Public health impacts of climate change: Extreme heat and hurricanes

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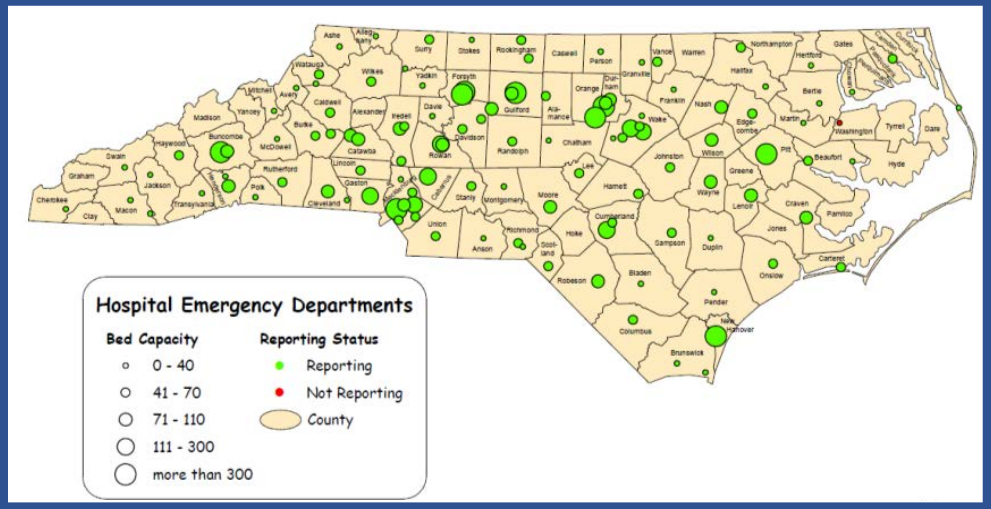
OUTLINE

1. Heat Vulnerability
   - Patterns of heat vulnerability in North Carolina
     - Web-based tool that predicts rates of heat illness
   - Patterns of teenage heat vulnerability
     - Web-based tool that predicts heat stress for high school athletics
2. Hurricane Inland Flood vulnerability
   - Hurricane Florence
   - Hurricane Floyd

Heat Illness in North Carolina: Data and Methods

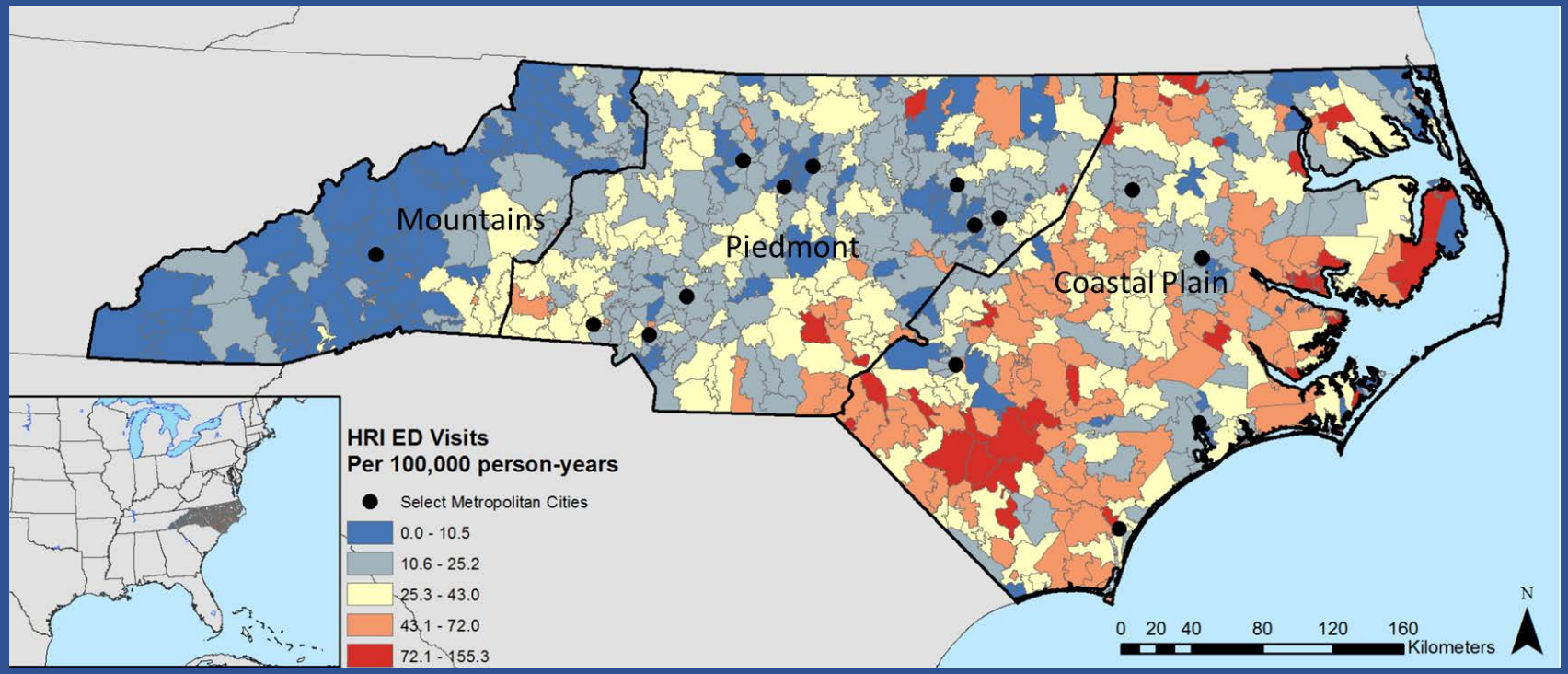
- North Carolina Disease Event Tracking and Epidemiologic Collection Tool (NC DETECT)
- Age, gender, billing address county, and zip code
- Dates Available: 01/01/2007 – 12/31/2012
- Acquire all emergency department visits with ICD-9: 992.xx for both primary and secondary diagnostic codes (May – September)
- Each ED visit linked to the daily maximum temperature at the nearest weather station.



NC- DETECT (2007 – 2012)

- Age
- Gender
- Date and Time of Visit
- All diagnostic codes(992)
- Zip code/County of residence
- Insurance information

Patterns of Heat Related Illness in North Carolina



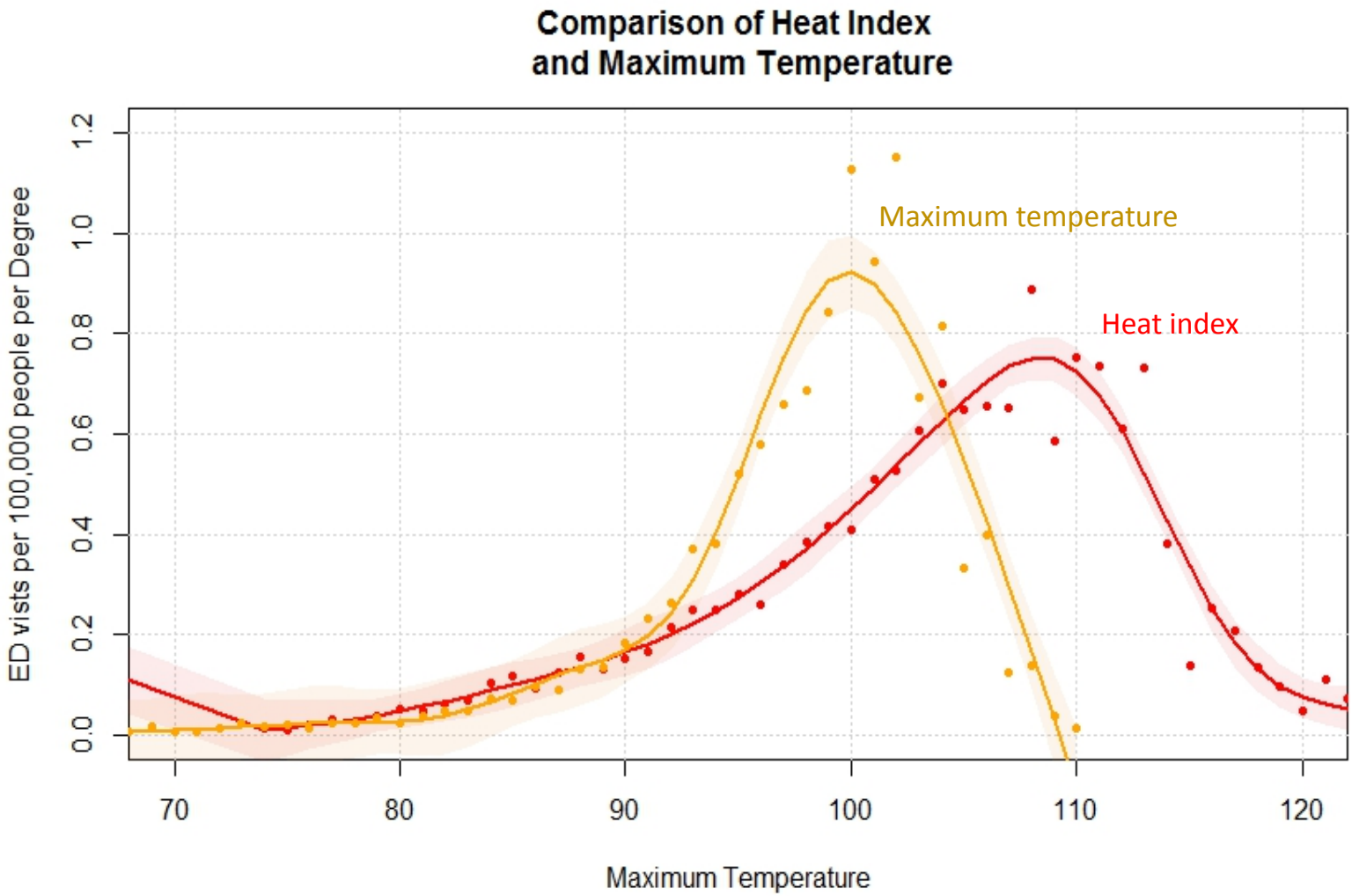
Credit: Maggie Sugg, Southeast Regional Climate Center

Rural areas especially vulnerable – Why?

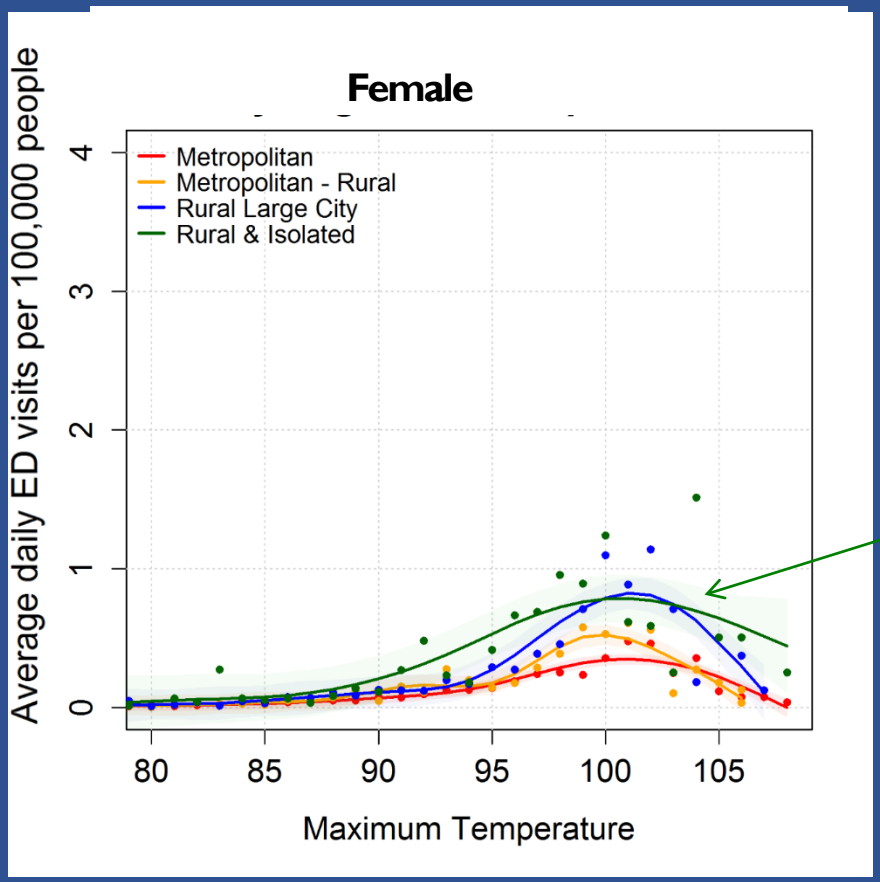
- More outdoor workers, especially in labor-intensive agriculture (produce/tobacco)
- More manufactured homes with poor insulation
- Much energy poverty
- Absence of health care

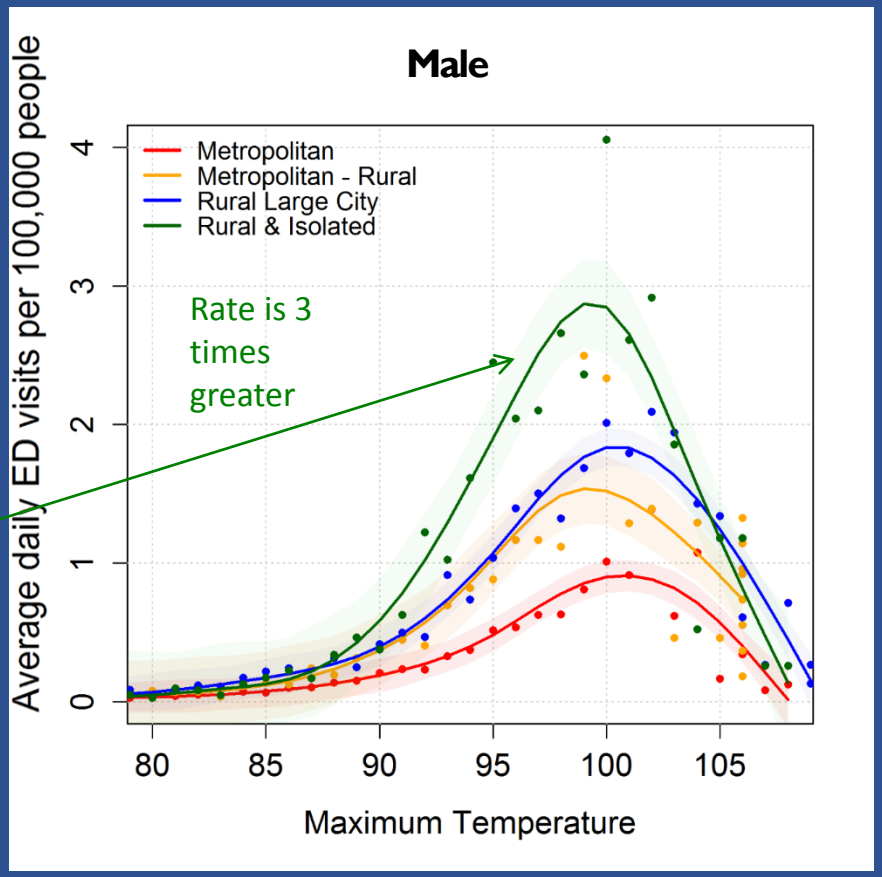
➢ Portions of Southside Virginia and Tidewater may be similar

Relationship between temperature and heat-related emergency room visits

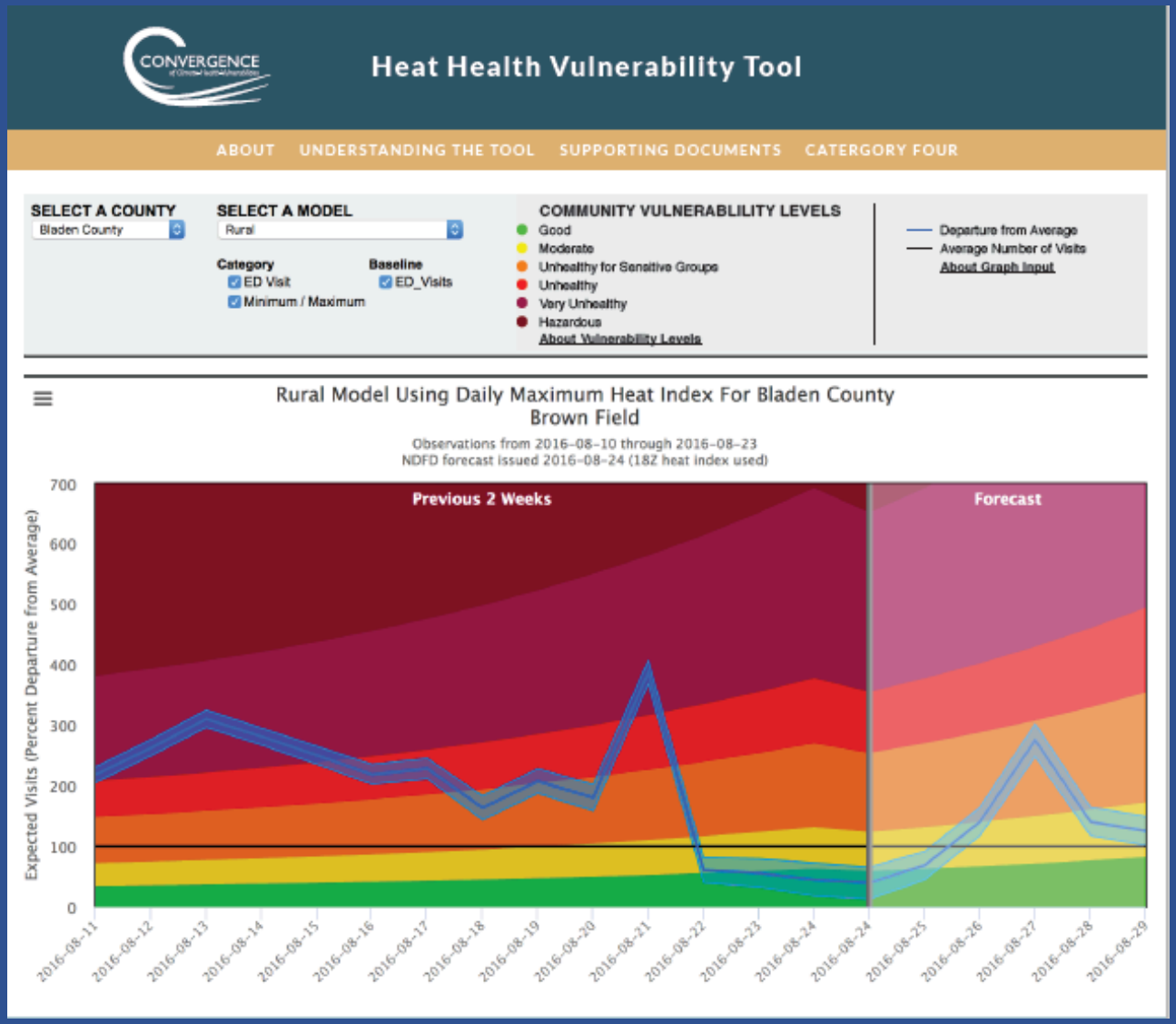


- Marked differences in rates with respect to gender and rurality

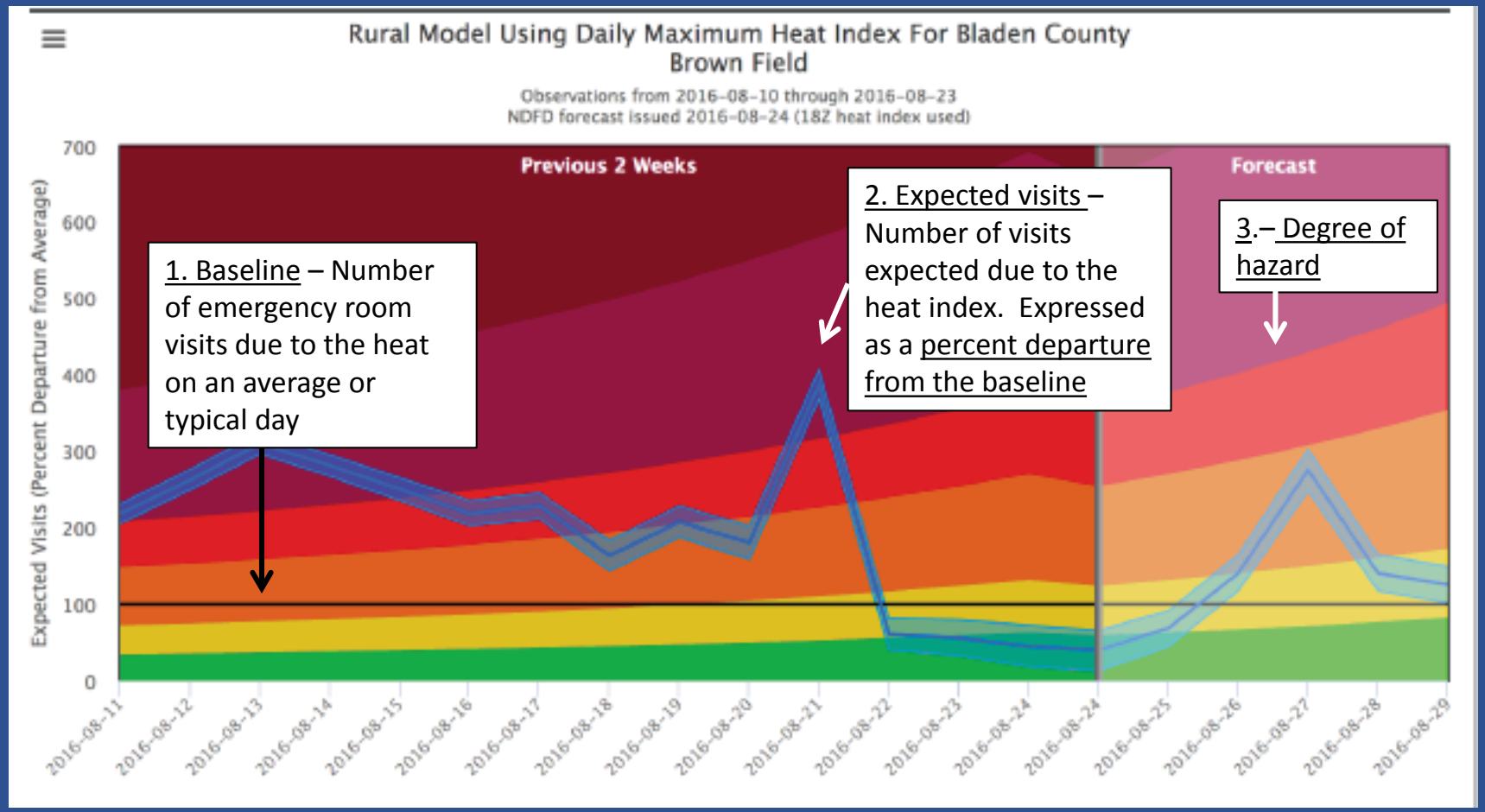




Web-based Tool that uses identified relationships to predict rates of heat illness

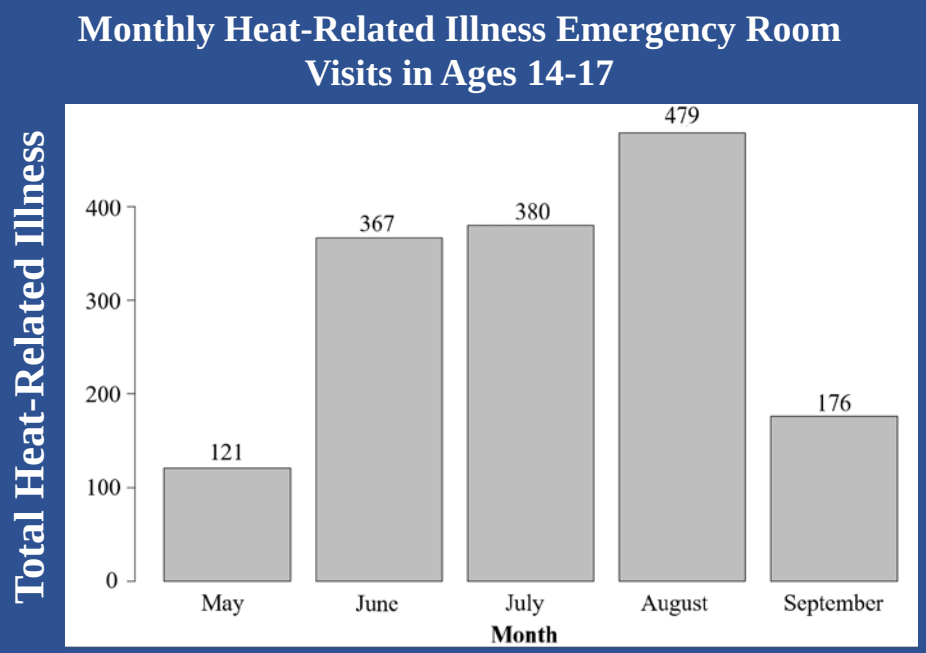


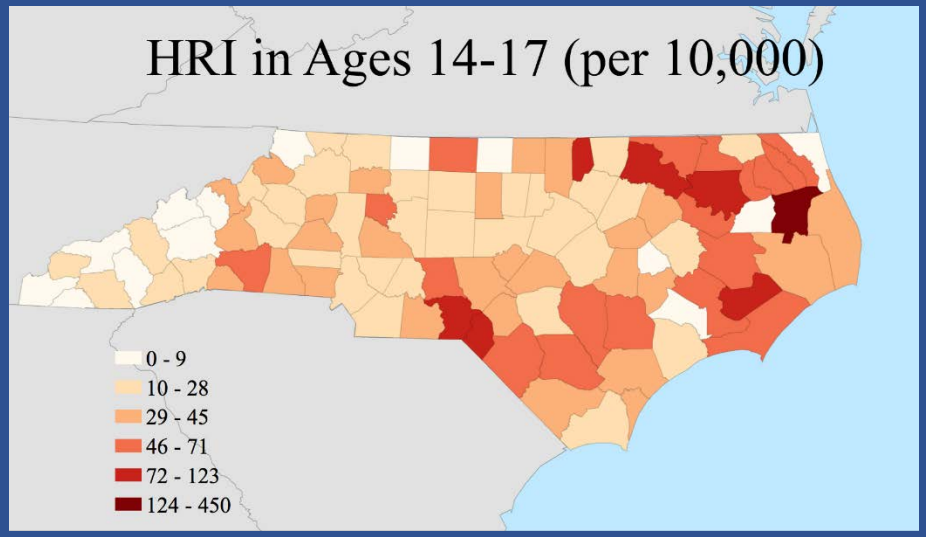
Closer look at the Heat Health Vulnerability Tool output



https://convergence.unc.edu/tools/heat/

Teenage heat Illness and the development of a tool for predicting heat stress on athletes





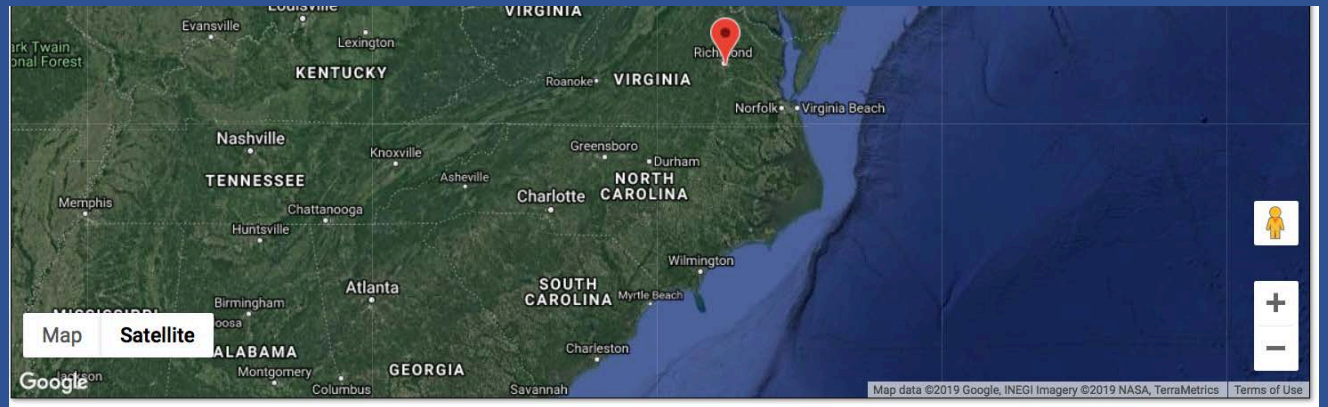
- Warmest, most humid conditions in July.
- But peak in August, which corresponds to the beginning of the fall athletic season

- An increasing number of states have developed practice guidelines on hot days based on wet bulb globe temperature.
- WBGT accounts not only for temperature and humidity, but also for solar radiation and wind speed.

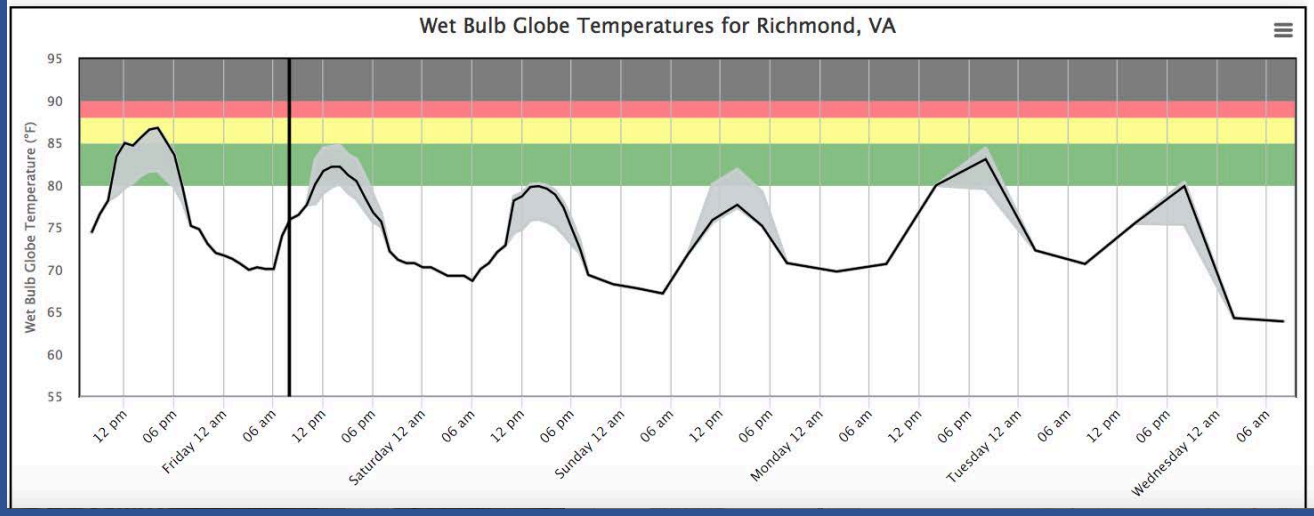
WBGT Activity Guidelines and Rest/Break Guidelines for Athletes

Heat Category	WBGT Index (F)	Activity Guidelines
No Flag	Under 80	Unlimited activity with primary cautions for new or unconditioned athletes or extreme exertion; schedule mandatory rest/water breaks. (5 min rest/water break every 30 min)
Low (Green Flag)	80-84.9	Normal practice for athletes; closely monitor new or unconditioned athletes and all athletes during extreme exertion. Schedule mandatory rest/water breaks. (5 min water/rest break every 25 min)
Moderate (Yellow Flag)	85-87.9	New or unconditioned athletes should have reduced intensity practice and modifications in clothing. Well-conditioned athletes should have more frequent rest breaks and hydration as well as cautious monitoring for symptoms of heat illness. Schedule frequent mandatory rest/water breaks. (5 min rest/water break every 20 min) Have cold or ice immersion pool on site for practice.
High (Red Flag)	88-89.9	All athletes must be under constant observation and supervision. Remove pads and equipment. Schedule frequent mandatory rest/water breaks. (5 min rest/water break every 15 min) Have cold or ice immersion pool on site for practice.
Extreme (Black Flag)	Over 90	SUSPEND PRACTICE

- The Southeast Regional Climate Center has developed a web-based tool that predicts wet bulb globe temperature for NC and VA



Submit



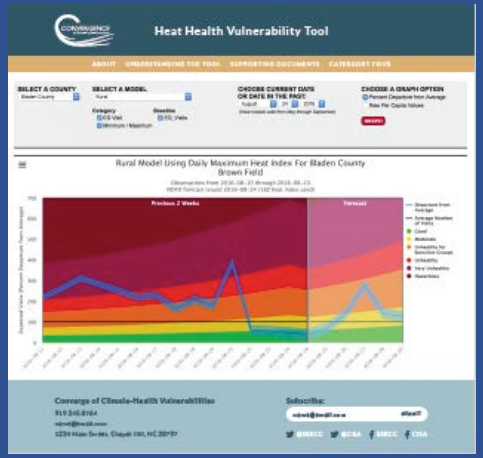
https://convergence.unc.edu/tools/nc-wbgt/

SERCC tools reside in the Convergence website

- Convergence provides much needed resources for public health and emergency management to plan for extreme weather events across North Carolina

Open access to research journal articles and other publications

http://convergence.unc.edu

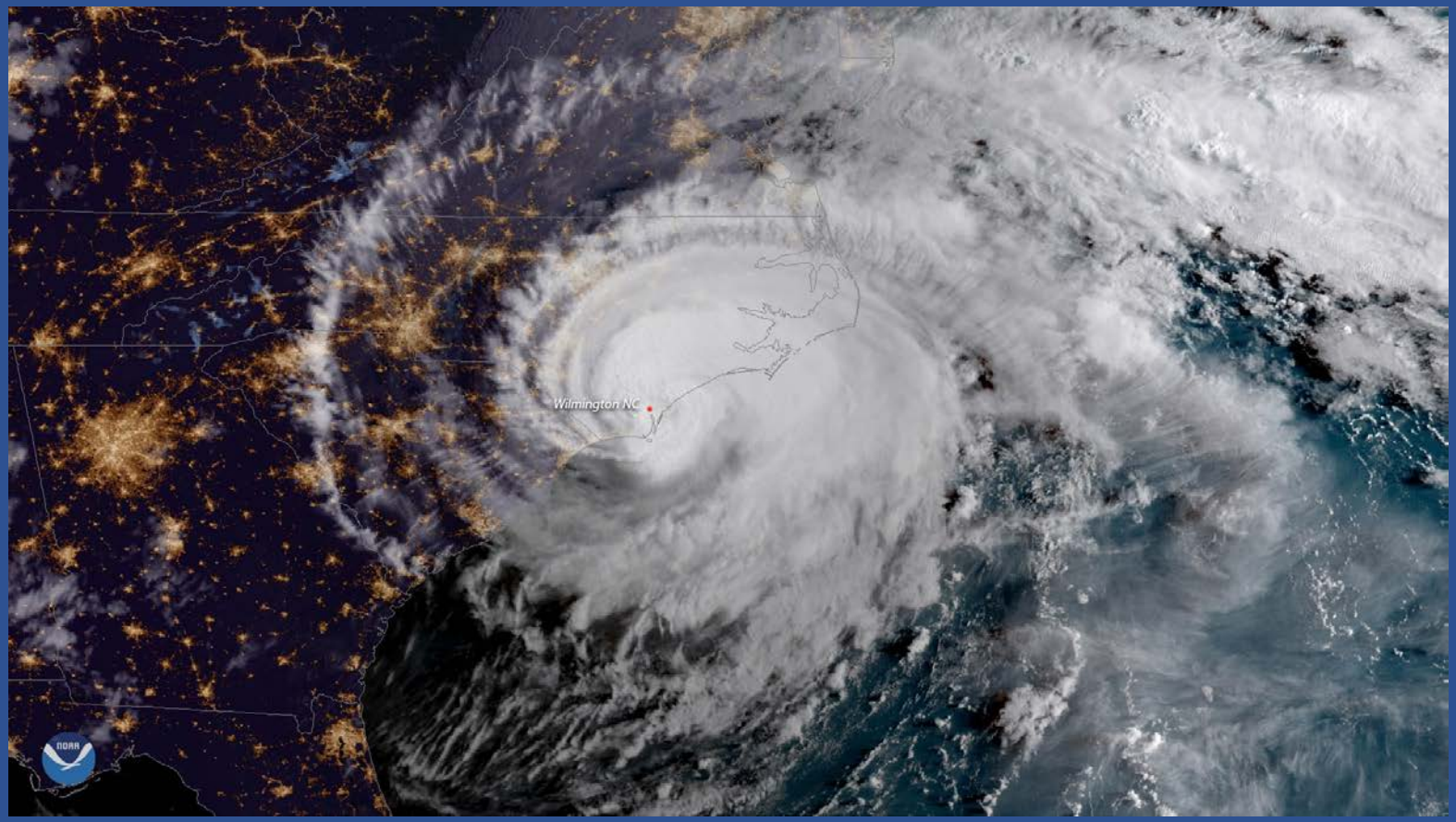


House tools and other resources for community stakeholders and decision makers

Data visualizations of vulnerabilities such as poverty, energy poverty, infrastructure, housing, demographics, and many more.

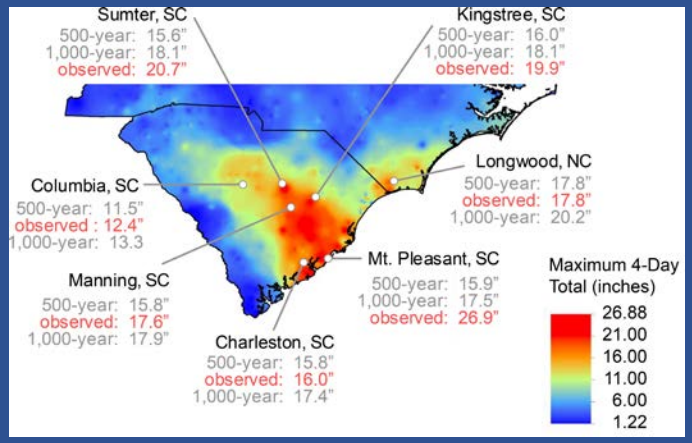
Inland flood vulnerability due to hurricanes

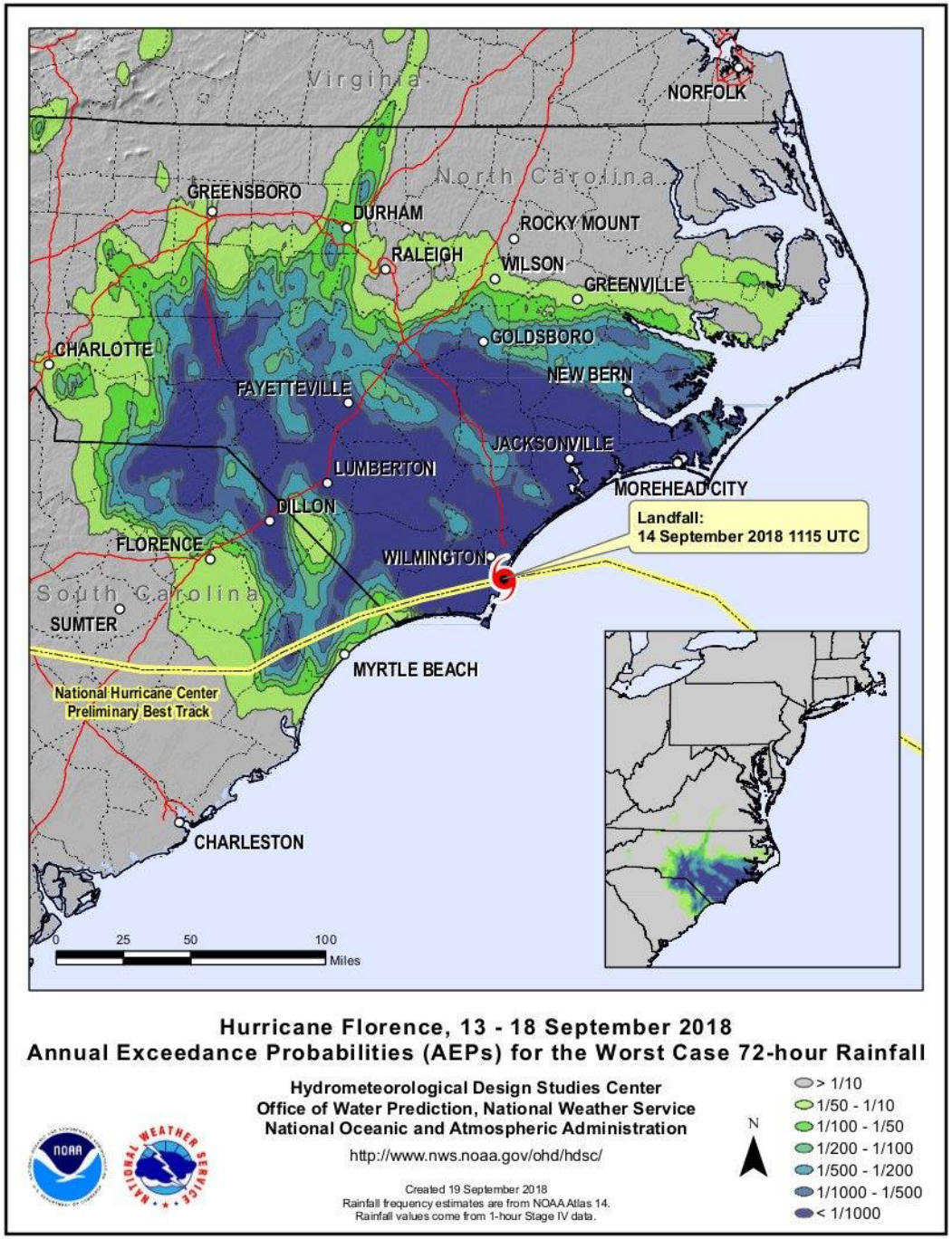
Hurricane Florence



Hurricane Florence

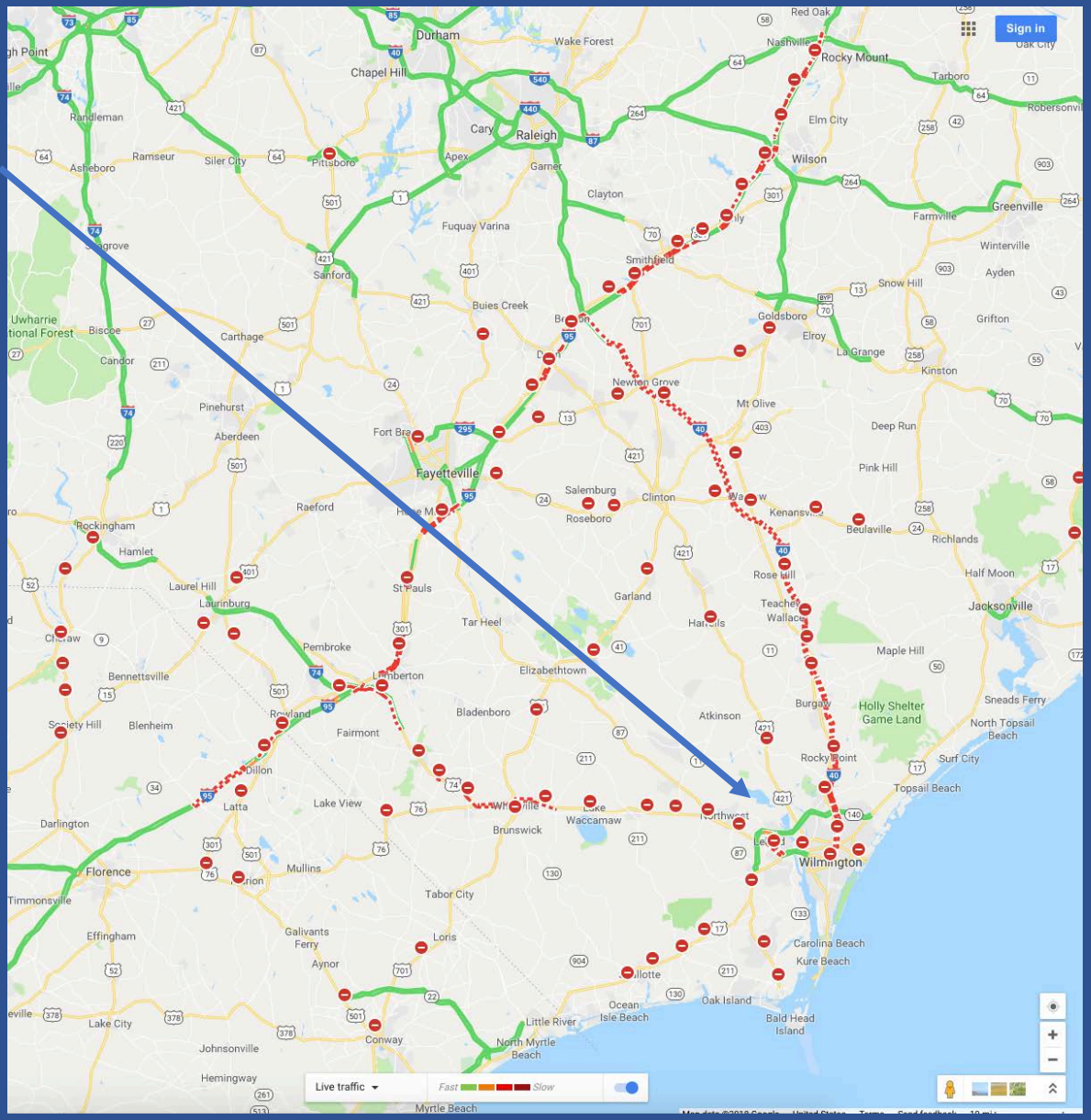
- Many areas experienced the 1000+ year precipitation event over a 3 day period
- Including Hurricane Florence, some areas experienced <u>three</u> 300+ year events in 3 year period:
  - Hurricane Matthew (2016)
  - Upper level low interaction with Hurricane **Joaquin** (2015)





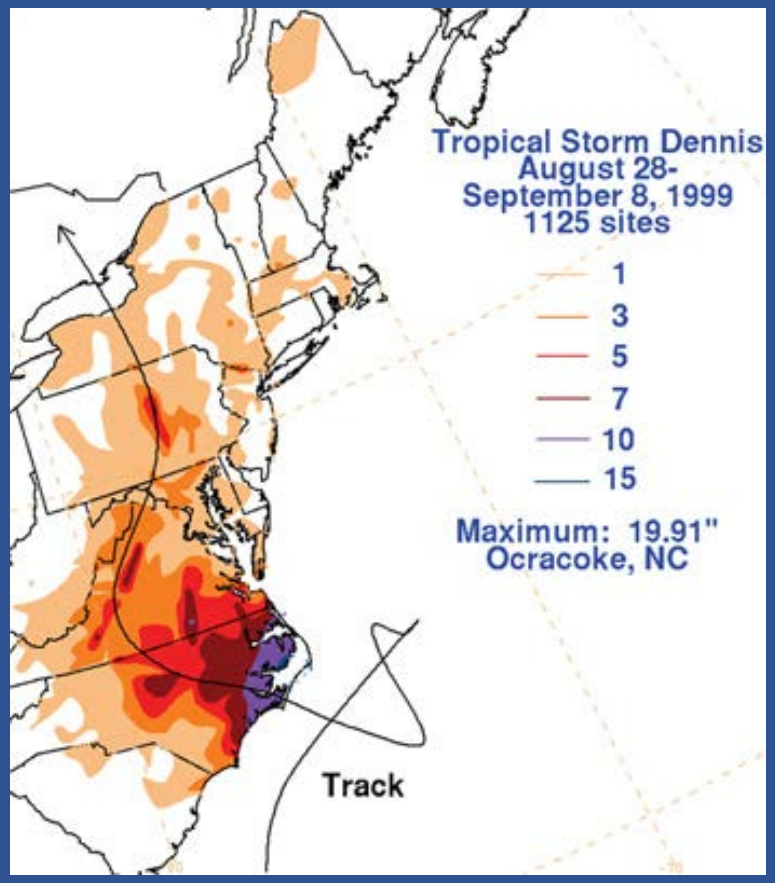
Road closures in the wake of Hurricane Florence

- Wilmington became an island separated from the mainland
- Numerous rural areas isolated for one week or more
- Many rural people, especially the elderly, in poor health and had no access to health care.

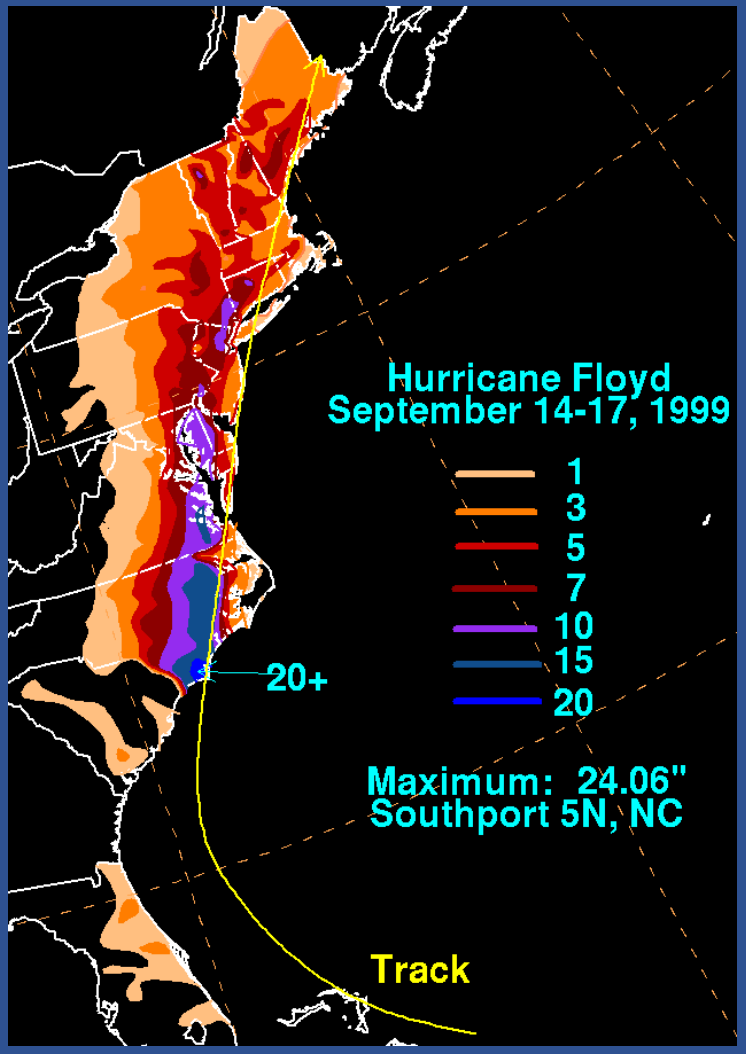


Hurricane Floyd (and Dennis)

- Hurricanes tend to be clustered in space & time



https://www.weather.gov/mhx/Sep161999EventReview



https://www.wpc.ncep.noaa.gov/tropical/rain/floyd1999.html

Hurricane Floyd

- 76 deaths, mostly from inland flooding, most since Hurricane Agnes in 1972
- 6.9 billion in damages
- Losses of 30,000 hogs, 700,000 turkeys, and 2.4 million chickens
  - Ecological disaster and public health nightmare

https://www.ecu.edu/renci/StormsToLife/Floyd/images/inlandflooding.jpg

https://www.ncpedia.org/anchor/floyd-and-agriculture

THANK YOU!

Questions?

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Heat and health in Virginia

Jeremy S. Hoffman, Ph.D.,

Chief Scientist

Science Museum of Virginia

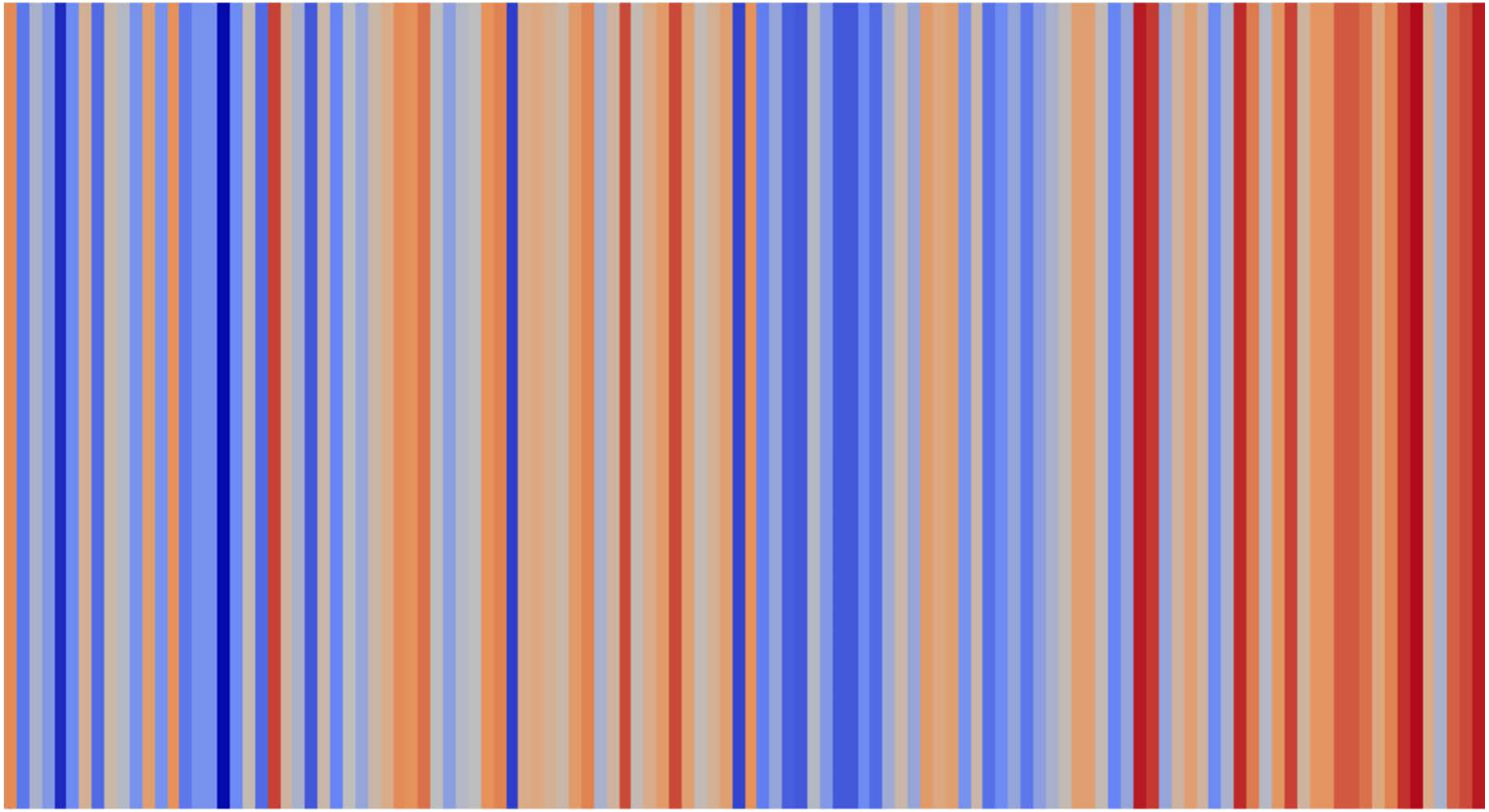
With a lot of help from a lot of amazing people

@jer_science

- Note: Any findings or data presented should be considered preliminary in nature.

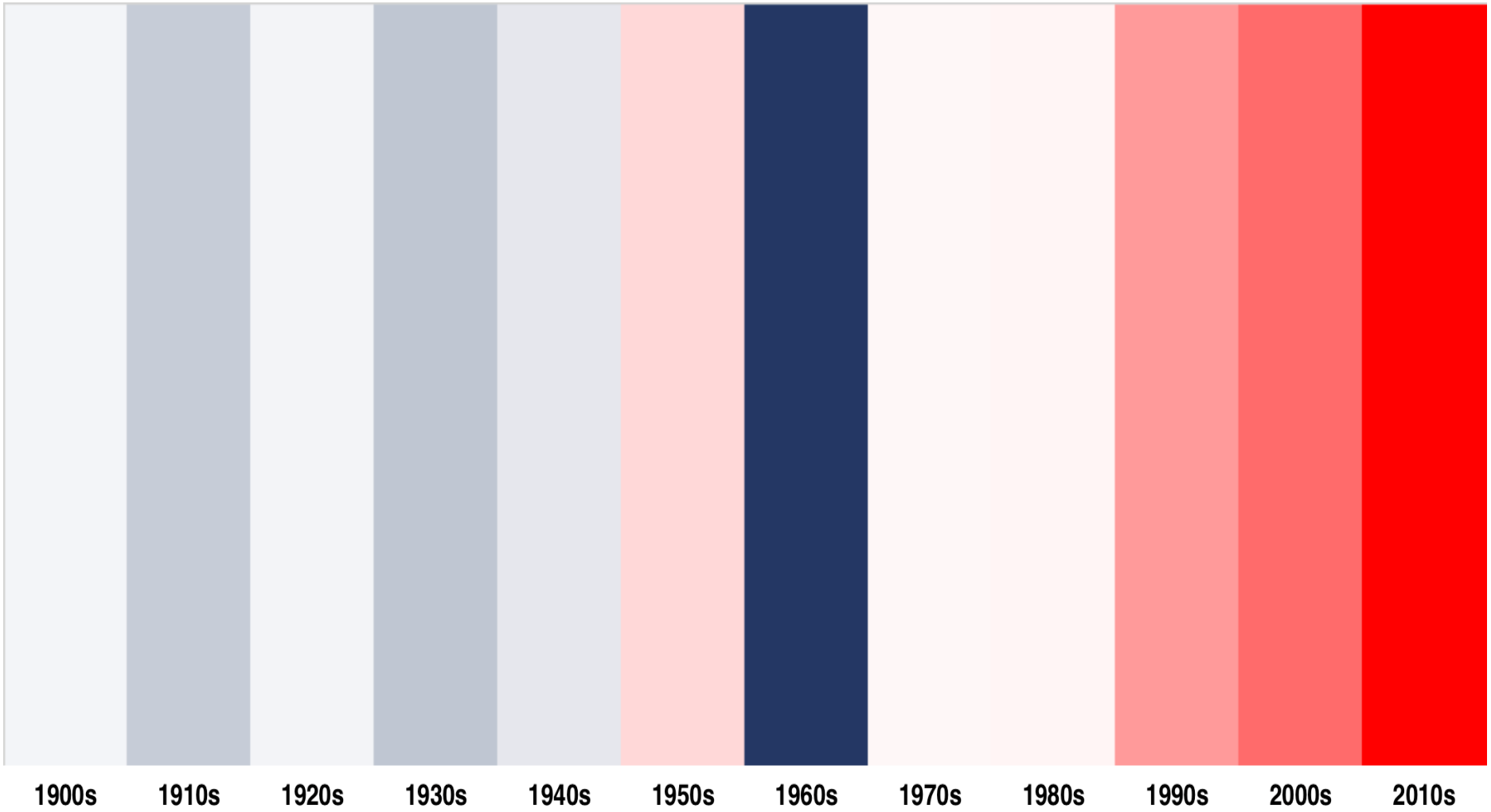
First up – heat in Virginia

Annual Average Temperatures in Tidewater VA



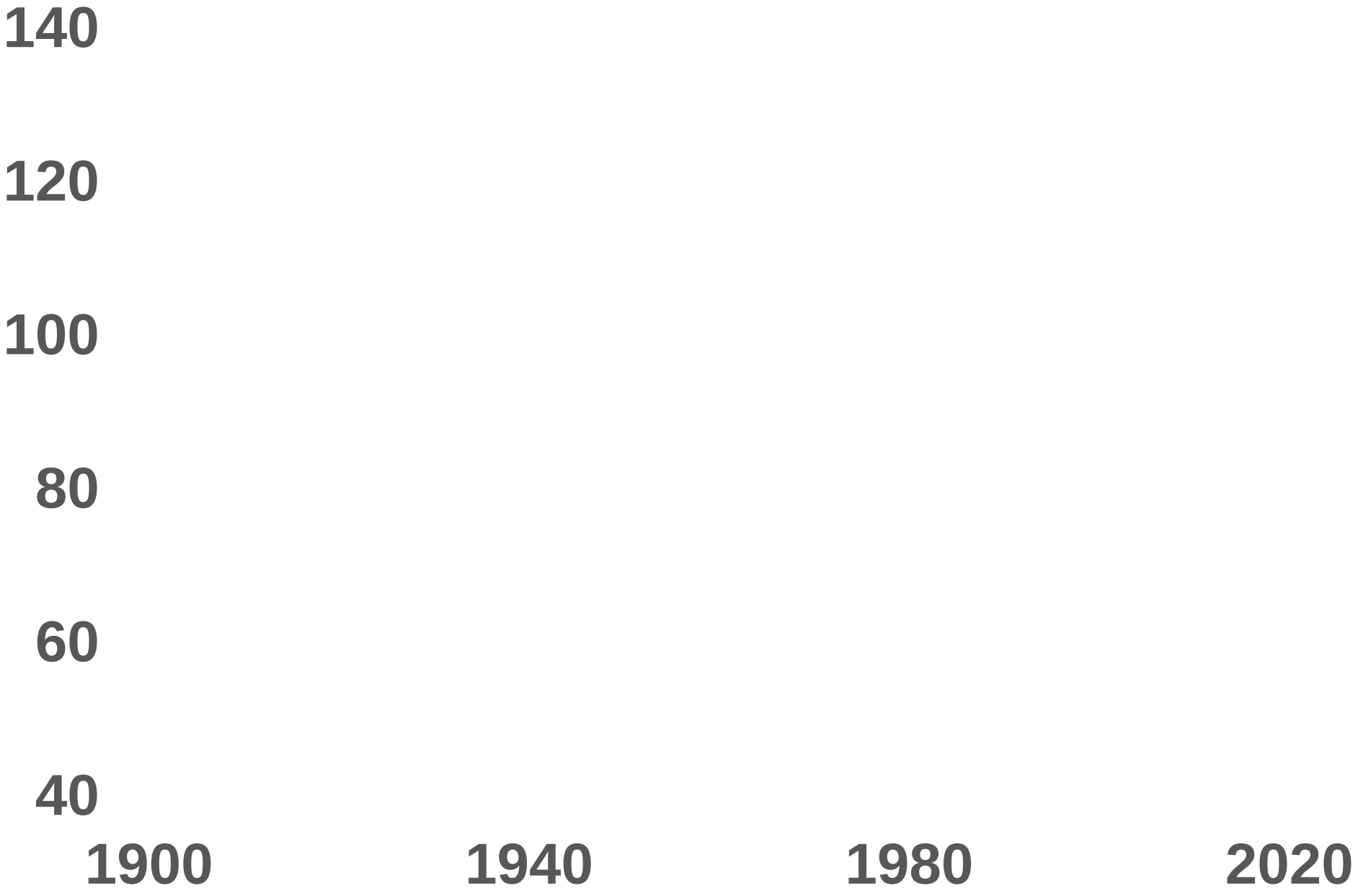
1900 Now

Decadal Temperatures in Richmond VA

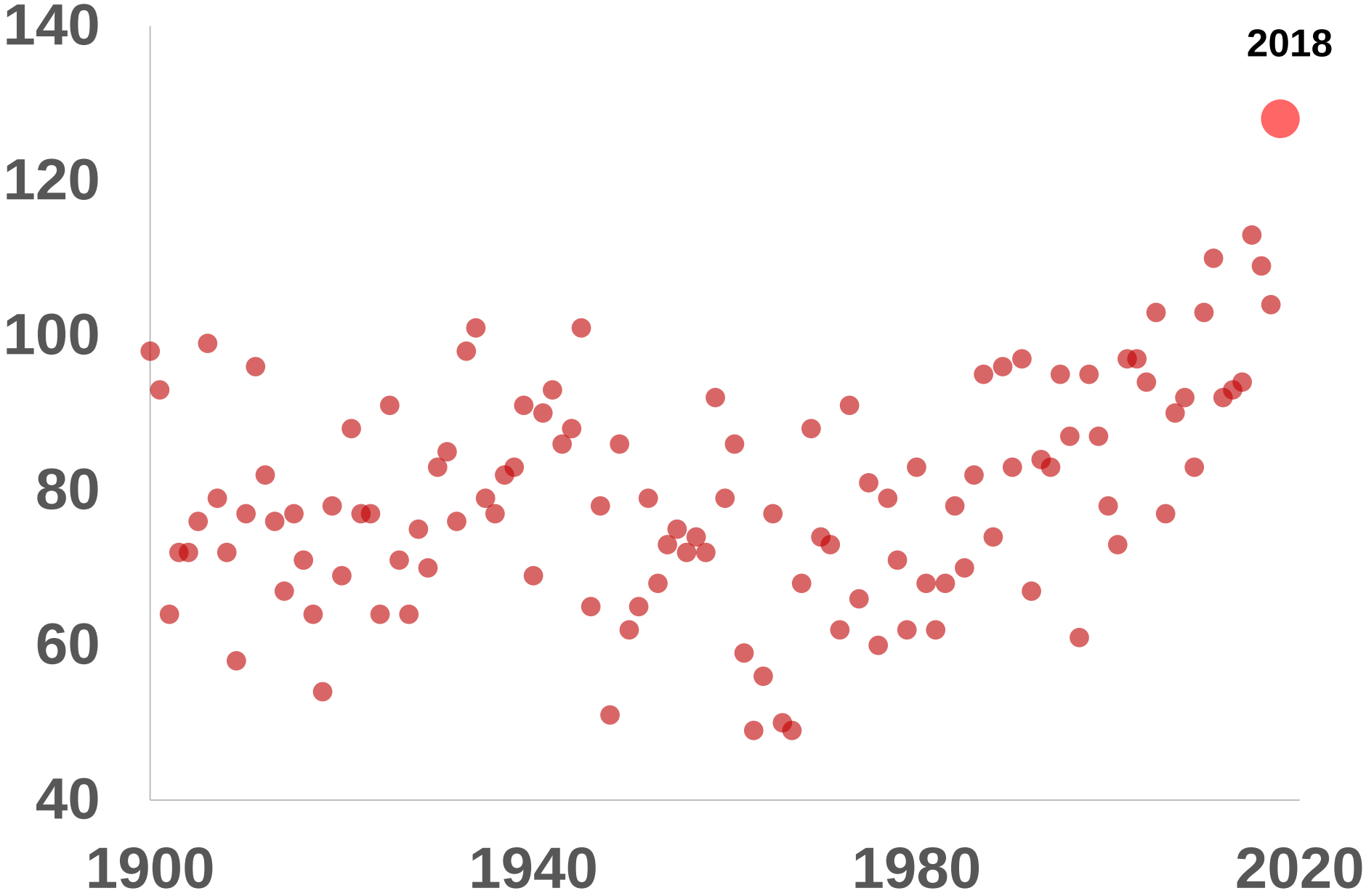


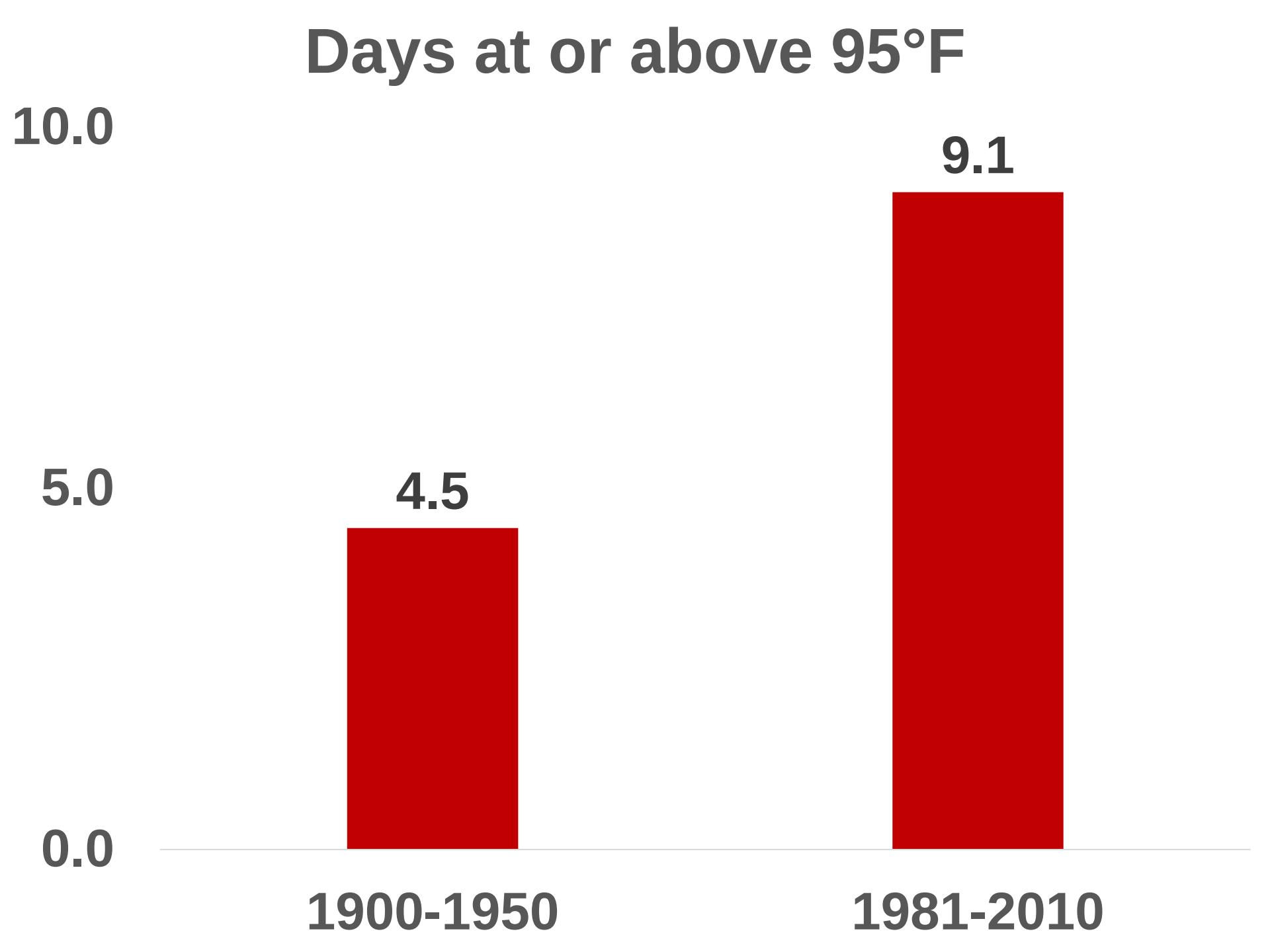
1900 **Now**

Tidewater Tropical Nights (≥68°F)

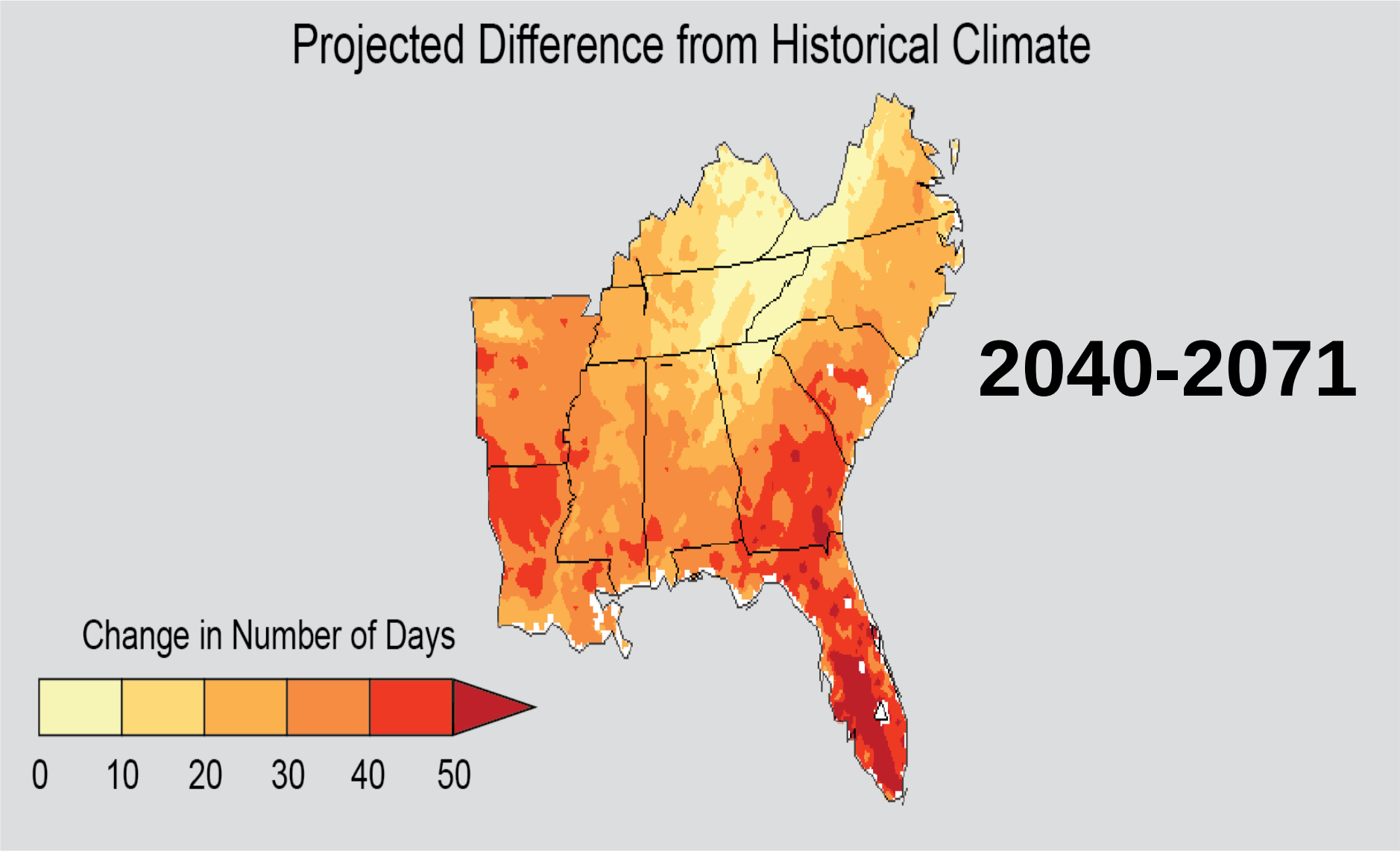


Tidewater Tropical Nights (≥68°F)



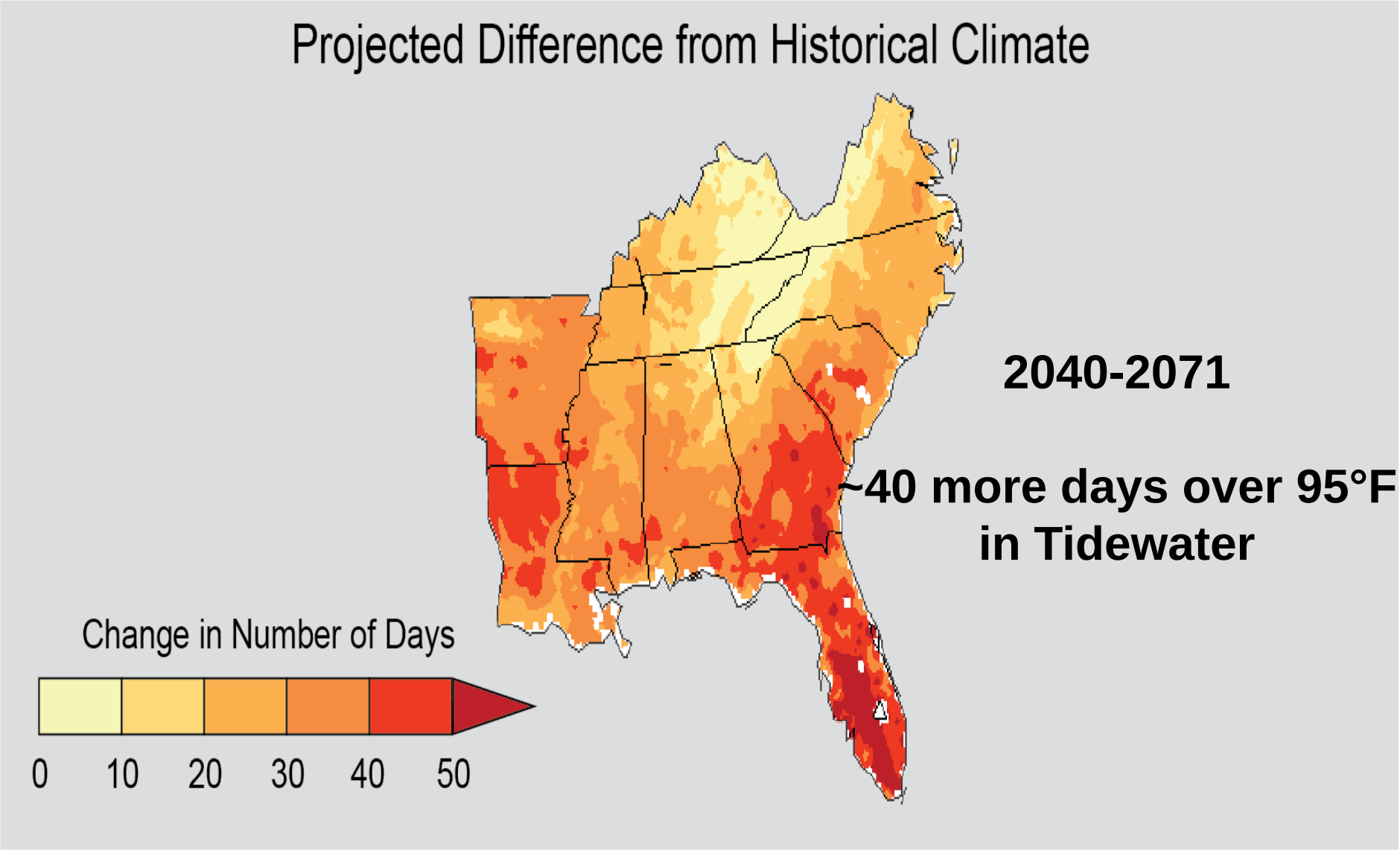

Days at or above 95°F
10.0
5.0
0.0
4.5
9.1
1900-1950
1981-2010

Projected Change in Number of Days Over 95°F



NCA, 2014

Projected Change in Number of Days Over 95°F



NCA, 2014

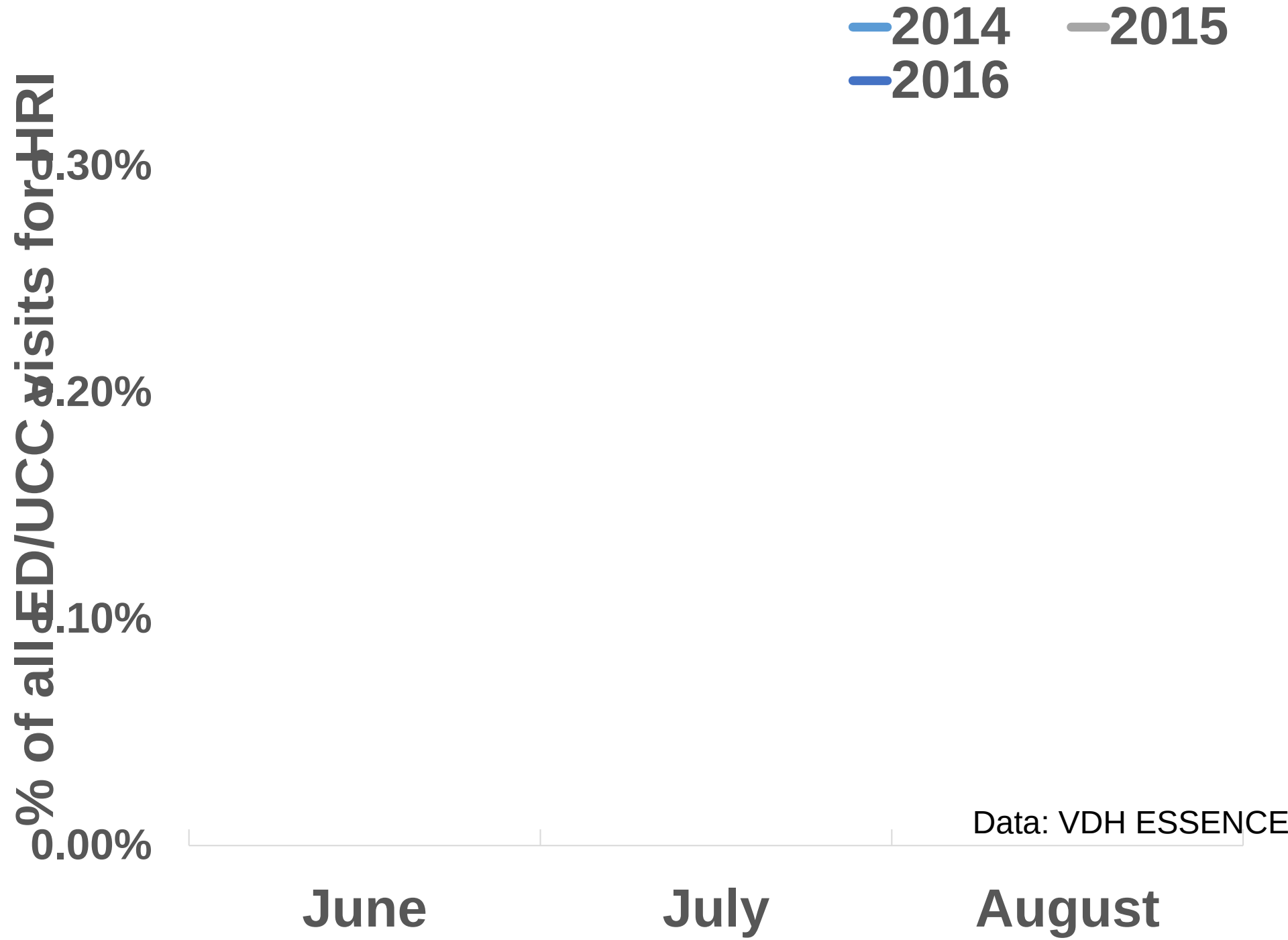
THE TIDEWATER OF TOMORROW(?)

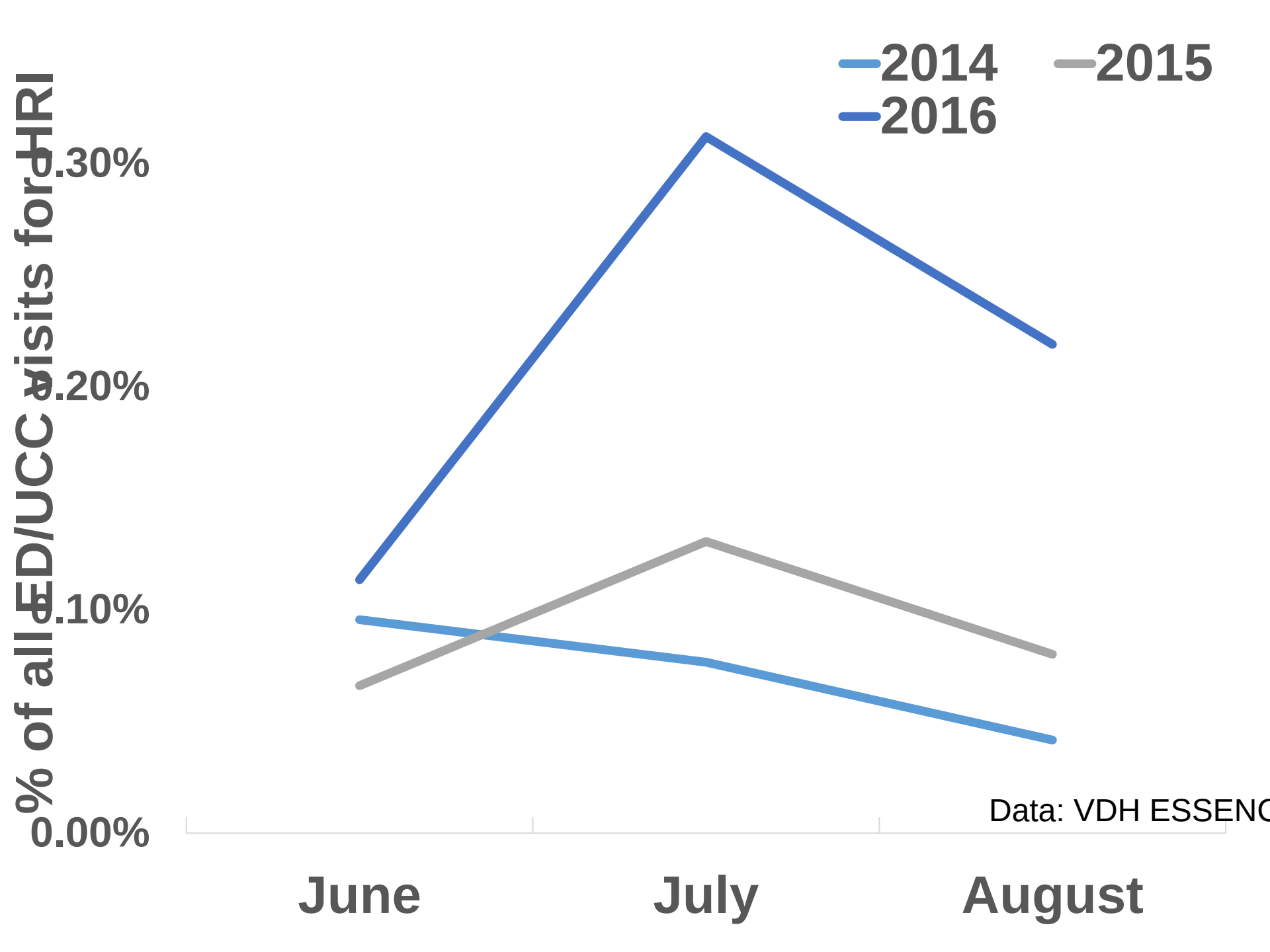
HOTTER, LONGER HEAT WAVES

THE ~~TIDEWATER~~-VIRGINIA OF TOMORROW(?)

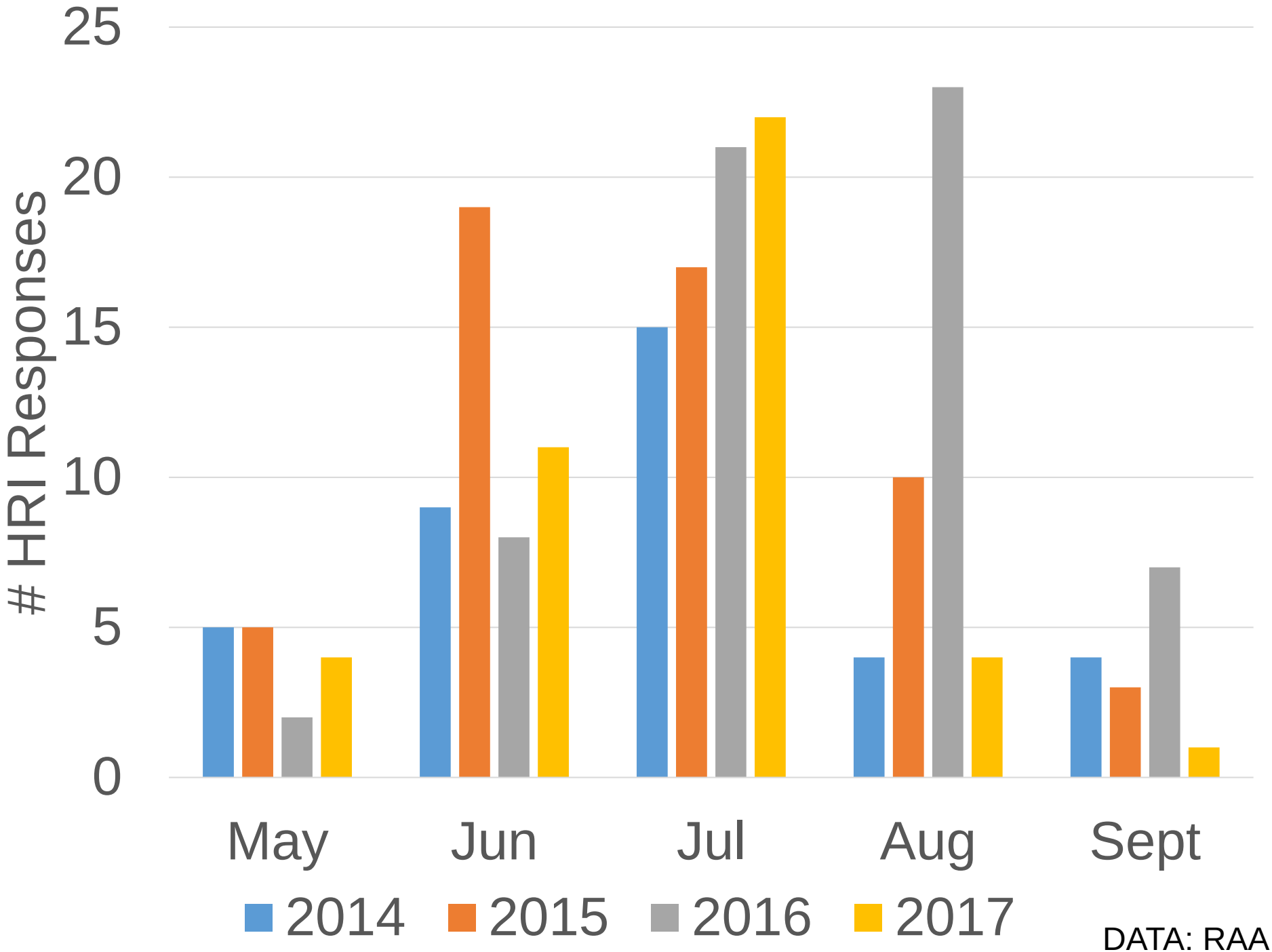
HOTTER, LONGER HEAT WAVES

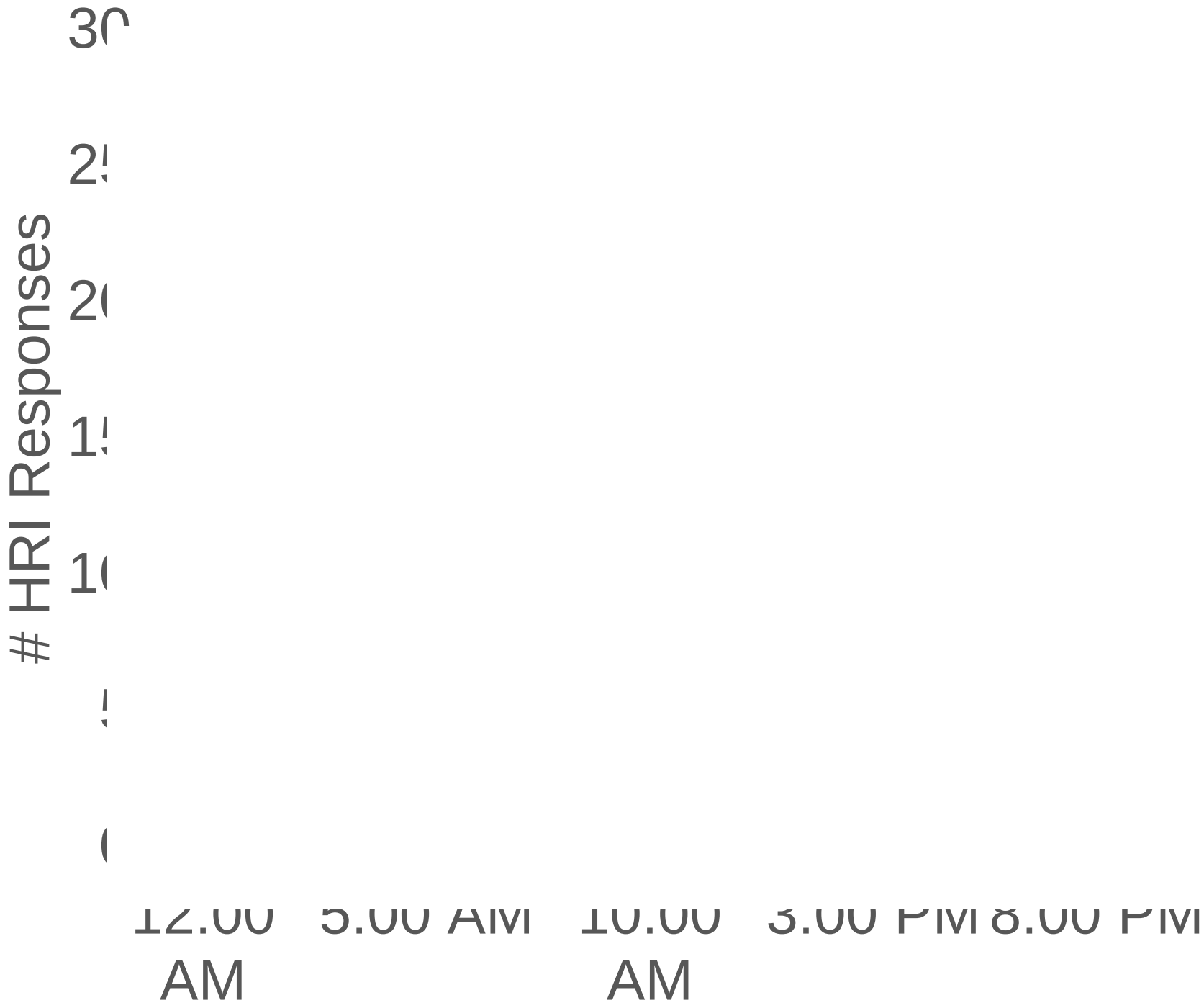
Heat and public health in VA?


2014
2015
2016
% of all ED/UCC visits for URI
0.30%
0.20%
0.10%
0.00%
Data: VDH ESSENCE
June
July
August

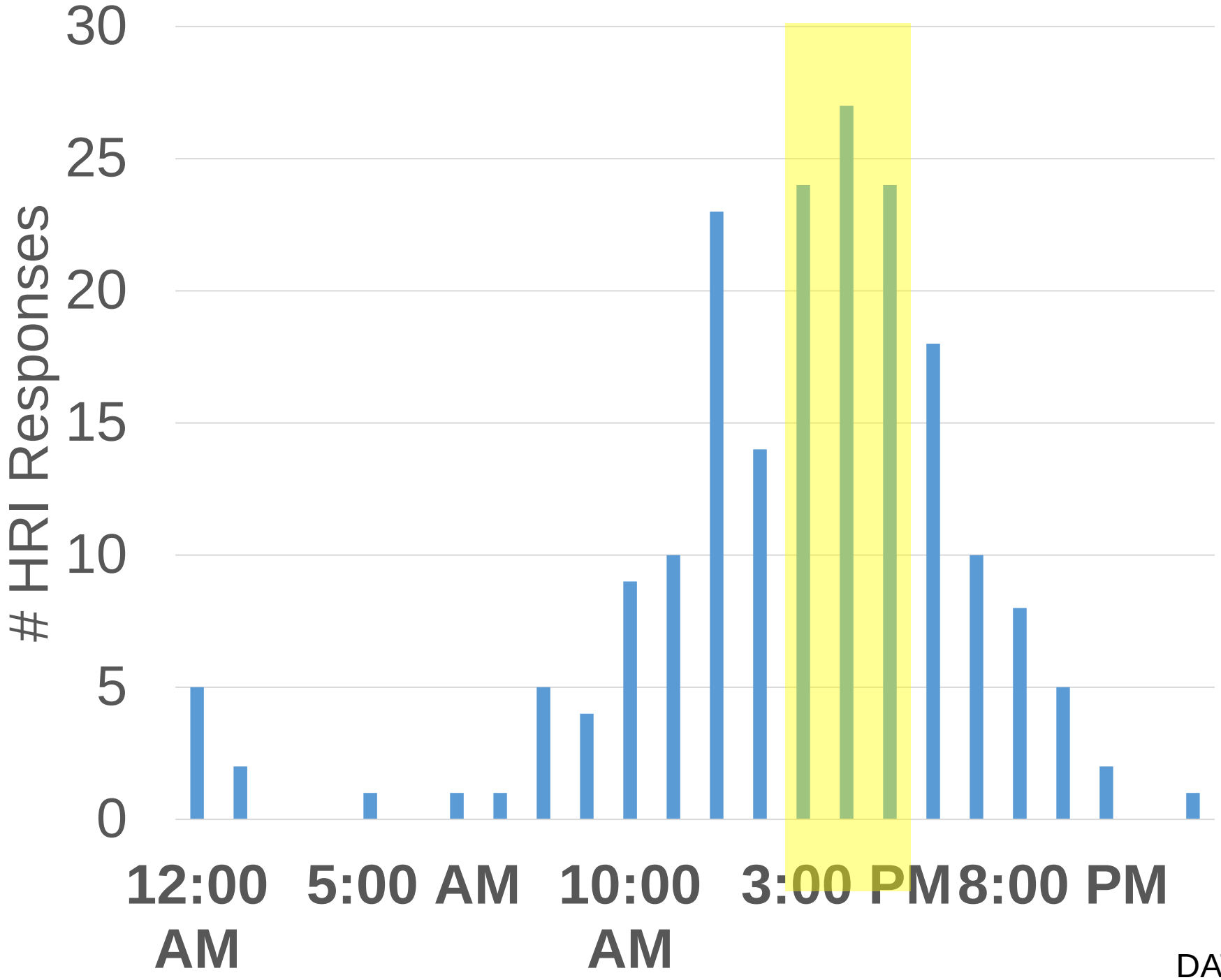

2014
2015
2016
% of all ED/UCC visits for URI
0.30%
0.20%
0.10%
0.00%
June
July
August
Data: VDH ESSENC

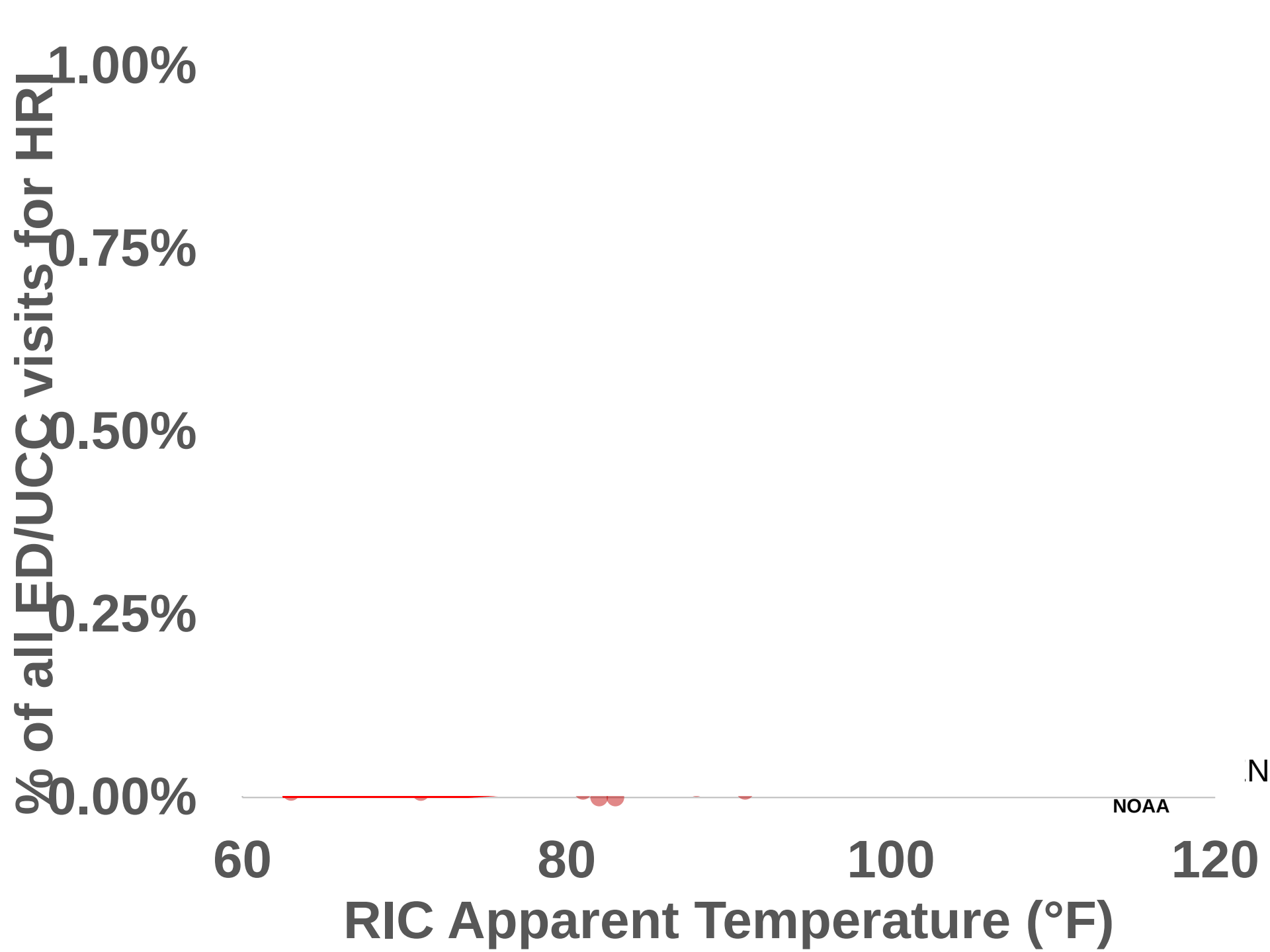
HRI Responses
25
20
15
10
5
0
May
Jun
Jul
Aug
Sept
2014
2015
2016
2017
DATA: RAA

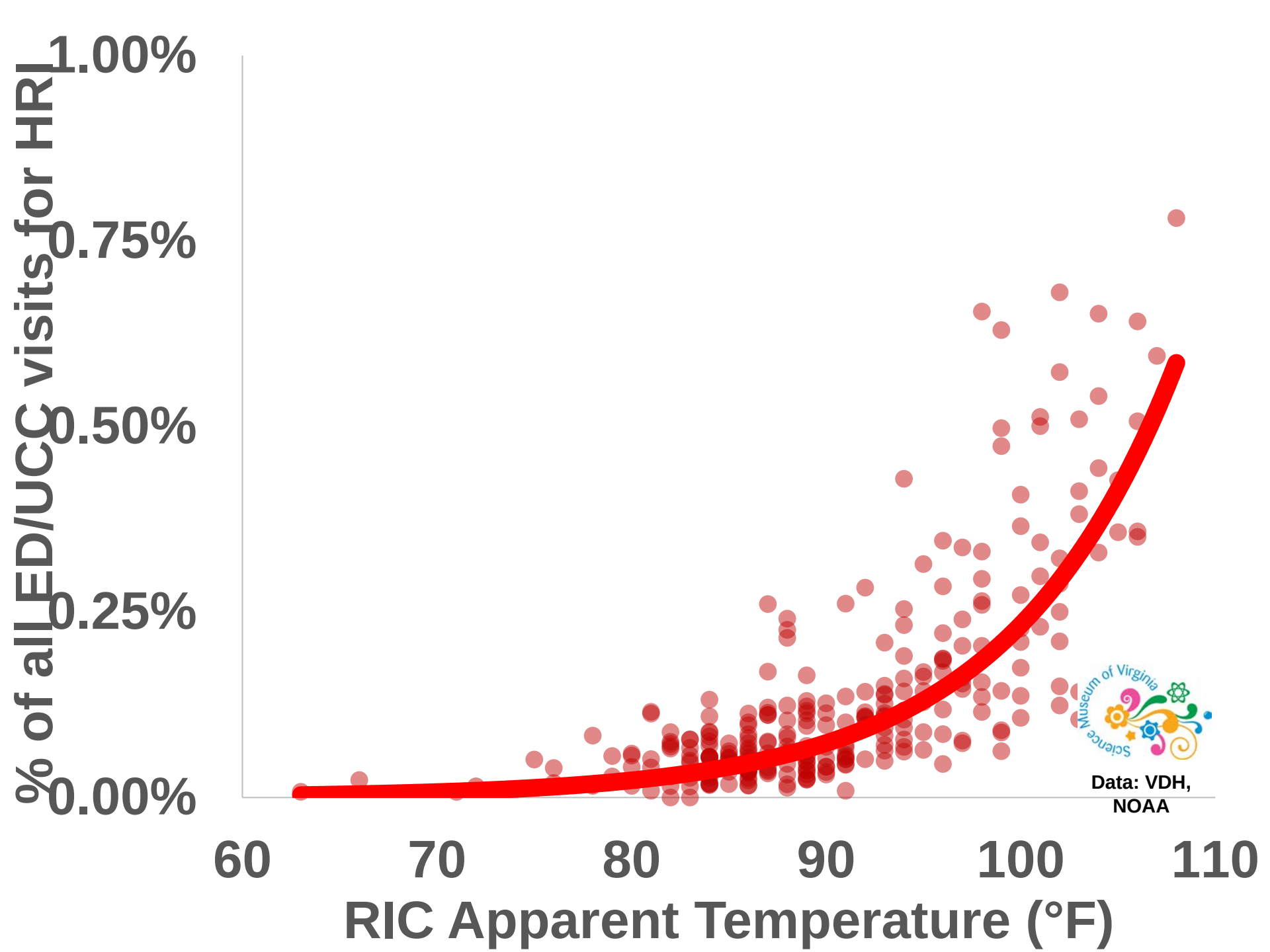

HRI Responses
25
20
15
10
5
0
May
Jun
Jul
Aug
Sept
2014
2015
2016
2017
DATA: RAA


HRI Responses
30
25
20
15
10
5
0
12:00 AM
5:00 AM
10:00 AM
3:00 PM
8:00 PM

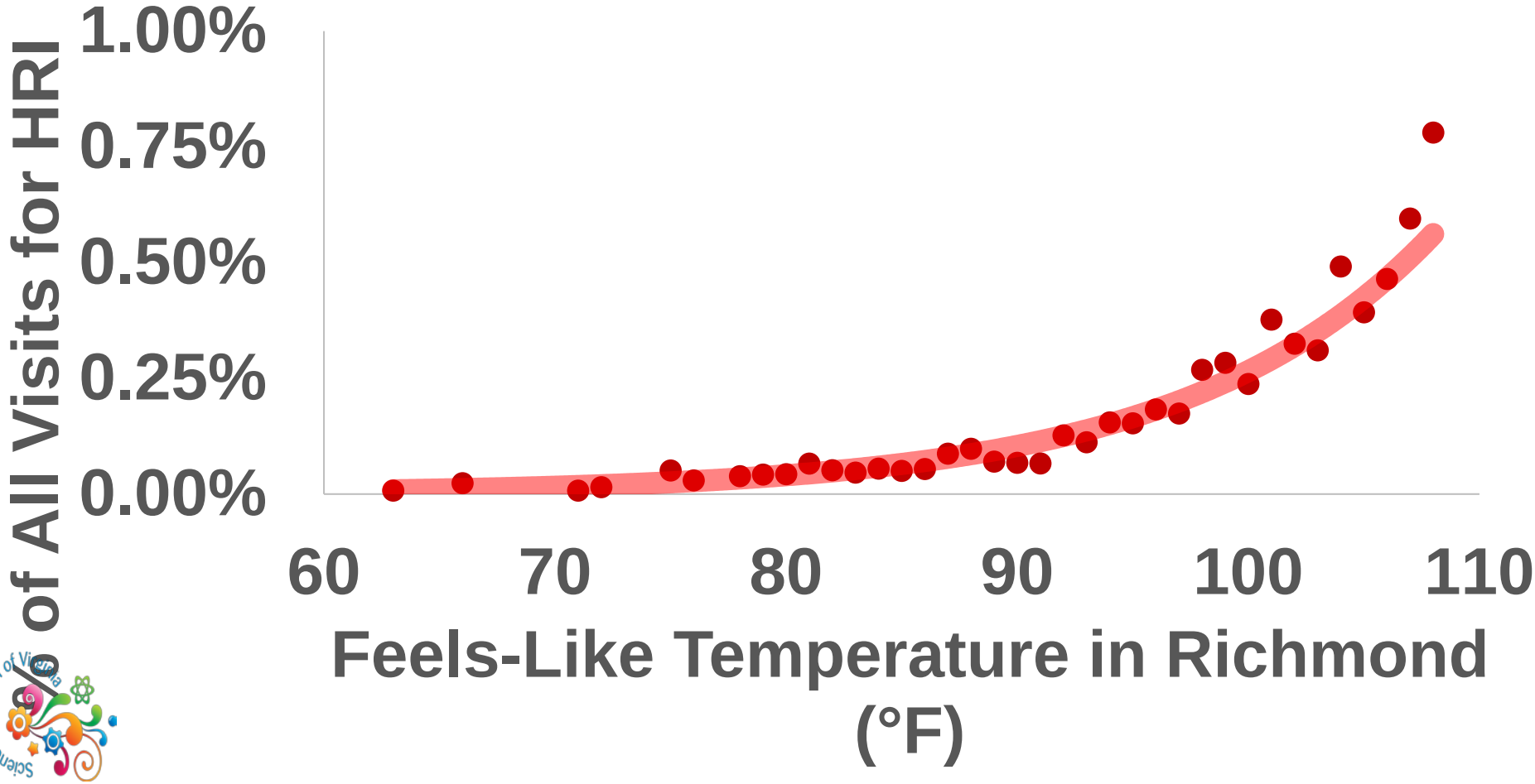
DATA: RA

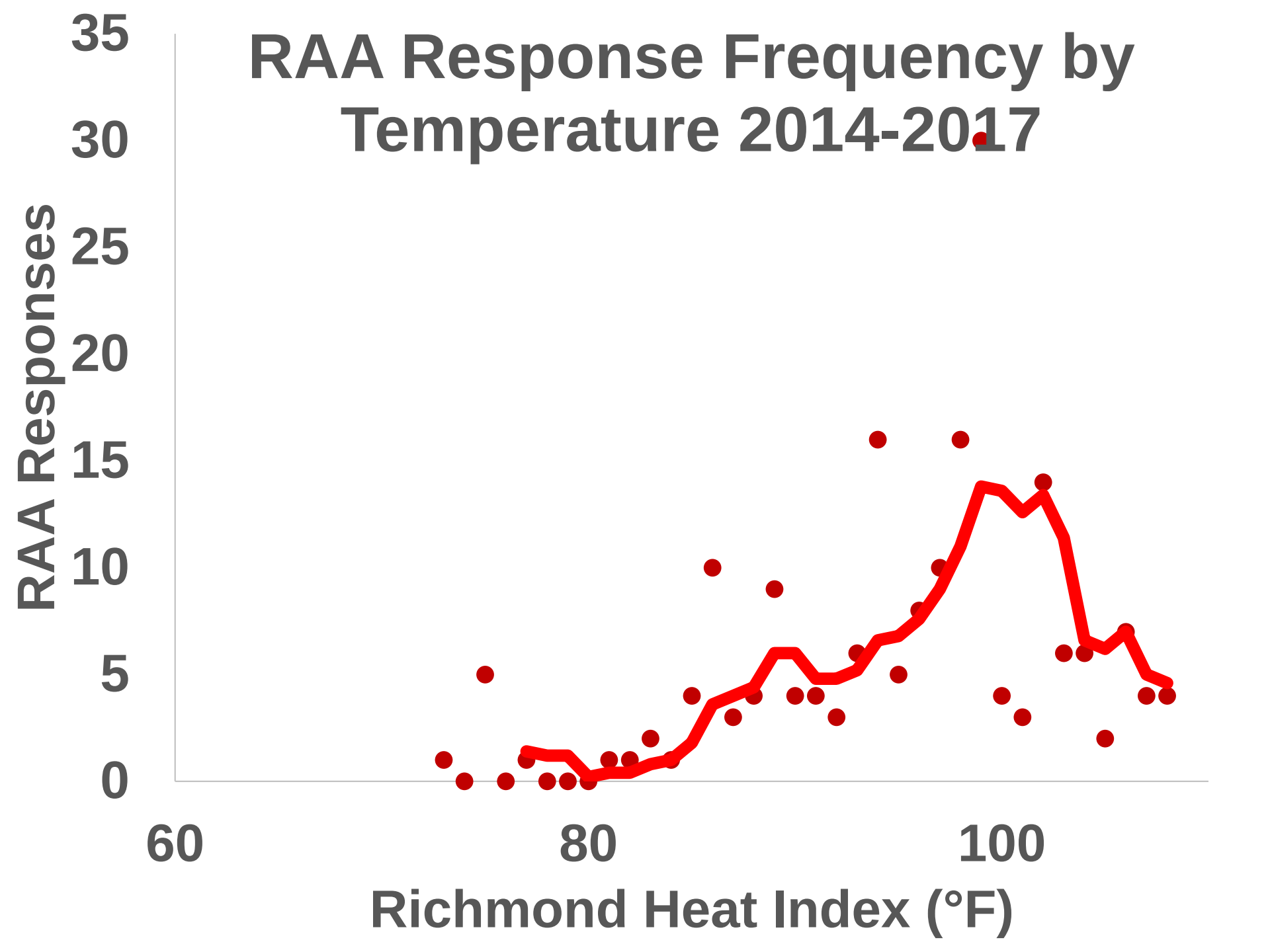

HRI Responses
30
25
20
15
10
5
0
12:00 AM
5:00 AM
10:00 AM
3:00 PM
8:00 PM
DATA: RA

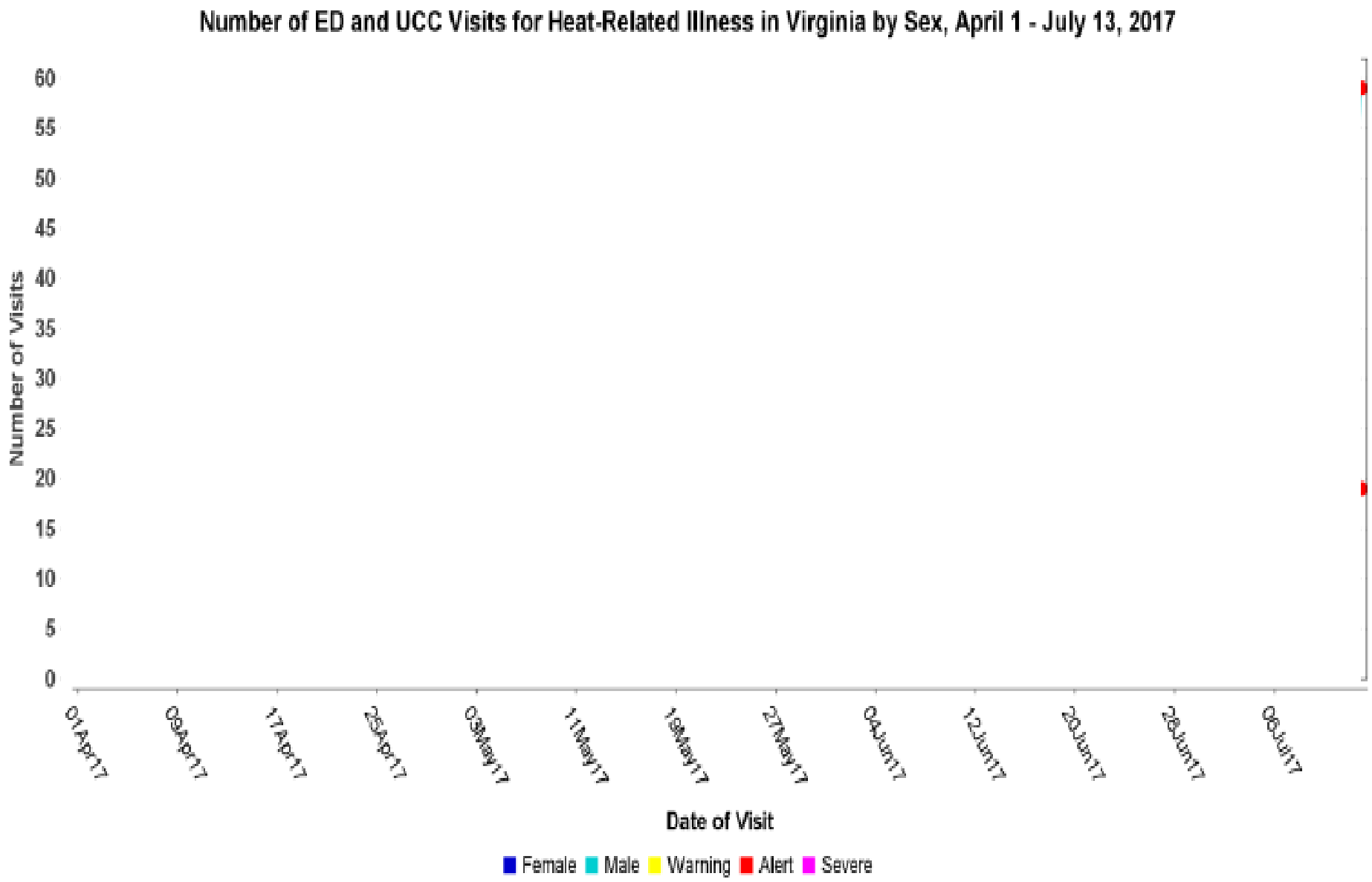

% of all ED/UCC visits for HRI
1.00%
0.75%
0.50%
0.25%
0.00%
NOAA
60
80
100
120
RIC Apparent Temperature (°F)


% of all ED/UCC visits for HRI
1.00%
0.75%
0.50%
0.25%
0.00%
60
70
80
90
100
110
RIC Apparent Temperature (°F)
Data: VDH, NOAA
Science Museum of Virginia

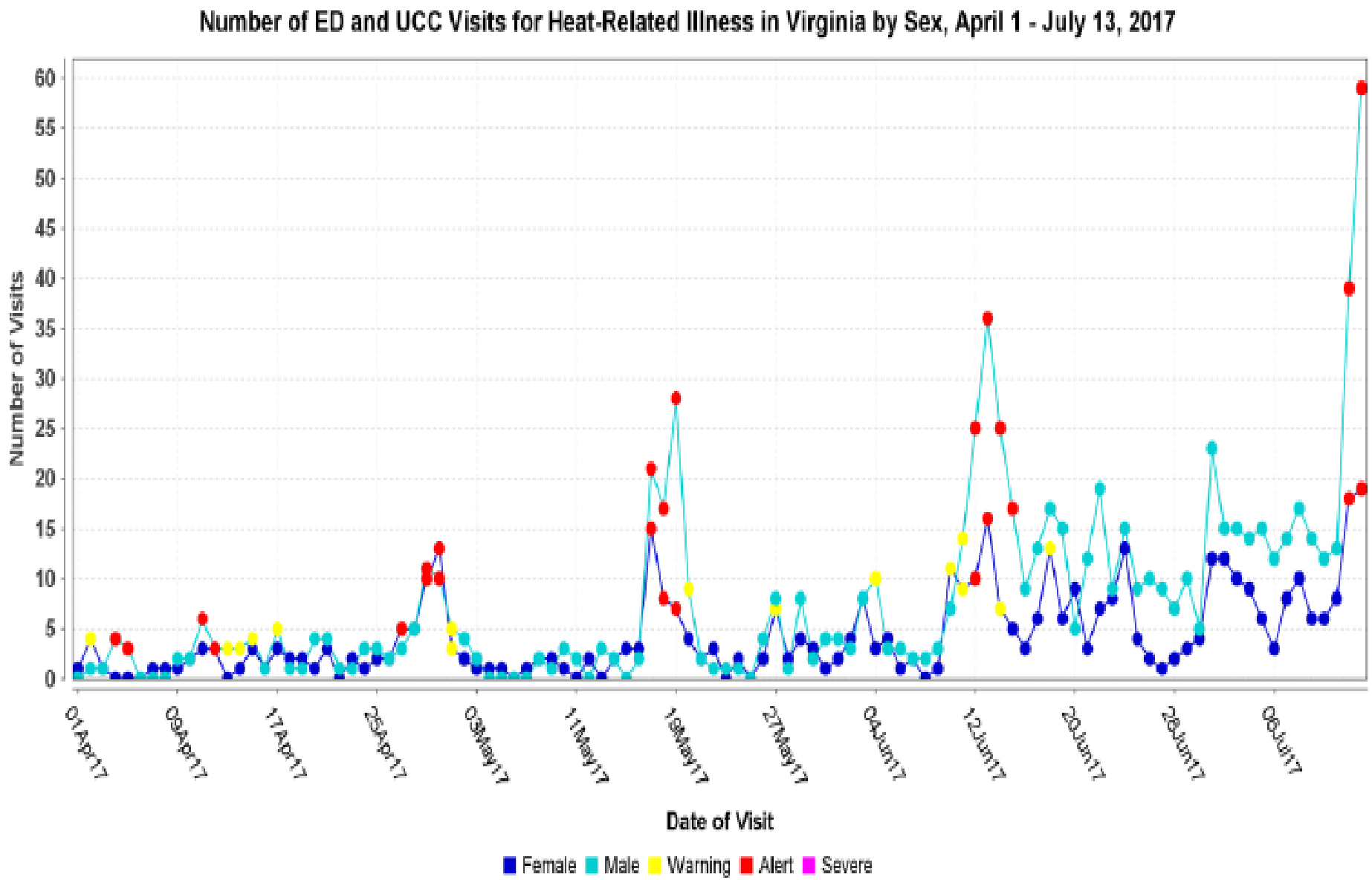
Average Summertime % UCC/ED Visits for Heat-Related Illnesses by Temperature




RAA Response Frequency by Temperature 2014-2017
RAA Responses
35
30
25
20
15
10
5
0
60
80
100
Richmond Heat Index (°F)



Data: VDH ESSE



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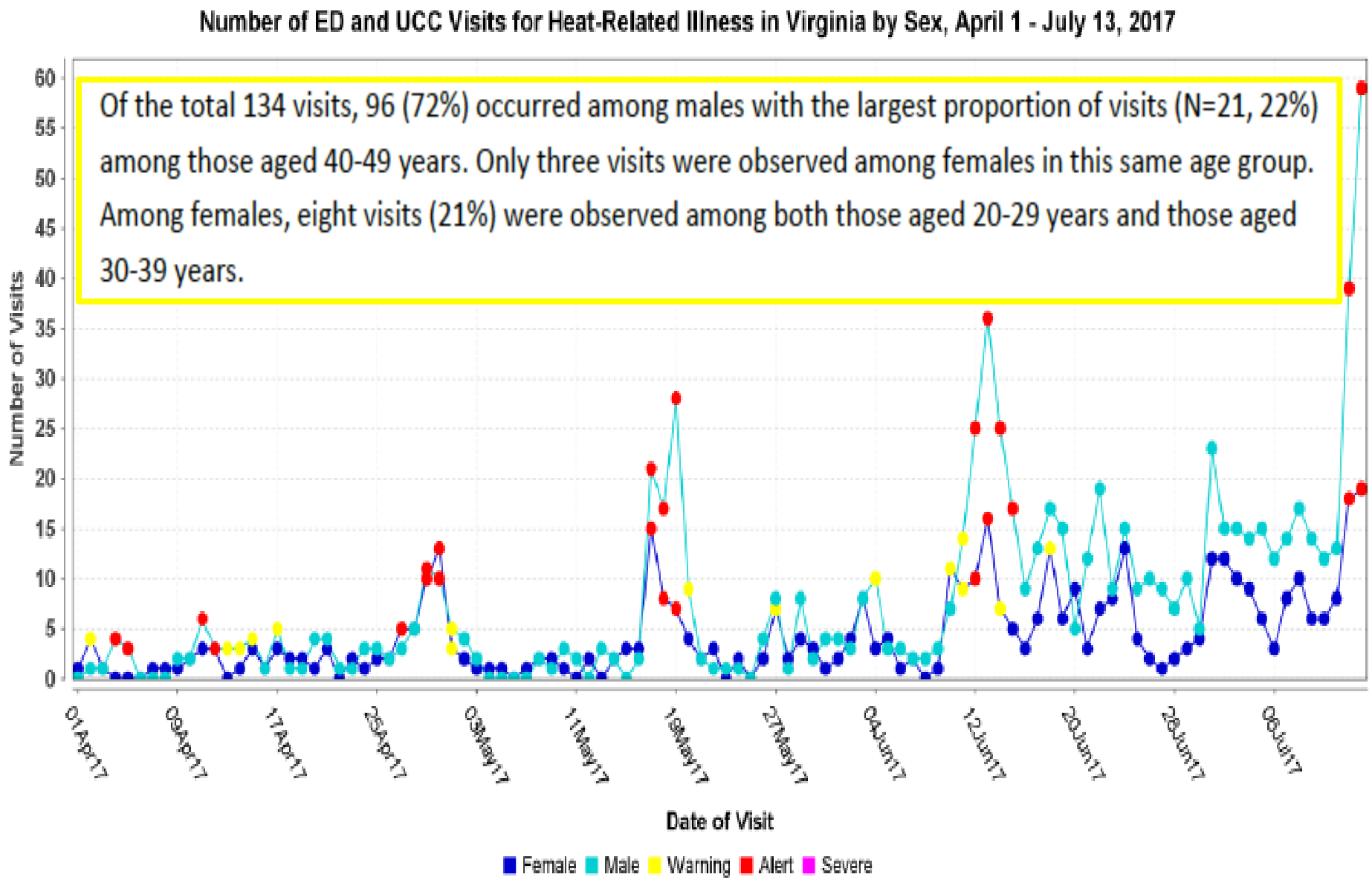
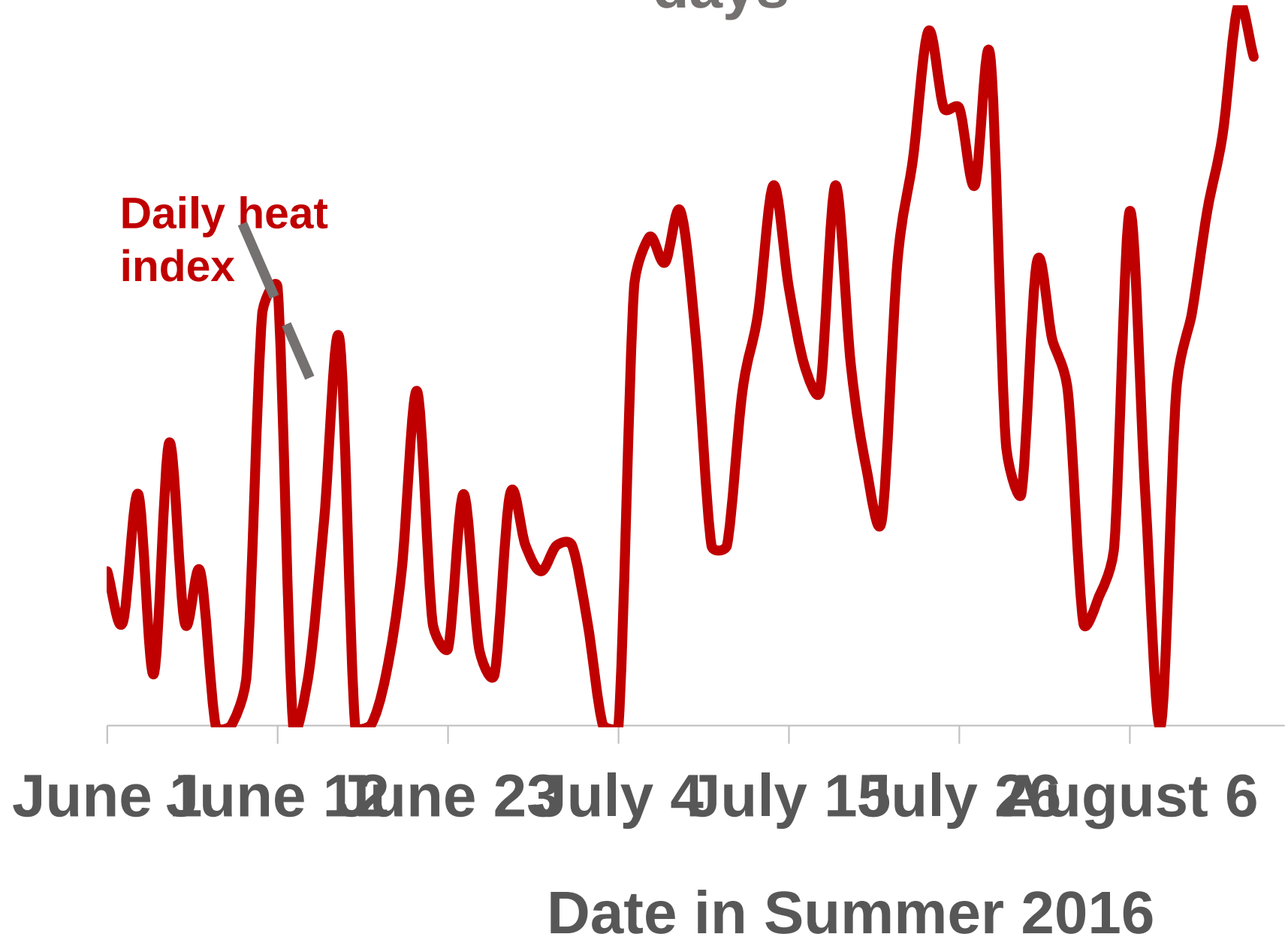


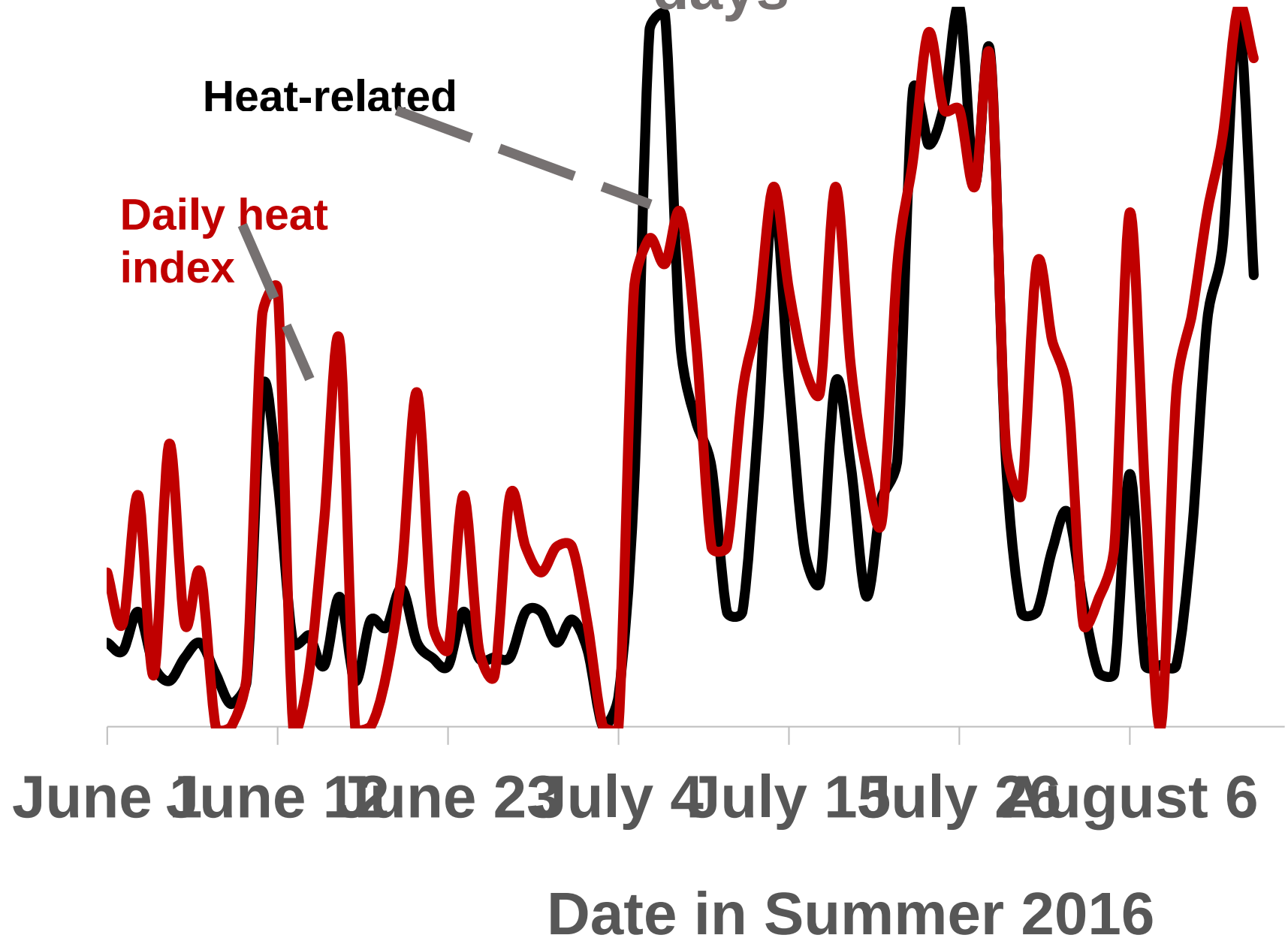
Data: VDH ESSE

Virginians go to the hospital on hot days

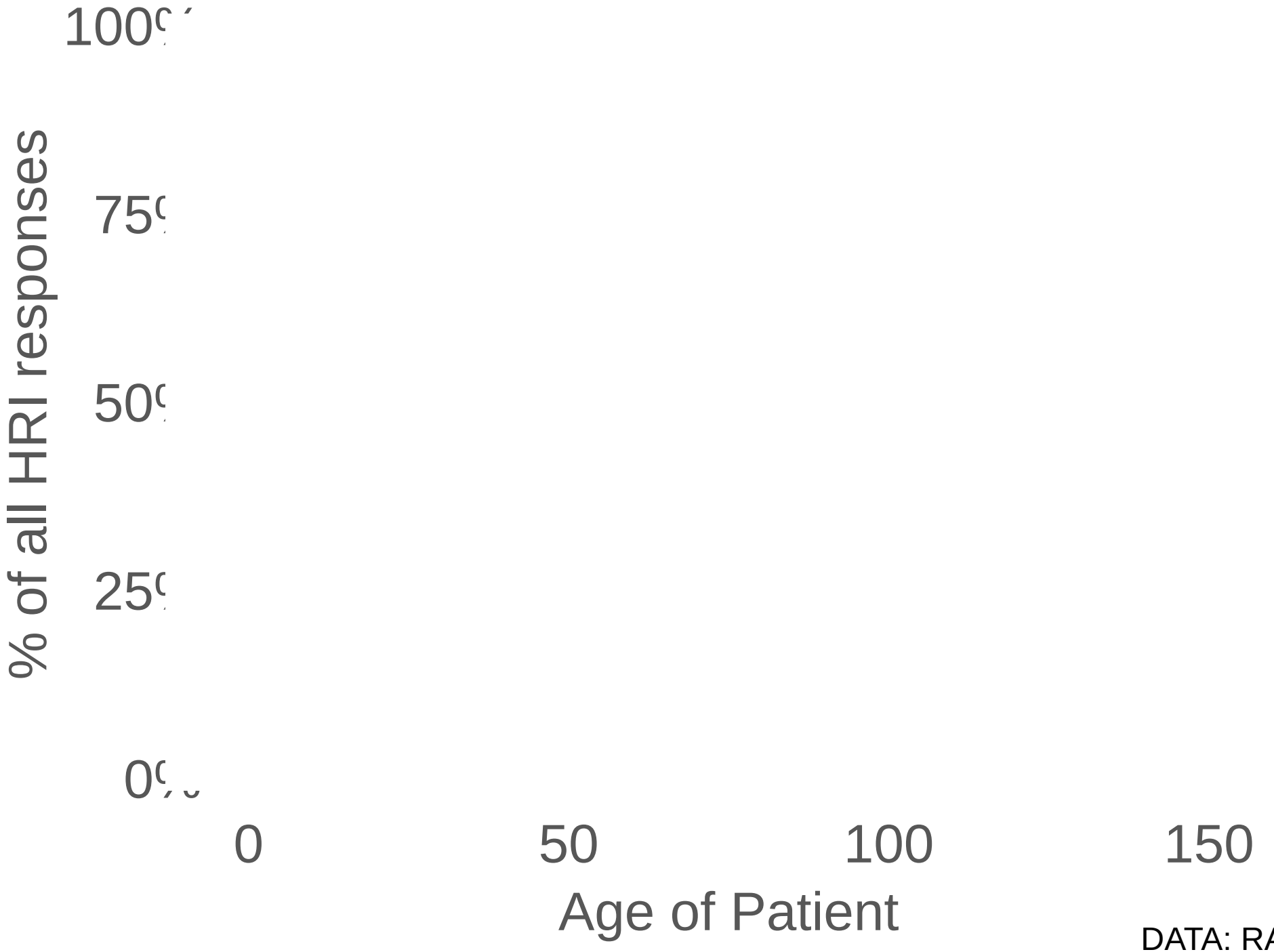


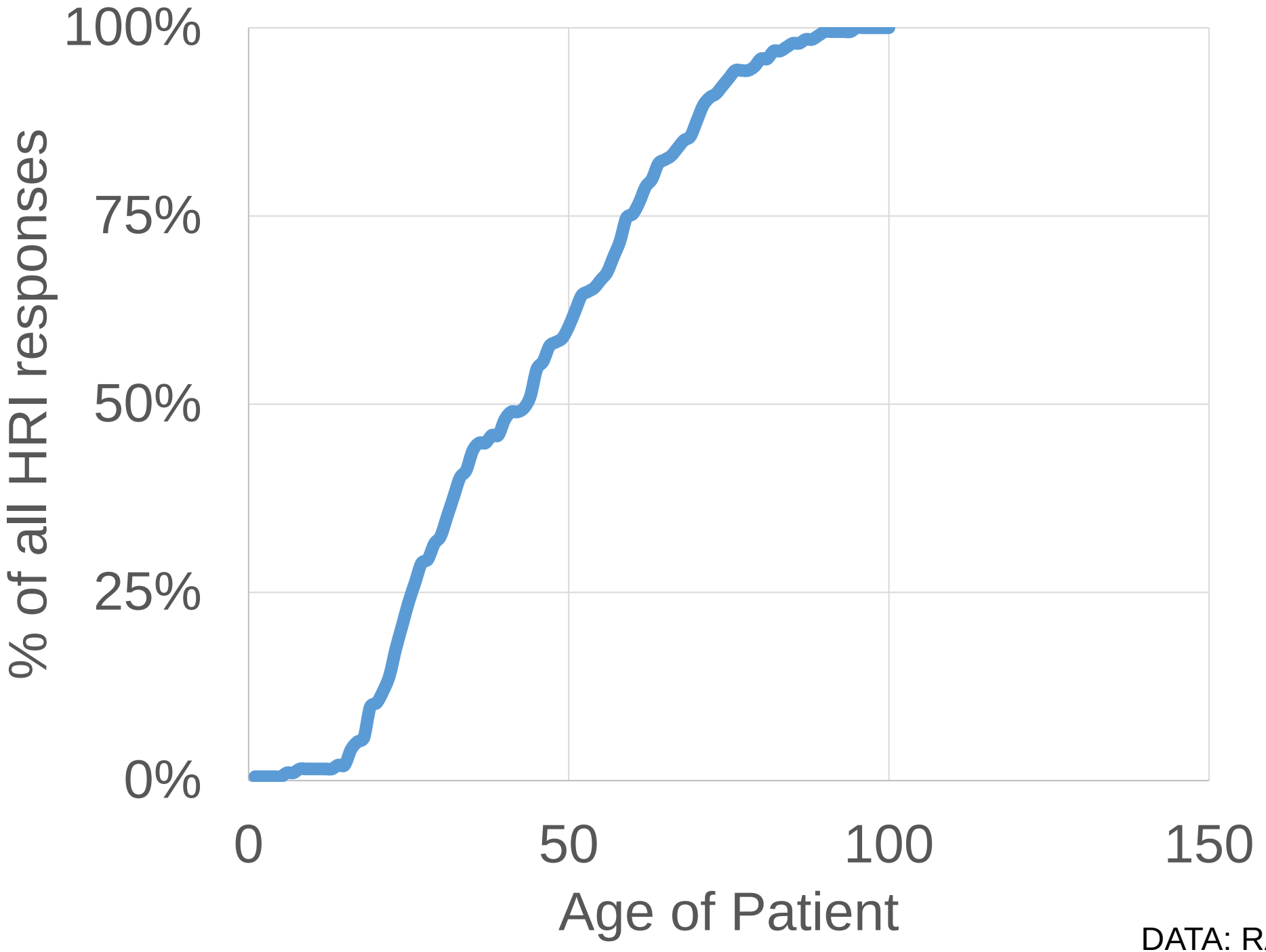
Data: VDH, NOAA

Virginians go to the hospital on hot days



Data: VDH, NOAA


100%
75%
50%
25%
0%
% of all HRI responses
0
50
100
150
Age of Patient
DATA: RA



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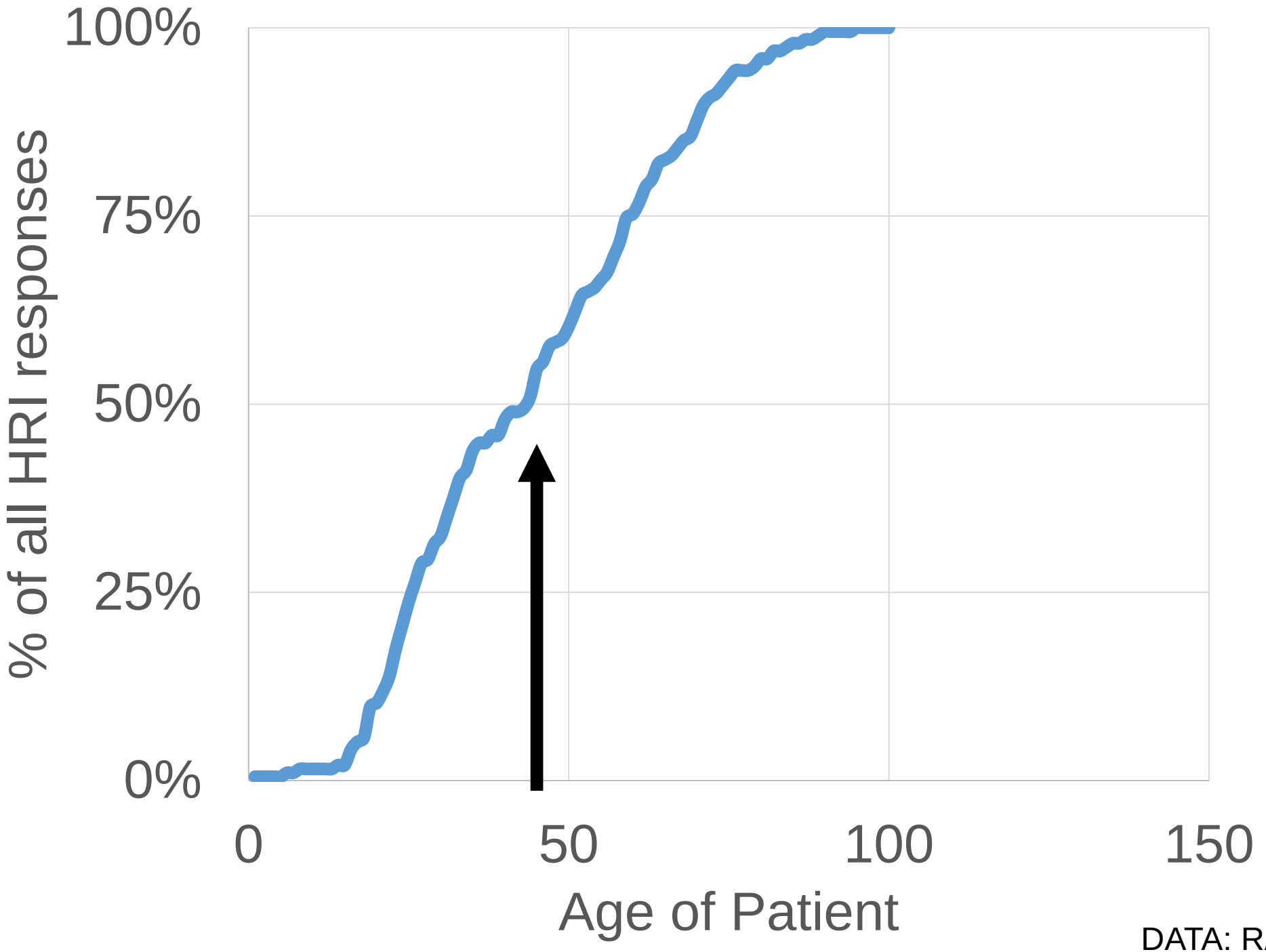

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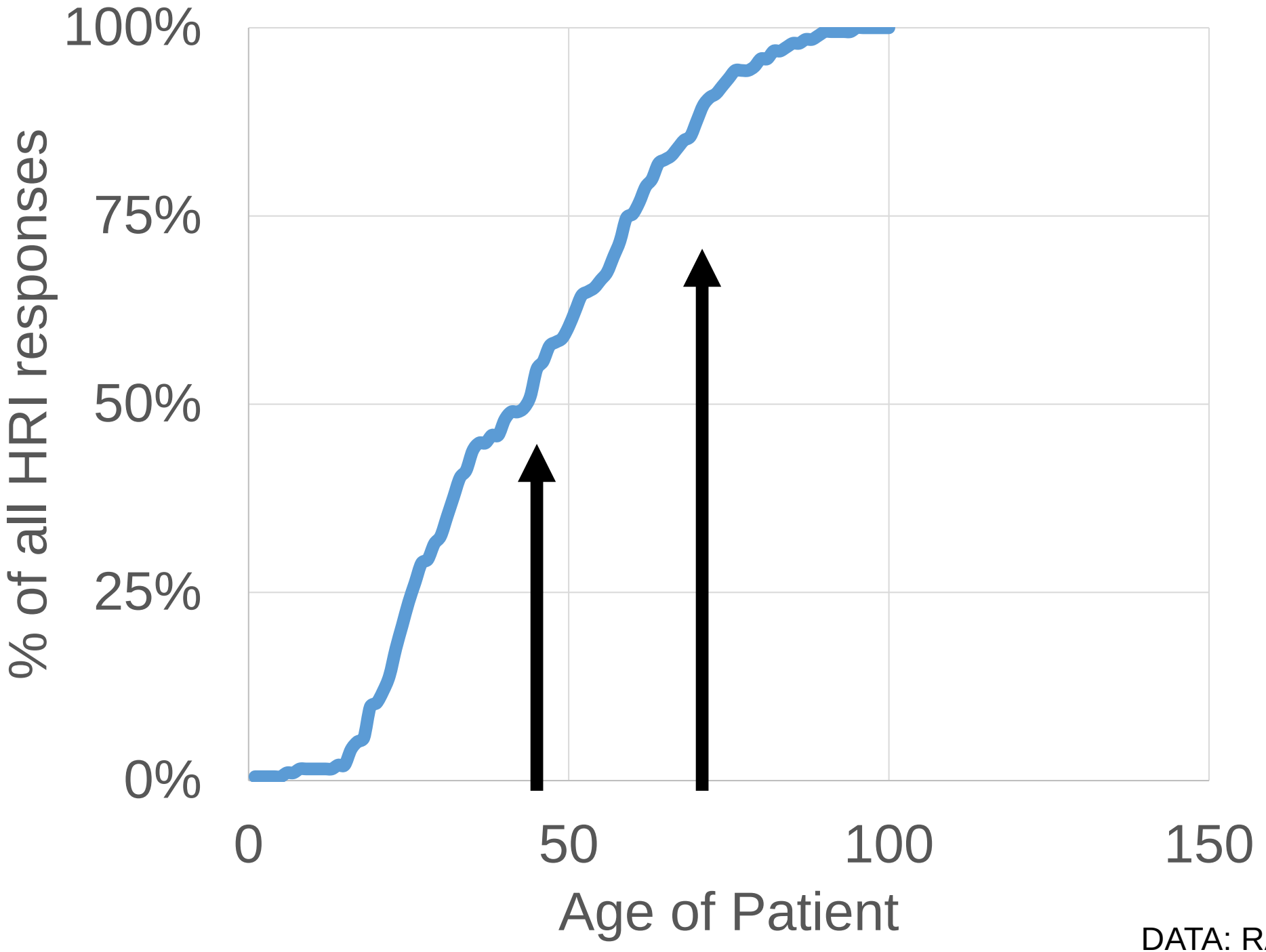


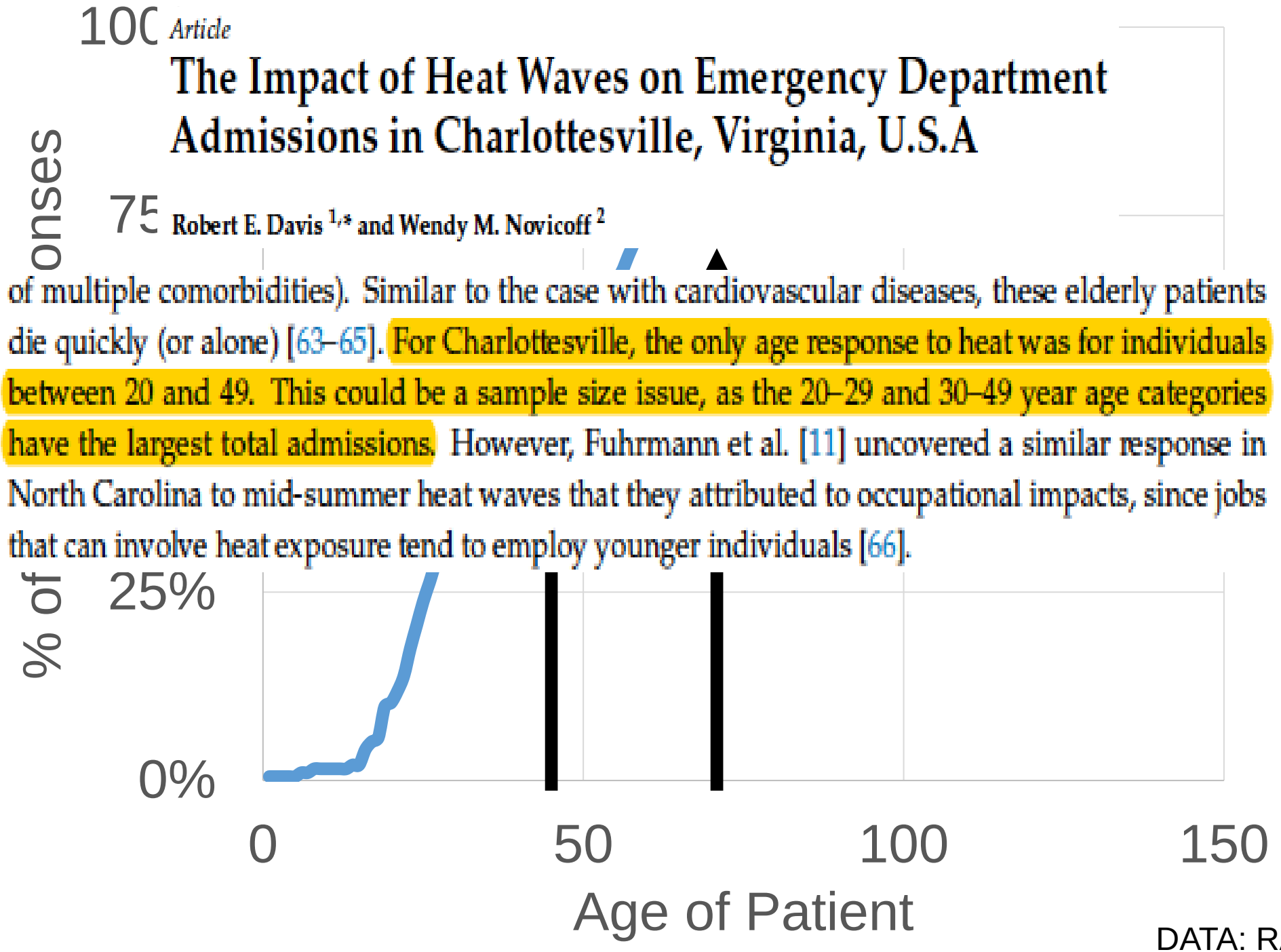
DATA: RA

Article

The Impact of Heat Waves on Emergency Department Admissions in Charlottesville, Virginia, U.S.A

Robert E. Davis [1,*] and Wendy M. Novicoff [2]

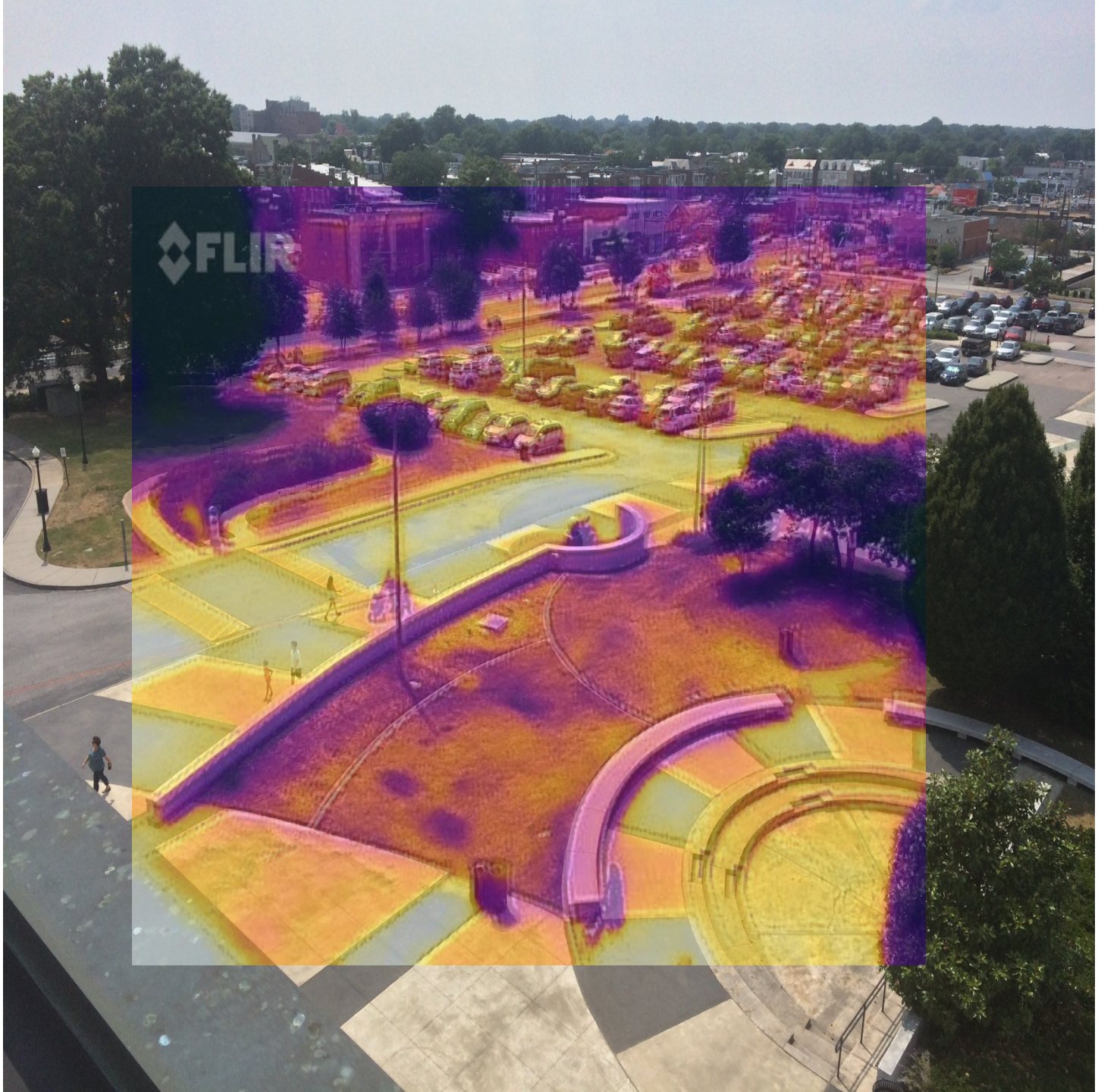
of multiple comorbidities). Similar to the case with cardiovascular diseases, these elderly patients die quickly (or alone) [63–65]. For Charlottesville, the only age response to heat was for individuals between 20 and 49. This could be a sample size issue, as the 20–29 and 30–49 year age categories have the largest total admissions. However, Fuhrmann et al. [11] uncovered a similar response in North Carolina to mid-summer heat waves that they attributed to occupational impacts, since jobs that can involve heat exposure tend to employ younger individuals [66].



DATA: RA

But more interesting stories exist…

Science Museum of Virginia



Science Museum of Virginia

RICHMOND URBAN HEAT ISLAND COLLECTIVE

RICHMOND

Science Museum of Virginia

VCU

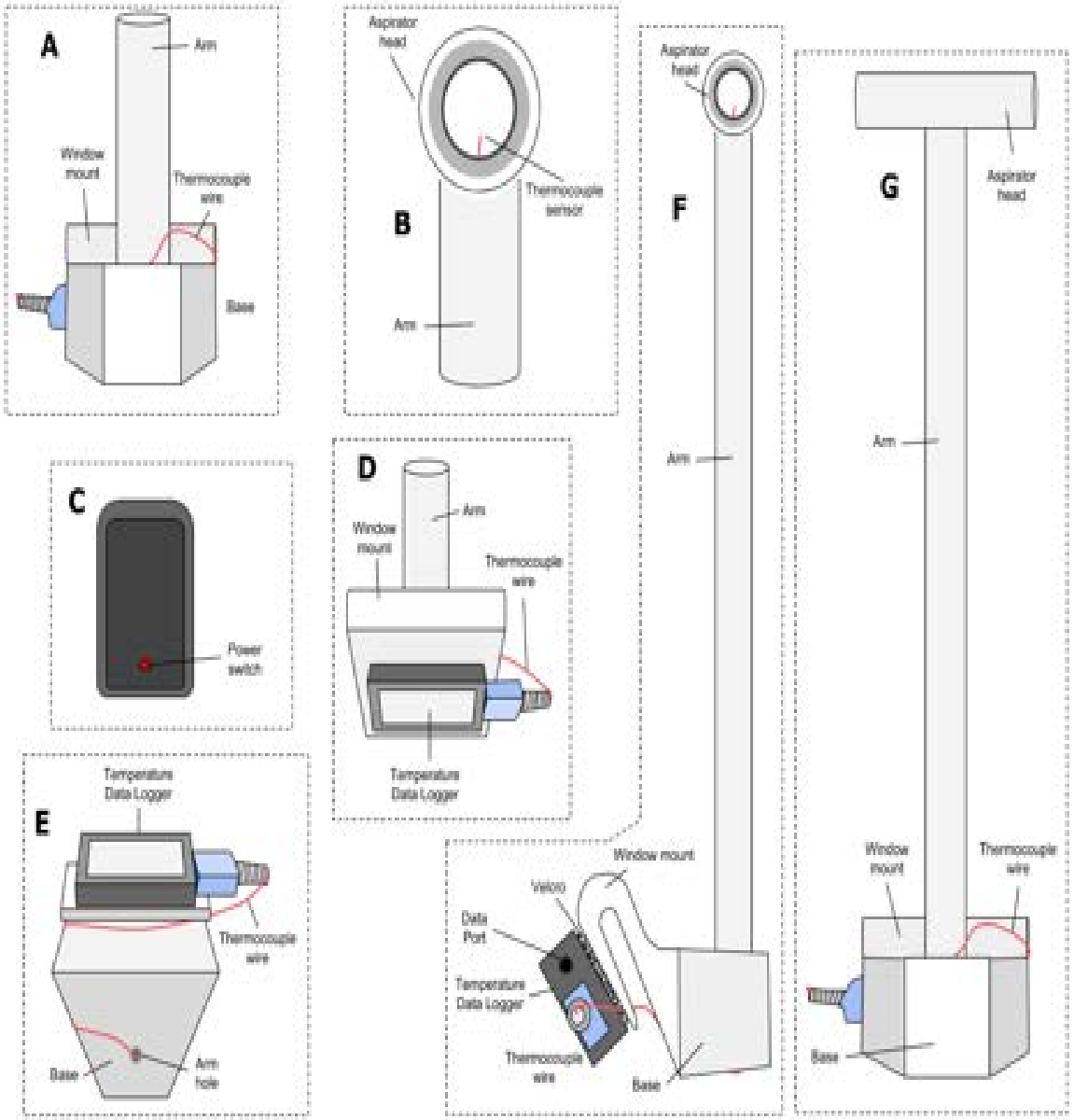
GROUNDWORK RVA
CHANGING PLACES CHANGING LIVES

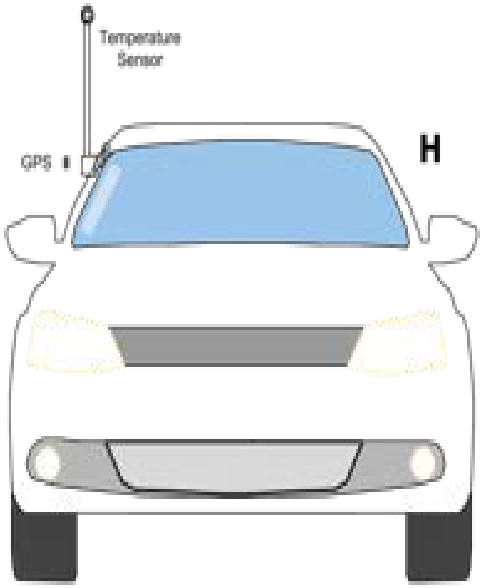
Richmond Times-Dispatch

City of Richmond RVAgreen 2050

VIRGINIA ACADEMY OF SCIENCE
IGNORANTIA SVPREMVS TYRANNVS

NOAA
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF COMMERCE

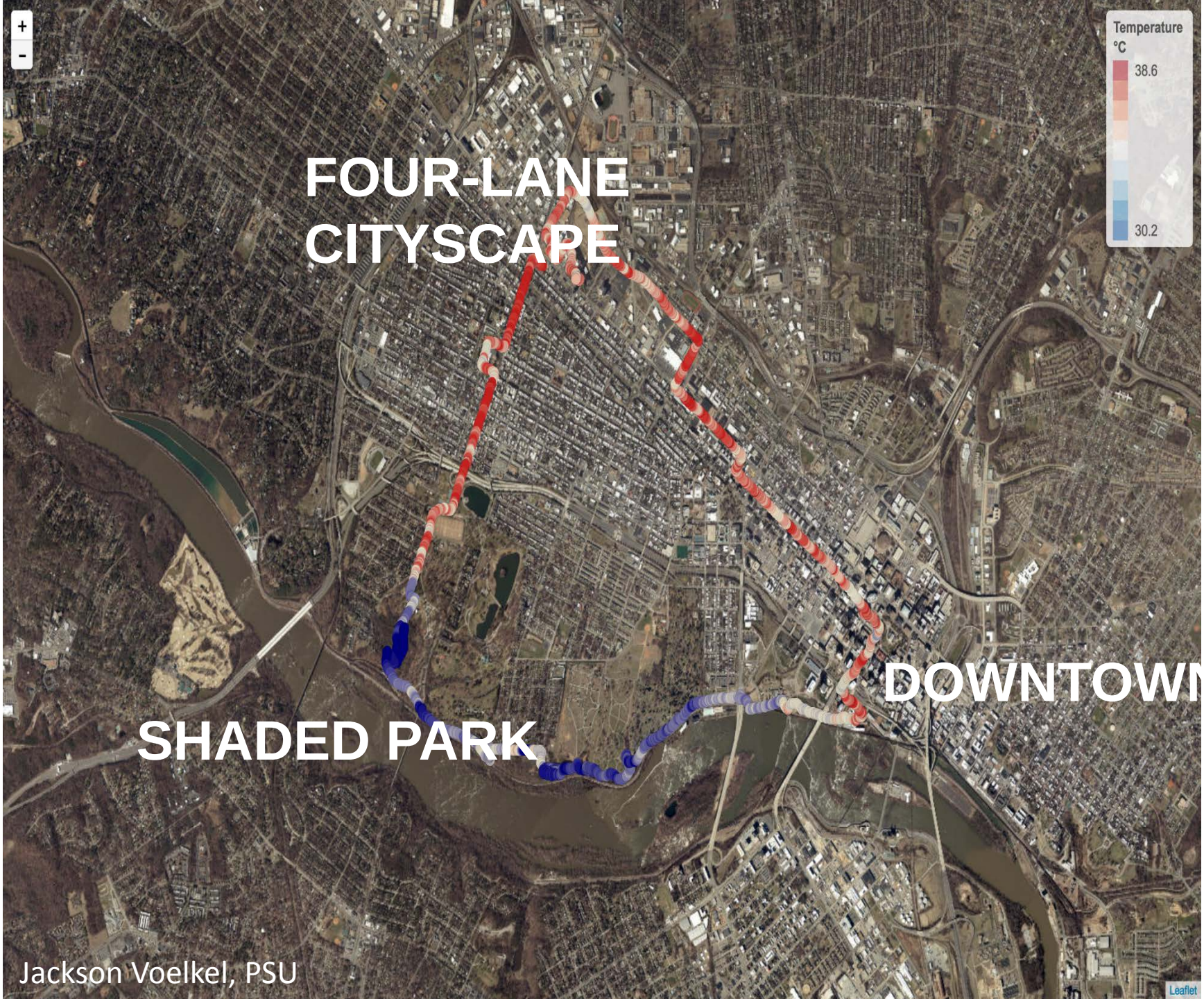




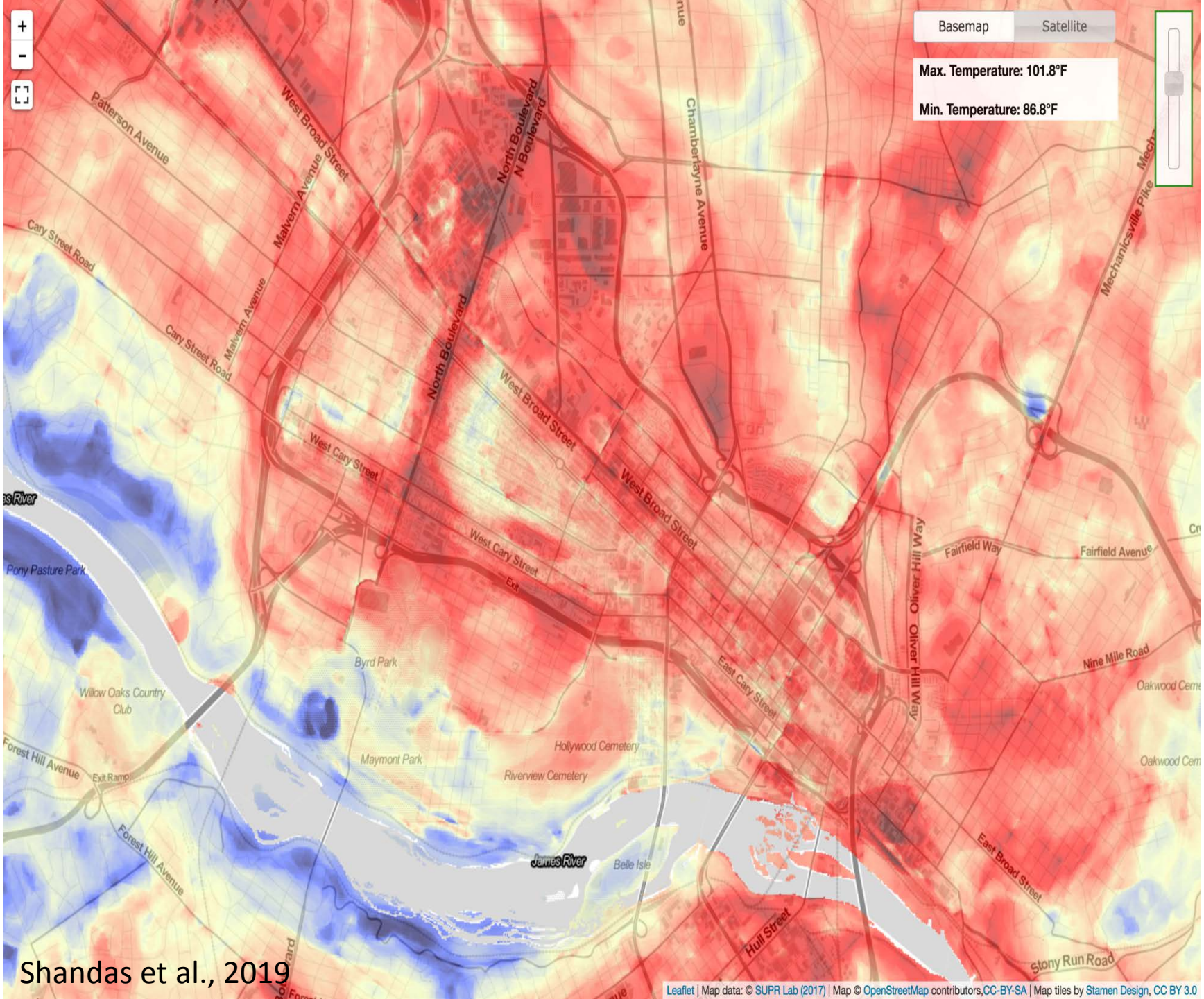
Jackson Voelkel,

Shelby Lum, RTD

Jackson Voelkel, PSU



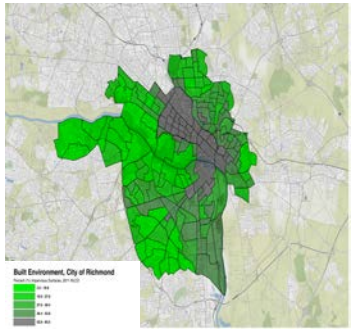
Jackson Voelkel, PSU



Shandas et al., 2019

Urban Heat Vulnerability

=



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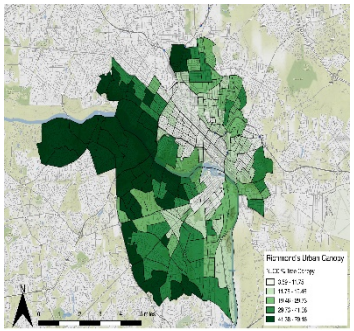

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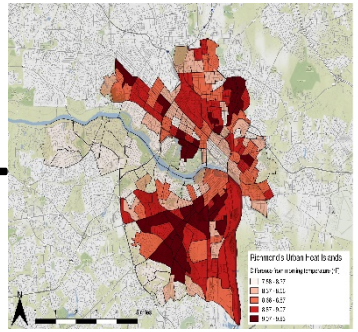

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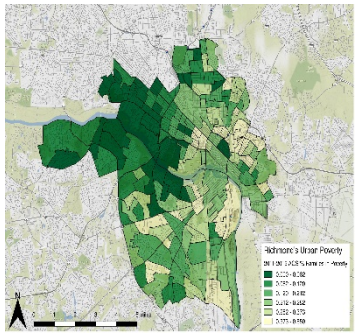

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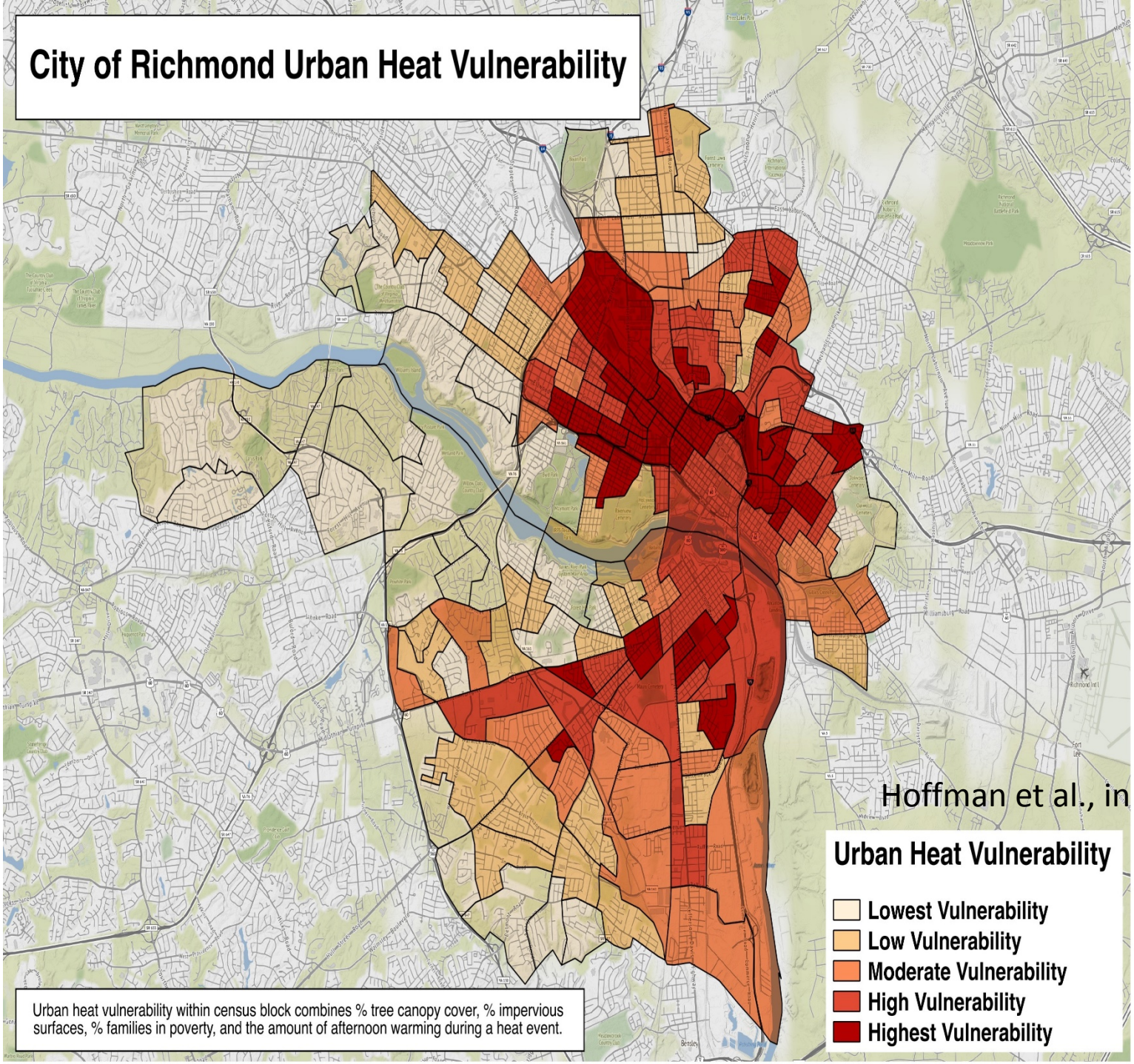
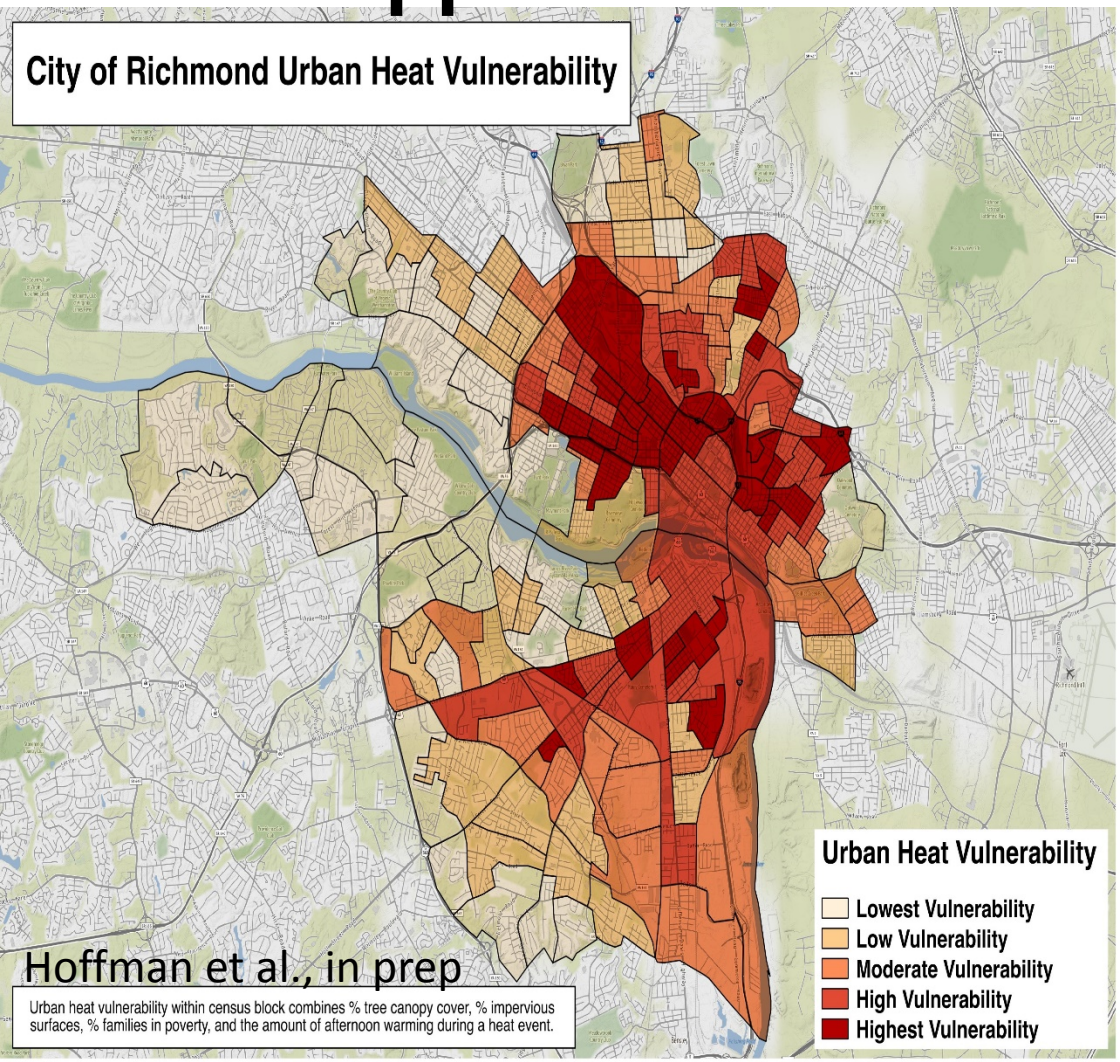


Hoffman et al., in prep

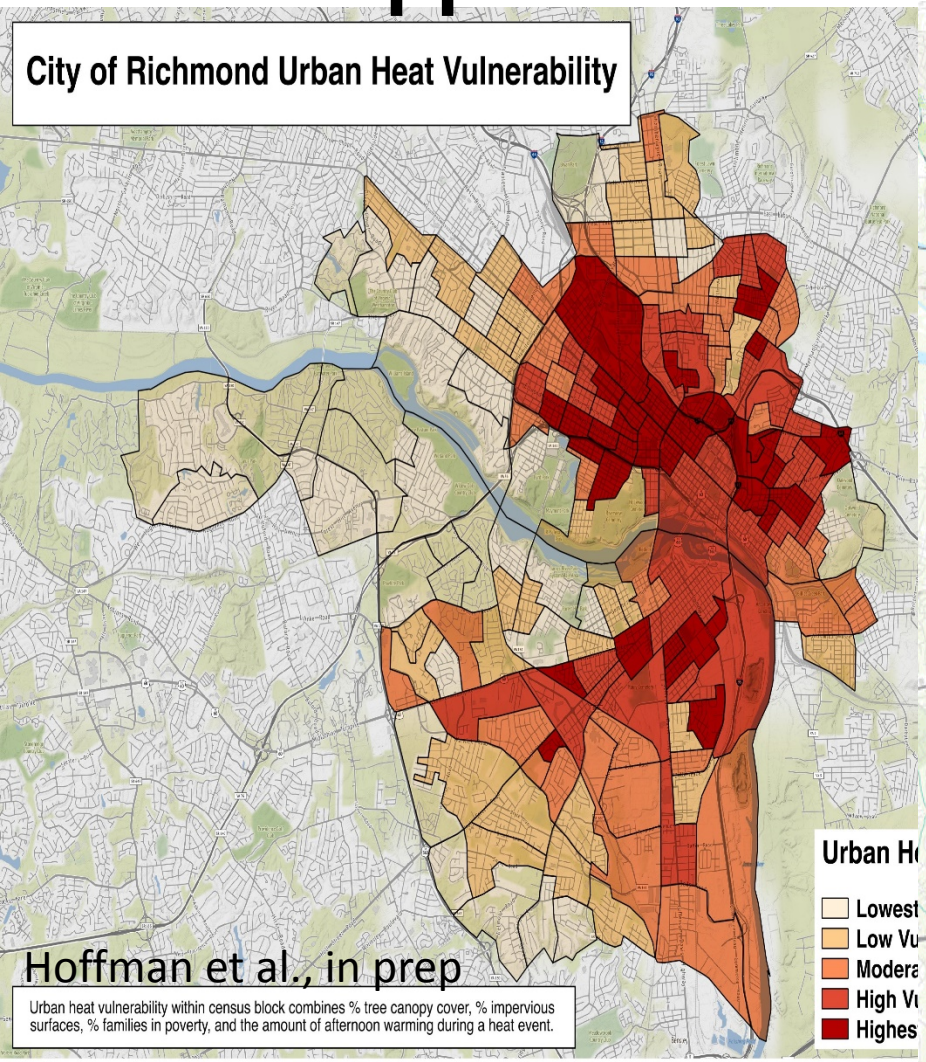
VULNERABILITY

RAA AMBULANCE RESPONSES

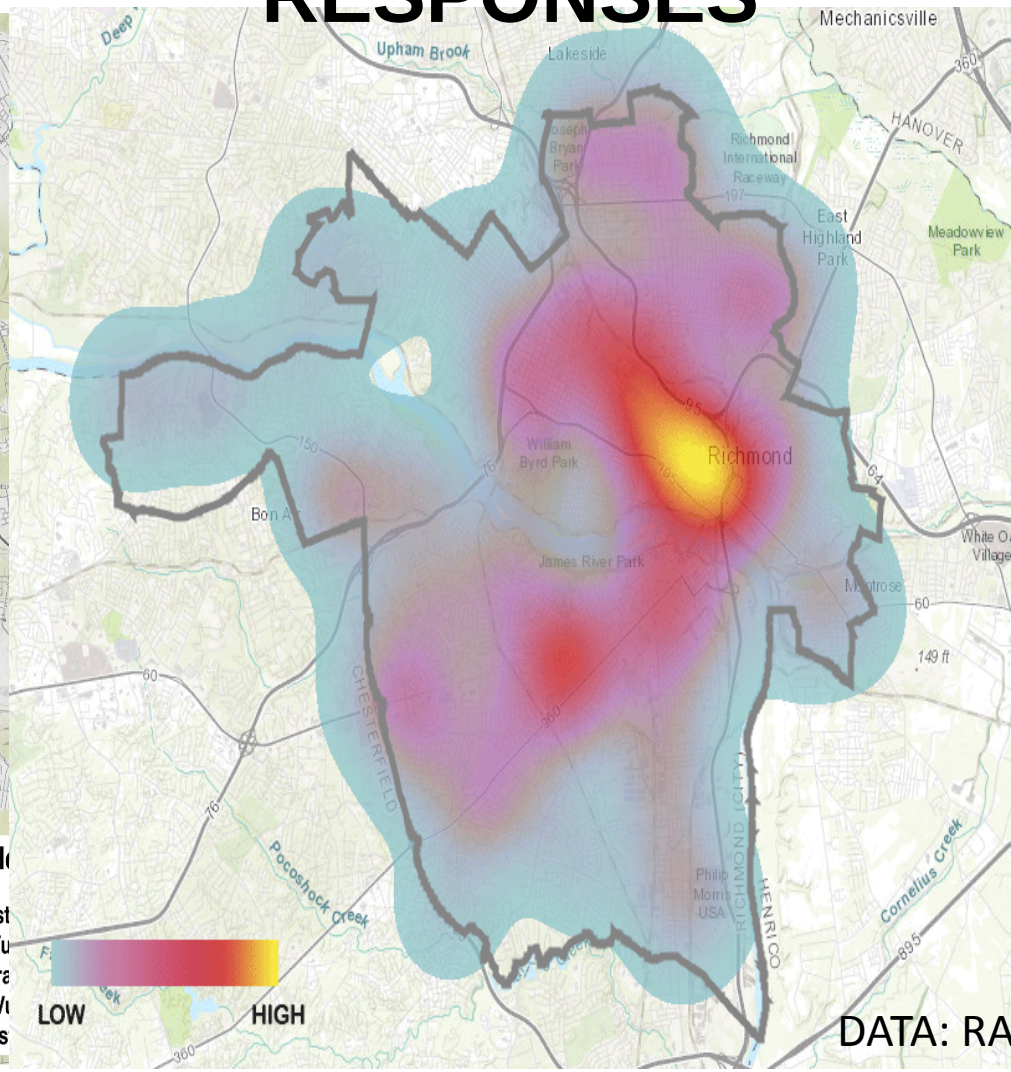


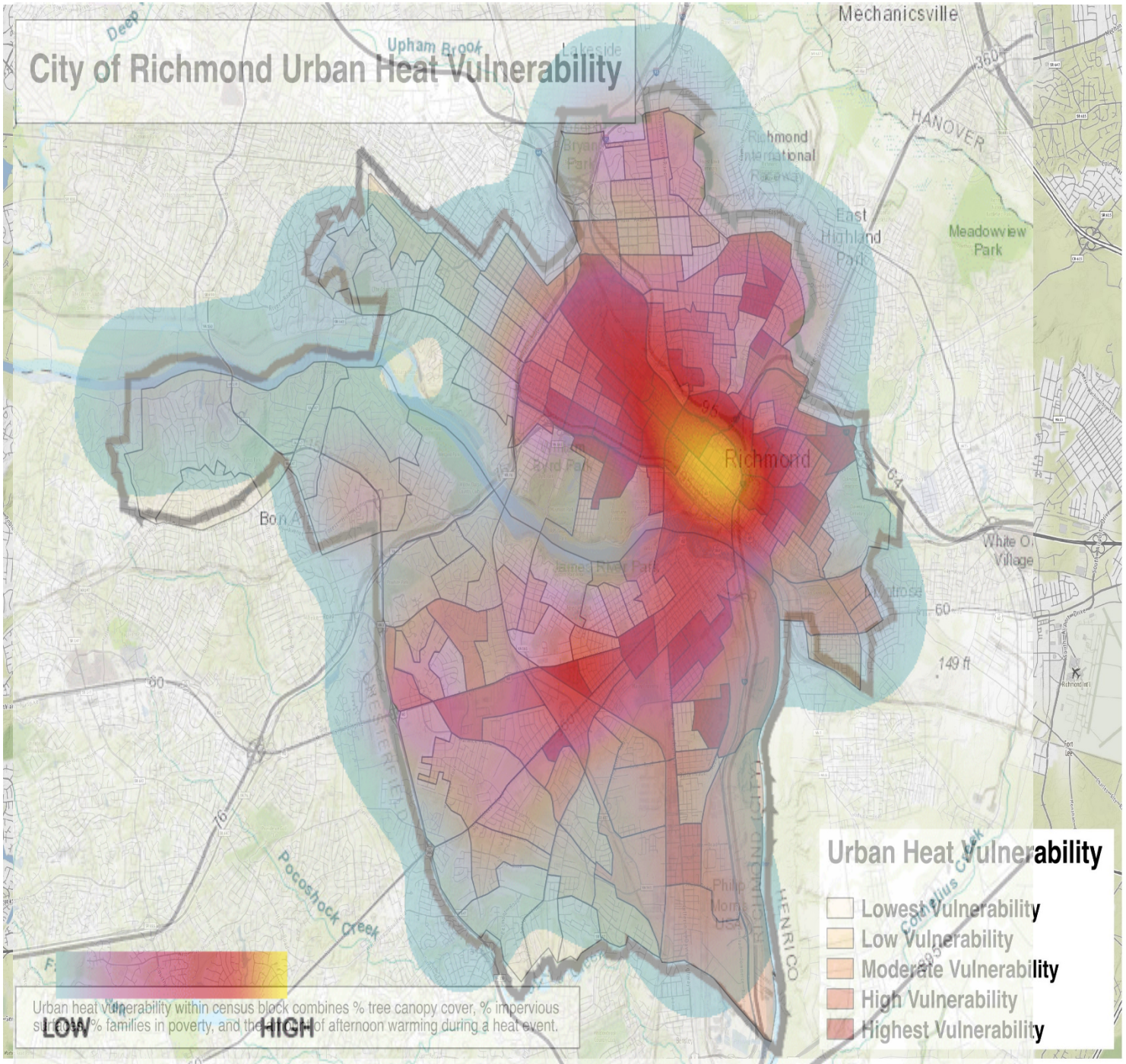
DATA: RA

VULNERABILITY



RAA AMBULANCE RESPONSES

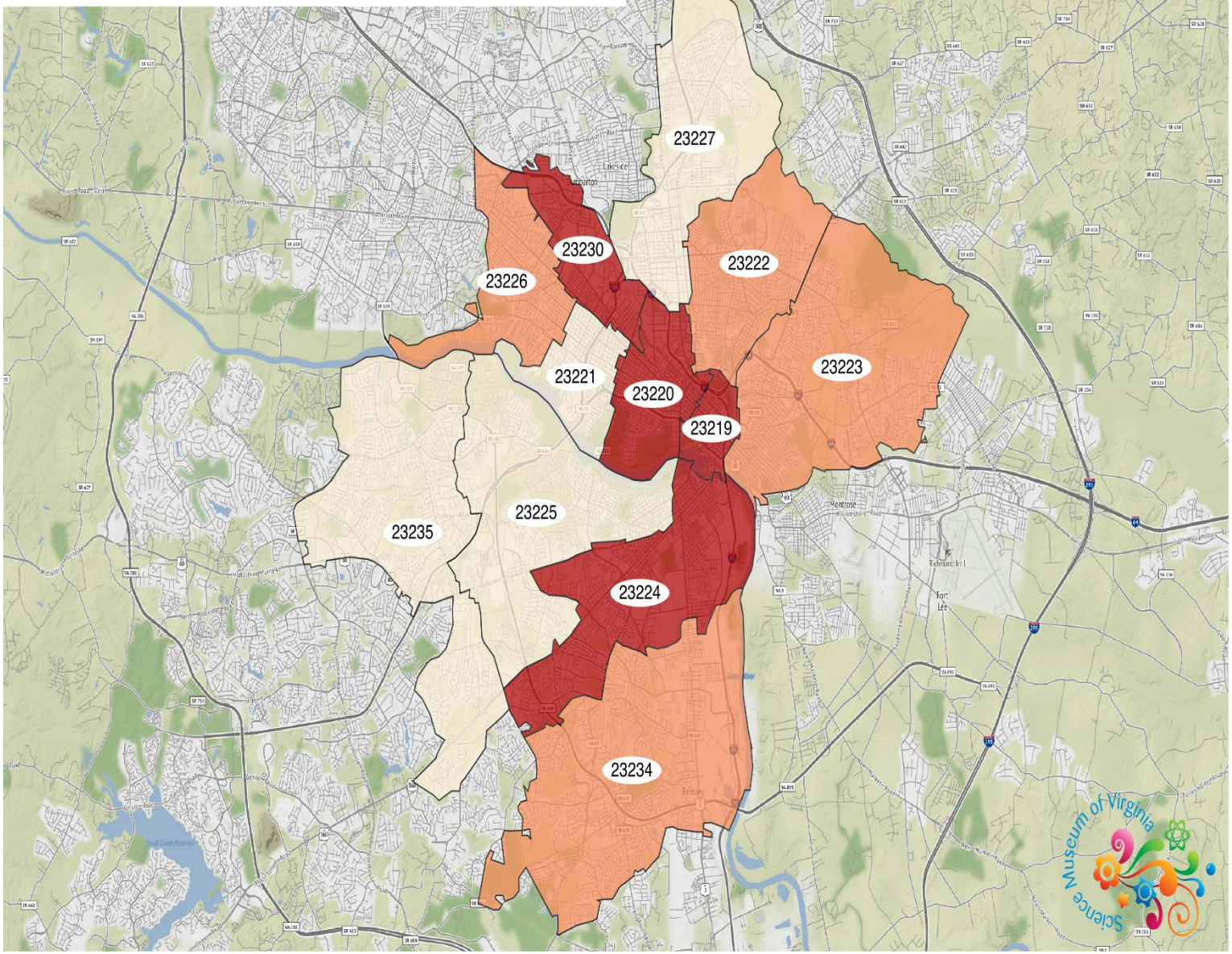



City of Richmond Urban Heat Vulnerability
Urban heat vulnerability within census block combines % tree canopy cover, % impervious surface, % families in poverty, and the degree of afternoon warming during a heat event.
LOW
HIGH
Urban Heat Vulnerability
Lowest Vulnerability
Low Vulnerability
Moderate Vulnerability
High Vulnerability
Highest Vulnerability
Mechanicsville
Upham Brook
Lakeside
Richmond International Raceway
East Highland Park
Meadowview Park
HANOVER
Richmond
Byrd Park
James River Park
Bon Air
Pocoshock Creek
CHESTERFIELD
RICHMOND CITY
HENRICO CO
Philip Morris USA
Cornelius Creek
Fort Lee
Richmond Int'l
149 ft
360
95
64
60
76

Urban Heat Islands in Richmond Zip Codes

Median Afternoon Temperatures, 7/13/2017

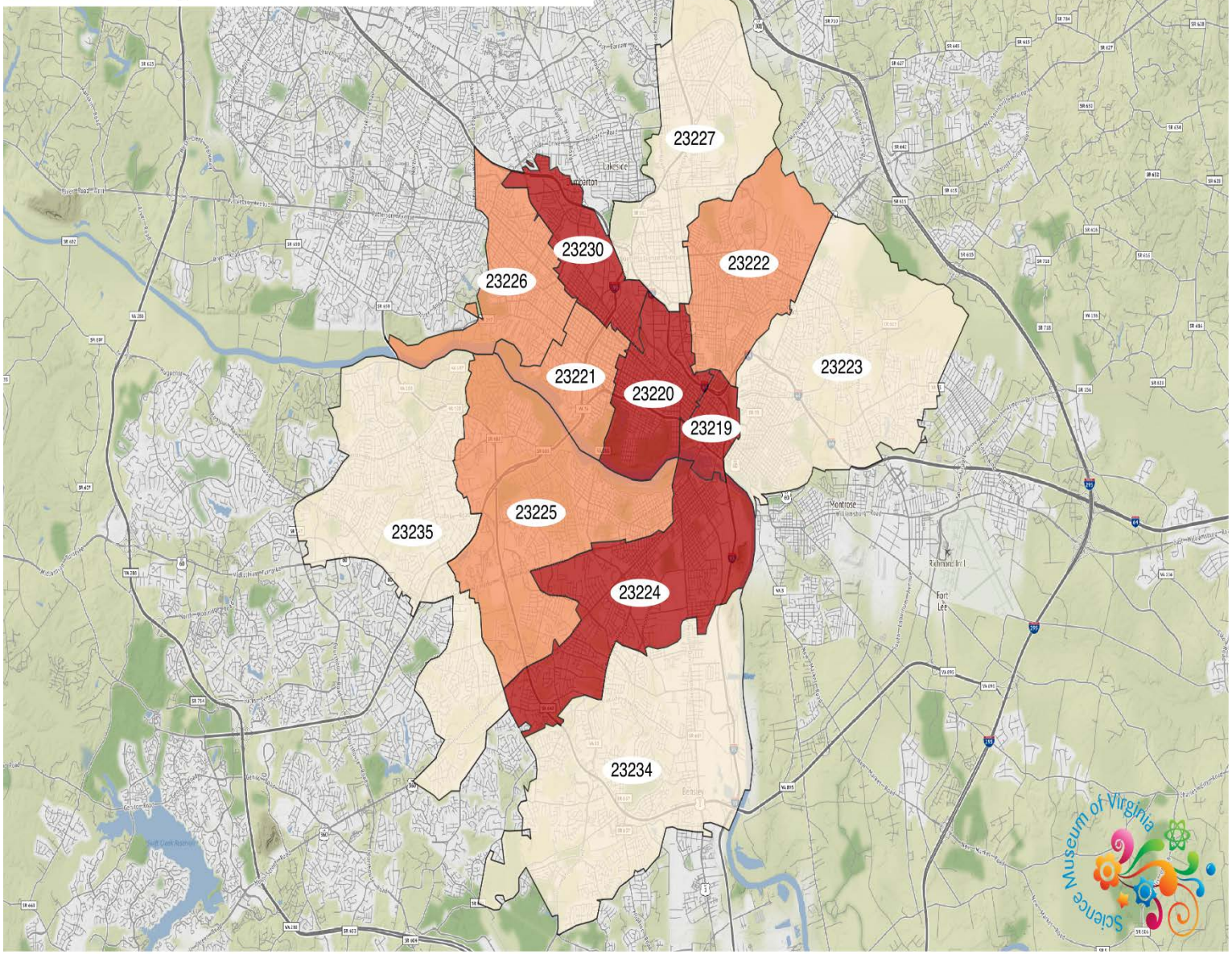
- Lowest Tercile
- Middle Tercile
- Highest Tercile



Heat-Related Illnesses Per 10,000 People

RAA Ambulance Response Data by Zip Code, 2014-2017

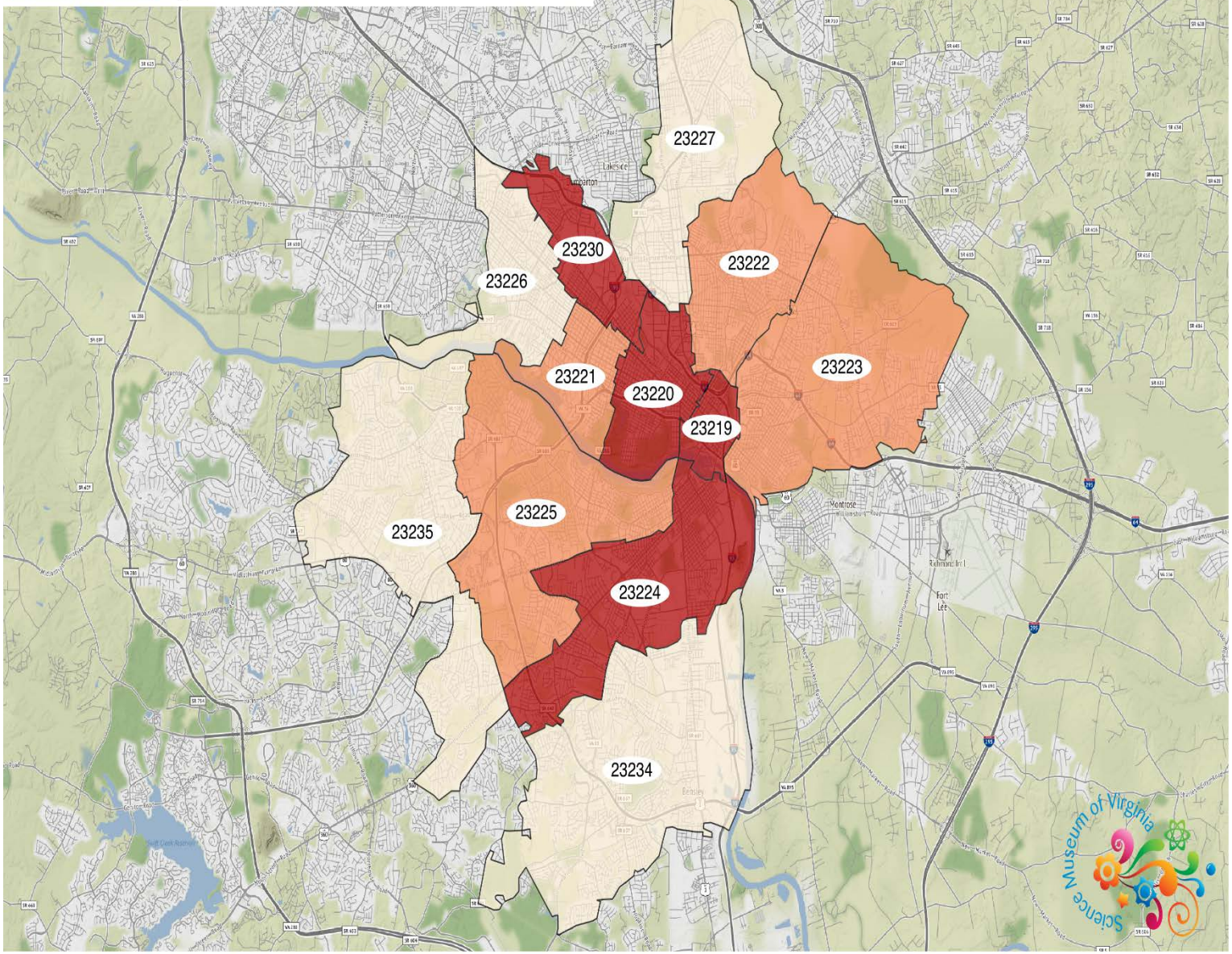
- Lowest Tercile
- Middle Tercile
- Highest Tercile

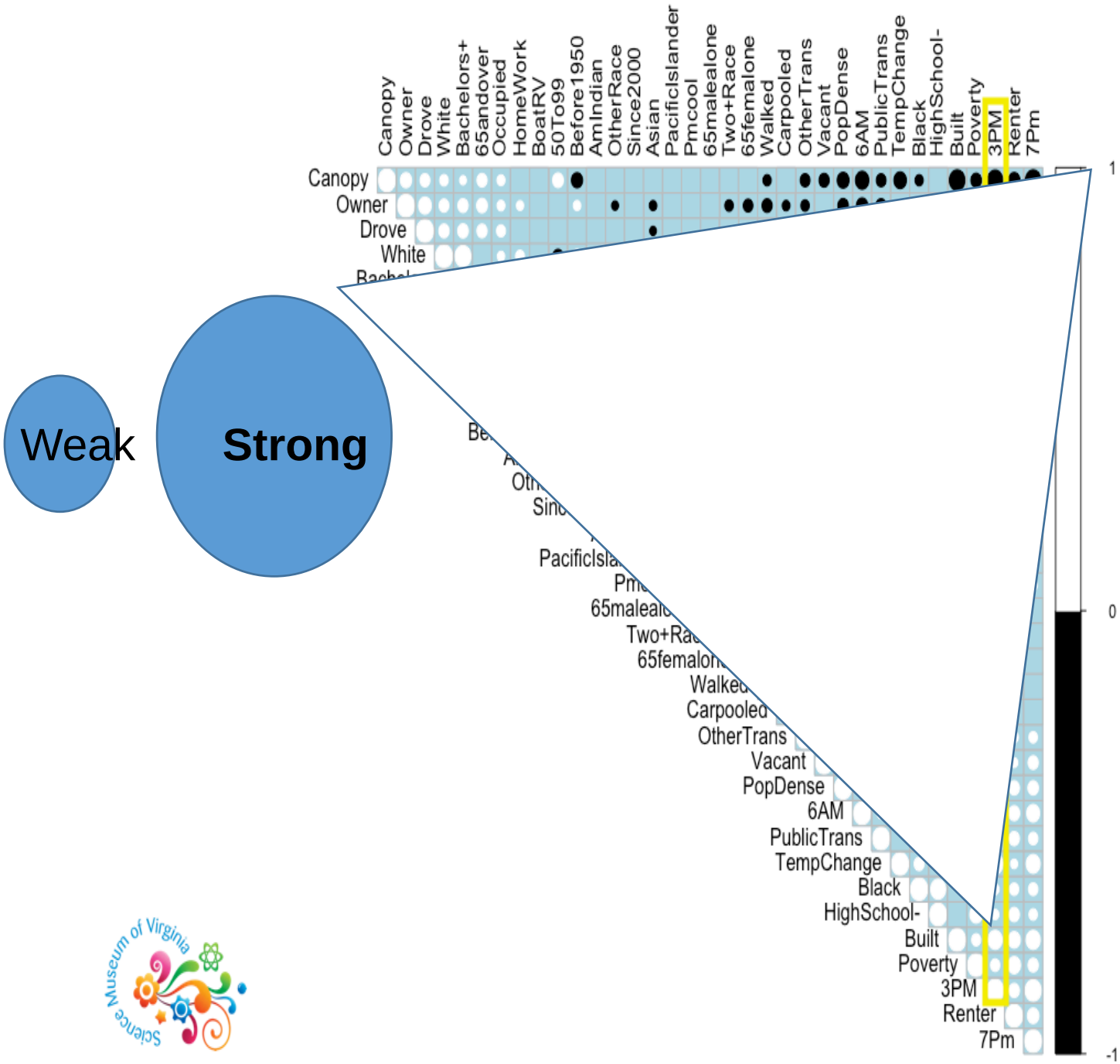


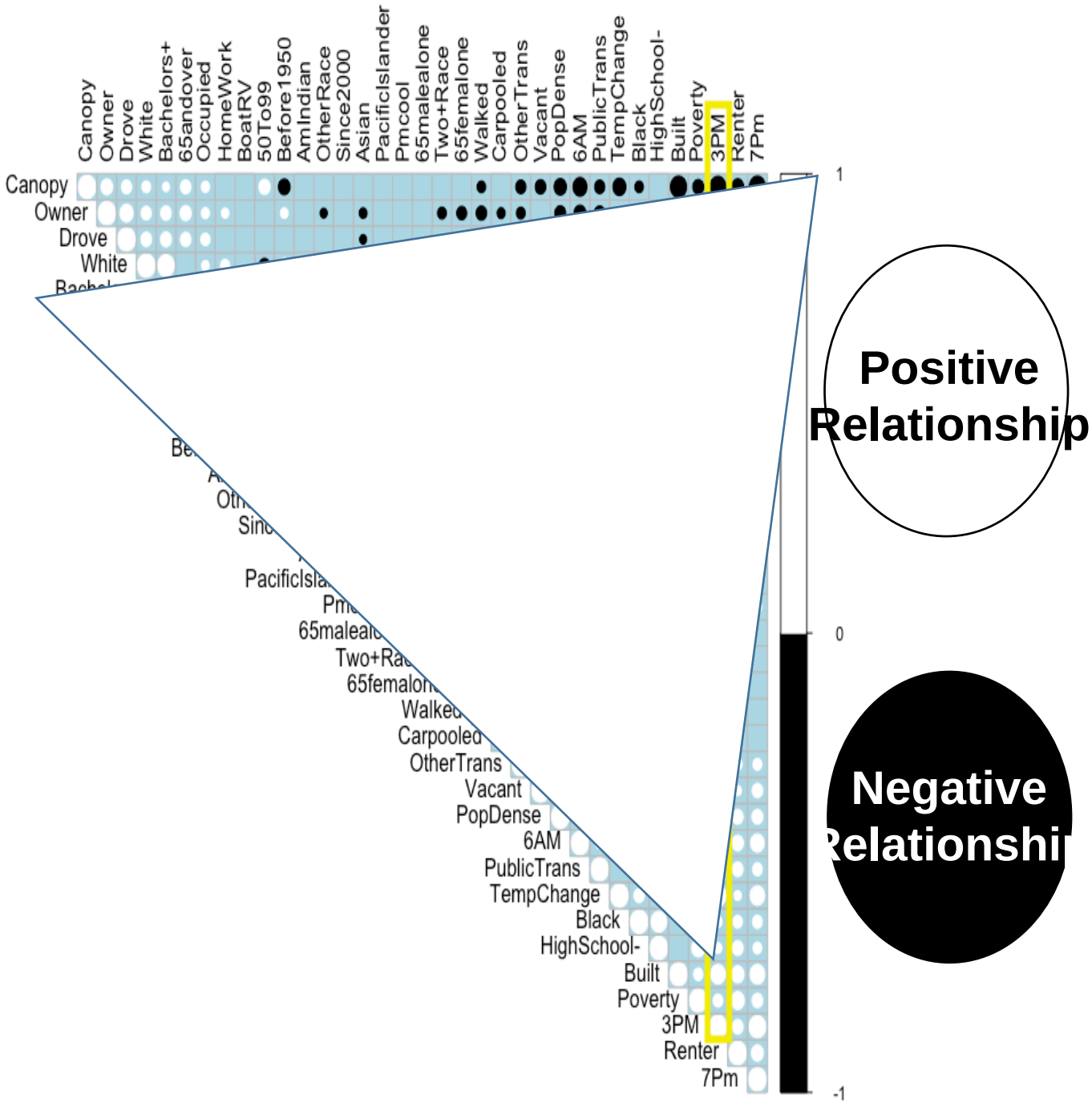
Heat-Related Illnesses Per 10,000 People

VDH ESSENCE Data by Zip Code, 2014-2017

- Lowest Tercile
- Middle Tercile
- Highest Tercile




Weak
Strong
Canopy
Owner
Drove
White
Bachelors+
65andover
Occupied
HomeWork
BoatRV
50To99
Before1950
AmIndian
OtherRace
Since2000
Asian
PacificIslander
Pmcool
65malealone
Two+Race
65femalone
Walked
Carpooled
OtherTrans
Vacant
PopDense
6AM
PublicTrans
TempChange
Black
HighSchool-
Built
Poverty
3PM
Renter
7Pm
1
0
-1


Canopy
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65femalone
Walked
Carpooled
OtherTrans
Vacant
PopDense
6AM
PublicTrans
TempChange
Black
HighSchool-
Built
Poverty
3PM
Renter
7Pm
1
0
-1
Positive Relationship
Negative Relationship

Higher T°F @ 3PM:

-Black

-Poverty

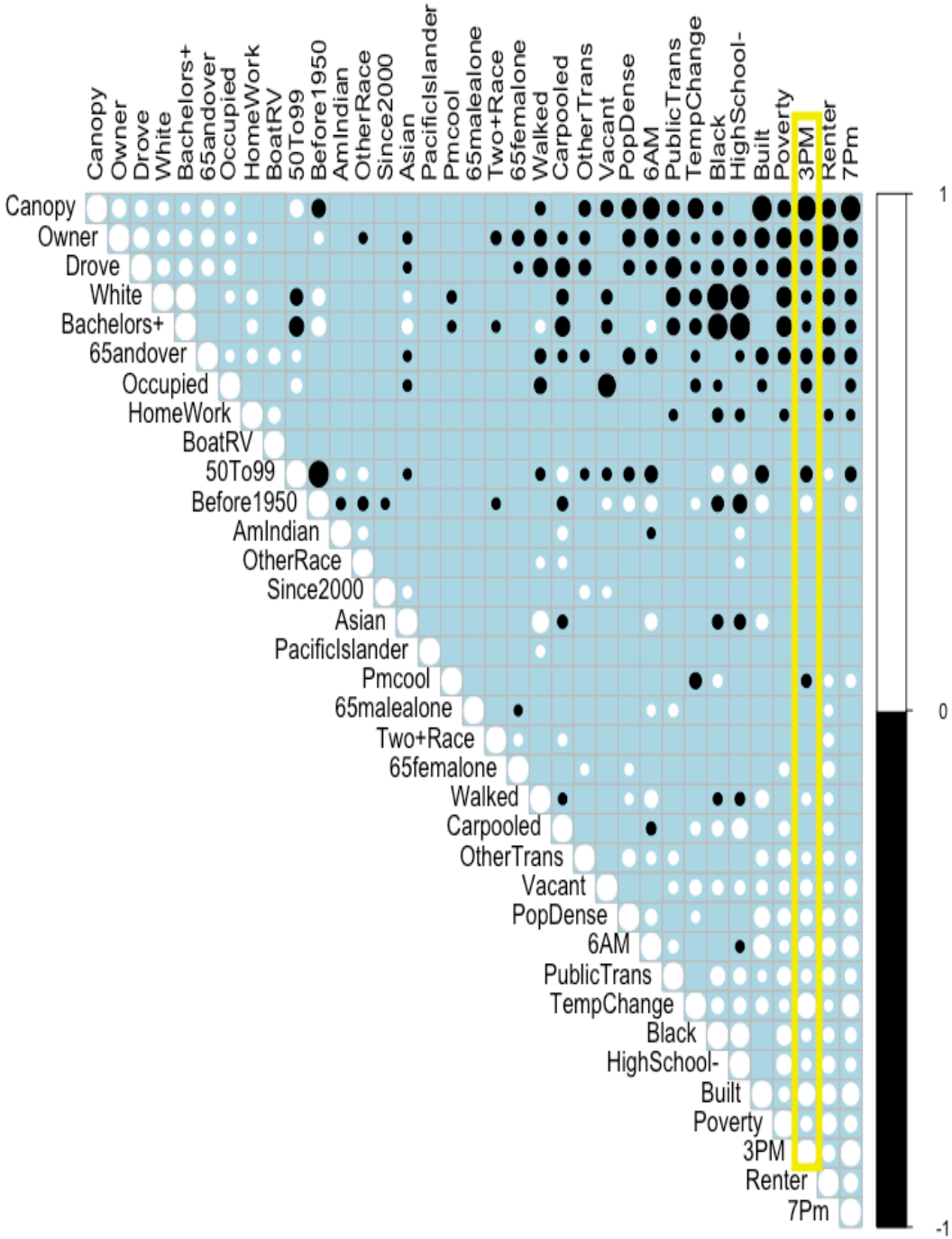
-Vacant properties

-Alternative transport

-Low educational attainment

-Low canopy

-Old houses



Lower T°F @ 3PM:

-White

-Low poverty

-Occupied properties

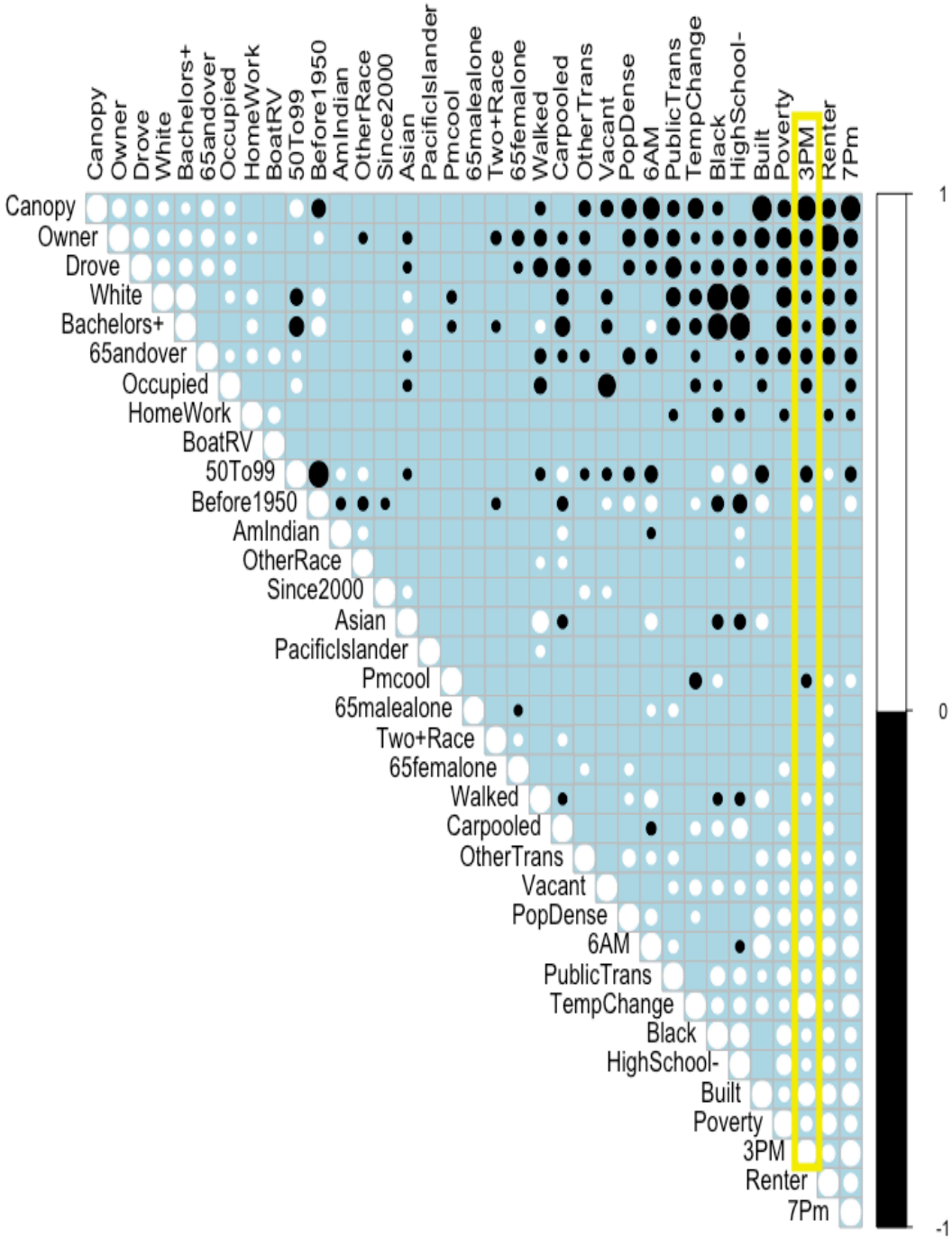
-Self transport

-High educational attainment

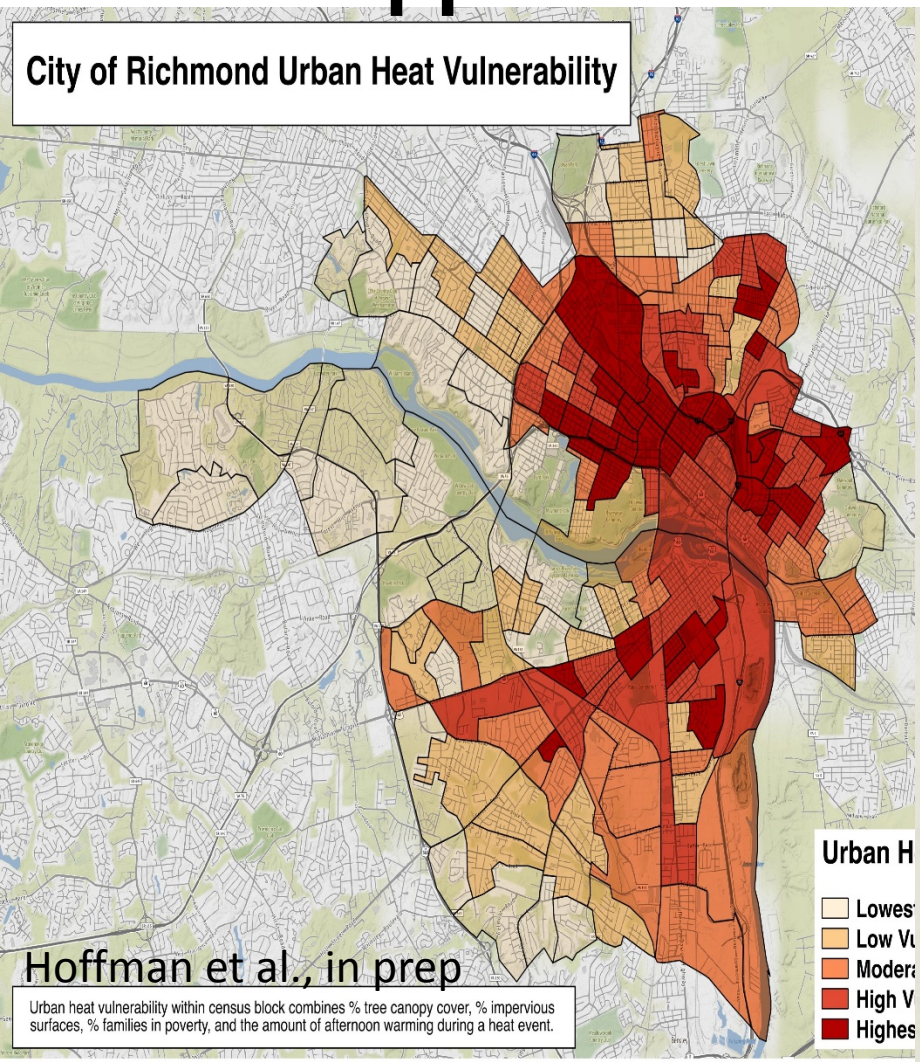
-High canopy

-New houses

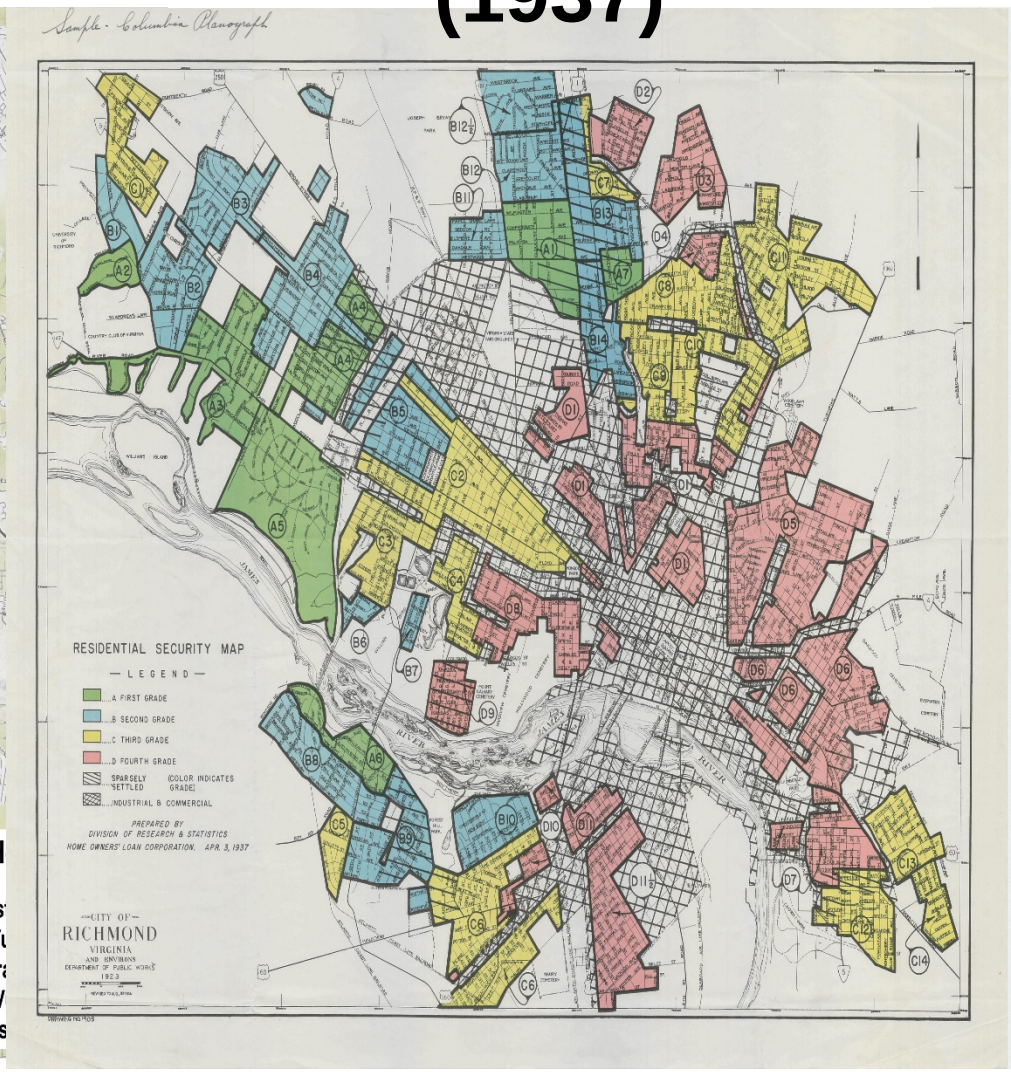
-Older population



VULNERABILITY

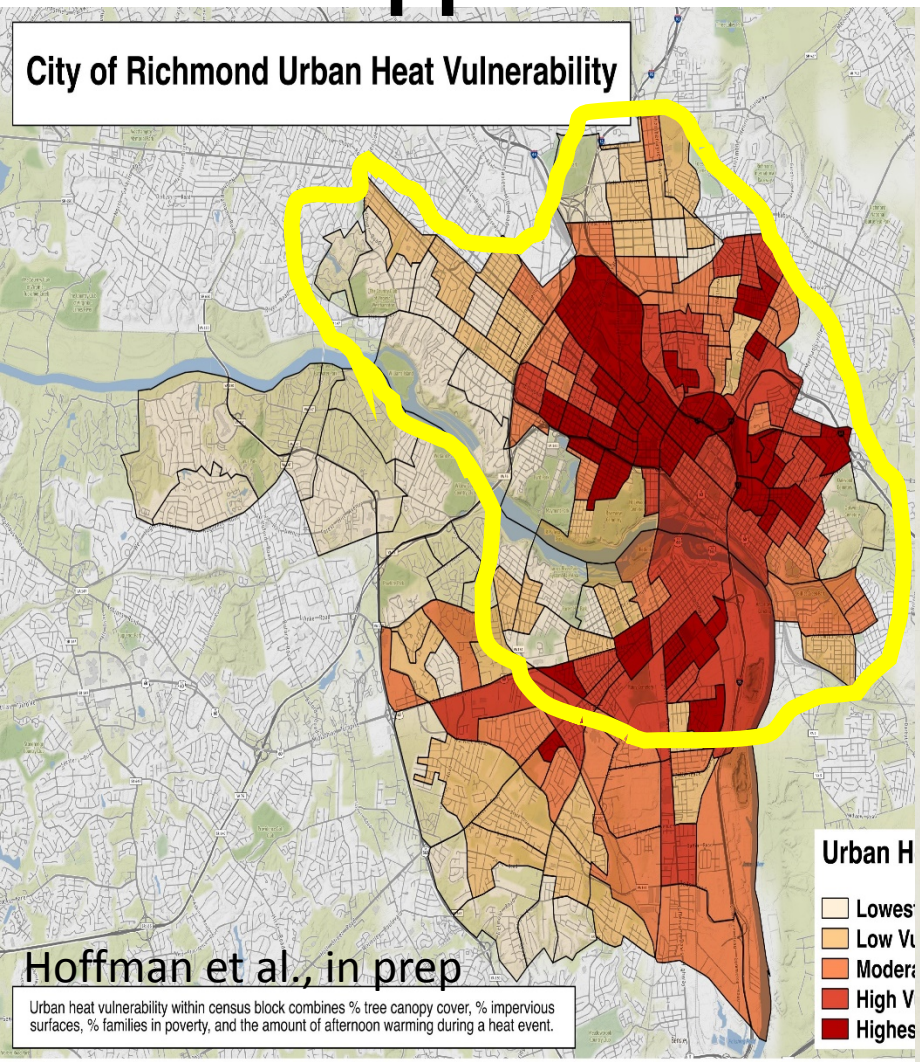


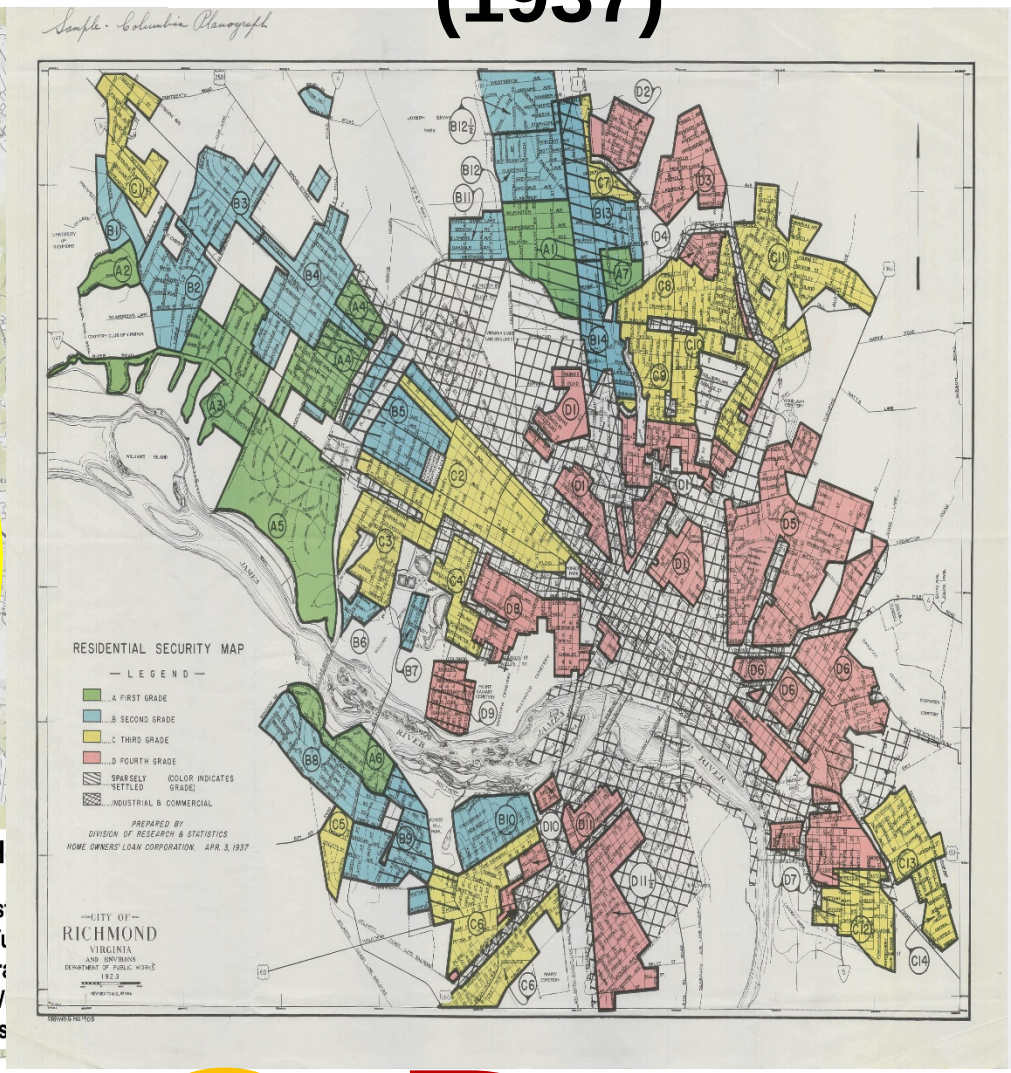
REDLINING MAP (1937)



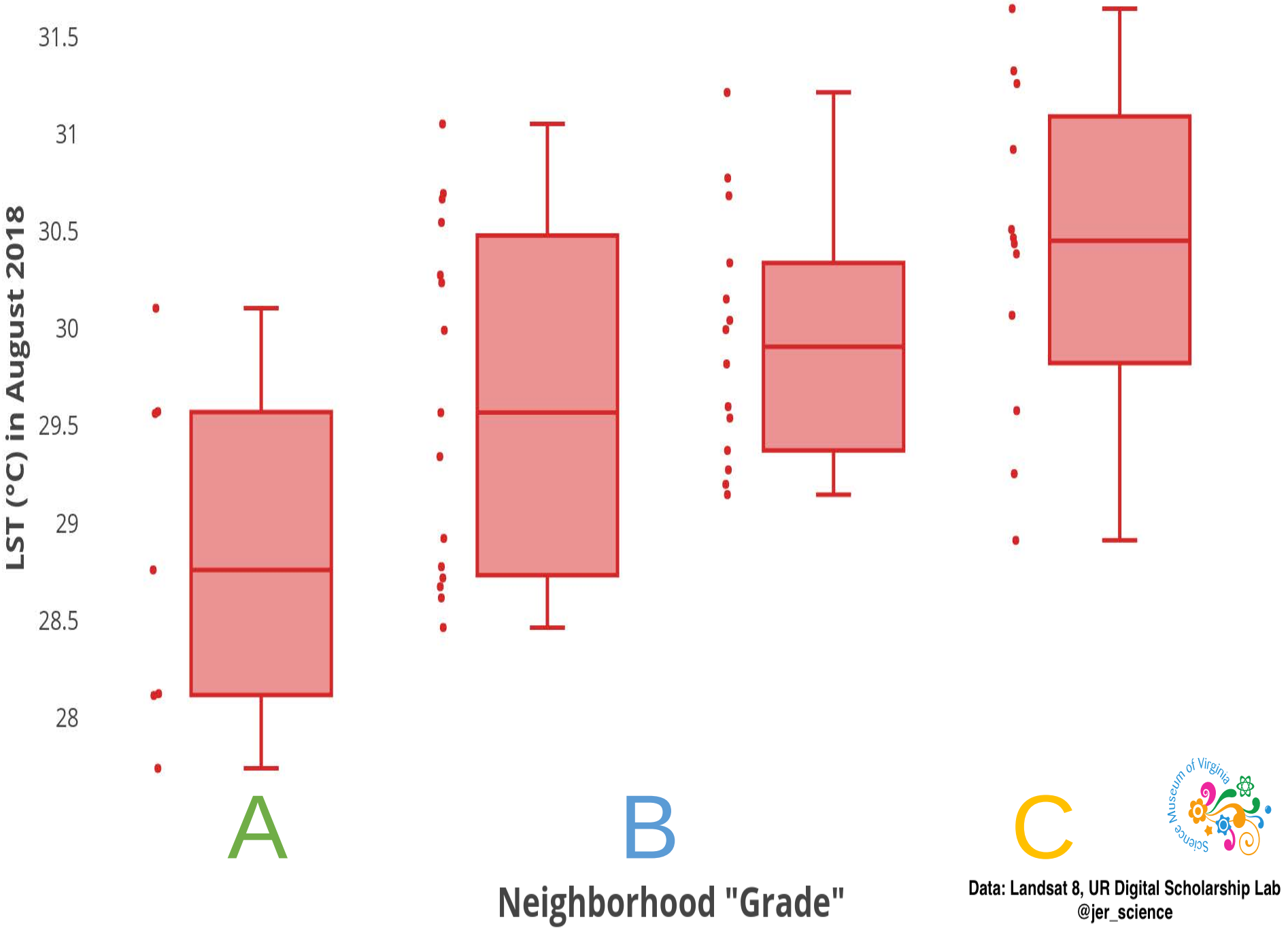
VULNERABILITY

REDLINING MAP (1937)





A B C D


LST (°C) in August 2018
31.5
31
30.5
30
29.5
29
28.5
28
A
B
C
Neighborhood "Grade"
Data: Landsat 8, UR Digital Scholarship Lab
@jer_science
Science Museum of Virginia

Next steps?

Thanks!

- @jer_science
- jhoffman@smv.org

Climate Change and Vulnerable Populations

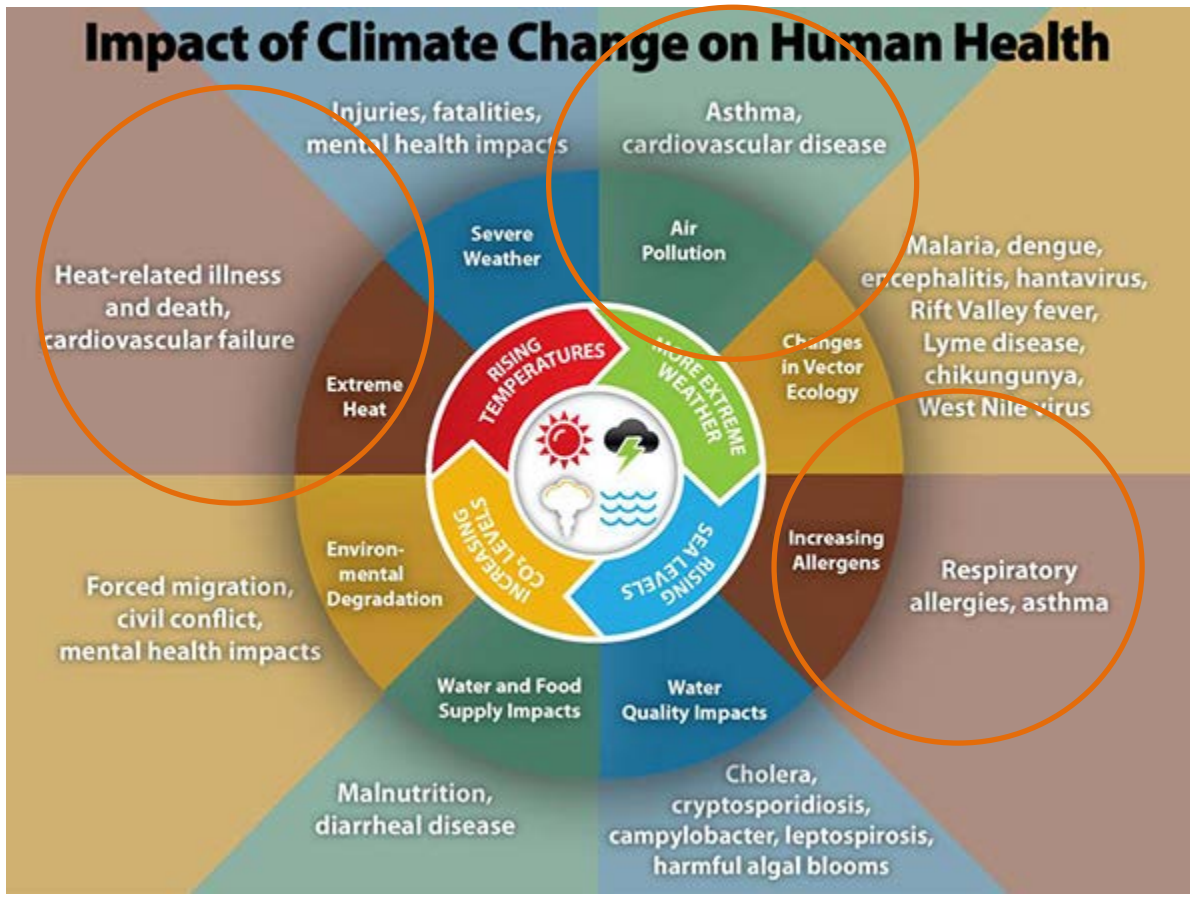
Melicent R. Miller, MSPH
Health Improvement Supervisor
Office of Family Health Services

Climate Change and Vulnerable Populations

Understanding the threats that climate change poses to human health can help us work together to lower risks and be prepared

US Environmental Protection Agency. (2016)

Climate Change and Vulnerable Populations



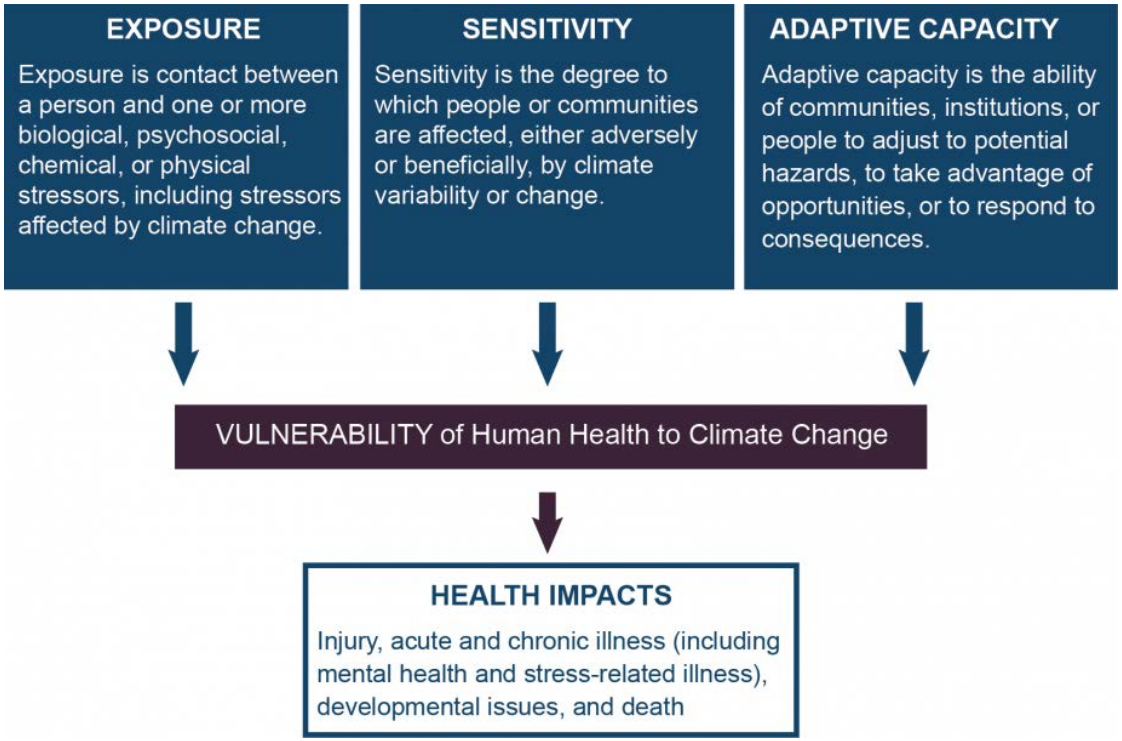
Climate Change and Vulnerable Populations

Vulnerable Populations (AKA) populations of concern

- Low income
- Communities of color
- Women and children
- Older adults (65 years or older)
- Occupational groups
- Persons with disabilities
- Persons with preexisting or chronic medical conditions

Climate Change and Vulnerable Populations

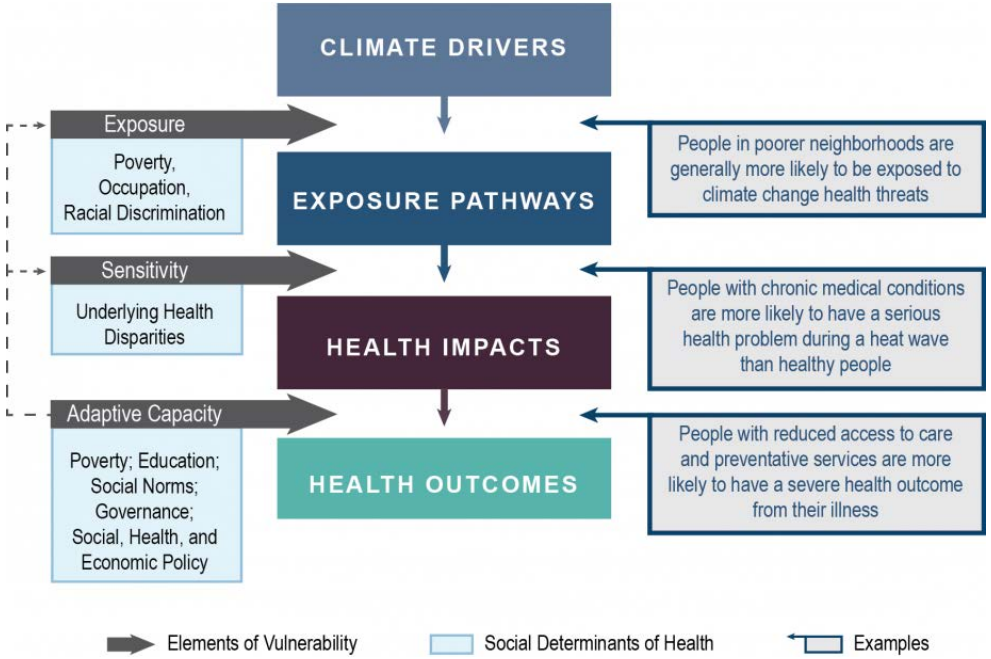
A Framework for Understanding Vulnerability



US Global Change Research Program, n.d.

Climate Change and Vulnerable Populations

Intersection of Social Determinants of Health and Vulnerability



US Global Change Research Program, n.d.

Climate Change and Vulnerable Populations

Other Considerations

- Biological sensitivity
  - age
  - chronic conditions
  - mental illness
- Adaptive capacity and response to climate change

Climate Change and Vulnerable Populations

Communities of Color, Low Income, Immigrants, and Limited English Proficiency Groups

- exposure given their higher likelihood of living in risk-prone areas
- areas with an increased burden of air pollution
- areas with older or poorly maintained infrastructure
- relatively greater incidence of chronic medical conditions

Climate Change and Vulnerable Populations

Communities of Color, Low Income, Immigrants, and Limited English Proficiency Groups

- socioeconomic and educational factors
- limited transportation
- limited access to health education and medical care
- social isolation related to language deficiencies
- citizenship status limit access to and use of health care and other social services

Climate Change and Vulnerable Populations

Indigenous Peoples in the United States

- health risks are higher among Indigenous populations
- greater exposure and lower resilience to climate-related health effects
- disrupt traditional hunting and subsistence practices
- threaten infrastructure
- contribute to a loss of cultural identity

Climate Change and Vulnerable Populations

Children and Pregnant Women

- distinct exposures
- biological sensitivities
- limitations to adaptive capacity

Climate Change and Vulnerable Populations

Older Adults

- increase in hospital admissions for cardiovascular and respiratory disorders and diabetes
- exposure to ground-level ozone can affect lung function and increase emergency department visits and hospital admissions

Climate Change and Vulnerable Populations

Occupational Groups

- Outdoor workers
  - ambient temperature
  - degraded air quality
  - industrial exposures
  - changes in the built environment
- Indoor work environments
  - extreme heat exposure

Climate Change and Vulnerable Populations

Persons with Disabilities

- disproportionately higher rates of:
  - poverty and lower educational attainment
  - poorer health outcomes during extreme events or climate-related emergencies
  - “invisibility” to decision-makers and planners

Climate Change and Vulnerable Populations

Persons with Chronic Medical Conditions

- increase illness and death associated with climate-related stressors
  - Heart Disease (3.8% of adults)
  - Diabetes (9.6% of adults)
  - Disability (32.6% of adults)
  - Asthma (8.9% of adults, X% of children)
  - Chronic Obstructive Pulmonary Disease (COPD) (5.7% of adults)
  - Mental Illness (19.0% of adults)

CDC, BRFSS (2017)

Climate Change and Vulnerable Populations

Measuring Vulnerability

- Vulnerability = Hazard Exposure x Sensitivity – Adaptive Capacity
- Difficult to measure
  - not readily measured or observable
  - need proxy measures and indicators
  - vulnerability is relative, not absolute

Climate Change and Vulnerable Populations

Public health implications

- reorientation to include a climate change lens into daily practice:
  - chronic disease prevention
  - context of vulnerable populations
- internal adaptation planning
- leveraged to support stakeholder engagement
- integration of health adaptation policies among local municipalities

References

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- US Global Change Research Program. (2016). *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*. Crimmins, A., J. Balbus, J.L. Gamble, C.B. Beard, J.E. Bell, D. Dodgen, R.J. Eisen, N. Fann, M.D. Hawkins, S.C. Herring, L. Jantarasami, D.M. Mills, S. Saha, M.C. Sarofim, J. Trtanj, and L. Ziska, Eds. U.S. Global Change Research Program, Washington, DC, pp312. Retrived from: http://dx.doi.org/10.7930/J0R49NQX

Public Health Impacts of Extreme Weather Events

R.P. Mauskapf, MPA
Director, Office of Emergency Preparedness
Virginia Department of Health

Examples of Public Health Threats

Natural Disasters

- Hurricanes, Tornadoes, Earthquakes, Floods, Wildfires

Communicable Disease Outbreaks

- Influenza, Ebola Virus Disease, Tuberculosis, Measles, new and emerging infections

Environmental Incidents

- Oil Spills, Train Derailments, Industrial Accidents, Drinking Water Contamination

Acts of Terrorism

- Bioterrorism, Chemical agents

Public Health Consequences of Disasters

- Loss of Clean Water
- Loss of Shelter
- Loss of Personal Property
- Major Population Movements
- Loss of Sanitation
- Loss of Routine Hygiene
- Loss of Electricity
- Standing Surface Water
- Disruption of Solid Waste Management
- Public Concern for Safety
- Increased Pests & Vector
- Damage to Healthcare Systems
- Worsening of Chronic Illnesses
- Toxic / Hazardous Exposure
- Loss of Food/Med Supply (supply chain mgt)
- Behavioral Health Impact
- Deaths
- Injuries

AFFECTING HEALTH DIRECTLY

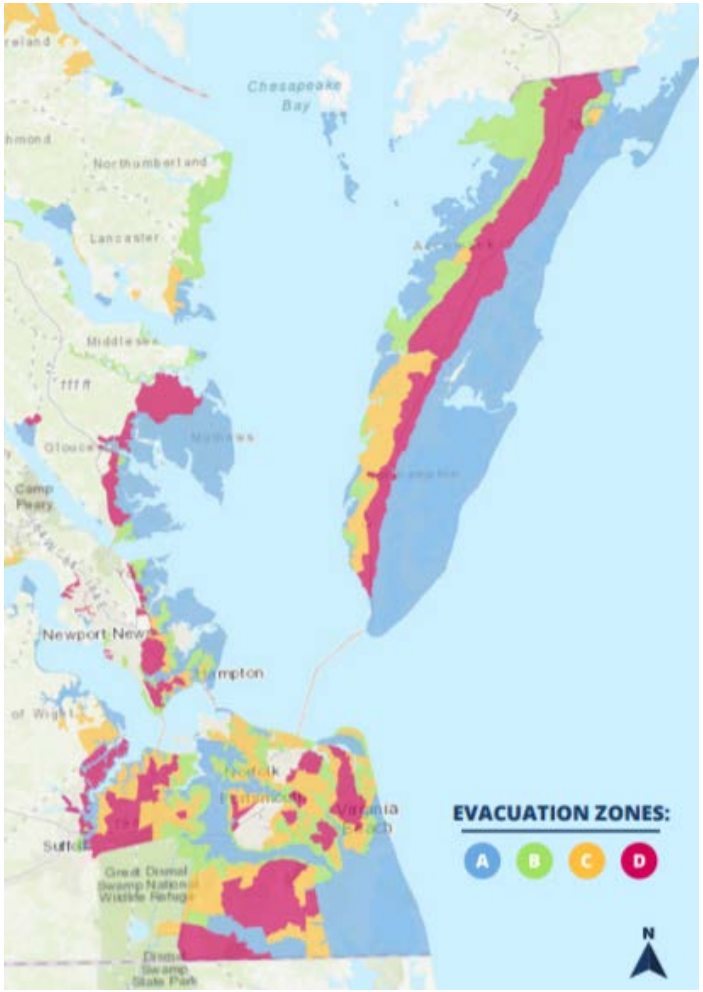
EXTREME WEATHER

Increased frequency and severity of heavy downpours, floods, droughts, and major storms can lead to:

injury, illness, displacement, and death

More Vulnerable: People who lack access to evacuation routes and people who can't use stairs when elevators are out of service, people in wheelchairs, older adults, the poor, and people with disabilities, particularly if they are unable to access elevators and evacuation routes

Impacts on Healthcare Facilities and Residents



Virginia Governor Orders Evacuation in Parts of State Ahead of Hurricane Florence

Hurricane Florence is expected to approach the most-damaging Category 5 status as it slows and strengthens off coast of North and South Carolina

By Alan Suderman and Sarah Rankin

Published Sep 11, 2018 at 6:01 AM | Updated at 7:14 PM EDT on Sep 11, 2018

Hurricane Florence Evacuation Orders Come With Tough Choices For Medical Facilities

As most people in the Carolinas obey orders to leave, fragile patients, as well as those who care for them, often must stay.

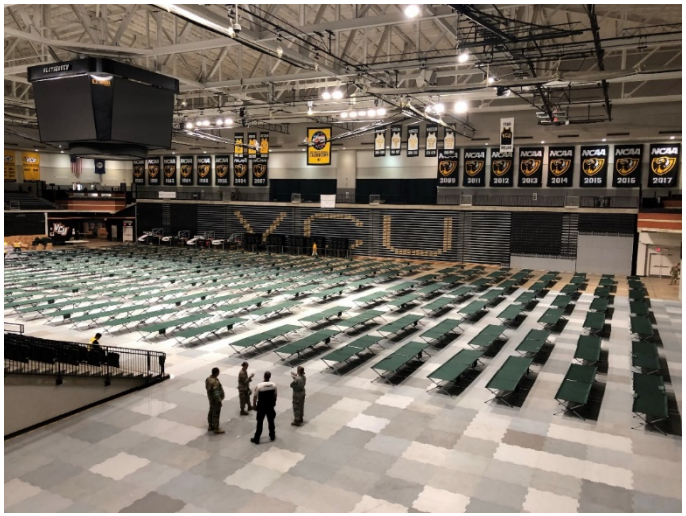
By Anna Almendrala

'A lot of anxiety': Nursing homes evacuate, hospitals hunker down as Hurricane Florence nears

Daniel J. Gross and Rick Jervis, USA TODAY Published 2:14 p.m. ET Sept. 12, 2018 | Updated 10:56 p.m. ET Sept. 12, 2018

Mass Care and Sheltering

- Established for various emergencies –extreme heat, winter weather, hurricanes, flooding
- Very resource intensive
- Most vulnerable residents

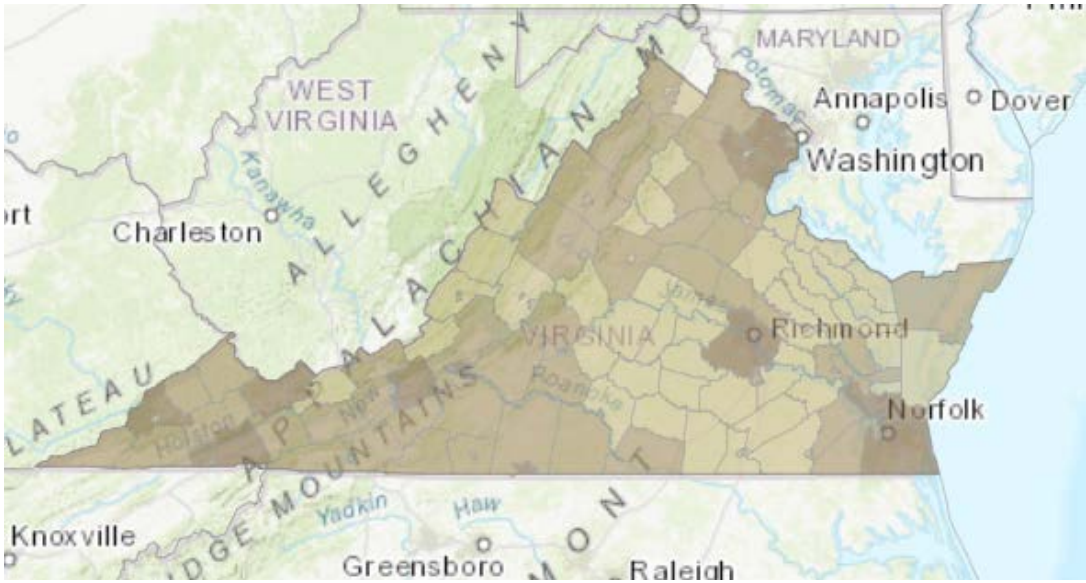


Loss of Electricity

- Inability to safely store and prepare food.
- Inability to safety store medications and vaccines.
- Loss of heating and cooling.
- Increased incidence of carbon monoxide poisoning.
- Impacts on healthcare facilities.
- Life-threatening impacts for people dependent on certain medical equipment.
  - Increased demand on healthcare facilities.

Loss of Electricity

Of Virginia's 1,340,772 Medicare beneficiaries, 64,593 people rely on electricity-dependent medical equipment, such as ventilators, to live independently in their homes.



Electricity-Dependent Scale

- 0 - 0
- 1 - 255
- 256 - 976
- 977 - 7,571
- 7,572 - 35,584

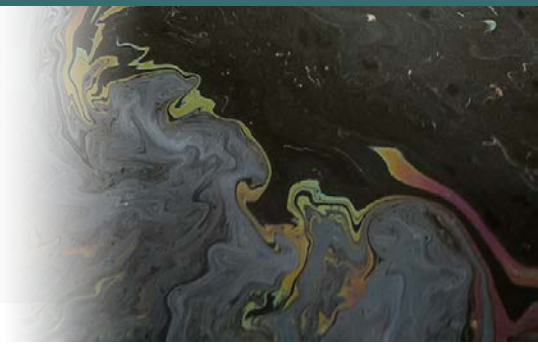
https://empowermap.hhs.gov/

SPREADING DISEASE

CONTAMINATED WATER

Higher water temperatures, heavier downpours, rising sea levels, and more flooding help spread:

gastrointestinal illness, diseases from toxins in swimming areas and drinking water

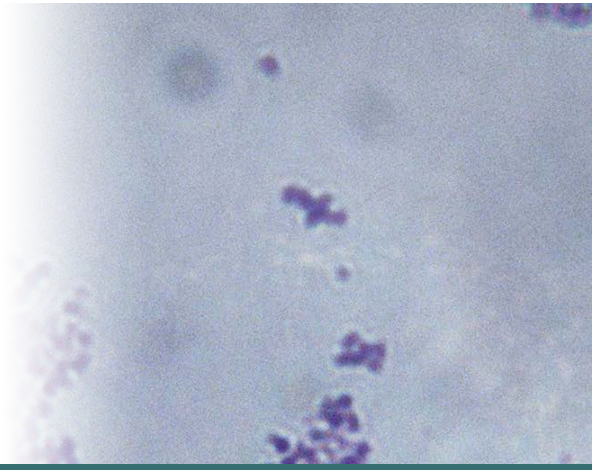


More Vulnerable: Children, the elderly, people with weakened immune systems, people in remote or low-income communities with inadequate water systems, and people in communities that are dependent on fish and shellfish

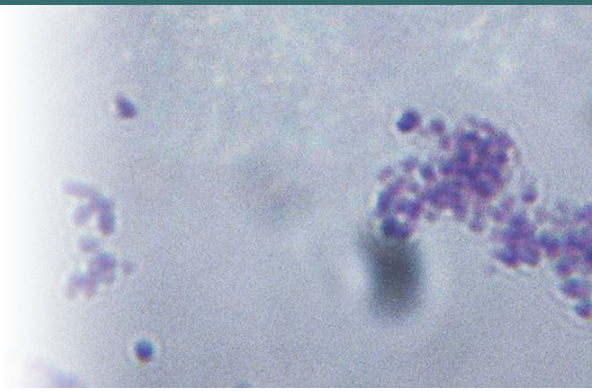
SPREADING DISEASE

CONTAMINATED FOOD

Increasing temperatures, humidity, and extreme weather events help spread:



illnesses from bacteria and toxins in food



More Vulnerable: Infants, young children, the elderly, the poor, agricultural workers, and people with weakened immune systems

DISRUPTING WELL-BEING

MENTAL HEALTH PROBLEMS

Increased frequency and severity of extreme weather events can lead to:

stress, depression, anxiety, PTSD, and suicidal thoughts

More Vulnerable: Children, older adults, pregnant and postpartum women, people with mental illnesses, the poor, homeless people, first responders, and people who rely on the environment for their livelihood

Assessing Vulnerability

Part of local and regional discussions around climate change adaptation should include evaluating and planning for changing health considerations from new weather patterns and threats.

Consider the following climate-risk management questions:

- What new hazards should be considered as possible scenarios in your jurisdictional risk assessment?
- What assets and liabilities does your jurisdiction need to consider when addressing these new hazards?
- What unique populations are in need of special health considerations?
- How will your unique populations change over the next five years, ten years?

Source: https://www.naccho.org/programs/public-health-preparedness/preparing-for-extreme-weather