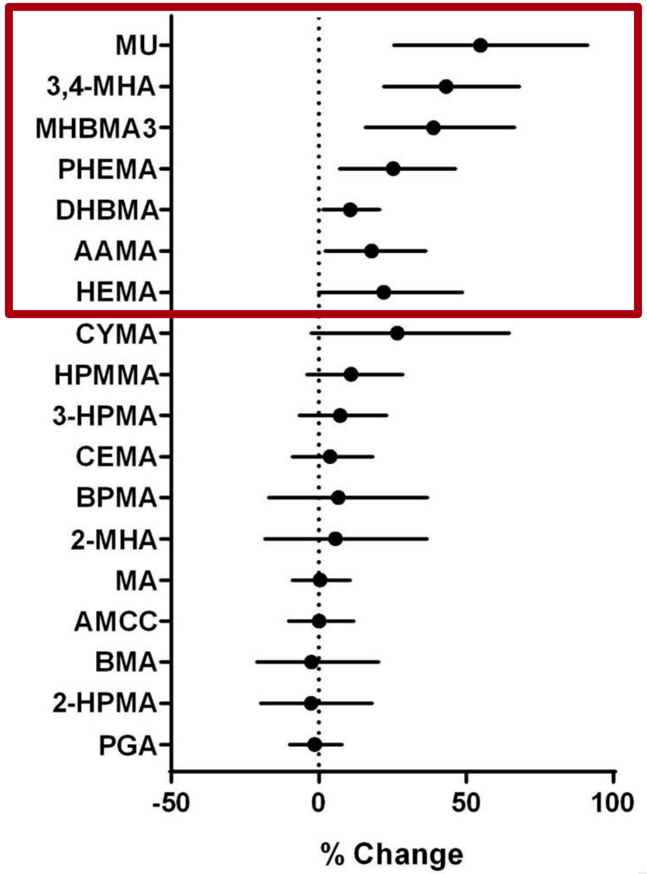
Abplanalp, DeJarnett, et al. 2017

Environmental Health Assessment

Distribution of Greenness in Louisville, KY

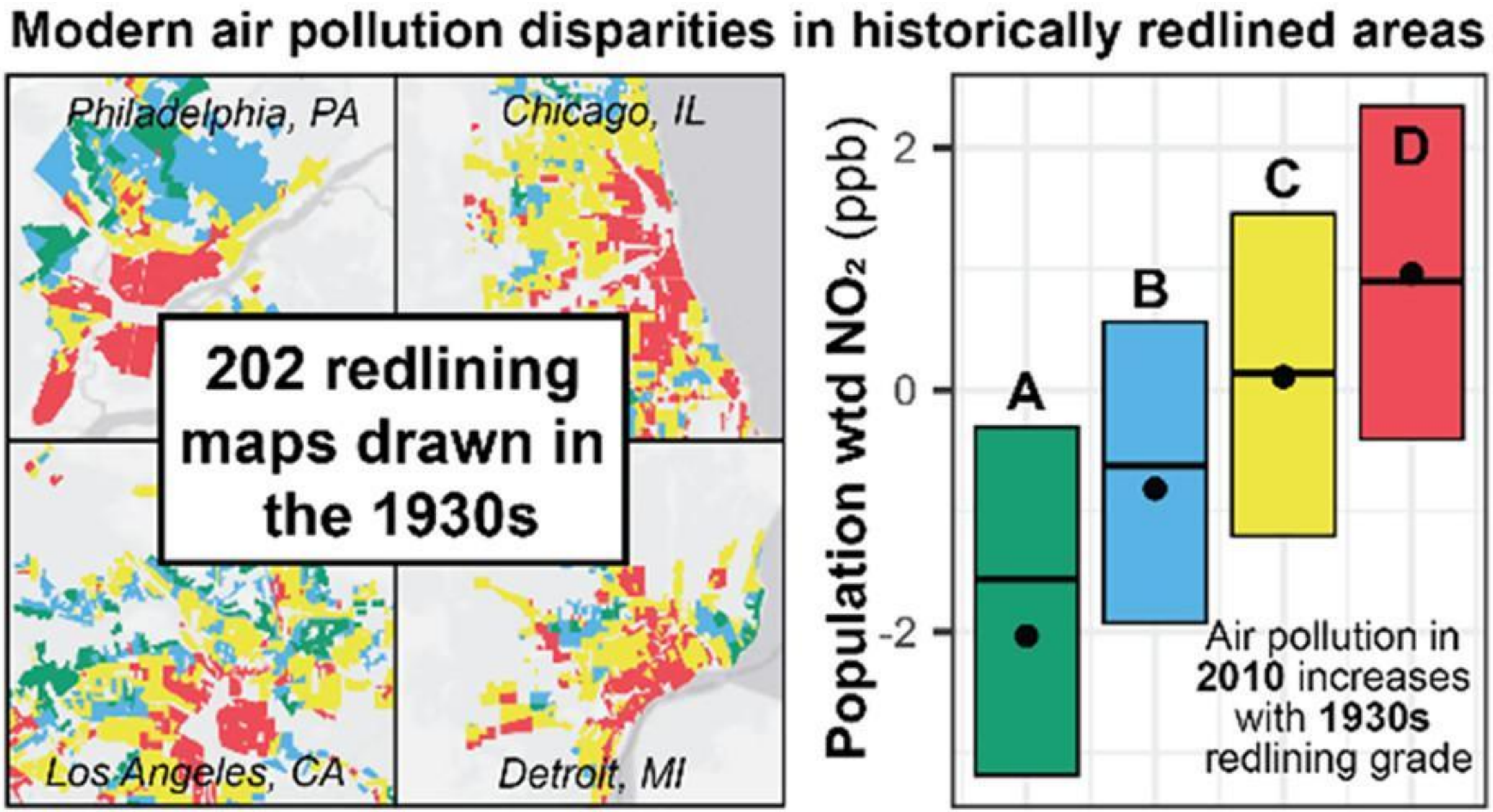


Inverse Association between Spatial Variation and Residential Greenness and Volatile Organic Compound Metabolites



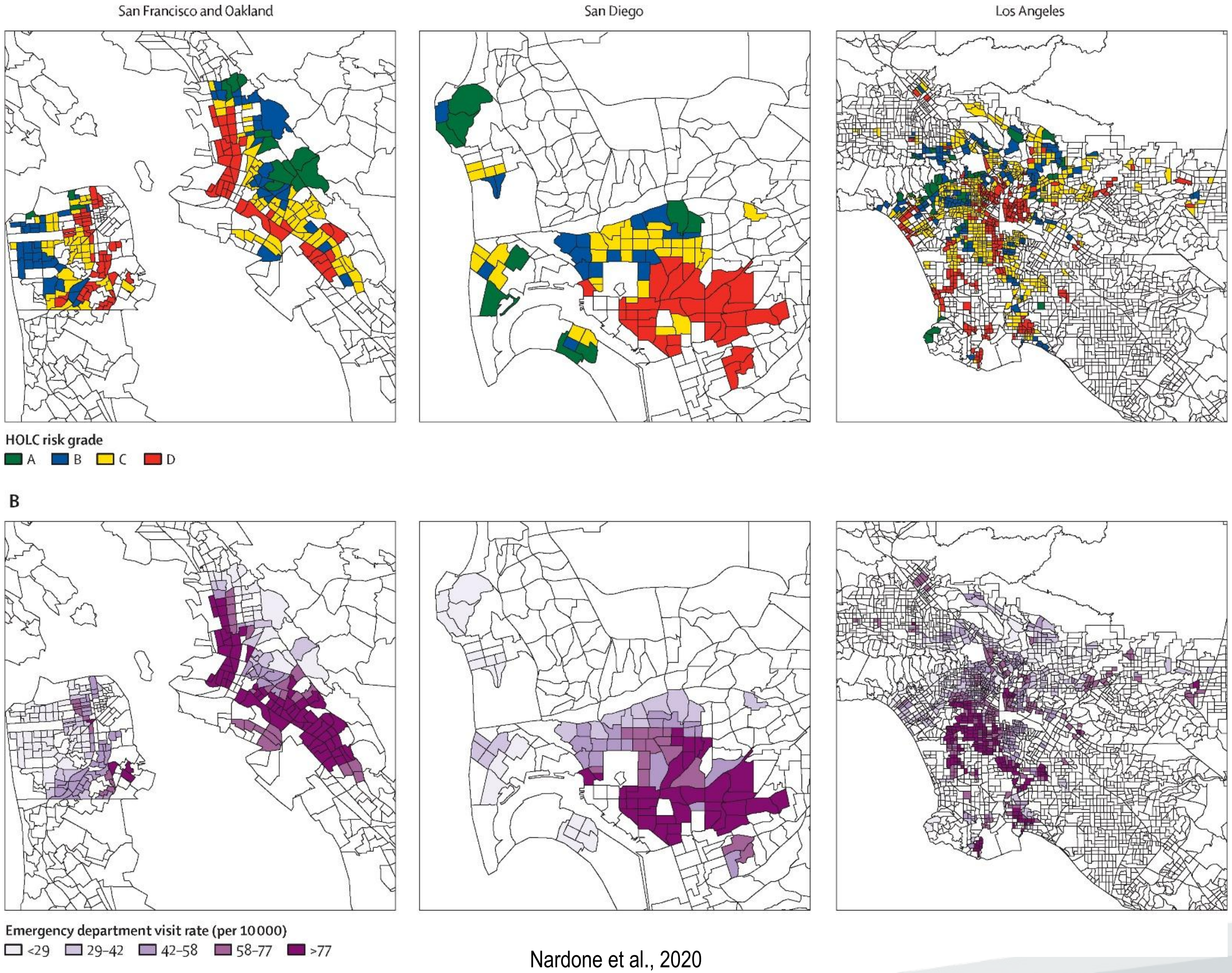
Yeager et al. 2018

Redlining and Air Quality



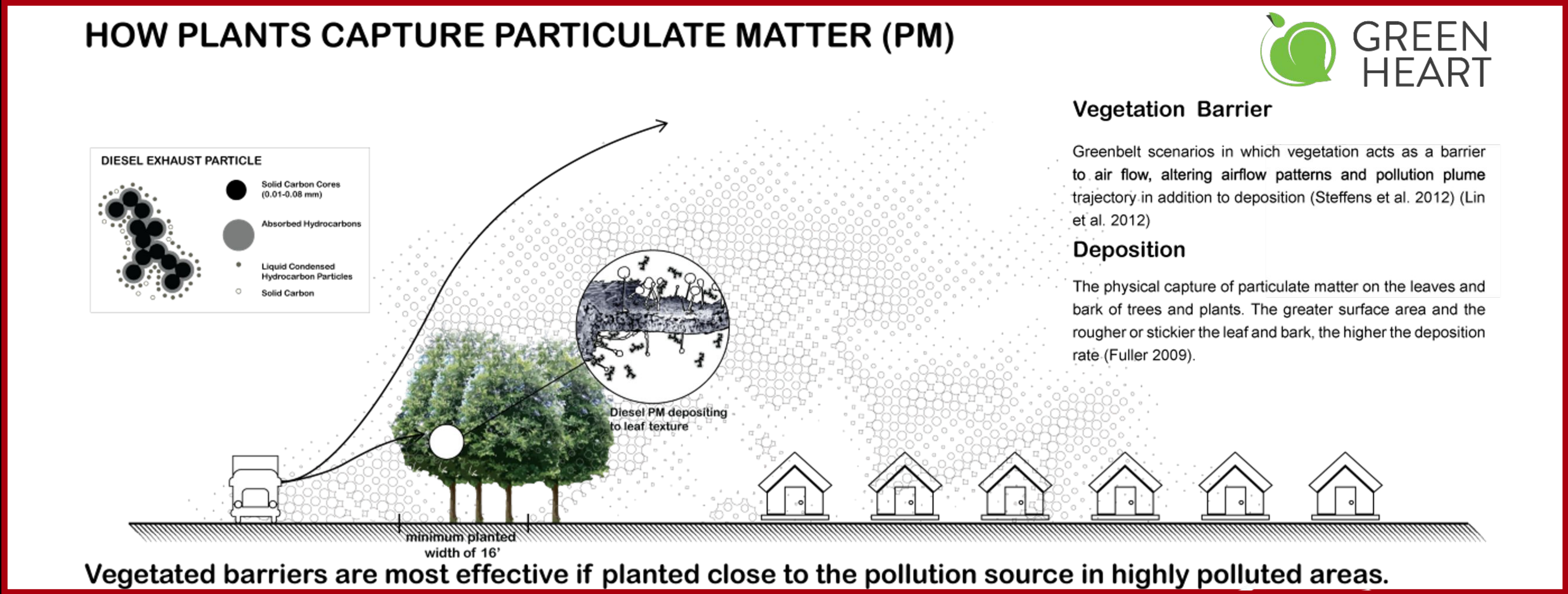
Lane et al. 2022

Redlining and Air Quality



Nardone et al., 2020

Air Quality Adaptation



Air Quality

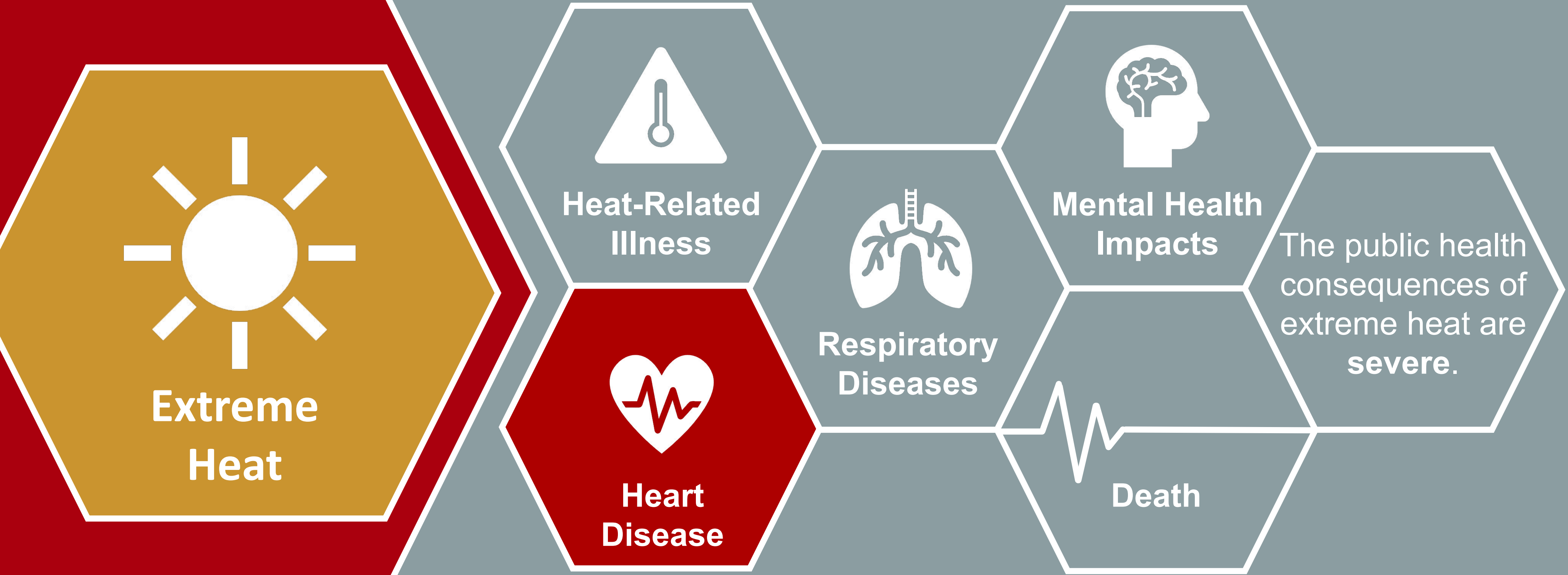
- Test air quality
- Disseminate alerts
- Enforce air quality regulations

Source: https://louisville.edu/**green**heart

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.



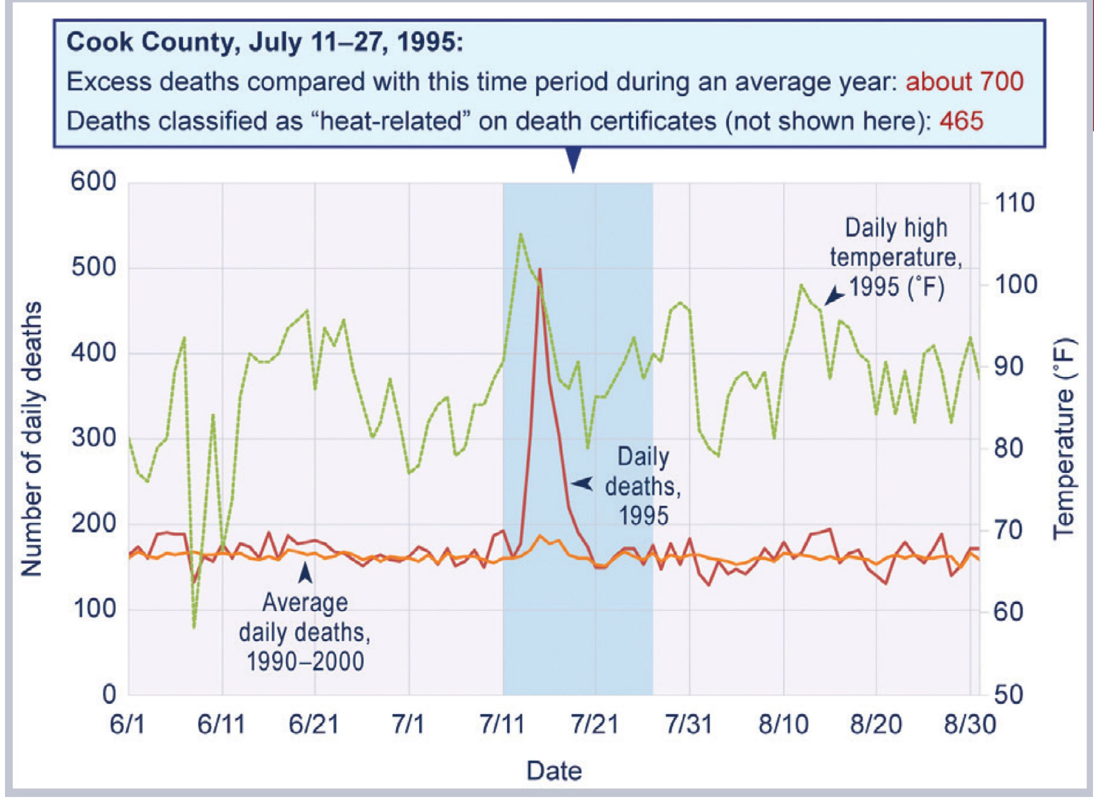
1995 Chicago Heat Wave

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

Heat-Related Deaths During the 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.

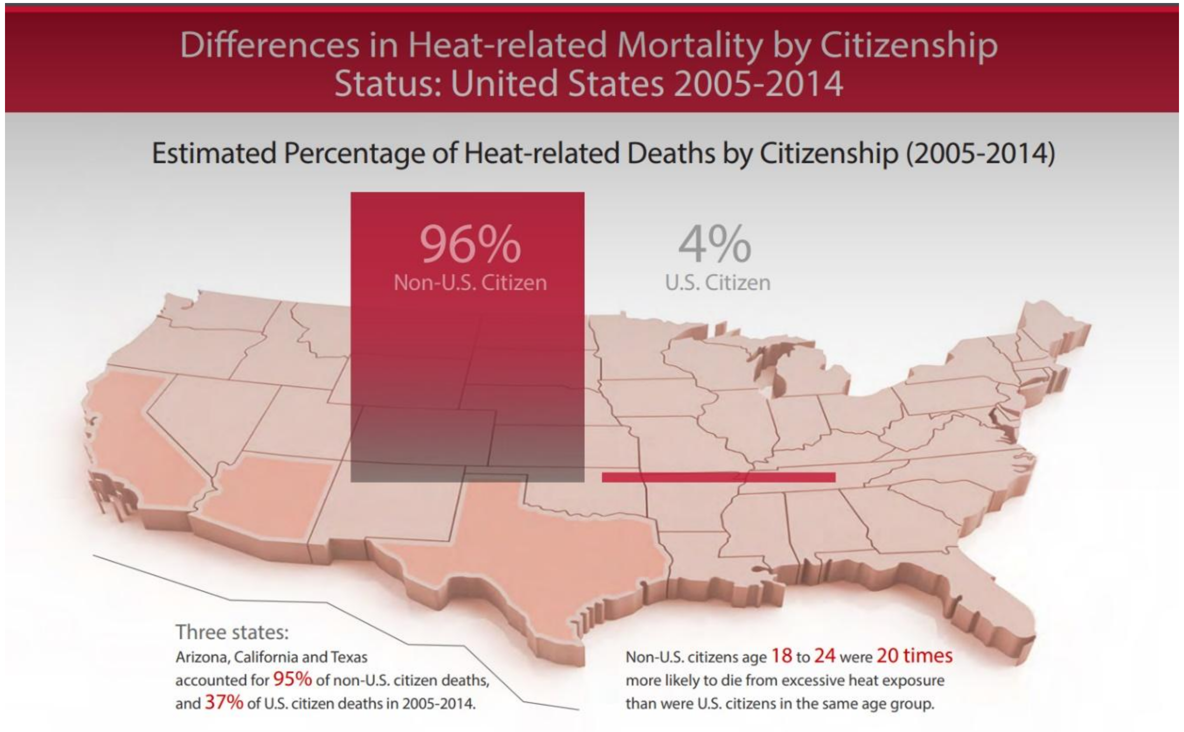
Whitman et al., 1997

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



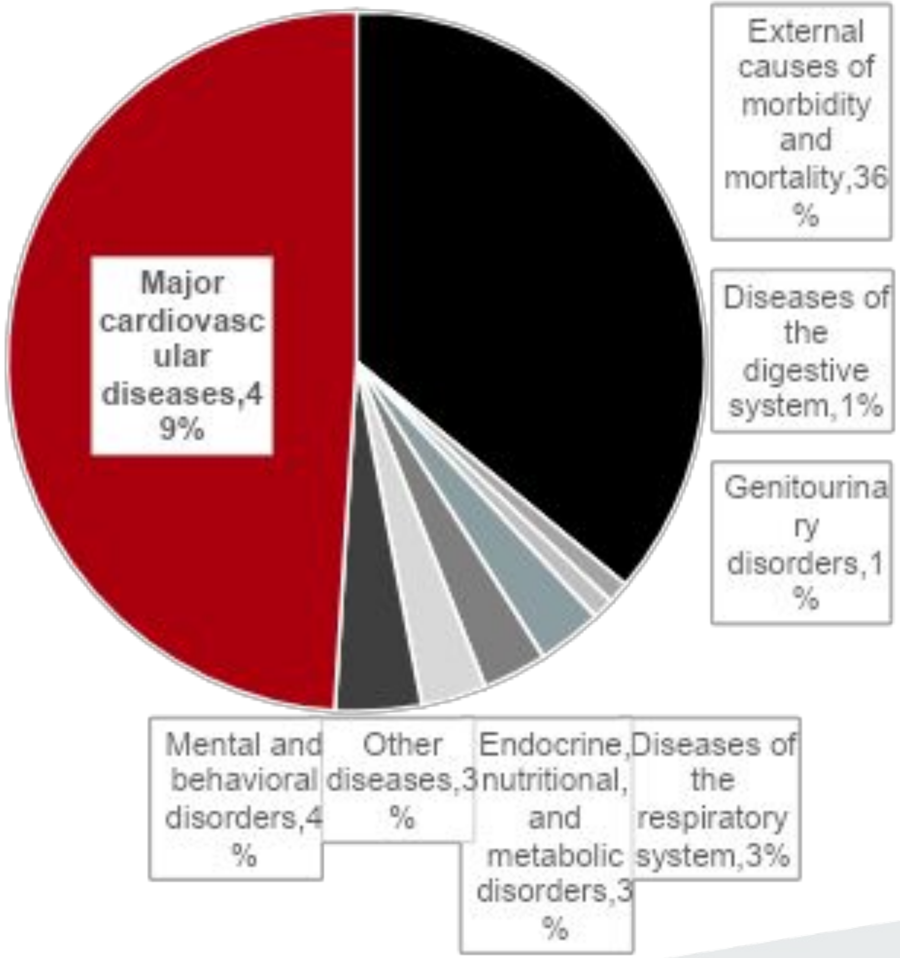
APHA, 2018
Taylor et al., 2018

Cardiovascular Disease (CVD) and Heat

TABLE 3. Selected underlying causes* of death for which heat-related conditions were listed as a contributing factor† — United States, 2004–2018§

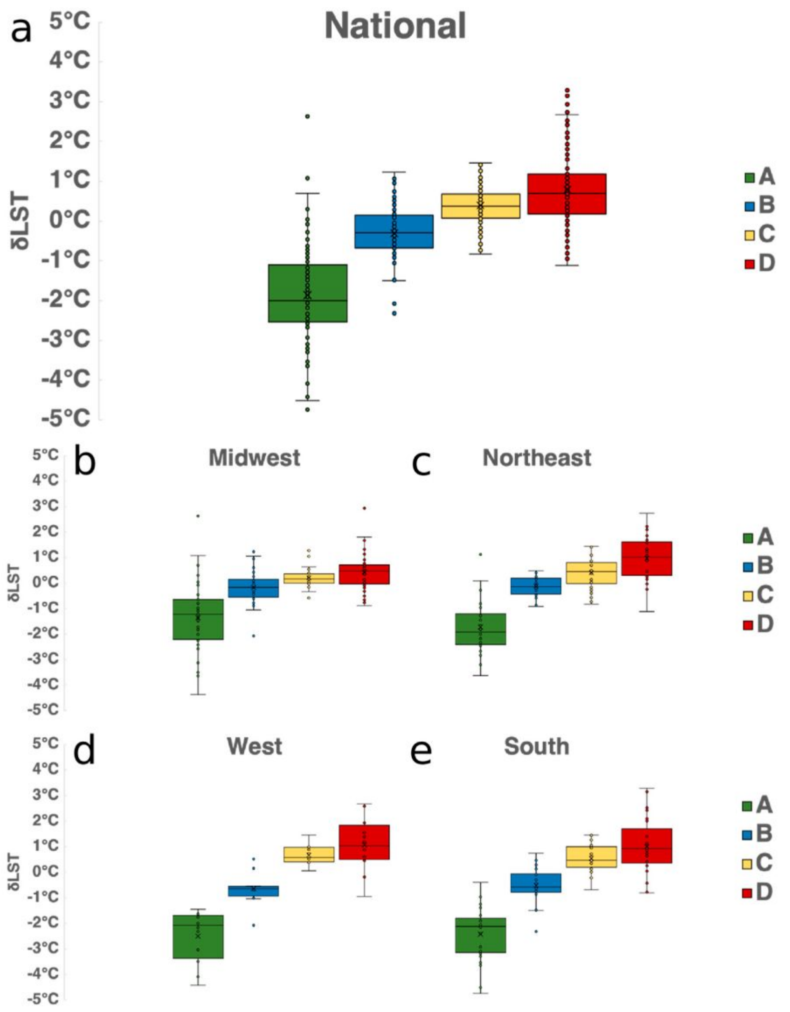
Underlying cause of death¶	No. (%)
Major cardiovascular diseases**	**2,112 (49)**
Hypertensive diseases	438 (10)
Ischemic heart diseases	1,463 (34)
Other cardiovascular diseases	211 (5)
External causes of morbidity and mortality††	**1,543 (36)**
Alcohol poisoning deaths	130 (3)
Drug overdose deaths	643 (15)
Other external causes of morbidity and mortality	770 (18)
Mental and behavioral disorders§§	**174 (4)**
Mental and behavioral disorders due to psychoactive substance use	151 (4)
Other mental and behavioral disorders	23 (0)
Diseases of the respiratory system¶¶	**127 (3)**
Chronic lower respiratory diseases	116 (3)
Other diseases of the respiratory system	11 (0)
Endocrine, nutritional, and metabolic disorders ***	**128 (3)**
Diabetes mellitus	78 (2)
Other endocrine, nutritional, and metabolic disorders	50 (1)
Diseases of the digestive system†††	**48 (1)**
Diseases of the liver	33 (1)
Other diseases of the digestive system	15 (0)
Genitourinary disorders§§§	**30 (1)**
Musculoskeletal disorders¶¶¶	**12 (0)**
Other diseases	**133 (3)**
Total underlying causes of death with heat-related conditions*** as a contributing factor**	**4,307 (100)**

Vaidyanathan et al., 2020

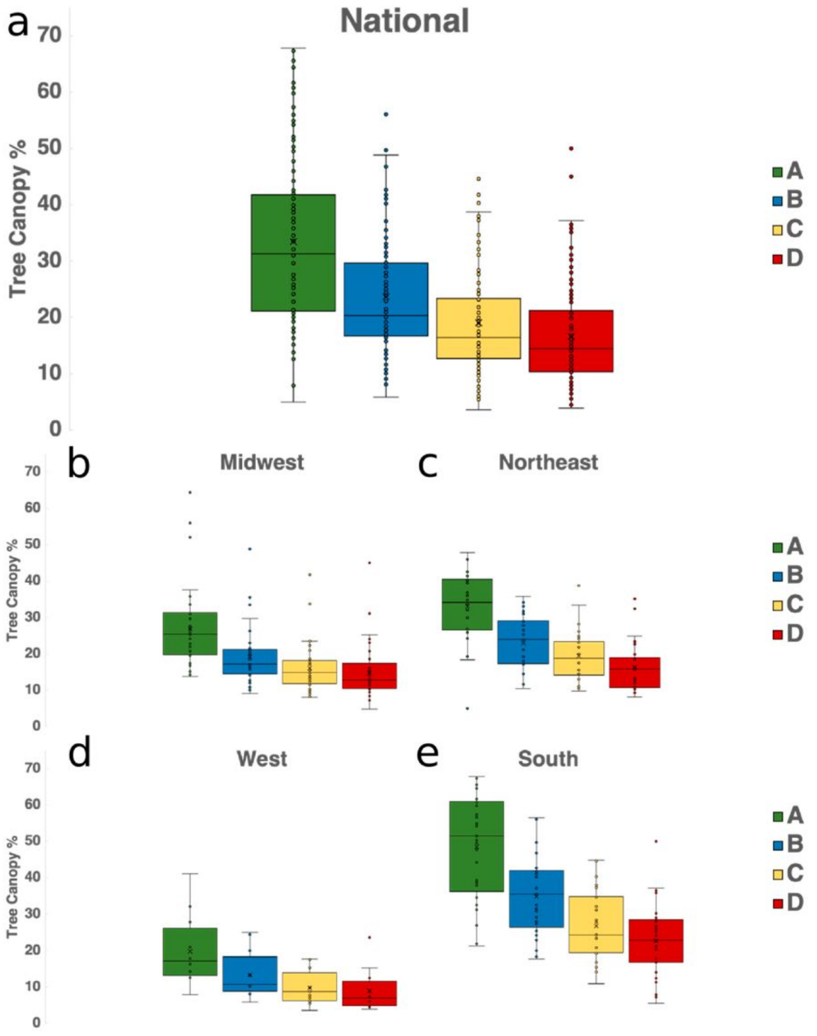


Redlining and Heat

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

Socioeconomic Status

Social Determinants of Health

Luber and McGeehin, 2008

+

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

Heat and Mortality Distribution in Louisville

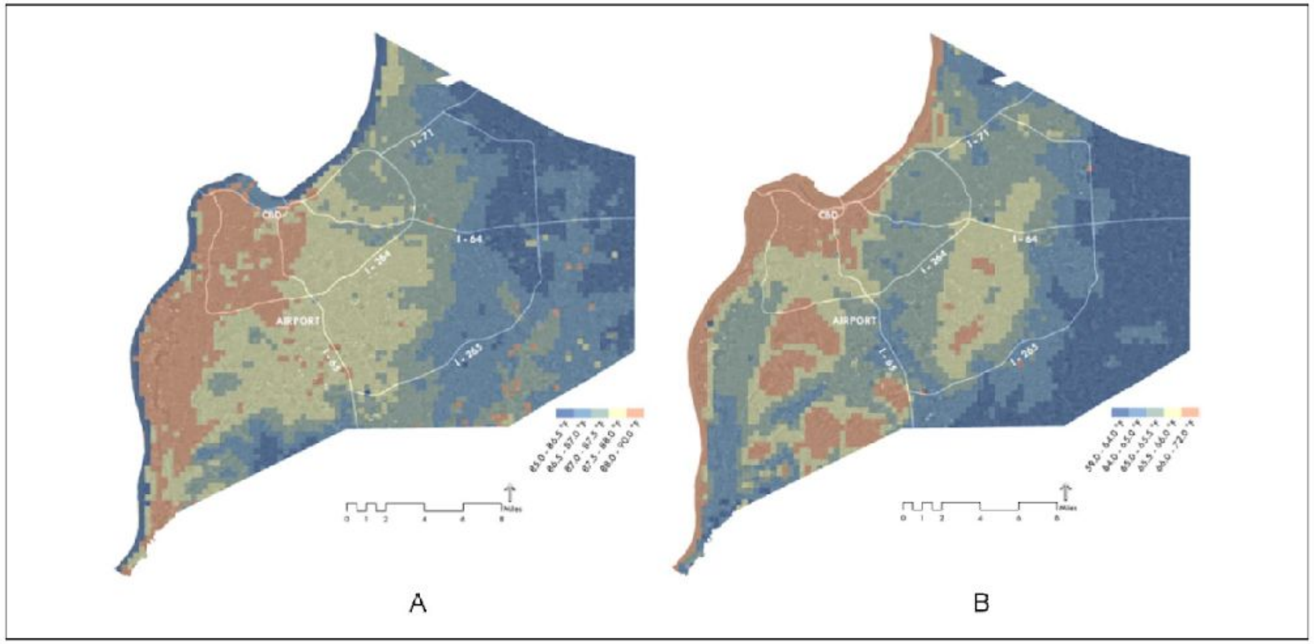


Figure 1. Average warm season (May through September 2012) daily (A) high and (B) low temperatures (°F).
Note: The Ohio River is the western boundary of the Louisville Metro, running from the southernmost point to the northernmost point of the region.
CBD = central business district.

Stone, Jr. et al, 2019

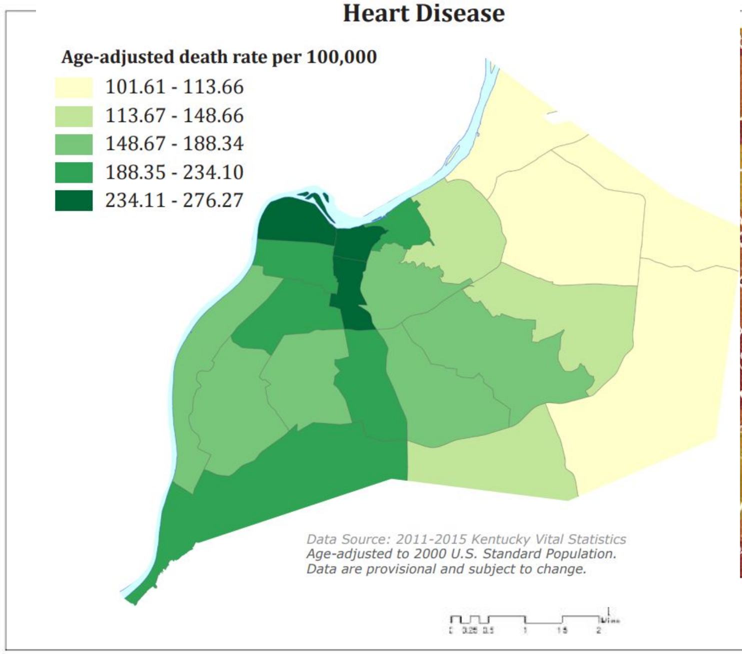


Figure 3. Distribution of estimated UHI-attributable heat mortality in Louisville urban core neighborhoods by grid cell during May to September of 2012.

LMPHW, 2018
Stone, Jr. et al, 2019

Green Heart Project

Meaningful Partnerships

Green Heart Louisville Community Advisory Board

Community Advisory Board virtual meeting

Shared Leadership

Community partner sharing with the CAB

Bi-directional Education

CAB member representing Green Heart at a community event

Participation

CAB member discussing Green Heart

Engagement

Meaningful Partnerships

Community Advisory Board

South Louisville residents meet quarterly, help determine community engagement activities, and participate in Green Heart Louisville events.

Community Organizations

Louisville Grows

Neighborhood associations

Local schools

Faith-based organizations

Activities

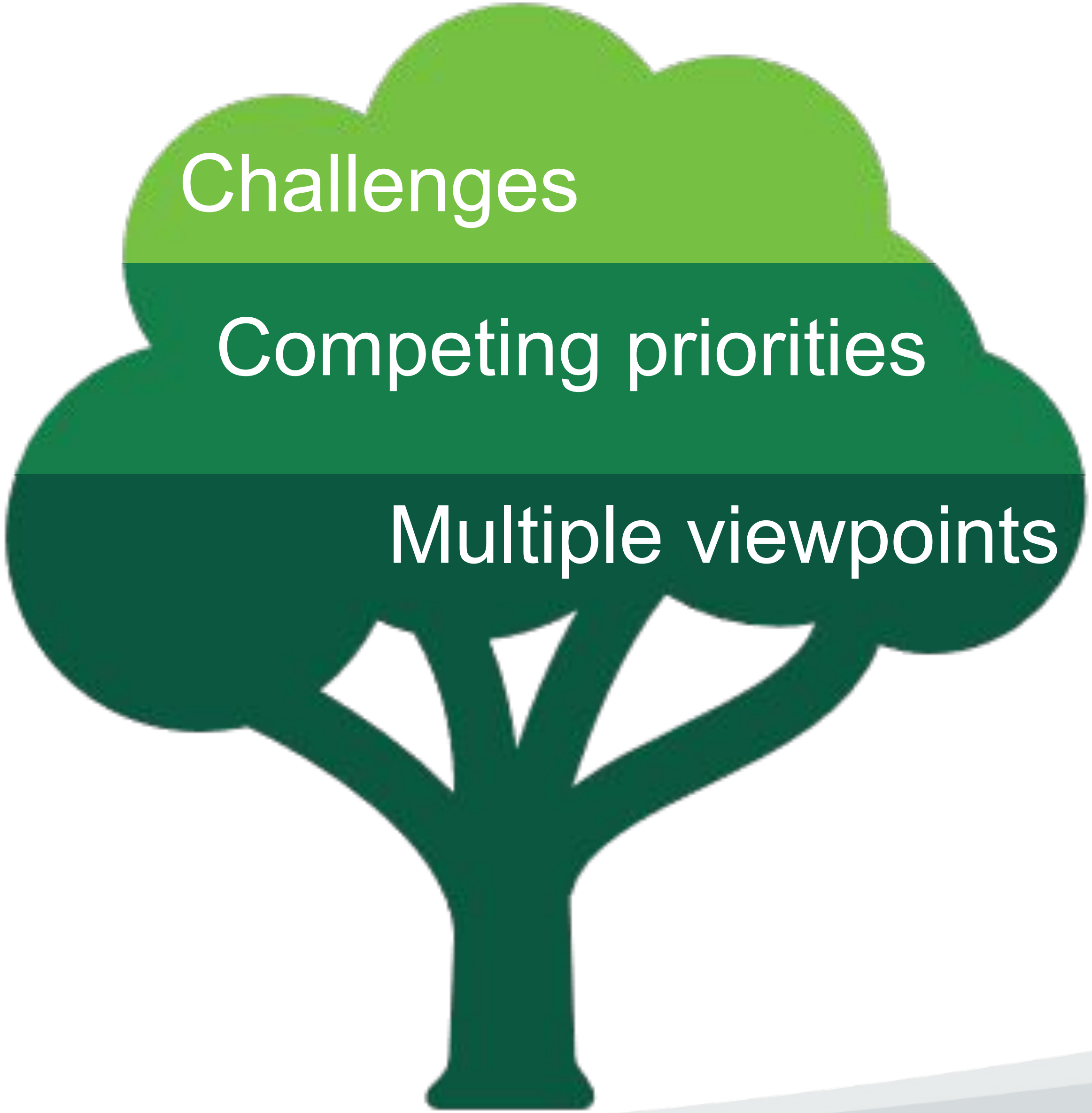
Health screenings

Conversation Club

The Canopy Newsletter

Art and Literature Showcase

Lessons Learned



Overcoming Barriers

TREE SELECTION

TREE ASSISTANCE FUND

STRATEGIC PARTNERSHIP

Temperatures in the Green Heart Study

Hypothesis: Increased area greenness changes temperature gradients within an urban neighborhood.

Temperature Exposure

- Ambient temperature within 300m of residence
- Temperature variability (standard deviation of daily temperatures)

Greenness

- NDVI
- Tree canopy
- LiDAR

CVD Risk

- CVD risk biomarkers (blood pressure, lipids, glucose regulation)
- Vascular function and injury (arterial stiffness, endothelial microparticles)
- Inflammation (hsCRP, fibrinogen)
- Immunity (immune cell populations)

hsCRP – High-Sensitivity C-Reactive Protein, NDVI – Normalized Difference Vegetation Index, LiDAR – Light Detection and Ranging

Examining Disparities in the Green Heart Study

Hypothesis: Discrimination will modify the relationship between environmental exposures and cardiovascular disease risk.

Exposures	CVD Risk	Modifiers
Volatile Organic Compounds (VOCs)	CVD risk biomarkers (blood pressure, lipids)	Discrimination Everyday and lifetime discrimination (occurrence/frequency, attribution, coping)
$PM_{2.5}$, Ozone	Vascular function (arterial stiffness)	Mental stress Questionnaire, urine catecholamine metabolites, depression, well-being, social cohesion
Greenness	Inflammation (hsCRP, fibrinogen)	

hsCRP – High-Sensitivity C-Reactive Protein

What's In The Air?

Partners and Collaborators

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Community, Study Participants, Volunteers, Collaborators, Stakeholders, Students, Contractors, Funders, and Others

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