

# Geocoding Pediatric Sepsis “Hot-Spots” Using Electronic Clinical Health Data

Anireddy Reddy, MD FAAP

Vicky Tam MA, Katie Hayes BS, Hongyan Liu, PhD, Heather M. Griffis, PhD  
Julie C. Fitzgerald, MD PhD MSCE, Scott Weiss MD, MSCE, Frances Balamuth MD, PhD

Pediatric Critical Care  
Children’s Hospital of Philadelphia

 @AniReddyMD

# Background

There are **racial<sup>1,2,3</sup> and socioeconomic<sup>3,4</sup> disparities** in pediatric sepsis recognition and outcomes

Causes of sepsis are **multifactorial** and can be exacerbated by **environmental factors**

## OBJECTIVE

To describe the spatial distribution of pediatric sepsis and identify "hot-spots" in our community

1. Raman J, Johnson TJ, Hayes K, Balamuth F. Racial differences in sepsis recognition in the emergency department. *Pediatrics* 2019; 144: e20190348.
2. Thavamani A, Umapathi KK, Dhanpalreddy H, et al. Epidemiology, clinical and microbiologic profile and risk factors for inpatient mortality in pediatric severe sepsis in the United States from 2003 to 2014: a large population analysis. *Pediatr Infect Dis J* 2020; 39: 781–88.
3. Mitchell HK, Reddy A, Montoya-Williams D, Harhay M, Fowler JC, Yehya N. Hospital outcomes for children with severe sepsis in the USA by race or ethnicity and insurance status: a population-based, retrospective cohort study. *The Lancet Child & Adolescent Health*. 2021;5(2):103-112.
4. Reddy AR, Badolato GM, Chamberlain JM, Goyal MK. Disparities Associated with Sepsis Mortality in Critically Ill Children. *Journal of Pediatric Intensive Care*. 2020.

# Methodology

Using Electronic Health Data to  
Identify Pediatric Sepsis Patients

# Redefining Pediatric Sepsis



Based on chart review



Based on billing codes

## New Algorithm Tracks Pediatric Sepsis Epidemiology Using Clinical Data

CHOP researchers developed computational tool aided by the CHOP Research Institute's Arcus Pediatric Knowledge Network

- Is independent of billing/coding practices
- Is based on objective clinical parameters
- Reflects infection AND organ dysfunction
- Uses a consistent algorithm (in place of variable physician review)

Sepsis Component	Surveillance Definition
Infection	Blood culture (ordered or collected) OR transfer from external healthcare facility, AND Antibiotics $\geq 4$ d within $\pm 2$ d of blood culture/transfer day OR death/hospice before day 4
Acute organ dysfunction (any one criteria present within $\pm 2$ calendar days of blood culture or transfer):	
Cardiovascular	$> 60$ mL/kg isotonic fluid boluses within 7 hr <sup>a</sup> , OR New, additional, or increased dose of vasoactive medication, OR Blood lactate $\geq 2.0$ mmol/L
Respiratory	New invasive/noninvasive mechanical ventilation <sup>b</sup> , OR Increase in noninvasive ventilation to $> 20$ hr/d <sup>b,c</sup>
Hematologic	Platelet $< 100,000$ cells/ $\mu$ L and $\geq 50\%$ decline from baseline (baseline required to be $\geq 100,000$ cells/ $\mu$ L) <sup>d,e</sup>
Kidney	Serum creatinine $\geq 2$ x baseline and exceeding threshold for age <sup>d,f</sup>

<sup>a</sup>Only 0.9% saline or lactated Ringer's fluid ordered as a bolus were included.

<sup>b</sup>Mechanical ventilation provided through an existing tracheostomy was excluded from this criteria.

<sup>c</sup>Noninvasive ventilation included continuous positive airway pressure (CPAP) or bilevel positive airway pressure (BiPAP). Patients using CPAP or BiPAP for  $\geq 20$  hr/d prior to blood culture or transfer were excluded from this criteria.

<sup>d</sup>Baseline was defined as the average of the three lowest values over the preceding 6 mo. If baseline was not available, then baseline was presumed "normal" and the requirement for " $\geq 50\%$  decline from baseline" was not required.

<sup>e</sup>Oncology patients, identified based at admission to the hospital's oncology service or *International Classification of Diseases, 9th Revision/International Classification of Diseases, 10th Revision* oncology codes within the preceding 1 yr, were excluded from the platelet criteria due to a high rate of false-positives outweighing the unlikely scenario of truly having sepsis based on thrombocytopenia alone.

<sup>f</sup>Serum creatinine thresholds for age were determined based on upper limit of normal values, renal pediatric Sequential Organ Failure Assessment score  $\geq 1$ , and renal Pediatric Logistic Organ Dysfunction-2 score  $\geq 2$  to yield thresholds for age of:  $< 1$  mo, 1.0 mg/dL; 1 to  $< 12$  mo, 0.5 mg/dL; 12 to  $< 24$  mo, 0.5 mg/dL; 2 to  $< 5$  yr, 0.6 mg/dL; 5 to  $< 12$  yr, 0.7 mg/dL; 12 to  $< 18$  yr, 1.0 mg/dL;  $\geq 18$  yr, 1.2 mg/dL.



# Methodology

**Design:** Retrospective single center study

**Data Source:** EPIC

**Inclusion Criteria:** Patients with sepsis as defined by algorithm (excluded cardiac and NICU patients) from Jan 20, 2011 – May 20, 2021

**Exposure:** Patient zip code

**Covariables:** Race/ethnicity, social disorganization index

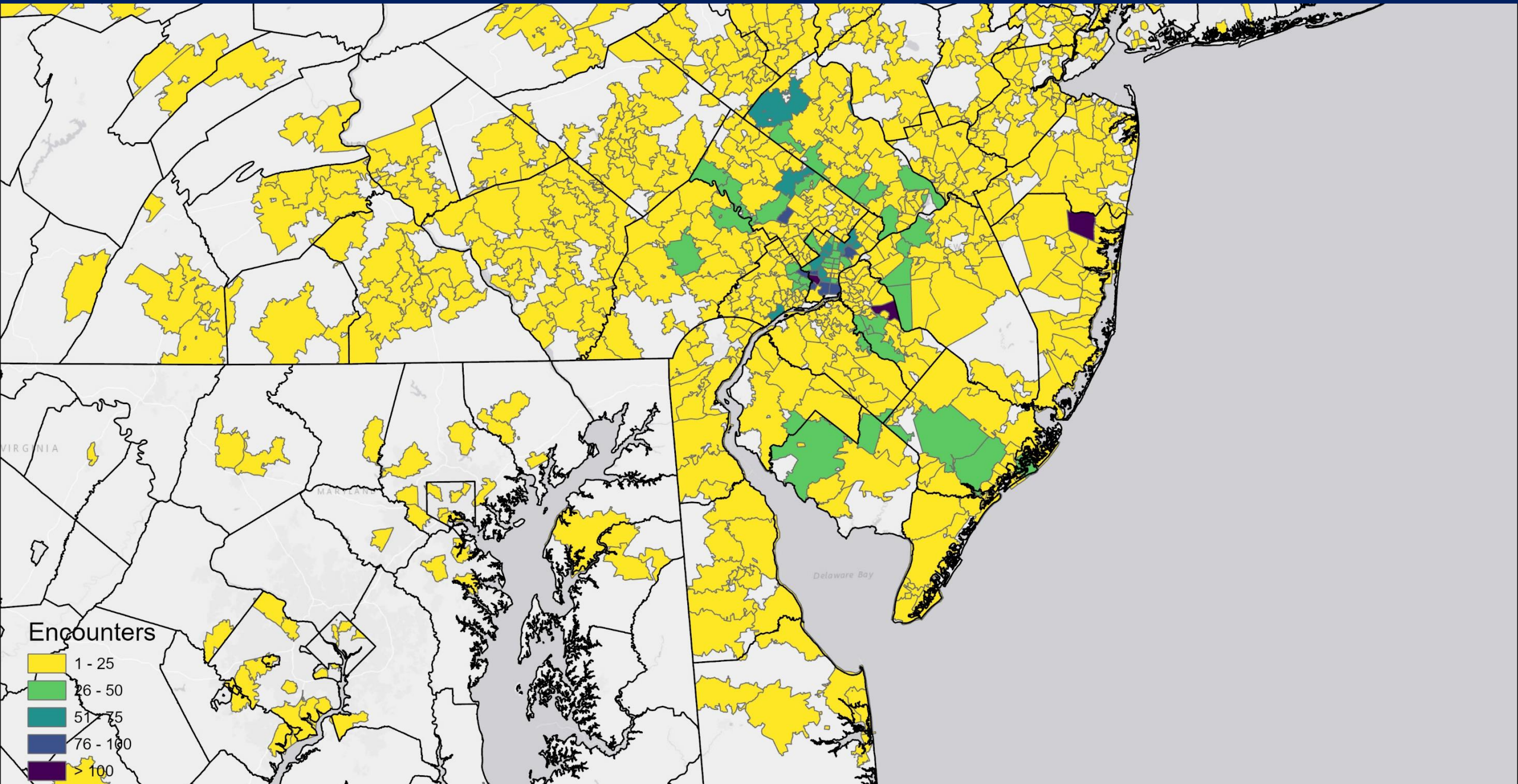
**Outcome:** Mapping the following using ArcGIS Pro

- All sepsis encounters per zip code
- All sepsis encounters per 10,000 children in zip code
- Encounter distribution by race and social disorganization index

**Table 1:**  
Demographic and  
Clinical Characteristics  
of Pediatric Sepsis  
Cohort Identified by  
Algorithm 2011-2021

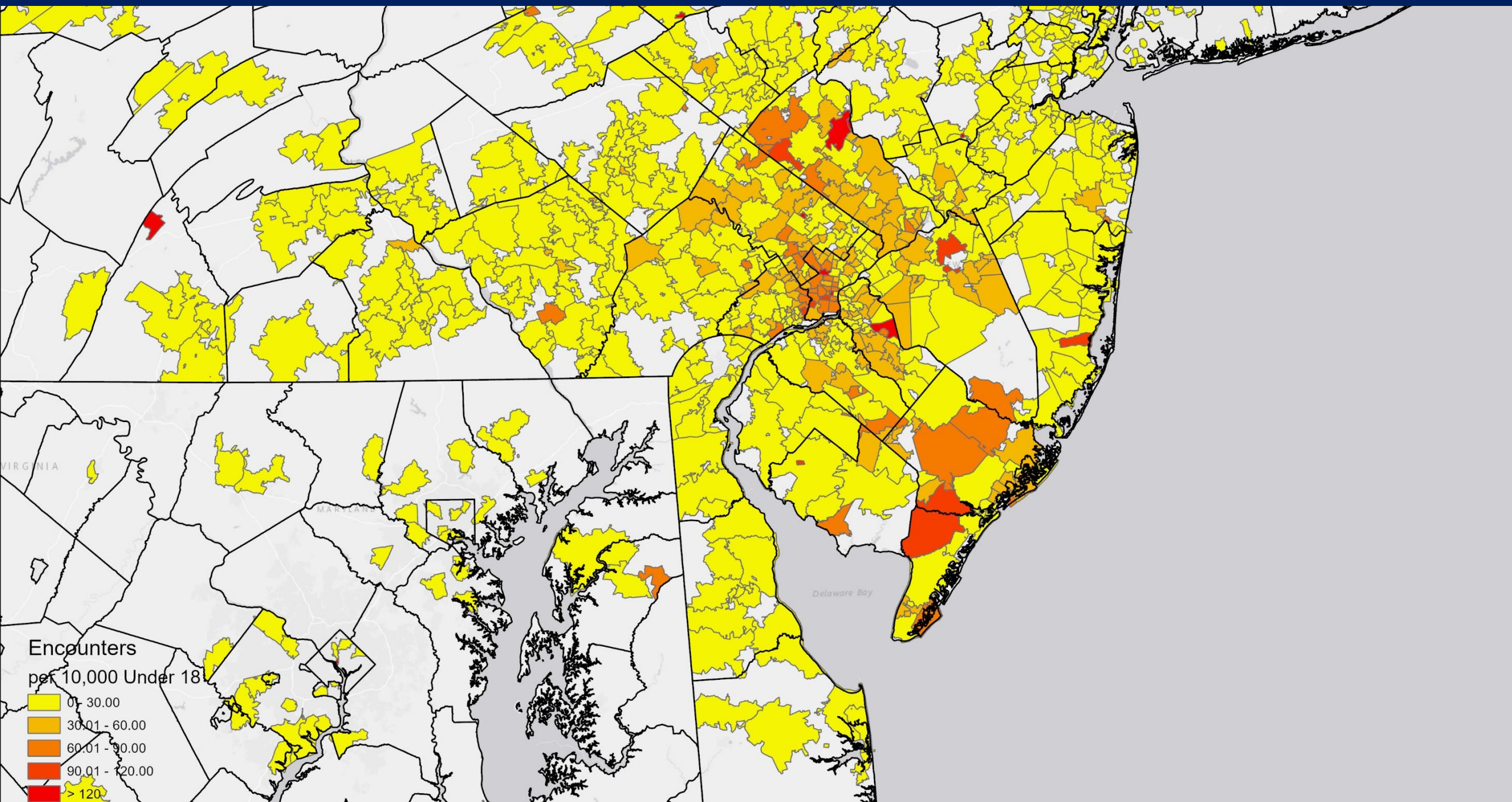
Characteristic	Overall, N = 4,532	Died, N = 441	Survived, N = 4,091	p-value
<b>Age</b>				0.007
<i>0-5 years</i>	2,201 (49%)	199 (45%)	2,002 (49%)	
<i>6-11 years</i>	911 (20%)	84 (19%)	827 (20%)	
<i>12-17 years</i>	1,030 (23%)	101 (23%)	929 (23%)	
<i>18 years and older</i>	390 (8.6%)	57 (13%)	333 (8.1%)	
<b>Sex</b>				0.507
<i>Female</i>	2,082 (46%)	196 (44%)	1,886 (46%)	
<i>Male</i>	2,450 (54%)	245 (56%)	2,205 (54%)	
<b>Race/Ethnicity</b>				<0.001
<i>Non-Hispanic White</i>	1,975 (44%)	212 (48%)	1,763 (43%)	
<i>Non-Hispanic Black</i>	1,269 (28%)	94 (21%)	1,175 (29%)	
<i>Hispanic or Latino</i>	629 (14%)	52 (12%)	577 (14%)	
<i>Other</i>	659 (15%)	83 (19%)	576 (14%)	
<b>Number of Complex Chronic Conditions</b>				<0.001
<i>None</i>	1,090 (24%)	7 (1.6%)	1,083 (26%)	
<i>One</i>	852 (19%)	52 (12%)	800 (20%)	
<i>Two or More</i>	2,586 (57%)	382 (87%)	2,204 (54%)	
<b>Insurance Status</b>				0.742
<i>Private</i>	2,153 (48%)	214 (49%)	1,939 (47%)	
<i>Public</i>	2,343 (52%)	225 (51%)	2,118 (52%)	
<i>Self-pay/Charity</i>	36 (0.8%)	2 (0.5%)	34 (0.8%)	
<b>Social Disorganization Index</b>				0.002
<i>Low</i>	1,816 (40%)	207 (47%)	1,609 (39%)	
<i>High</i>	2,716 (60%)	234 (53%)	2,482 (61%)	
<b>Source of Admission</b>				<0.001
<i>ED</i>	2,054 (45%)	74 (17%)	1,980 (48%)	
<i>ICU</i>	702 (16%)	141 (32%)	561 (14%)	
<i>Inpatient</i>	745 (16%)	67 (15%)	678 (17%)	
<i>OSH</i>	858 (19%)	157 (36%)	701 (17%)	
<i>Perioperative</i>	169 (3.7%)	2 (0.5%)	167 (4.1%)	

# Regional Sepsis Encounters (Count) by Zip Code, 2011-2021

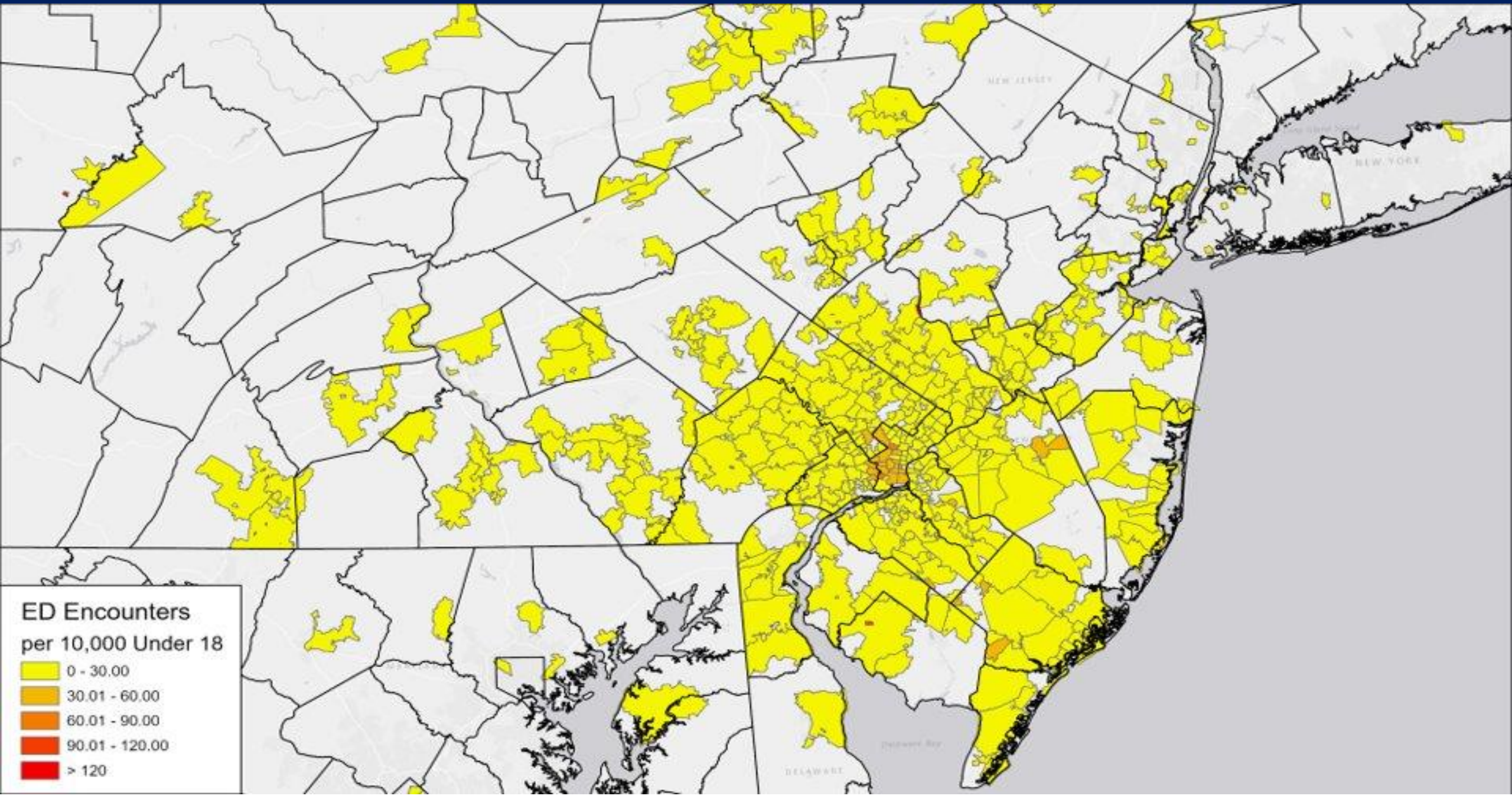




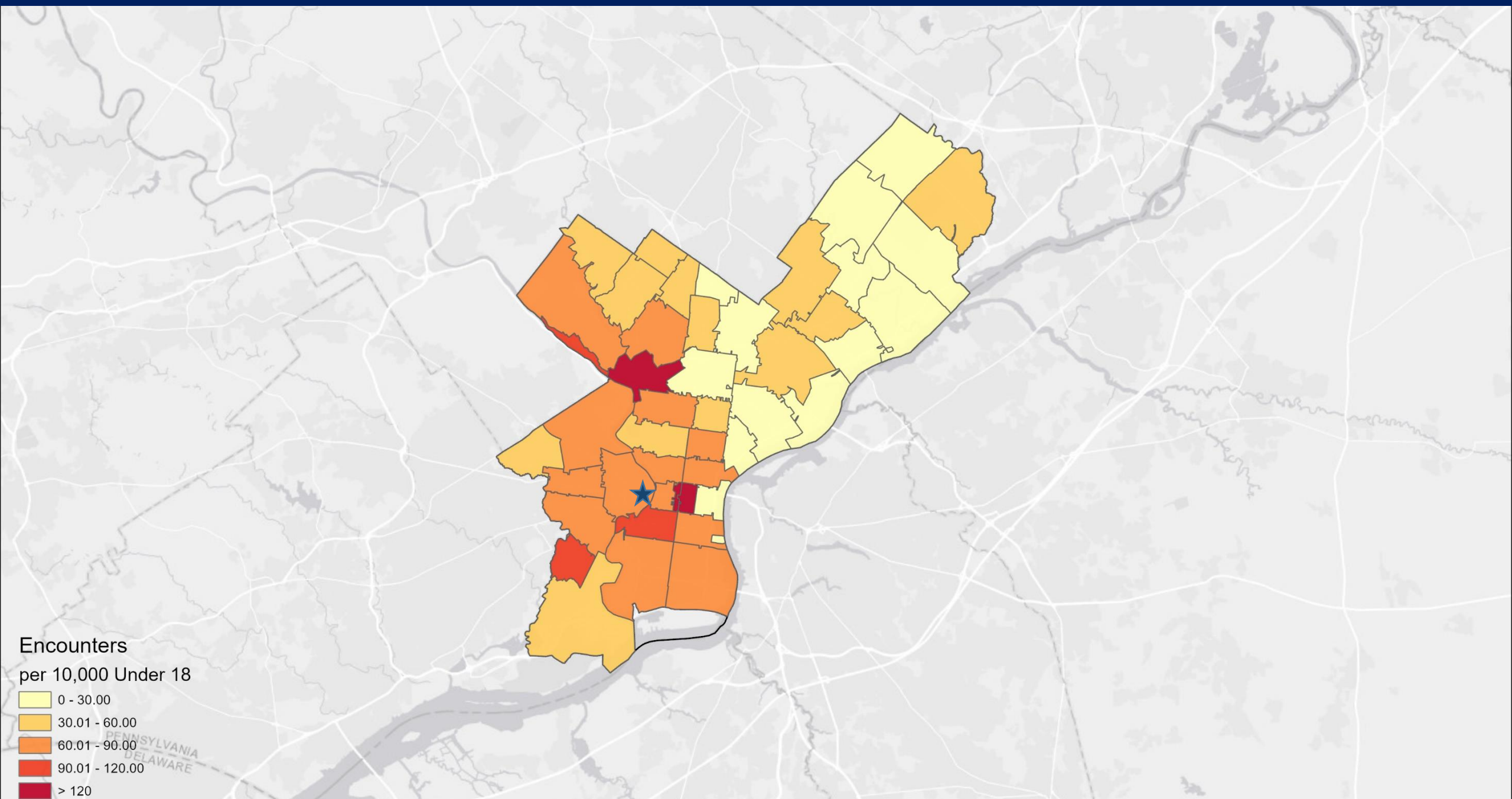
# Regional Sepsis Encounter Rate by Zip Code, 2011-2021



# Regional ED Sepsis Encounter Rate by Zip Code, 2011-2021



# Philadelphia Sepsis Encounter Rate by Zip Code, 2011-2021



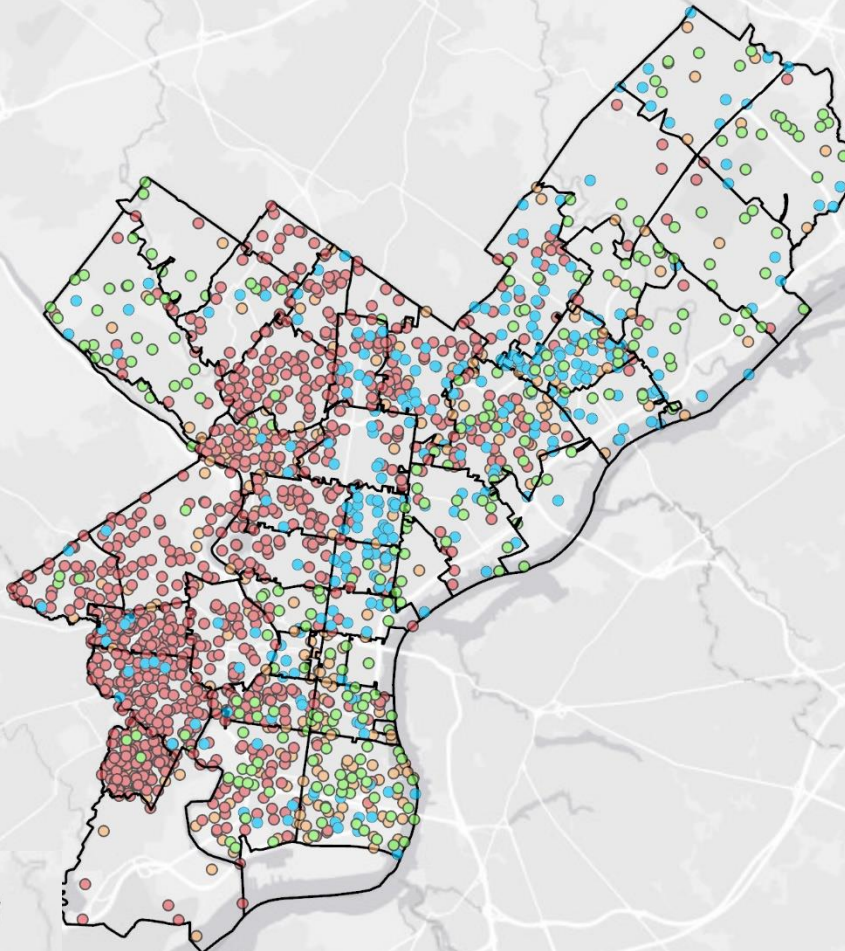
Encounters  
per 10,000 Under 18

- 0 - 30.00
- 30.01 - 60.00
- 60.01 - 90.00
- 90.01 - 120.00
- > 120

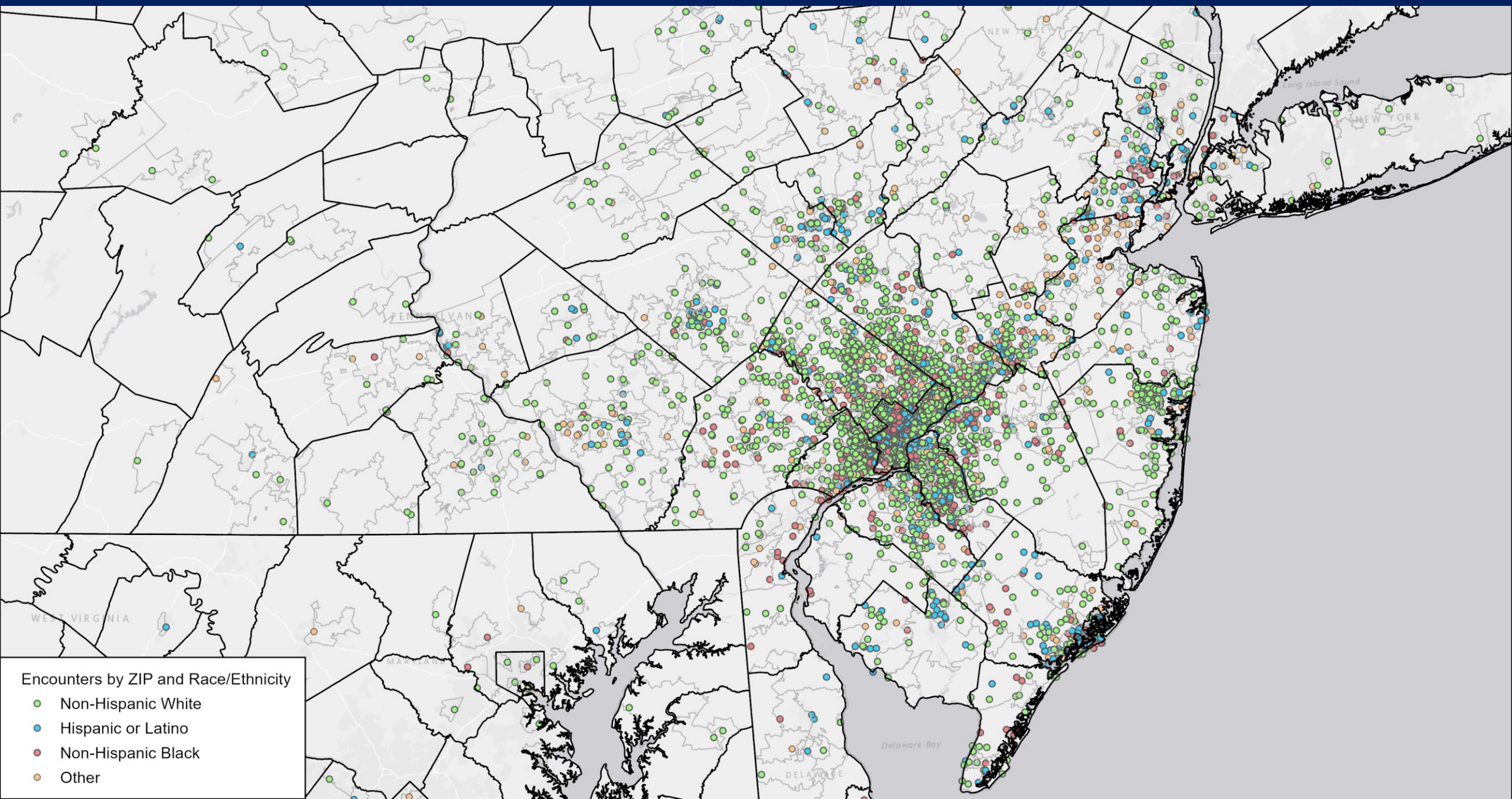
# Philadelphia Sepsis Encounters by Race, 2011-2021

## Encounters by ZIP and Race/Ethnicity

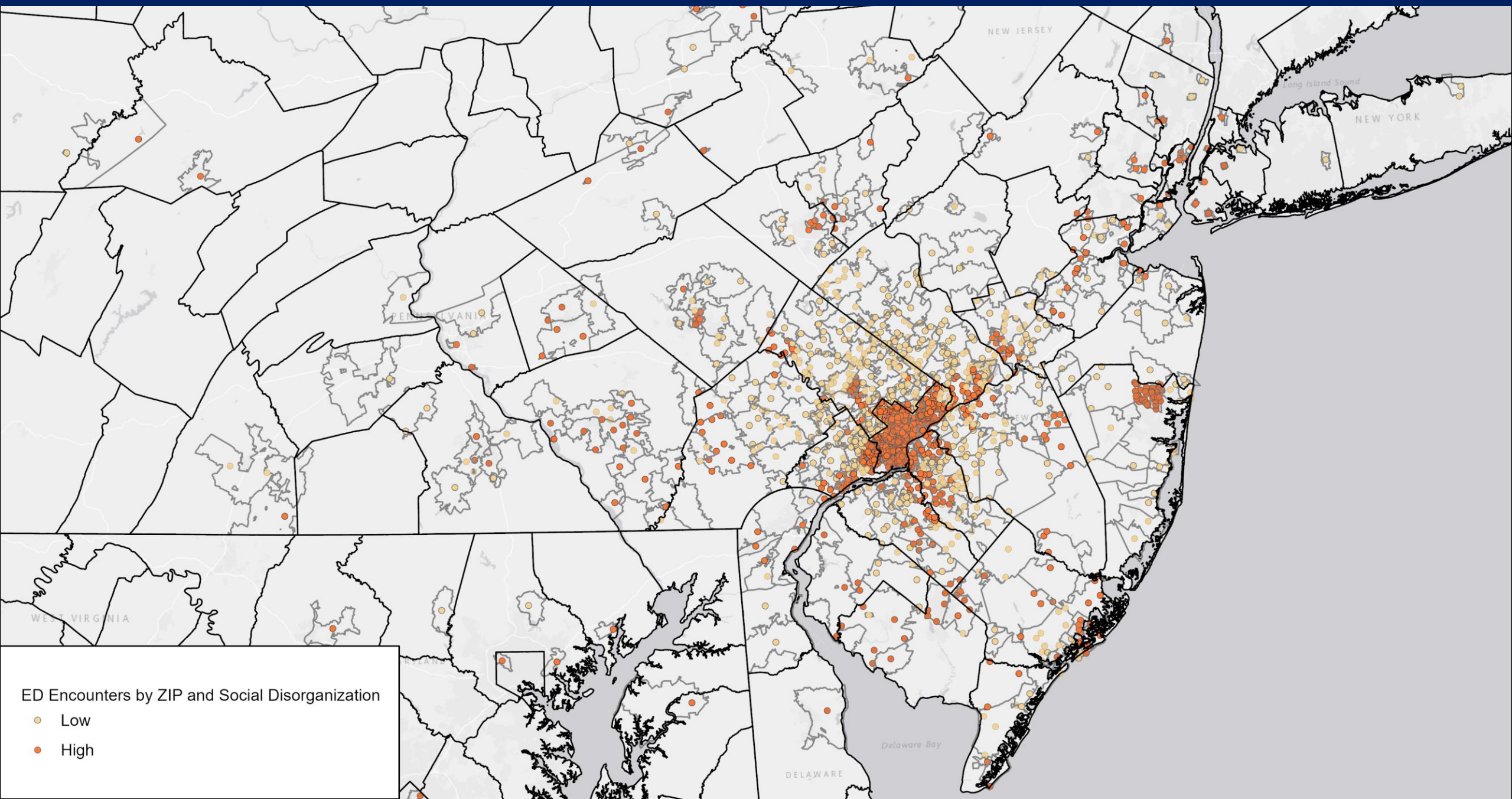
- Non-Hispanic White
- Hispanic or Latino
- Non-Hispanic Black
- Other



# Regional Sepsis Encounters by Race, 2011-2021



# Philadelphia ED Sepsis Encounters by Social Disorganization Index, 2011-2021



# Conclusions

## Conclusions

Identification of areas with high sepsis prevalence

Demonstration of large ED catchment area, with implications for longer distance/time

Visualized racial segregation of community and distance/time to CHOP

Greater distance and/or time has implications for potential delays in sepsis recognition or treatment

## Limitations

Single center cohort

Retrospective

Relies on zip code

## Strengths

Utilizes a novel (and efficient) way to identify sepsis

Provides important spatial data and context to sepsis equity and improvement efforts

## Future Directions

Closer look at environmental variables in hot-spot zip codes

Re-analyze differences in mortality

- Adjusting for distance to CHOP
- Examining bypass of hospitals

# Questions?

**Anireddy Reddy, MD**

Pediatric Critical Care

Children's Hospital of Philadelphia

 [@AniReddyMD](https://twitter.com/AniReddyMD)