Jaime Madrigano, ScD, MPH
The Earth Institute
Columbia University

Vulnerability to Heat-Related Mortality in New York City

Public Health Burden of Heat

- On average, heat kills more people every year than any other natural disaster in the United States
  - ~ 700 deaths in 1995 Chicago heat wave

- As a result of climate change
  - Increased temperatures
  - More frequent extreme temperature days

Heat-Related Mortality in NYC

- In 2006, approximately 140 excess deaths due to heat
- Why is understanding vulnerability important?
  - During heat waves, emergency management plans include opening cooling centers and increasing outreach to at-risk populations.
  - Urban planning initiatives (e.g. 1 million trees)
- Previous studies have mapped ‘expected’ vulnerability factors in NYC, but have not linked them with actual health outcome data.

Methods

- Case-Only Design
  - A way to assess how a characteristic that does not vary over time modifies the effect of a time-varying exposure
  - If a characteristic increases the risk of dying on hotter days, the proportion of deaths with that characteristic will be higher on hotter days

Methods

- Study Population
  - All decedents (cases) who are residents of New York City, 2000 – 2011
    - Non-external causes of death
    - May – September
    - n = 236,630
- Exposure
  - Heat wave days
    - Ambient temperature measured at LaGuardia airport
    - Days when either the maximum temperature or heat index > 95°F for at least two consecutive days
    - Two days following heat wave

Methods

Modifiers

- Gender, race, age, dying at home
- Underlying cause of death
  - Diabetes
  - Cardiovascular disease
  - Myocardial infarction
  - Congestive heart failure
  - Chronic obstructive pulmonary disease (COPD)
- Census tract of residence
  - Built space
  - Trees, grass, shrubs
  - % Families receiving public assistance
  - Relative daytime and nighttime temperature
  - Traffic density
  - Non-English speaking

Methods

- Statistical Analysis
  - Classic Poisson regression model

$$Log(E(Y_t)) = \beta_0 + \beta_1 Heatwave + \beta_2 Diabetes + \beta_3 Heatwave * Diabetes + otherstuff$$

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  - β3 is the parameter of interest to look at effect modification (e.g. susceptibility by diabetes status)

Methods

- If heatwave=0 and diabetes=0 the overall number of cases expected over the course of the study is

$$\sum_t \exp(\beta_0 + otherstuff) = k_0$$

- If heatwave=1 and diabetes=0 it is

$$\sum_t \exp(\beta_0 + \beta_1 heatwave + otherstuff) = k_1$$

Methods

- If heatwave=0 and diabetes=1 the overall number of cases expected over the course of the study is

$$\sum_t \exp(\beta_0 + \beta_2 + otherstuff) = k_0 \exp(\beta_2)$$

- If heatwave=1 and diabetes=1 it is

$$\sum_t \exp(\beta_0 + \beta_1 heatwave + \beta_2 + \beta_3 + otherstuff) = k_1 \exp(\beta_2 + \beta_3)$$

Methods

- Therefore:

	Diabetes		
		0	1
Heat Wave	0	k_0	$k_0 \exp(\beta_2)$
	1	k_1	$k_1 \exp(\beta_2 + \beta_3)$

- Odds Ratio

Methods

- Therefore:

	Diabetes		
		0	1
Heat Wave	0	k_0	$k_0\exp(\beta_2)$
	1	k_1	$k_1\exp(\beta_2 + \beta_3)$

- Odds Ratio = $k_1\exp(\beta_2 + \beta_3)/k_1 \,/\, k_0\exp(\beta_2)/k_0$

Methods

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$$\log it(diabetes = 1) = \beta_0 + \beta_3 HeatWave$$

Methods

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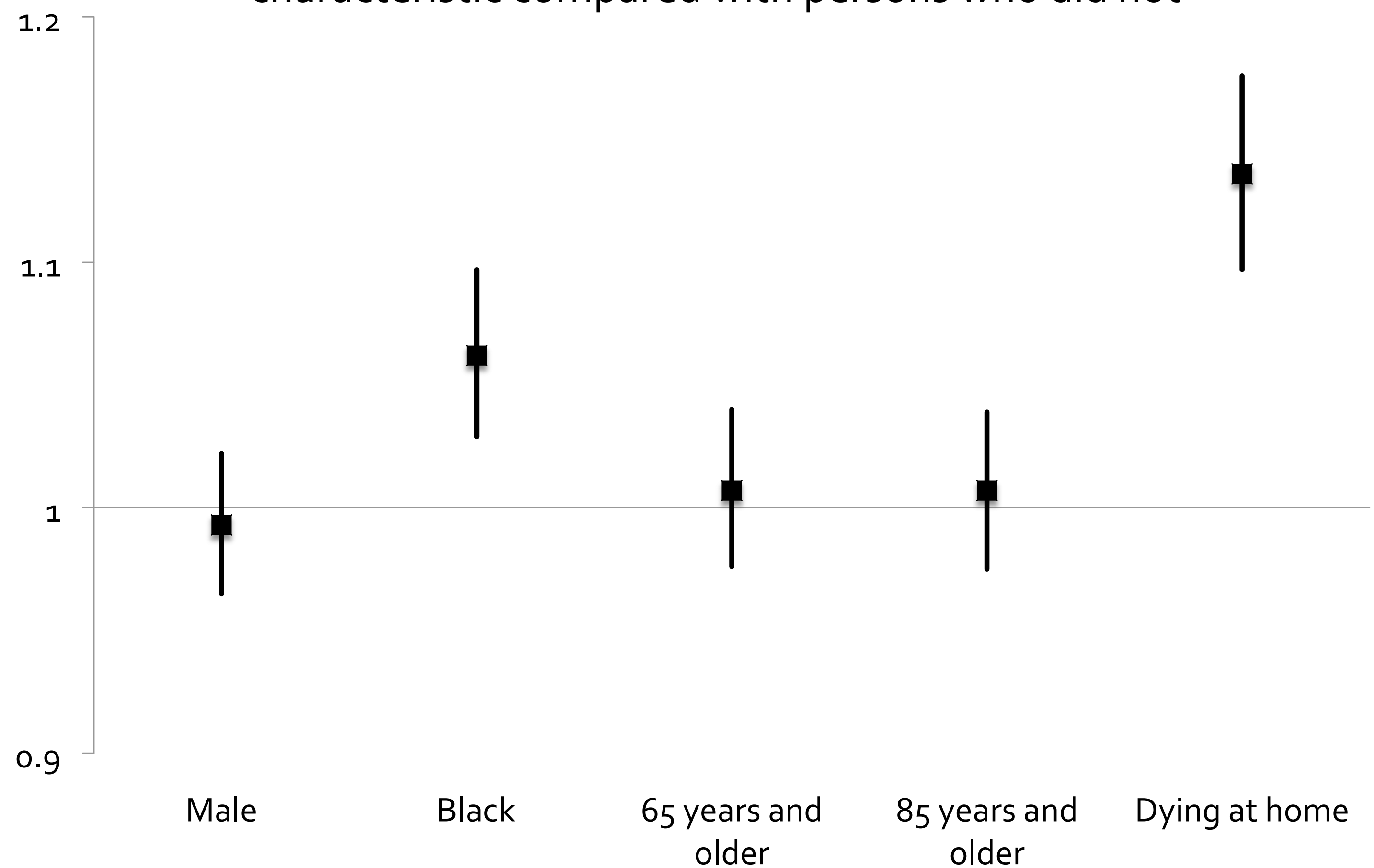
- Odds Ratio = $k_1\exp(\beta_2 + \beta_3)/k_1 \,/\, k_0\exp(\beta_2)/k_0 = \exp(\beta_3)$

$$\operatorname{logit}(diabetes = 1) = \beta_0 + \beta_3 HeatWave$$

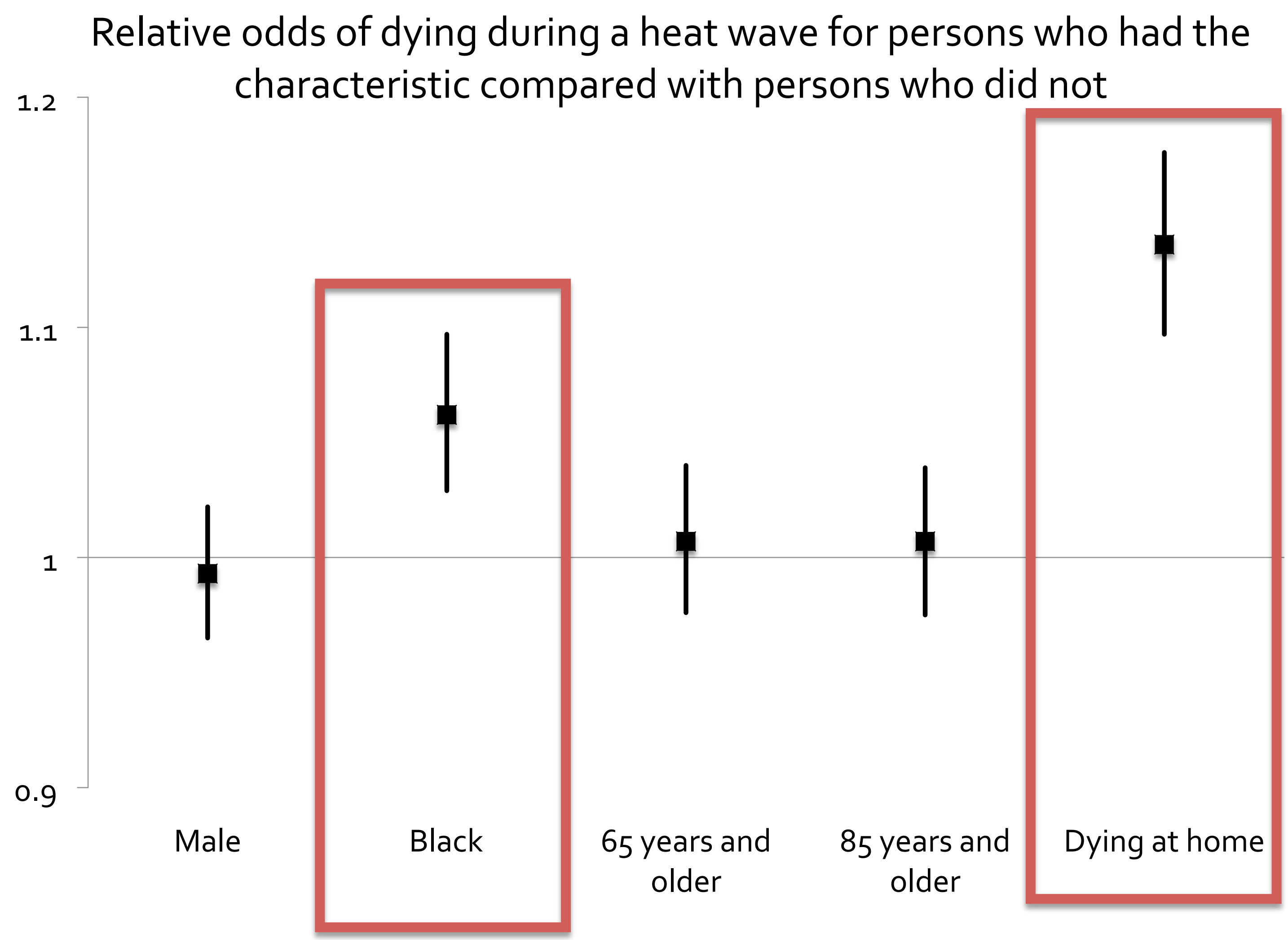
- **We can use a logistic regression predicting presence of the modifier (in cases) to obtain the parameter of interest!**

Results

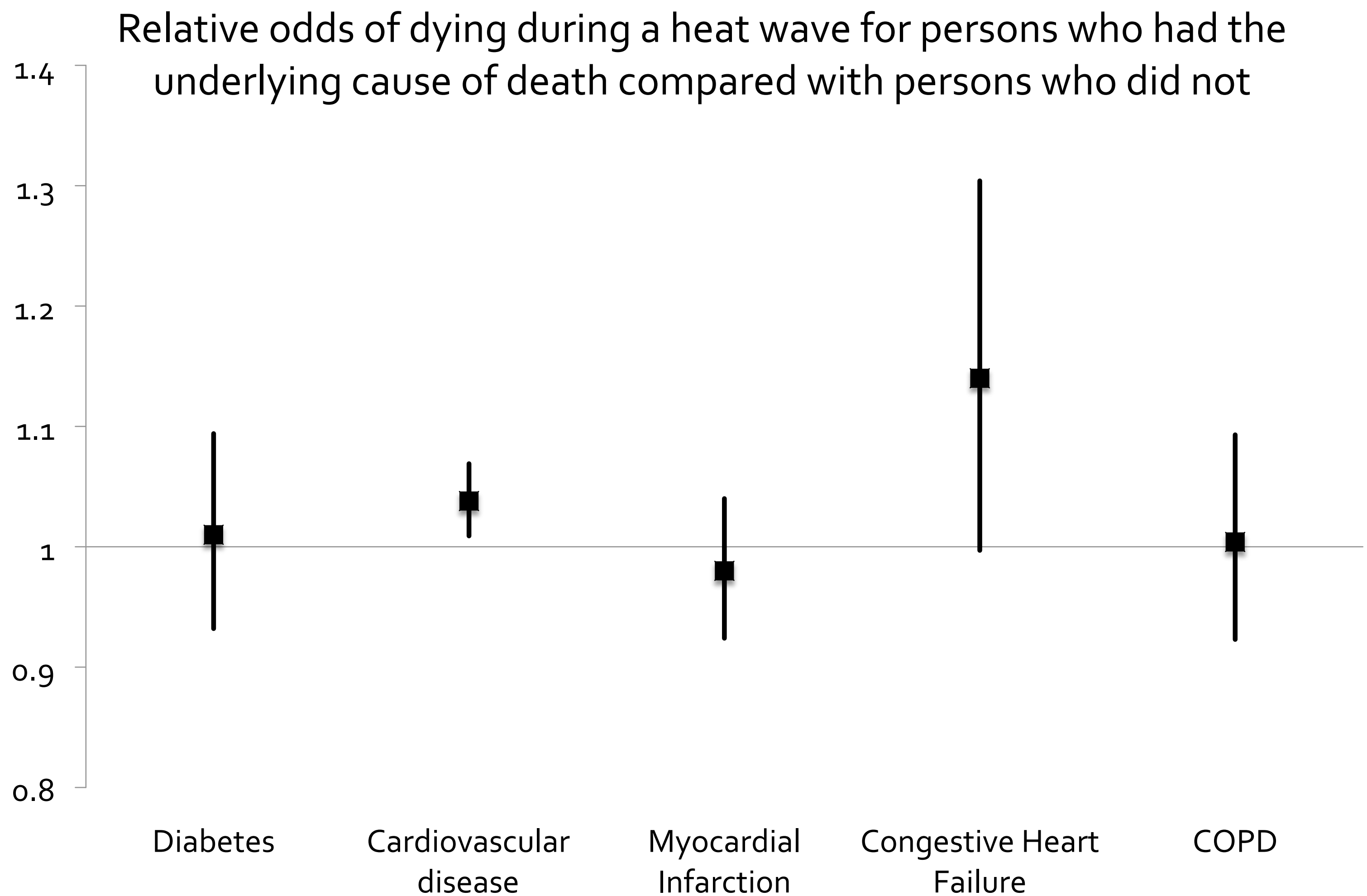
Relative odds of dying during a heat wave for persons who had the characteristic compared with persons who did not



Results

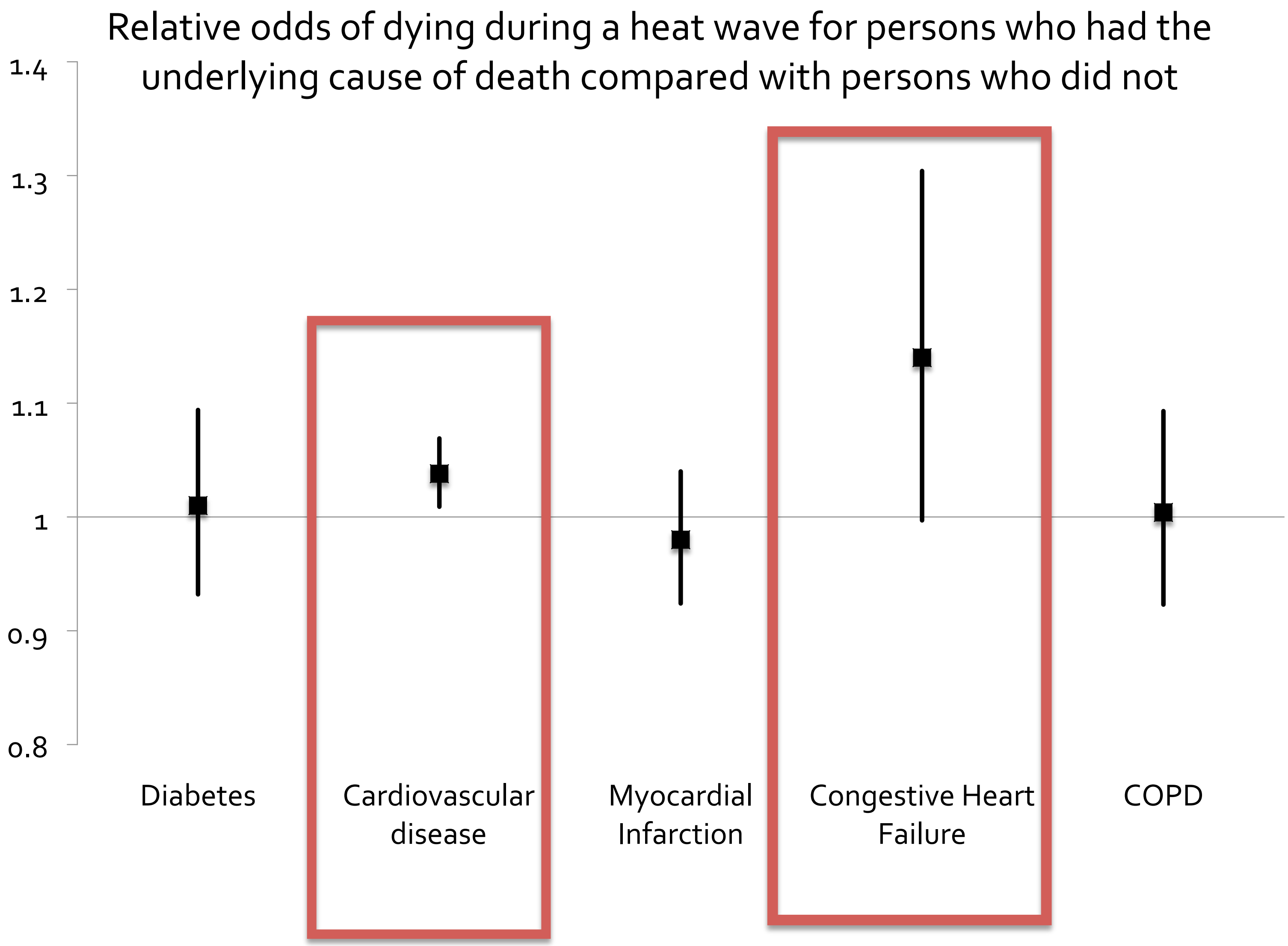

Relative odds of dying during a heat wave for persons who had the characteristic compared with persons who did not
1.2
1.1
1
0.9
Male
Black
65 years and older
85 years and older
Dying at home

Results



Relative odds of dying during a heat wave for persons who had the underlying cause of death compared with persons who did not
1.4
1.3
1.2
1.1
1
0.9
0.8
Diabetes
Cardiovascular disease
Myocardial Infarction
Congestive Heart Failure
COPD

Results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1.4
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Diabetes
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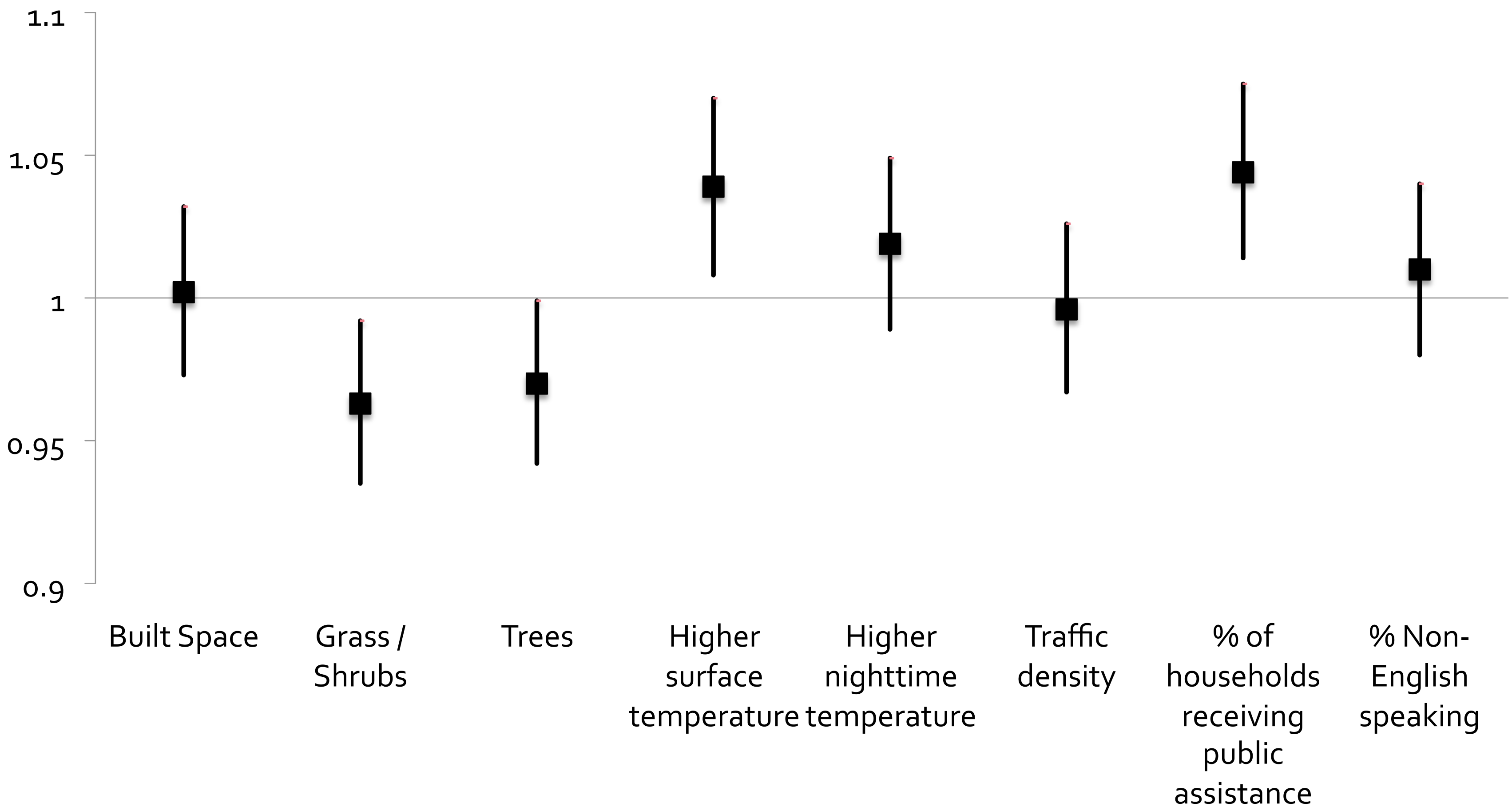
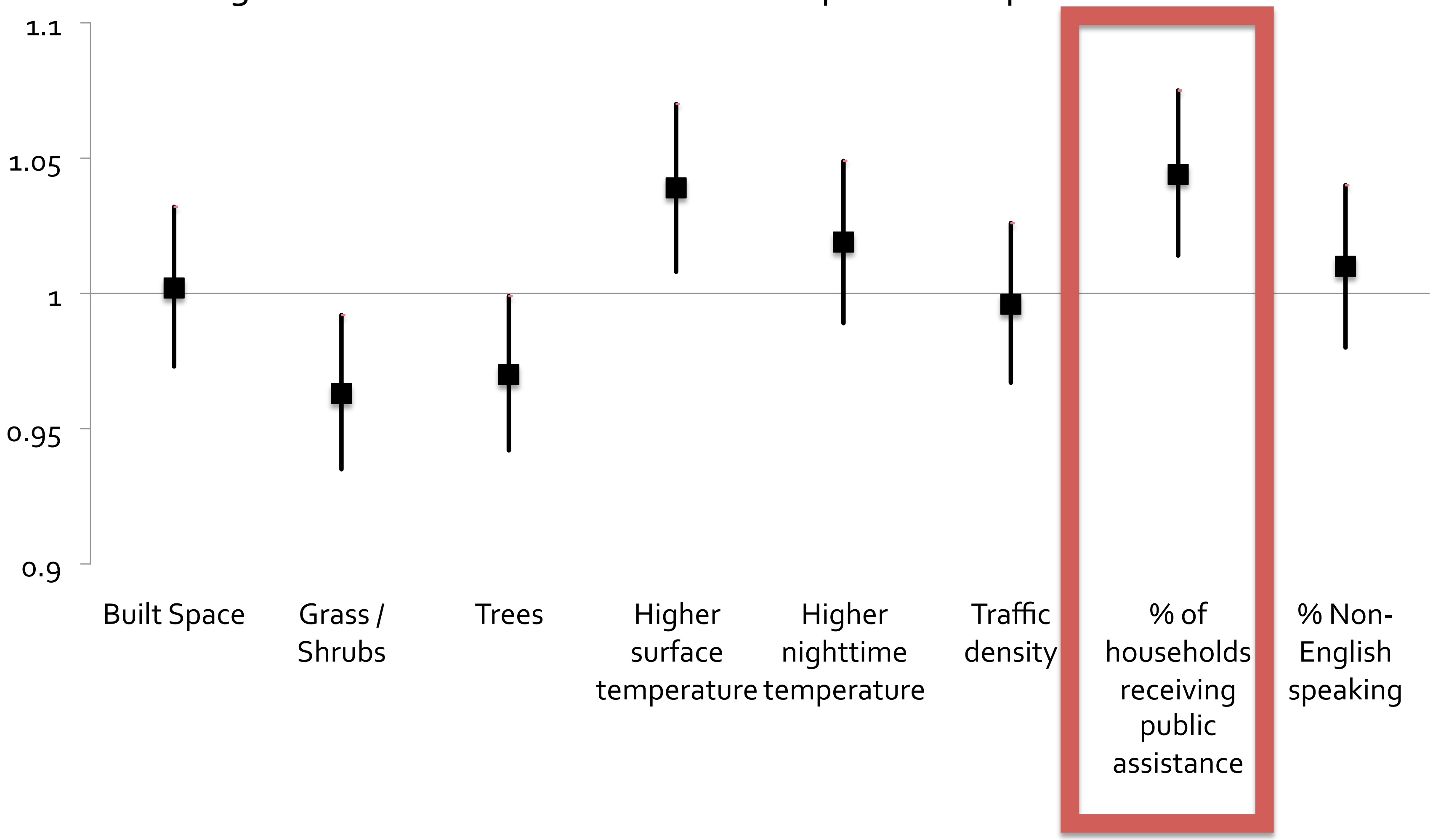
Results

Relative odds of dying during a heat wave for persons who lived in a census tract with higher levels of the characteristic compared with persons who did not



Results

Relative odds of dying during a heat wave for persons who lived in a census tract with higher levels of the characteristic compared with persons who did not



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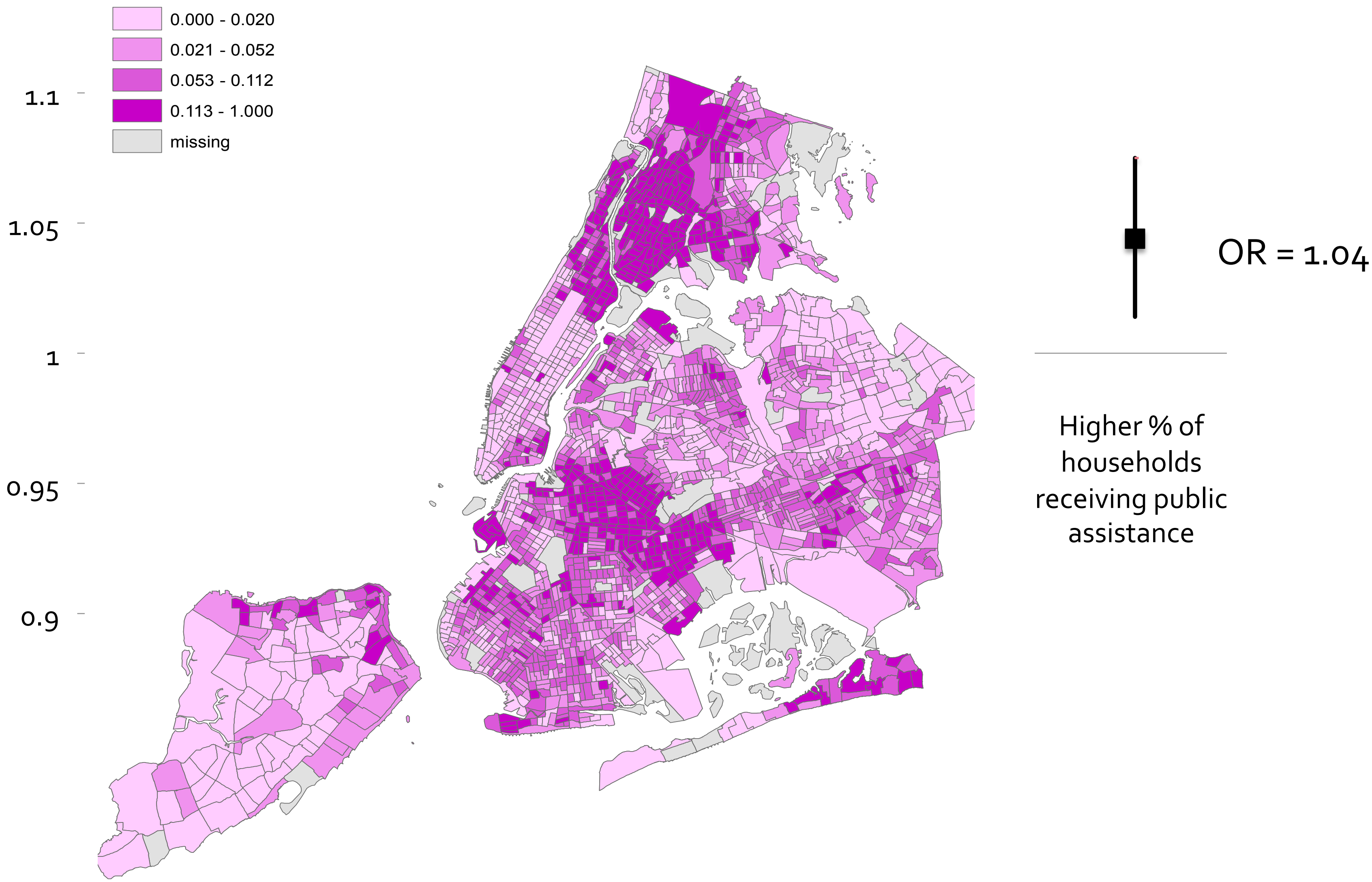
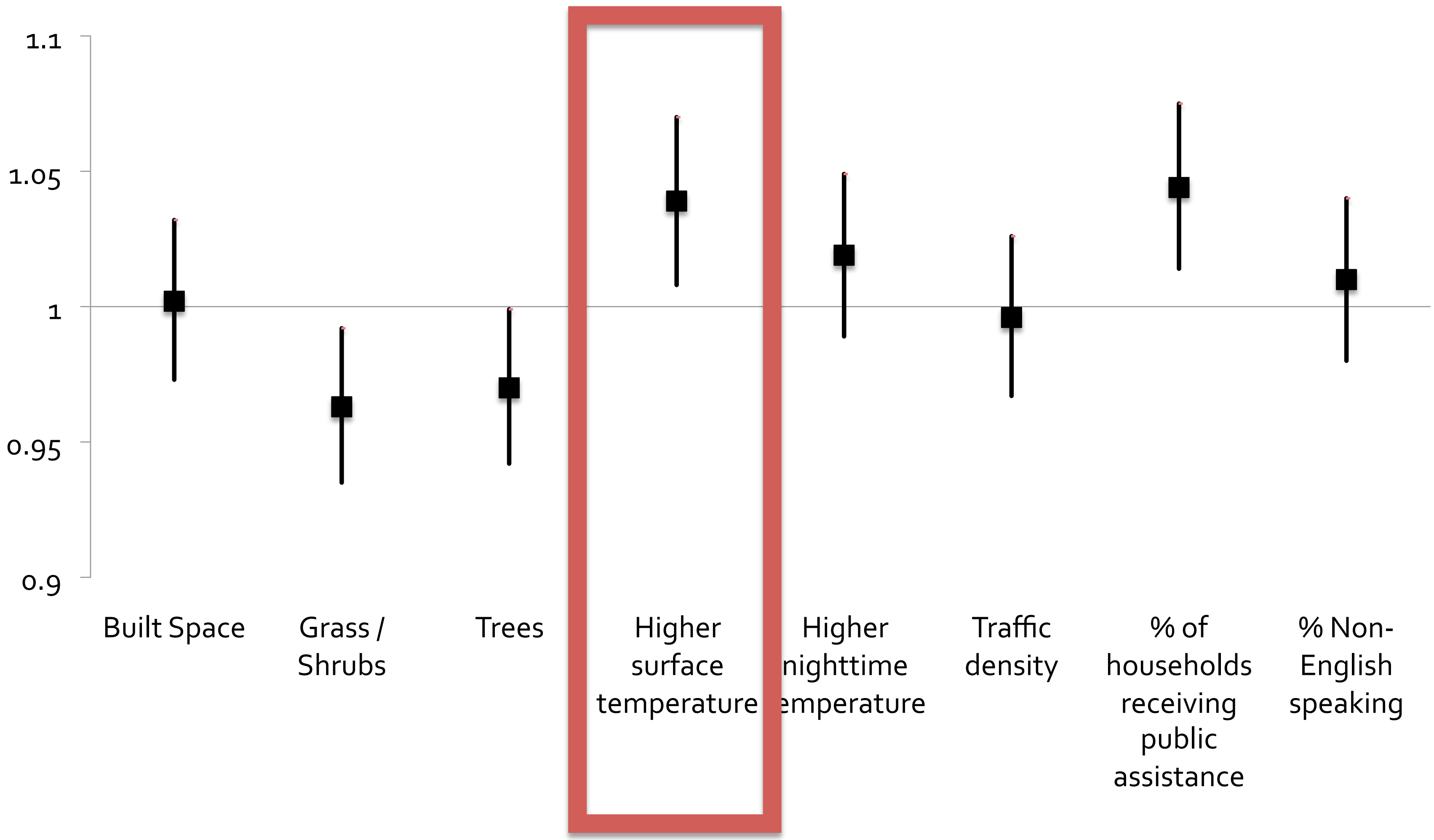
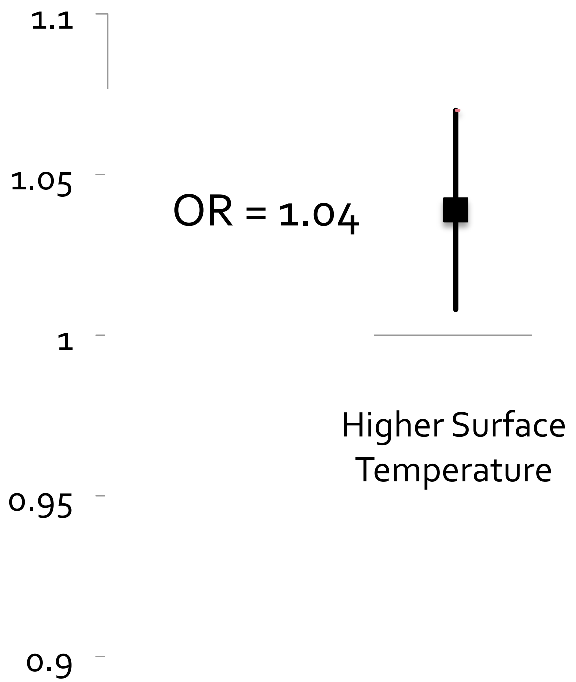

0.000 - 0.020
0.021 - 0.052
0.053 - 0.112
0.113 - 1.000
missing
1.1
1.05
1
0.95
0.9
OR = 1.04
Higher % of households receiving public assistance

Results



1.1
1.05
1
0.95
0.9
Built Space
Grass / Shrubs
Trees
Higher surface temperature
Higher nighttime temperature
Traffic density
% of households receiving public assistance
% Non-English speaking

Results


1.1
1.05
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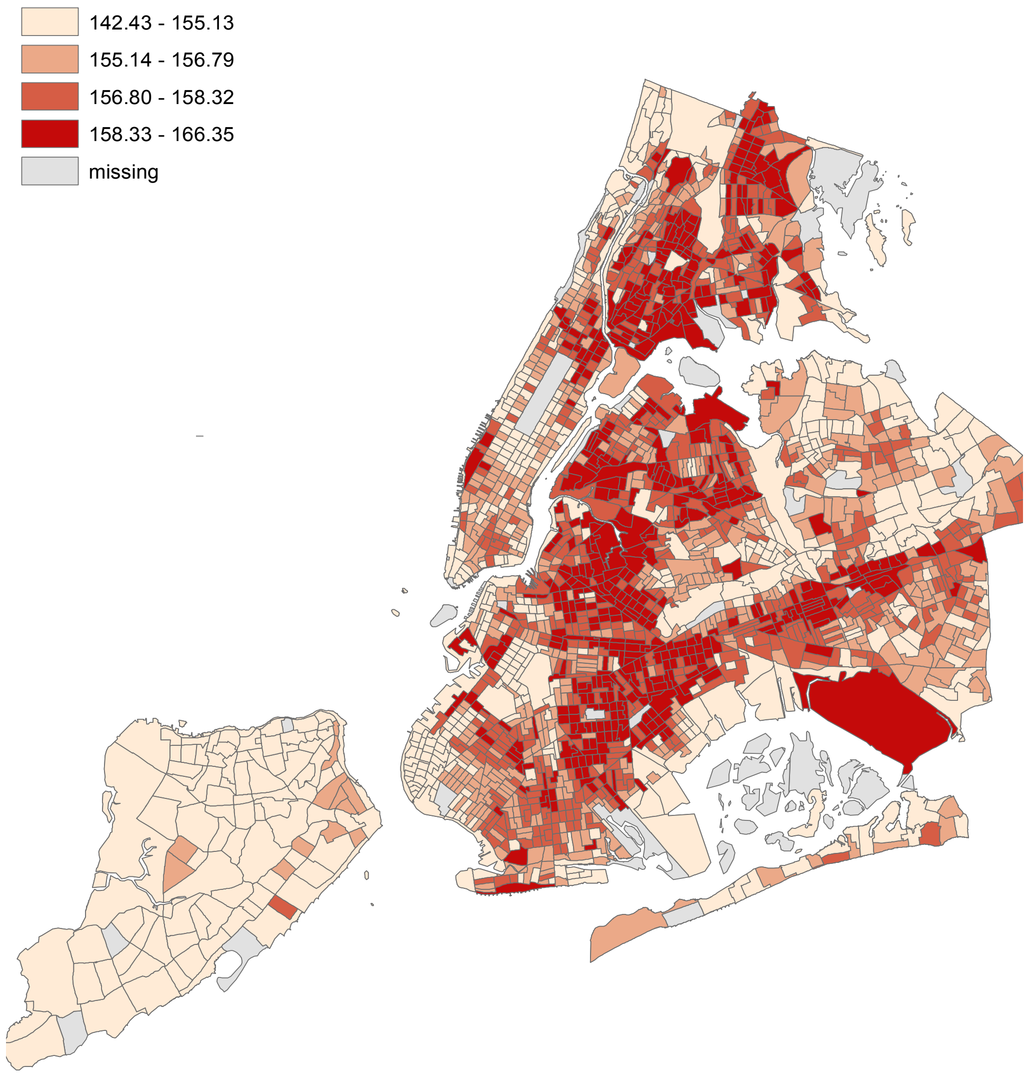
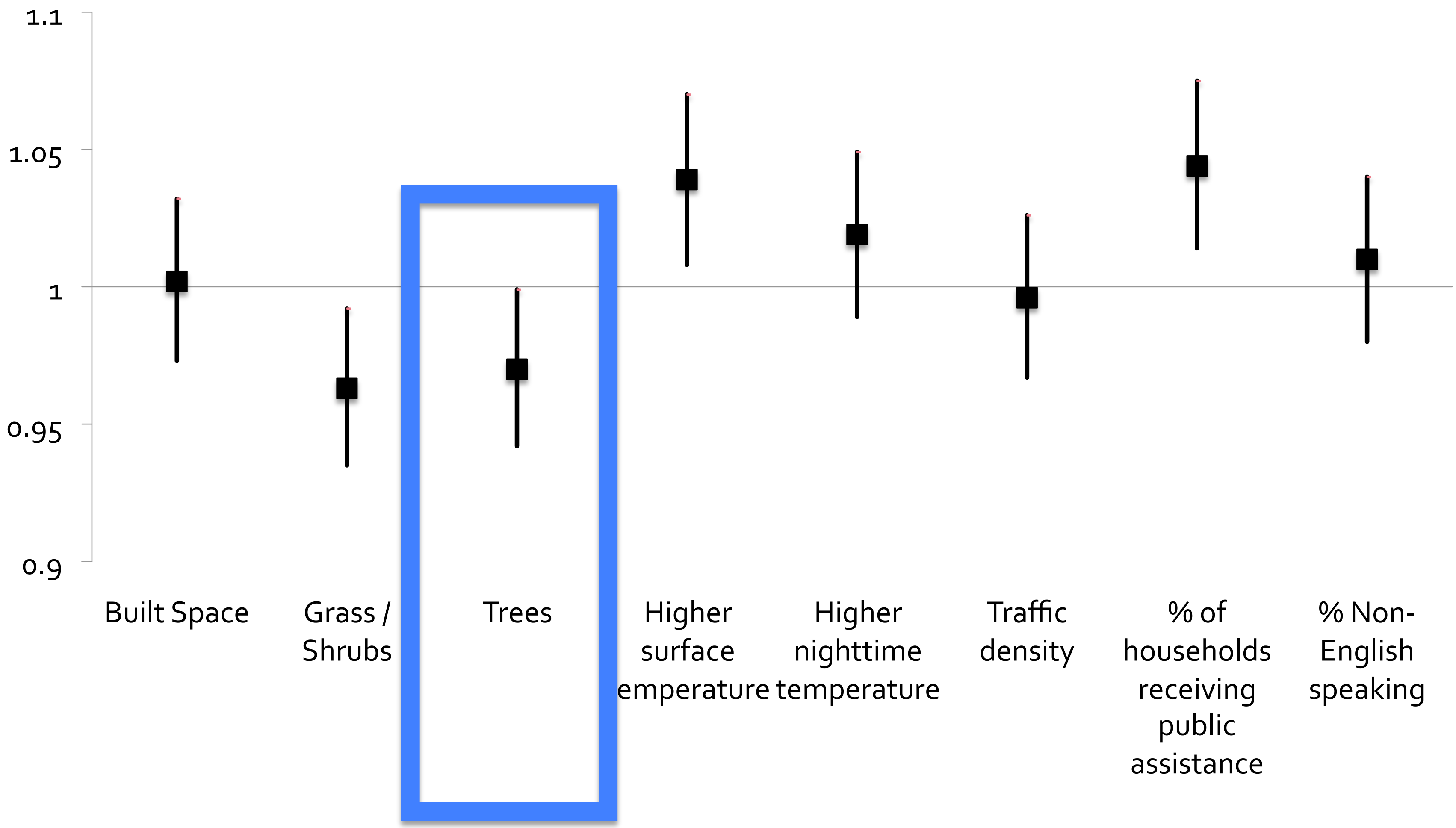
OR = 1.04
Higher Surface Temperature


142.43 - 155.13
155.14 - 156.79
156.80 - 158.32
158.33 - 166.35
missing

Results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1.05
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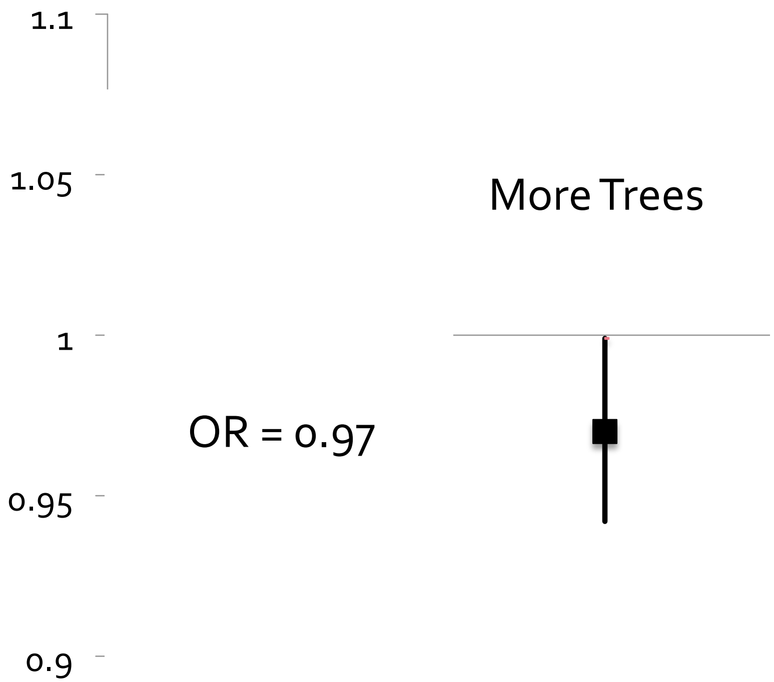
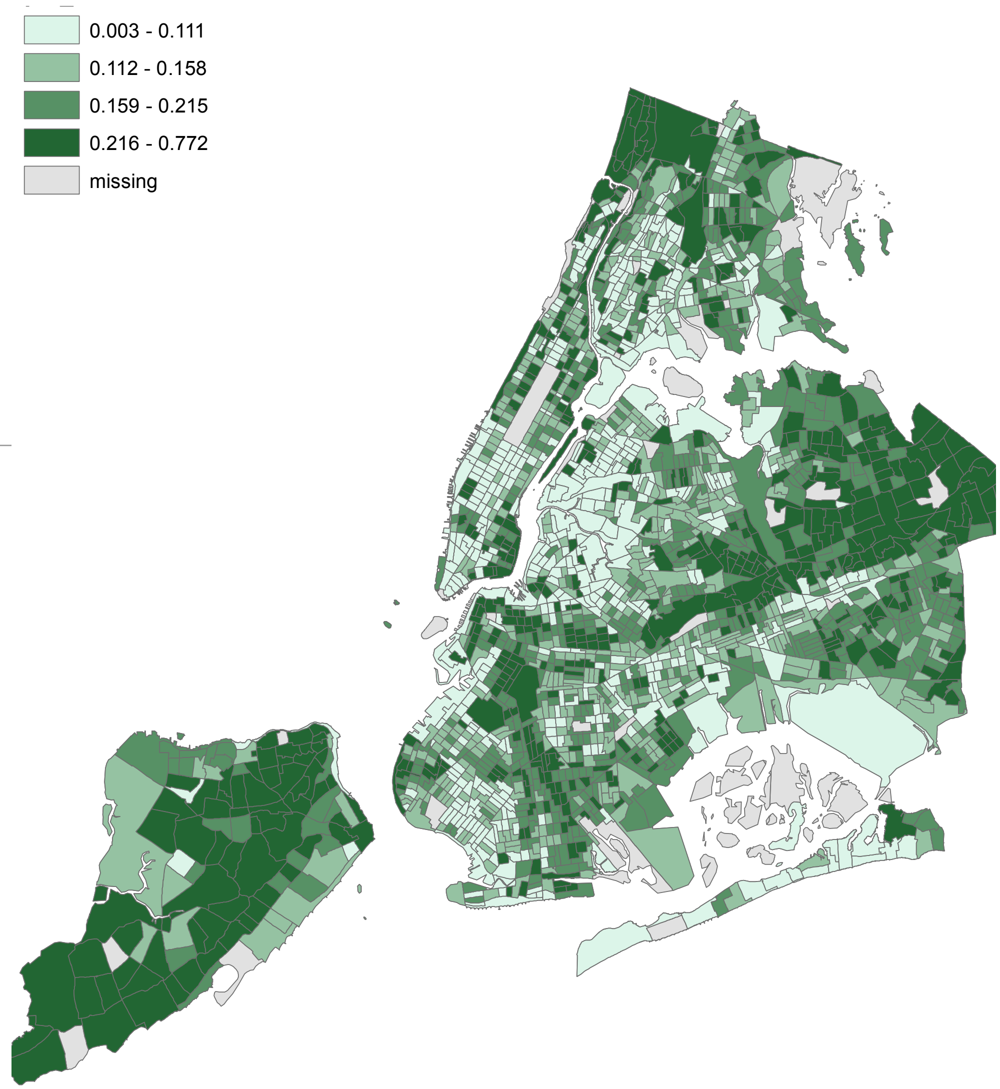
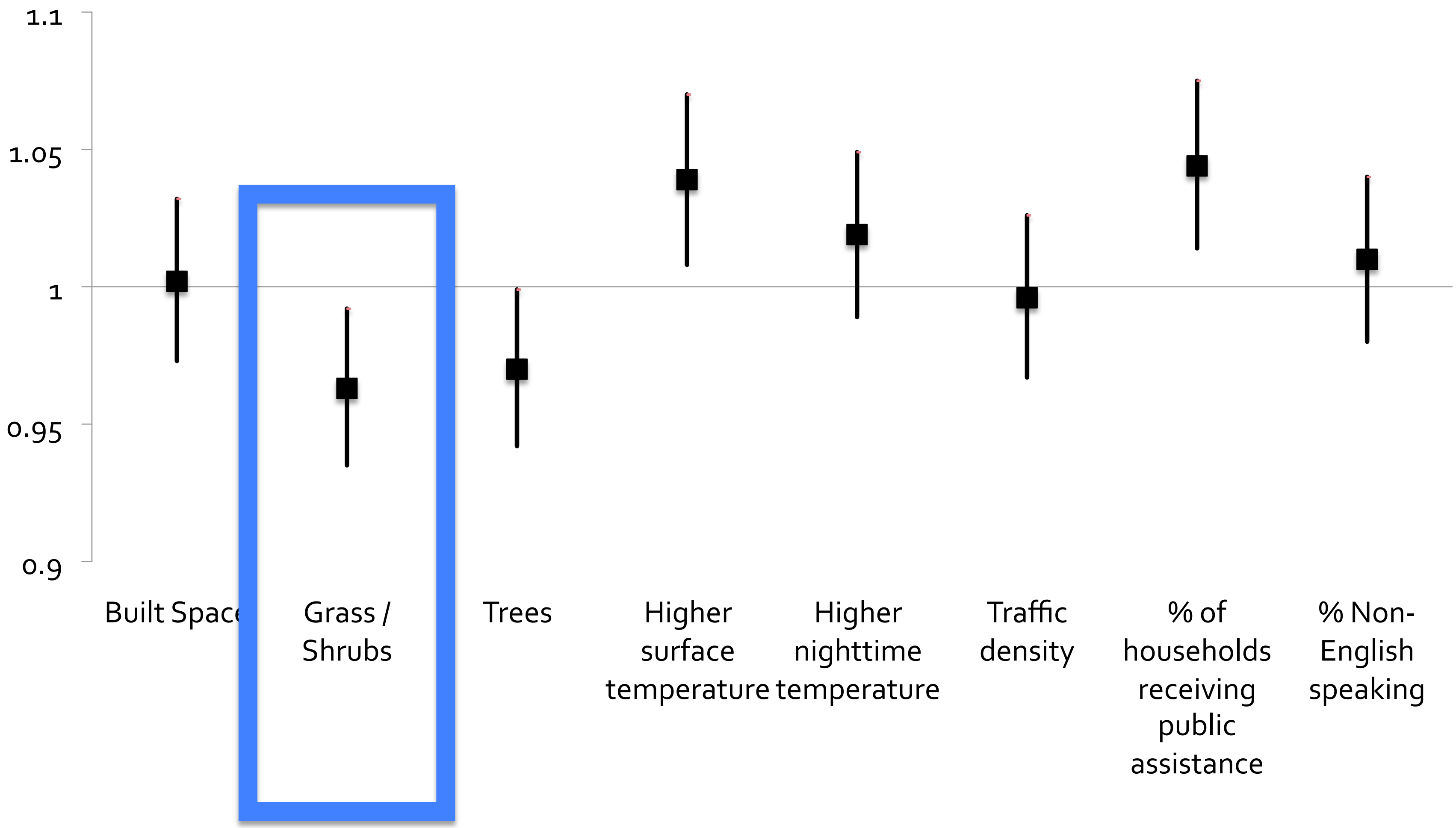

1.1
1.05
1
0.95
0.9
More Trees
OR = 0.97


0.003 - 0.111
0.112 - 0.158
0.159 - 0.215
0.216 - 0.772
missing

Results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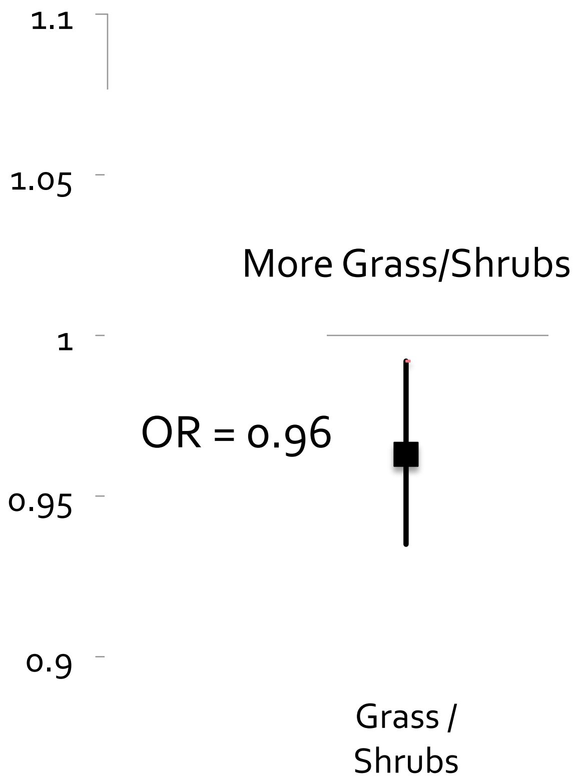
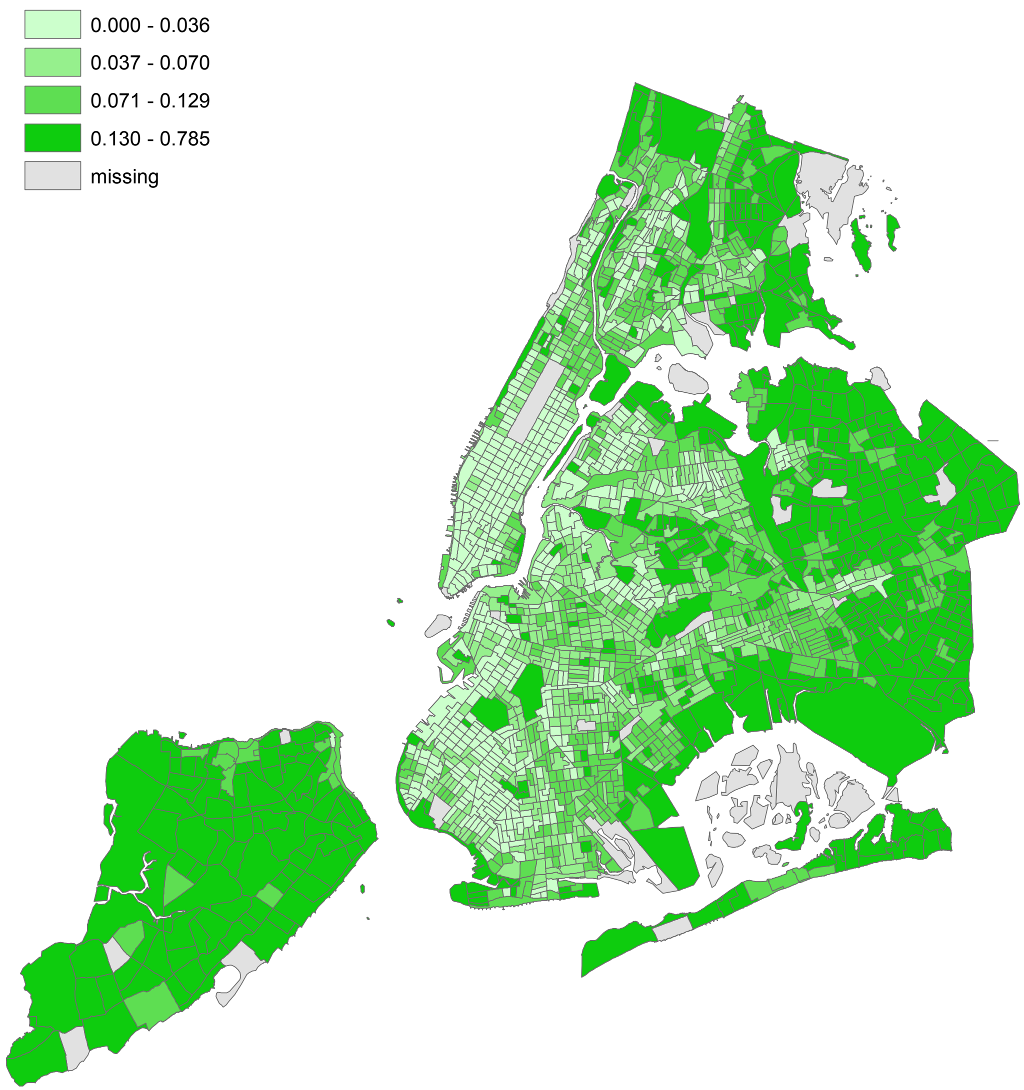

1.1
1.05
More Grass/Shrubs
1
OR = 0.96
0.95
0.9
Grass /
Shrubs


0.000 - 0.036
0.037 - 0.070
0.071 - 0.129
0.130 - 0.785
missing

Conclusions

- In the last decade in NYC, increased vulnerability to heat-related mortality in:
  - Black race
  - Persons dying at home
  - Individuals dying of cardiovascular disease and congestive heart failure
  - Persons living in areas receiving greater public assistance
- Spatial variability in surface temperature predicts heat-related mortality
- Urban 'greening' initiatives may offer protection against heat-related mortality

Acknowledgements

- New York City Department of Health and Mental Hygiene (NYC DOHMH), Bureau of Environmental Surveillance and Policy
  - Thomas Matte
  - Kazuhiko Ito
  - Grant Pezeshki
  - Sarah Johnson
- Columbia University
  - Patrick Kinney