Pennsylvania Census Tract-Level Vulnerability Assessment: Predicting Bloodborne Infection, Outbreak, and Overdose Death Risk Related to Injection Drug Use in Pennsylvania, Excluding Philadelphia, 2021

Bureau of Epidemiology

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Abbreviations

Term	Abbreviation
Centers for Disease Control and Prevention	CDC
Council of State and Territorial Epidemiologists	CSTE
Hepatitis C virus	HCV
Human immunodeficiency virus	HIV/AIDS
Morphine milligram equivalents	MME
Pennsylvania National Electronic Disease Surveillance System	PA-NEDSS
Prescription Drug Monitoring Program	PDMP
Sexually Transmitted Diseases	
State Unintentional Drug Overdose Reporting System	SUDORS
Years of potential life lost	YPLL

Executive Summary

Following a 2015 HIV and hepatitis C (HCV) outbreak in Scott County, Indiana, largely driven by injection drug use, a nationwide bloodborne infection vulnerability assessment was conducted by the Centers for Disease Control and Prevention (CDC) in 2016. A more detailed Pennsylvania vulnerability assessment was conducted by the Pennsylvania Department of Health (Department) in 2020, which identified several areas across the state vulnerable to both bloodborne infections related to injection drug use and overdose deaths. In 2024, the Department updated the statewide vulnerability assessment to determine communities vulnerable to these negative outcomes using more recent data and updated methods.

HCV case data were sourced from the Pennsylvania National Electronic Disease Surveillance System (PA-NEDSS) and overdose death data were sourced from the State Unintentional Drug Overdose Reporting System (SUDORS) database. Two generalized linear mixed models, one with HCV case counts among those under 40 years old as a proxy for bloodborne infection due to injection drug use as the outcome and another with overdose death counts as the outcome, were created with census tract-level data. Twelve indicator variables were selected after consultation with CDC and the Council of State and Territorial Epidemiologists (CSTE), and data were sourced from the Bureau of Labor Statistics, the Census Bureau, the American Community Survey, and the Department. The predicted rates of HCV cases and overdose deaths generated by these models for each census tract were used to assign vulnerability categories, which were then mapped. Philadelphia County (or City) data were not included in this assessment as the Philadelphia Department of Public Health has conducted their own analyses to inform prevention efforts for vulnerable communities in their census tracts.

Statistically significant indicators in the HCV outcome model were the percent vacant housing, years of potential life lost (YPLL), HIV incidence rate, opioid prescription rate, and the rate of average daily morphine milligram equivalents (MME) >90 mg. Statistically significant indicators in the overdose death outcome model were rurality, percent without a high school diploma, percent vacant housing, HIV incidence rate, early syphilis rate, Gini index score, YPLL, percent reporting poor/fair health, opioid prescription rate, and the rate of average daily MME >90. In both the HCV and overdose death outcome model maps, high vulnerability communities were found in the southwest, northwest, and northeast regions. Five of the top ten counties containing the high vulnerability census tracts in the HCV outcome model map and four of the top ten counties containing the high vulnerability census tracts in the overdose death outcome model map were in the southwest region, with Allegheny County containing approximately 20% of the high vulnerability census tracts in the HCV outcome model map, and almost one third of the high vulnerability census tracts in the overdose death outcome model map.

The communities identified to be high vulnerability in this assessment differed from the previous state assessment. The previous assessment found that areas vulnerable to bloodborne infection were distributed throughout the state while areas vulnerable to overdose death were near Pennsylvania's urban centers. This updated vulnerability assessment found that the same areas of Pennsylvania were highly vulnerable to both outcomes. The results of

this updated vulnerability assessment will allow the Department, other local and state agencies, and community organizations to allocate more resources and interventions to communities in need.

Background

In 2015, an outbreak of HIV was identified in the rural area of Scott County, Indiana.[1] The outbreak occurred from November 2014 to October 2015, in which 235 incidence cases of HIV were identified[1] with 92% of those cases also being coinfected with hepatitis C virus.[2] Transmission was primarily fueled by needle sharing among people who inject drugs in the town of Austin, which had a population of about 3,000. To underscore the massive scale of the outbreak, Scott County had reported less than five new HIV infections in the ten years prior to the outbreak.[3] Following the outbreak, concerns grew regarding the risks of additional outbreaks. In 2016, the CDC conducted a nationwide vulnerability assessment to identify communities that were vulnerable to an outbreak of HIV or HCV among people who inject drugs. In this 2016 report, three Pennsylvania counties, Crawford, Luzerne, and Cambria, were identified to be within the top 5% of most vulnerable counties in the country.[4]

In 2019, the Department conducted a more detailed vulnerability assessment to identify census tracts vulnerable to both bloodborne infections related to injection drug use and overdose deaths. The statewide vulnerability assessment found that areas at risk of bloodborne infections were different than those at risk of overdose death. Census tracts at higher risk of bloodborne infection were more scattered throughout the state and tended to be more rural, while census tracts in and around Pennsylvania's urban centers like Pittsburgh and Philadelphia were found to be at higher risk of overdose deaths.[5] In 2024, we updated this census tract-level vulnerability assessment, and the updated methods and results are presented in this report.

Objectives

1. Estimate counties and census tracts in Pennsylvania at increased risk of bloodborne infection related to injection drug use and overdose death.

2. Compare the results of this analysis to the results of the previous statewide census tract-level vulnerability assessment.

Methods

Outcome Data

This vulnerability assessment includes two statistical models, one with HCV case rates and the other with overdose death rates. HCV cases were used as a proxy for bloodborne infections associated with injection drug use. Separate models were developed since the previous vulnerability assessment suggested that geographic areas at risk of bloodborne infections were different than those at risk of overdose deaths.[5]

HCV Outcome Data

Confirmed acute and chronic HCV cases reported in 2021 were selected from Pennsylvania's electronic reportable disease surveillance system, PA-NEDSS. HCV is often asymptomatic and undiagnosed for many years, making the time of first report an unreliable proxy for the time of infection. Therefore, cases were further reduced to those under 40 years old to include only those who were more likely to be infected recently. Philadelphia Department of Public Health has conducted its own analyses to inform prevention efforts for vulnerable communities in their census tracts, so Philadelphia cases were excluded from this analysis to identify other areas in the state at increased vulnerability. Lastly, cases associated with correctional institutions and drug and alcohol facilities (institution's address listed as patient's address in PA-NEDSS) were excluded because the prevalence of screening for HCV is much higher among those populations, so including them would have skewed the geographic results toward communities that contained those facilities. A total of 2,476 (96.6%) cases of HCV met these criteria and had an available census tract. Address data were geocoded using SAS® 9.4 to produce geographic XY coordinates. Inexact address matches were assigned the geographic coordinates of their zip code centroid. The assigned geographic coordinates were displayed in ArcGIS Pro® 3.1.0, and a spatial join was performed to obtain the number of cases falling within each census tract.

Overdose Death Outcome Data

All unintentional and undetermined overdose deaths reported in 2021 were selected from the SUDORS database. Alcohol-only overdoses and overdoses where the manner of death was suicide or homicide when someone intended to harm another person by poisoning are excluded from SUDORS case definitions. Deaths where Philadelphia was listed as the county of residence were excluded since they were also excluded from the HCV outcome variable model. Address data were geocoded using SAS® 9.4 to produce geographic XY coordinates. A total of 3,895 (97.3%) overdose deaths met these criteria, had a usable census tract, and were included in the analysis. Address data were geocoded using SAS® 9.4 to produce geographic XY coordinates. Inexact address matches were assigned the geographic coordinates of their zip code centroid. The assigned geographic coordinates were displayed in ArcGIS Pro® 3.1.0, and a spatial join was performed to obtain the number of deaths falling within each census tract.

Indicator Data

Through consultation with CDC and CSTE, we selected the following 12 indicators to be included in both models: percent unemployed, percent without a high school diploma, percent vacant housing, teen birth rate, Gini index (measure of statistical dispersion intended to represent the income inequality within a group), a rural/urban categorical variable, percent

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reporting poor/fair health, premature death rate measured by YPLL, rate of average prescribed daily MME > 90 mg, opioid prescription rate, early syphilis rate (reported primary and secondary case rate), and HIV incidence rate.[6] Appendix B Table SI presents collinearity diagnostic results to highlight correlation between variables and aid in variable selection. These variables were selected due to their hypothesized impact on the outcome variables, being selected for inclusion in the previous vulnerability assessment, and relatively minimal collinearity amongst them (Appendix B **Table S1**). The rural/urban variable was created at the census tract level by calculating the population density of each census tract. If the census tract population density was greater than the statewide population density of 291 people per square mile, the census tract was considered urban. Otherwise, the census tract was considered rural. These data were sourced from publicly available sources like the Bureau of Labor Statistics, the Census Bureau (the American Community Survey), and the Pennsylvania Department of Health. Census tract level data were available for some indicators, while others were only reported on at the county level. For those that were available only at the county level, those county values were applied to all census tracts within that county (Appendix 1 **Table 1**).

Census Tracts
Census tracts were excluded in the HCV model if residents under 40 years old were not represented in the census tract in 2020. Census tracts were excluded in the overdose death model if residents (any age) were not represented in the census tract in 2020.

Statistical Analyses
Using SAS® 9.4, we created two generalized linear mixed models with HCV rate per 100,000 and overdose death rate per 100,000 as the outcome variables, the 12 variables discussed above as fixed effects, and county of residence as a random effect. These models were used to generate predicted rates at the census tract level. Predicted rates were categorized into quantiles, i.e., vulnerability categories one through five. Vulnerability category five denotes highest vulnerability.

Mapping
Maps were created using ArcGIS Pro® 3.1.0 to visualize the predicted HCV case rate and overdose death rate for each census tract. Those predicted rates were grouped into five vulnerability categories using the Jenks natural breaks method. Jenks Natural Breaks Classification or Optimization method organizes data so values within a class have a minimum deviation from the class mean and so the deviation between class means is maximized.[7]

Results

In the HCV outcome model, the following indicators were found to be statistically significant (p<0.05): percent vacant housing, HIV incidence rate, YPLL, opioid prescription rate, and the rate of average prescribed daily MME >90 (**Appendix A Table 2**). In the overdose death outcome model, the following indicators were found to be statistically significant (p<0.05): rurality, Gini Index, percent without a high school diploma, percent vacant housing, HIV incidence rate, early syphilis rate, YPLL, percent reporting poor/fair health, opioid prescription rate, and the rate of average daily MME >90 (**Appendix A Table 2**).

The distribution of the vulnerability levels created from the predicted rates generated by the regression models is presented in **Appendix A Table 3**. More vulnerability level 5 census tracts were found in the overdose death model compared to the HCV model. Tables displaying the top counties with the greatest proportions of high vulnerability census tracts for each model are displayed in **Appendix A Tables 4 and 5**. Allegheny County had the highest number of vulnerability level 4 and 5 census tracts in both models. Statewide census tract-level maps of vulnerability categories are presented in **Appendix A Figures 1 and 2**. County-level maps are presented in **Appendix B** (**Figures S1 – S2**) to allow for easier viewing of small census tracts.

Discussion

Although the statistically significant indicators differed between the HCV model and the overdose model, all significant indicators were related to poverty, other bloodborne infections, and opioid use in both models.

In the HCV outcome model, the southwest, northwest, and northeast regions of the state contained more high vulnerability census tracts while the southeast region, excluding Philadelphia, contains fewer high vulnerability census tracts. Nevertheless, Chester County contained one vulnerability level 5 census tract. Allegheny County contained almost 20% of the state's vulnerability level 4 census tracts, and one of two vulnerability level 5 census tracts.

In the overdose death outcome model, similar counties were affected by high vulnerability in the southwest, northwest, and northeast regions of the state compared to the HCV model. Allegheny County contained almost one third of the state's vulnerability level 4 and 5 census tracts. Luzerne County contained 8% of the state's vulnerability level 4 and 5 census tracts.

High vulnerability areas identified in the HCV and overdose death models were found in the same areas, which contrasts with the findings of the previous vulnerability assessment which found that areas vulnerable to HCV infection were more evenly distributed throughout the state while areas highly vulnerable to overdose death were concentrated in and around urban centers.

Strengths and Limitations

Conducting this analysis at the census tract level, rather than at the county or ZIP code level, highlights smaller geographic areas in need of interventions, which is especially important for a larger state like Pennsylvania. Targeting smaller geographic areas also allows for more efficient and appropriate allocation of limited resources. Additionally, excluding cases geographically associated with correctional institutions and drug and alcohol facilities helped to ensure we would not be inappropriately assigning a "high vulnerability" designation to a census tract solely because it contained one of these facilities, rather those designations were being assigned based on community transmission of HCV. We also excluded census tracts without population to further refine the results and ensure identification of areas in need. Some indicator data were unfortunately only available at the county level; however, we included county of residence as a random effect in the models to mitigate this challenge. Also, 2021 outcome variable data were used in this analysis, rather than two years of data as had been utilized in the previous census tract-level vulnerability assessment. We chose to include only 2021 data due in part to the COVID-19 pandemic's impact on disease patterns in 2020. This led to a smaller number of cases and deaths meeting the inclusion criteria compared to the previous assessment. A smaller sample size may have increased sampling errors and provided a less accurate representation of the population.

Next Steps

The overdose epidemic is not over in Pennsylvania, and we are continuing to see its negative effects across the Commonwealth. This vulnerability assessment provides guidance to more efficiently and effectively allocate resources and interventions to prevent the spread of bloodborne infections and overdose deaths related to injection drug use. Specifically, for communities where local syringes service programs and other community organizations are operating, these results can help them to focus their efforts on the most vulnerable communities in their areas to increase access to substance use disorder treatment as well as HIV and viral hepatitis prevention and care services. And conversely, for areas without local syringe service organizations, the Pennsylvania Department of Health will work to increase services like HCV and HIV testing; safe injection education; hepatitis A and B vaccination; distribution of naloxone; fentanyl test strips and xylazine test strips. The most efficient and effective interventions are localized. The Department is working to share the results of this assessment with partners across the Commonwealth so these findings may inform local interventions and resource allocation.

Appendix A: Figures and Tables

Table 1: List of Indicator Variables

Variable	Source	Year
Percent unemployed*	Bureau of Labor Statistics	2021
Percent without a high school diploma	American Community Survey	2021
Percent vacant housing	American Community Survey	2021
Percent reporting poor / fair health*	County Health Rankings Report	2021
Teen birth rate (per 1,000 live births)*	American Community Survey	2021
Gini index	Census Bureau	2021
Rural / urban categorical variable	County Health Rankings Report	2021
Premature death rate (YPLL)*	County Health Rankings Report	2021
Rate of average daily morphine milligram equivalent (MME) > 90mg (per 10,000)*	PDMP Information Data Report	2021
Opioid prescription rate (per 100,000)*	PDMP Information Data Report	2021
Early syphilis rate (per 100,000)	Pennsylvania STD Program	2021
HIV incidence rate (per 100,000)	Pennsylvania HIV/AIDS Surveillance and Epidemiology	2021

*Available only at the county level

Table 2: Regression Model Results

Indicator	HCV Model Estimate*	HCV Model P-value	OD Death Estimate*	OD Death P-value
Rural/Urban Category	0.98	0.53	**0.77**	**<0.0001**
Gini Index	1.34	0.30	**1.63**	**0.040**
Percent without a HS Diploma	1.00	0.14	**1.02**	**<0.0001**
Percent Vacant Housing	**1.01**	**<0.0001**	**1.02**	**<0.0001**
HIV Incidence Rate	**1.01**	**<0.0001**	**1.00**	**0.0002**
Early Syphilis Rate	1.00	0.90	**1.00**	**<0.0001**
Teen Birth Rate	0.99	0.50	0.99	0.083
Percent Unemployment	0.98	0.59	1.05	0.13
YPLL	**1.00**	**<0.0001**	**1.00**	**<0.0001**
Percent Reporting Poor/Fair Health	0.98	0.43	**0.95**	**0.013**
Opioid Prescription Rate	**1.00**	**<0.0001**	**1.00**	**<0.0001**
MME > 90 Rate	**0.99**	**0.0001**	**0.99**	**<0.0001**

*log transformed

Table 3: Breakdown of Vulnerability Levels

Vulnerability Level	HCV Model – Percent of Census Tracts (n)	OD Model – Percent of Census Tracts (n)
Level 1	35.2% (1063)	48.8% (404)
Level 2	31.5% (950)	32.1% (971)
Level 3	26.5% (799)	28.8% (871)
Level 4	6.8% (205)	20.0% (604)
Level 5	0.07% (2)	5.7% (172)
Total	N=3019	N=3022

Table 4: HCV Model – Top 10 High Vulnerability Census Tracts

County	Vulnerability Level 4	Vulnerability Level 5
Allegheny	40 (19.5%)	1 (50.0%)
Chester	0	1 (50.0%)
Westmoreland	25 (12.2%)	0
Washington	12 (5.8%)	0
Fayette	11 (5.4%)	0
Pike	11 (5.4%)	0
Cambria	9 (4.4%)	0
Erie	8 (3.9%)	0
Luzerne	7 (3.4%)	0
Lackawanna	6 (2.9%)	0
Lawrence	6 (2.9%)	0

* Excludes Philadelphia

Table 5: OD Model – Top 10 High Vulnerability Census Tracts

County	Vulnerability Level 4	Vulnerability Level 5
Allegheny	162 (26.8%)	56 (32.6%)
Luzerne	48 1(8.0%)	14 (8.1%)
Erie	11 (1.8%)	10 (5.8%)
Cambria	12 (2.0%)	9 (5.2%)
Delaware	26 (4.3%)	9 (5.2%)
Washington	24 (4.0%)	9 (5.2%)
Westmoreland	44 (7.3%)	9 (5.2%)
Pike	10 (1.7%)	8 (4.7%)
Schuylkill	12 (2.0%)	6 (3.5%)
Lawrence	5 (1.5%)	9 (2.9%)

* Excludes Philadelphia

Figure 1: Predicted HCV Rates and Vulnerability Levels by Census Tracts, Pennsylvania, 2021, Excluding Philadelphia
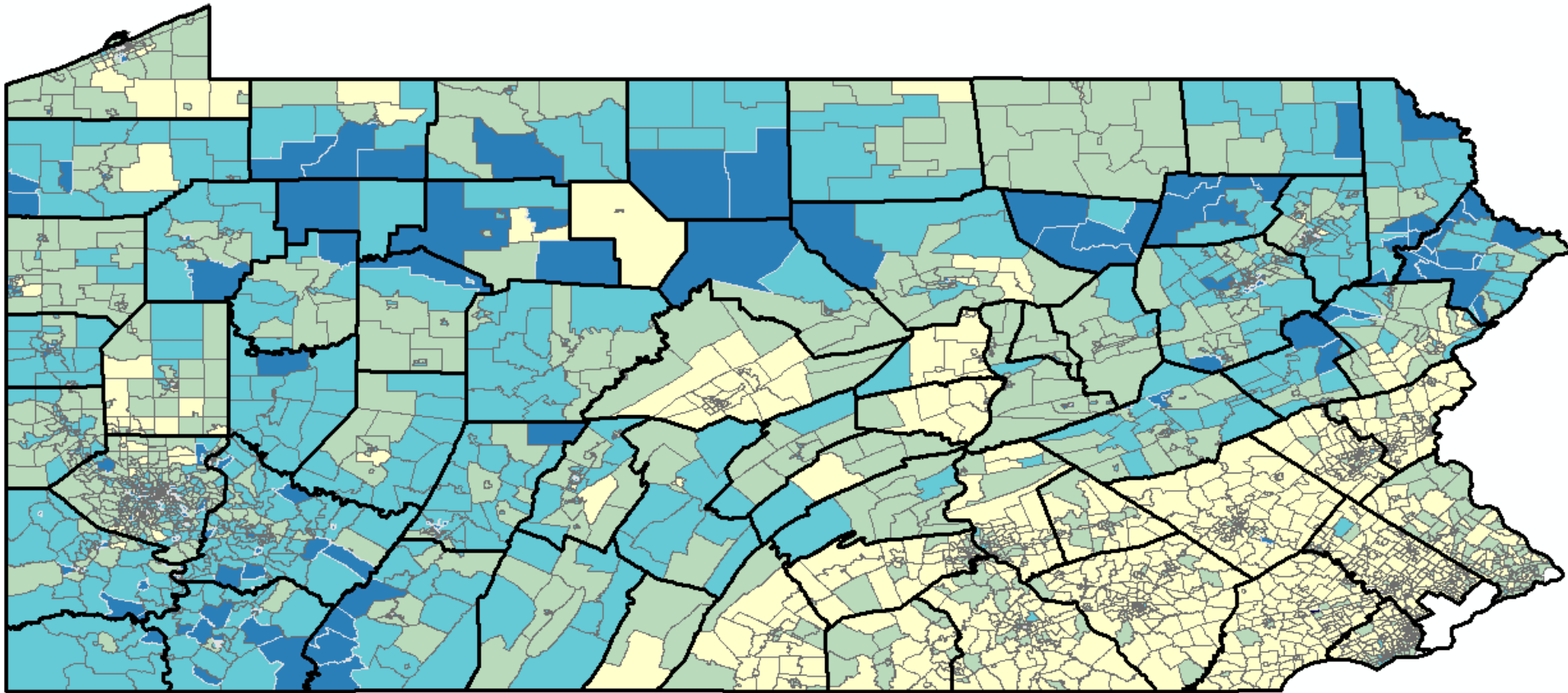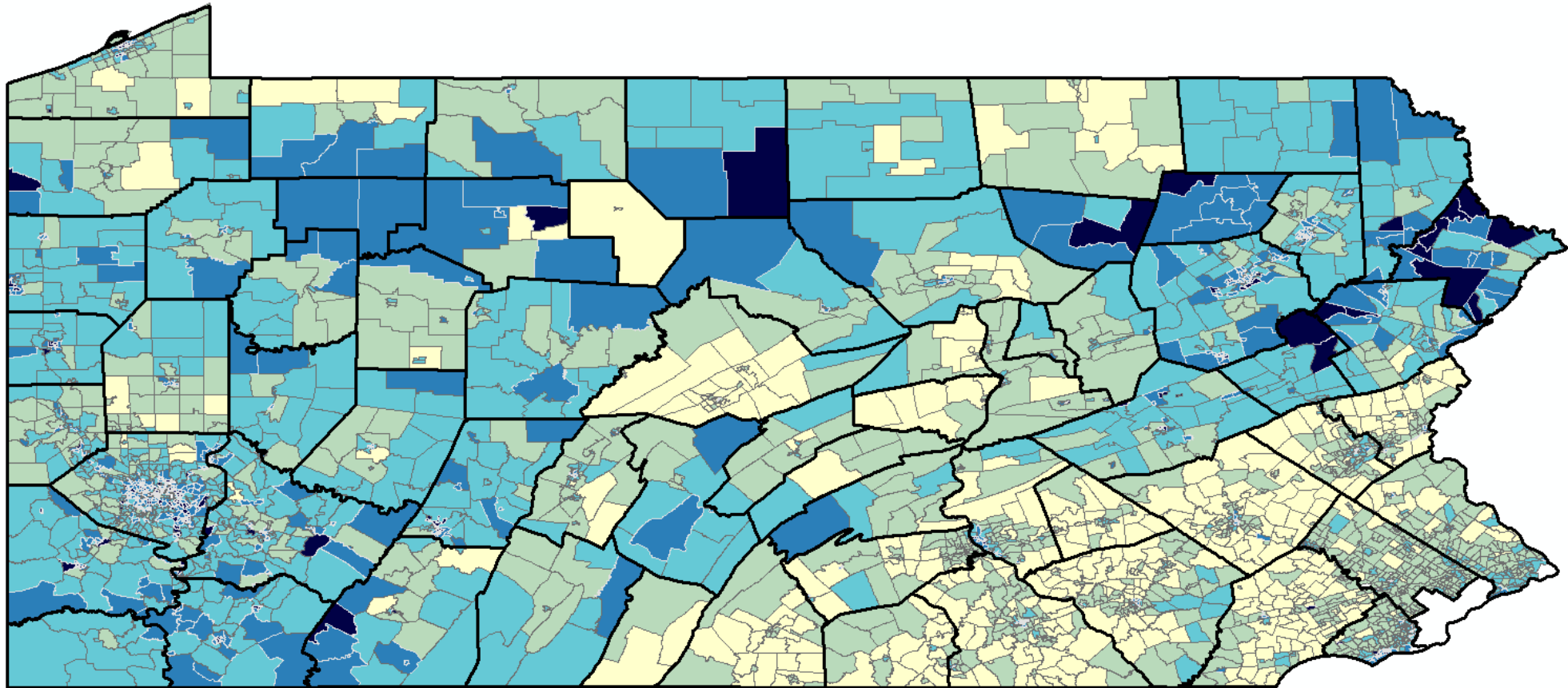

HCV Predicted Rate (per 100,000 population)

- Vulnerability Level 1 (1.72 - 4.22)
- Vulnerability Level 2 (4.22 - 4.54)
- Vulnerability Level 3 (4.54 - 4.94)
- Vulnerability Level 4 (4.94 - 7.20)
- Vulnerability Level 5 (7.20 - 13.17)*
- Missing data

*Two vulnerability level 5 census tracts were identified. One is located in Allegheny County and the other is located in Chester County. Due to the size of the census tracts, they are not visible on the state map, but are visible in supplemental figures in Appendix B.

Figure 2: Predicted Overdose Death Rates and Vulnerability Levels by Census Tracts, Pennsylvania, 2021, Excluding Philadelphia

Overdose Death Predicted Rate (per 100,000 population)

- Vulnerability Level 1 (1.40 - 3.41)
- Vulnerability Level 2 (3.41 - 3.73)
- Vulnerability Level 3 (3.73 - 4.06)
- Vulnerability Level 4 (4.06 - 4.48)
- Vulnerability Level 5 (4.48 - 8.82)
- Missing data

Appendix B: Supplementary Tables and Figures

Table S1: Indicator Variable Collinearity Diagnostics

Eigenvalue	Condition Index	Proportion of Variation												
		Intercept	Teen Birth Rate	Rural/Urban Category	% Unemployed	Gini Index	% Without a HS Diploma	% Vacant Housing	YPLL	HIV Incidence Rate	Early Syphilis Rate	MME > 90	Opioid Prescription Rate	% Reporting Poor or Fair Health
8.46302	1	6.5E-05	0.00039	0.0027	9.8E-05	0.00038	0.00302	0.00307	0.00013	0.00095	0.00201	0.00214	7.1E-05	4.4E-05
1.02335	2.87574	8E-06	0.00037	0.00217	2.4E-05	9.1E-05	0.00272	0.00456	2.7E-05	0.19484	0.07188	0.01056	0.56585	1.4E-05
0.97551	2.94542	1.6E-05	0.00024	0.00312	3.2E-05	4.9E-05	5.7E-05	0.00231	4.4E-05	0.35623	0.16542	0.00108	0.37644	1.6E-05
0.85707	3.14236	4.33E-08	0.00048	0.01363	1.2E-05	1.8E-06	0.00256	0.02826	1.1E-05	0.41903	0.38896	0.02298	0.00151	7.5E-06
0.68802	3.50721	4.1E-05	0.00073	0.0599	8.64E-07	0.00019	0.02822	0.12362	5.1E-06	0.00632	0.3103	0.10553	0.02069	1.32E-08
0.37474	4.75224	8.55E-07	0.00284	0.01032	1.31E-07	1.4E-05	0.28914	0.49251	5.2E-06	0.00316	2.4E-06	0.09668	0.00984	2.1E-05
0.2742	5.55562	0.00033	0.01308	0.0709	0.00108	0.0017	0.50433	0.17808	0.00174	0.01052	0.04939	0.08183	1.6E-06	0.00039
0.23639	5.98336	6.2E-05	4.85E-07	0.75629	1.2E-05	5.8E-05	0.08464	0.06334	0.00015	0.00205	0.00098	0.29825	0.00879	2.4E-05
0.06394	11.5047	0.00881	0.26607	0.04205	0.00046	0.11695	0.00193	0.01924	0.00013	0.00649	0.00263	0.26218	0.00429	0.00039
0.02356	18.9545	0.00367	0.18842	0.00337	0.05535	0.57446	0.01453	0.01139	0.07269	0.00025	0.00079	0.0403	0.00893	0.00106
0.0128	25.7163	0.10256	0.01248	0.00014	0.01866	0.24642	0.05586	0.02385	0.25435	0.00012	0.00702	0.00748	0.00313	0.06133
0.00544	39.4419	0.10149	0.00148	0.00852	0.75487	0.03565	0.0001	0.02099	0.55034	2.3E-05	0.00044	0.06261	0.00026	0.00229
0.00197	65.5531	0.78294	0.51342	0.02689	0.16941	0.02404	0.01288	0.02878	0.12038	2.3E-05	0.00019	0.00836	0.0002	0.93442

Predicted HCV Vulnerability – Allegheny County

For the HCV model, **vulnerability levels 4 and 5** are considered to be highly vulnerable to HCV related to injection drug use.
- **20%** (41/207) of high-vulnerability census tracts **across the state** are found in Allegheny County.
- **11%** (41/383) of census tracts **within Allegheny County** are high vulnerability.
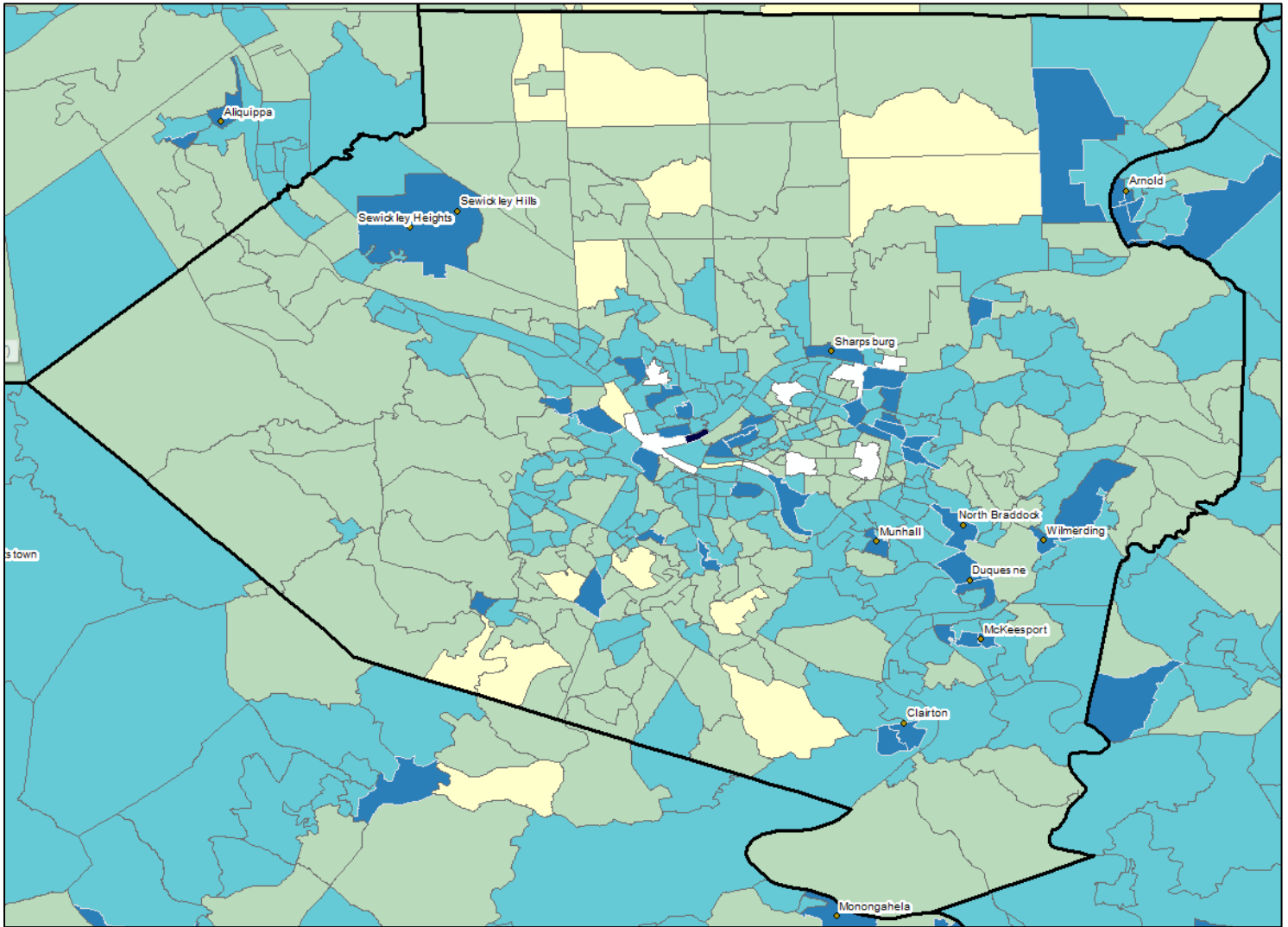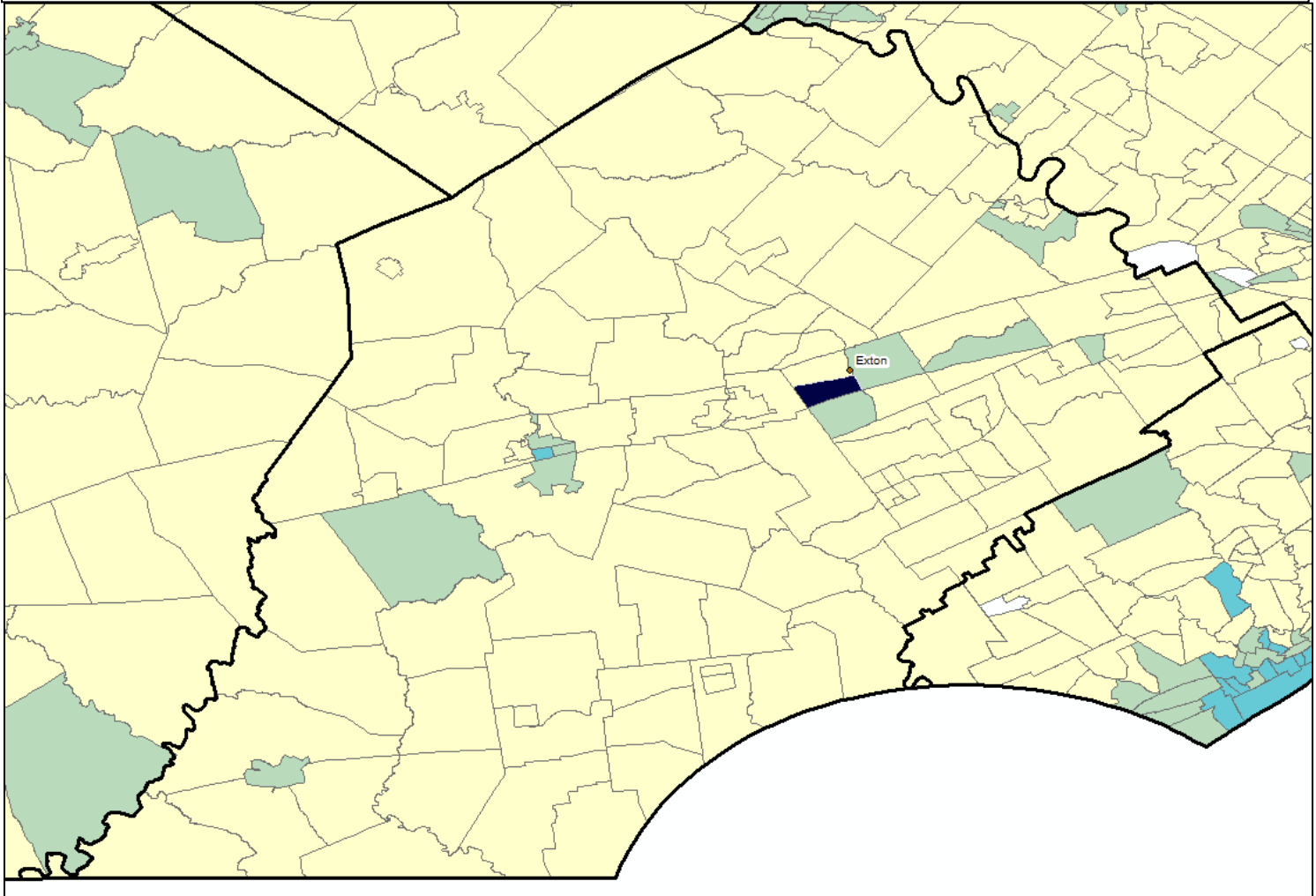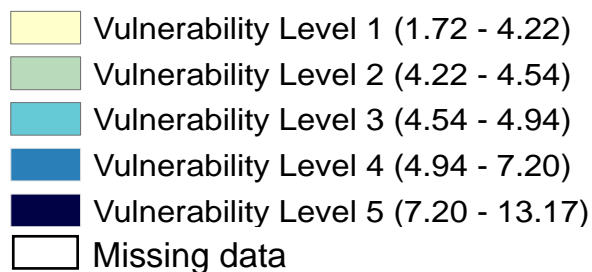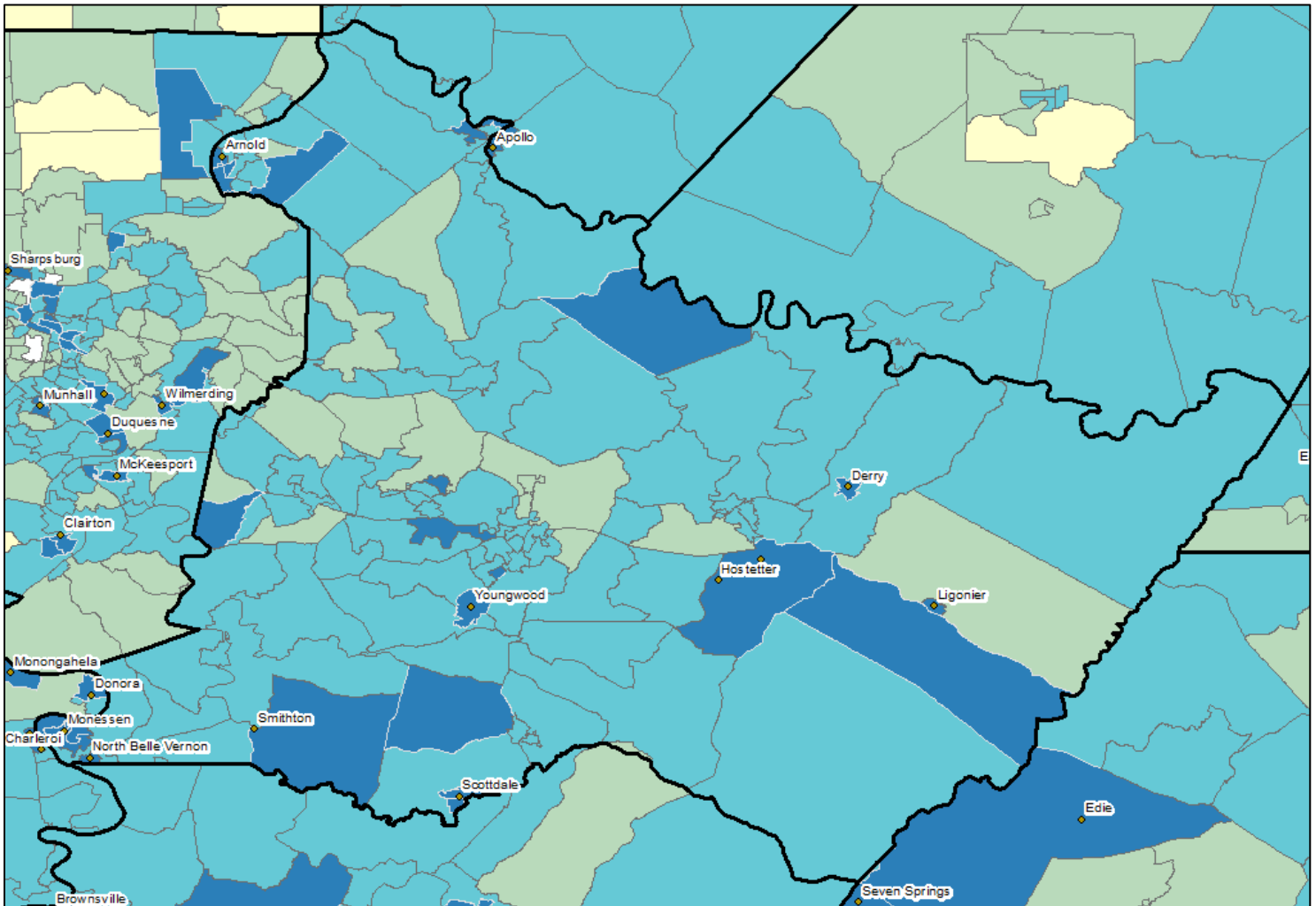

HCV Predicted Rate (per 100,000 population)

- Vulnerability Level 1 (1.72 - 4.22)
- Vulnerability Level 2 (4.22 - 4.54)
- Vulnerability Level 3 (4.54 - 4.94)
- Vulnerability Level 4 (4.94 - 7.20)
- Vulnerability Level 5 (7.20 - 13.17)
- Missing data

Census tracts labeled in white are not included in the HCV model given a population under 40 years old was not represented in the census tract in 2020.

Predicted HCV Vulnerability – Chester County

For the HCV model, **vulnerability levels 4 and 5** are considered to be highly vulnerable to HCV related to injection drug use.
- **<u><1%</u>** (1/207) of high-vulnerability census tracts **<u>across the state</u>** are found in Chester County.
- **<u>1%</u>** (1/124) of census tracts **<u>within Chester County</u>** are high vulnerability.
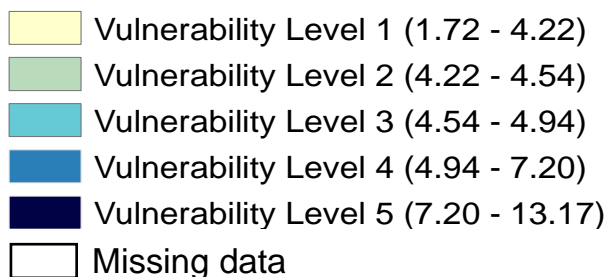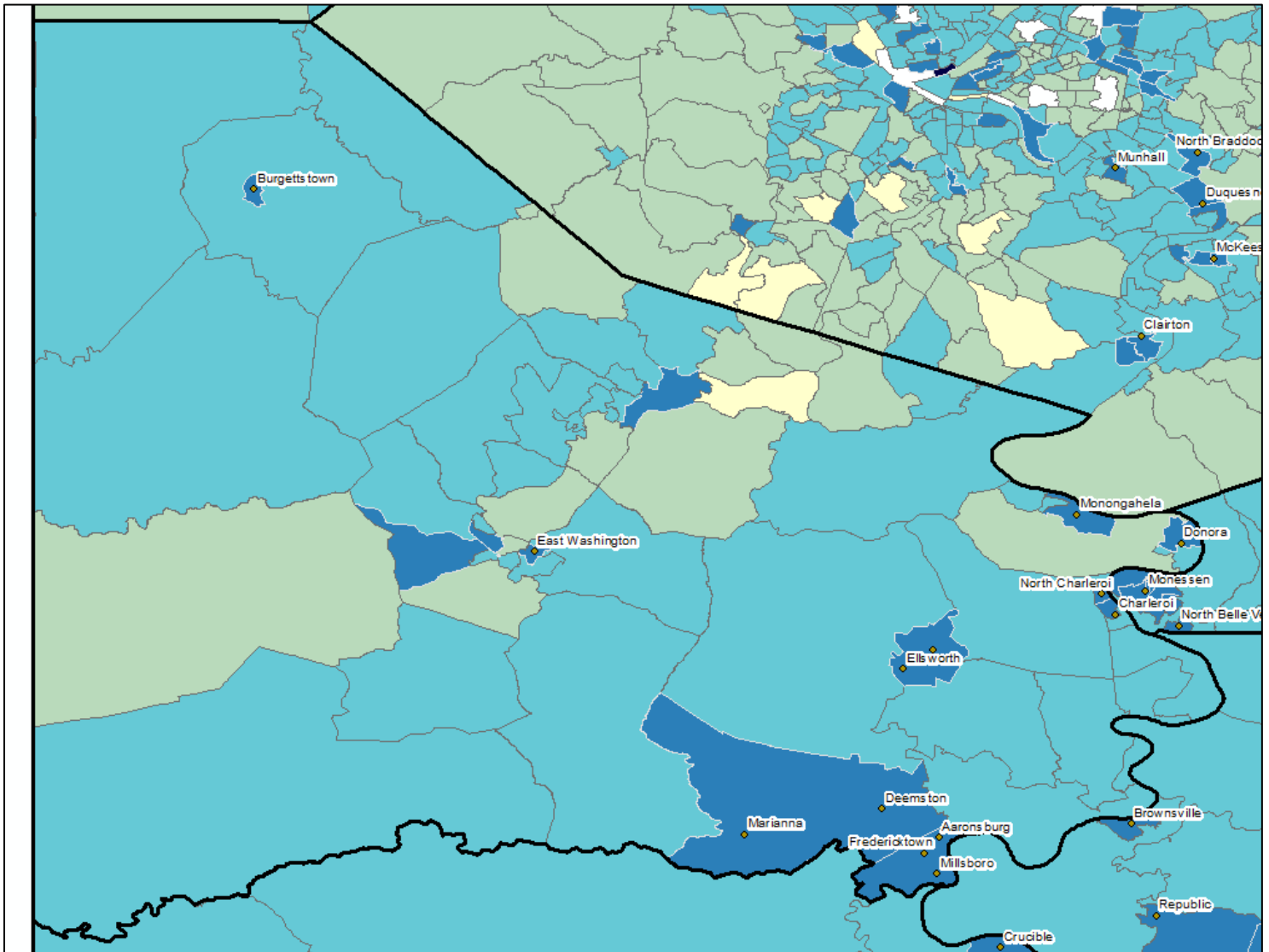

HCV Predicted Rate (per 100,000 population)

- Vulnerability Level 1 (1.72 - 4.22)
- Vulnerability Level 2 (4.22 - 4.54)
- Vulnerability Level 3 (4.54 - 4.94)
- Vulnerability Level 4 (4.94 - 7.20)
- Vulnerability Level 5 (7.20 - 13.17)
- Missing data

Predicted HCV Vulnerability – Westmoreland County

For the HCV model, **vulnerability levels 4 and 5** are considered to be highly vulnerable to HCV infections related to injection drug use.

- **12%** (25/207) of high-vulnerability census tracts **across the state** are found in Westmoreland County.
- **22%** (25/113) of census tracts **within Westmoreland County** are high vulnerability.
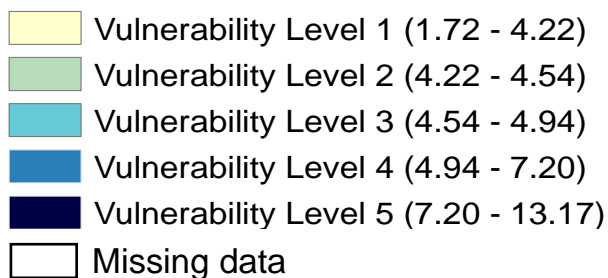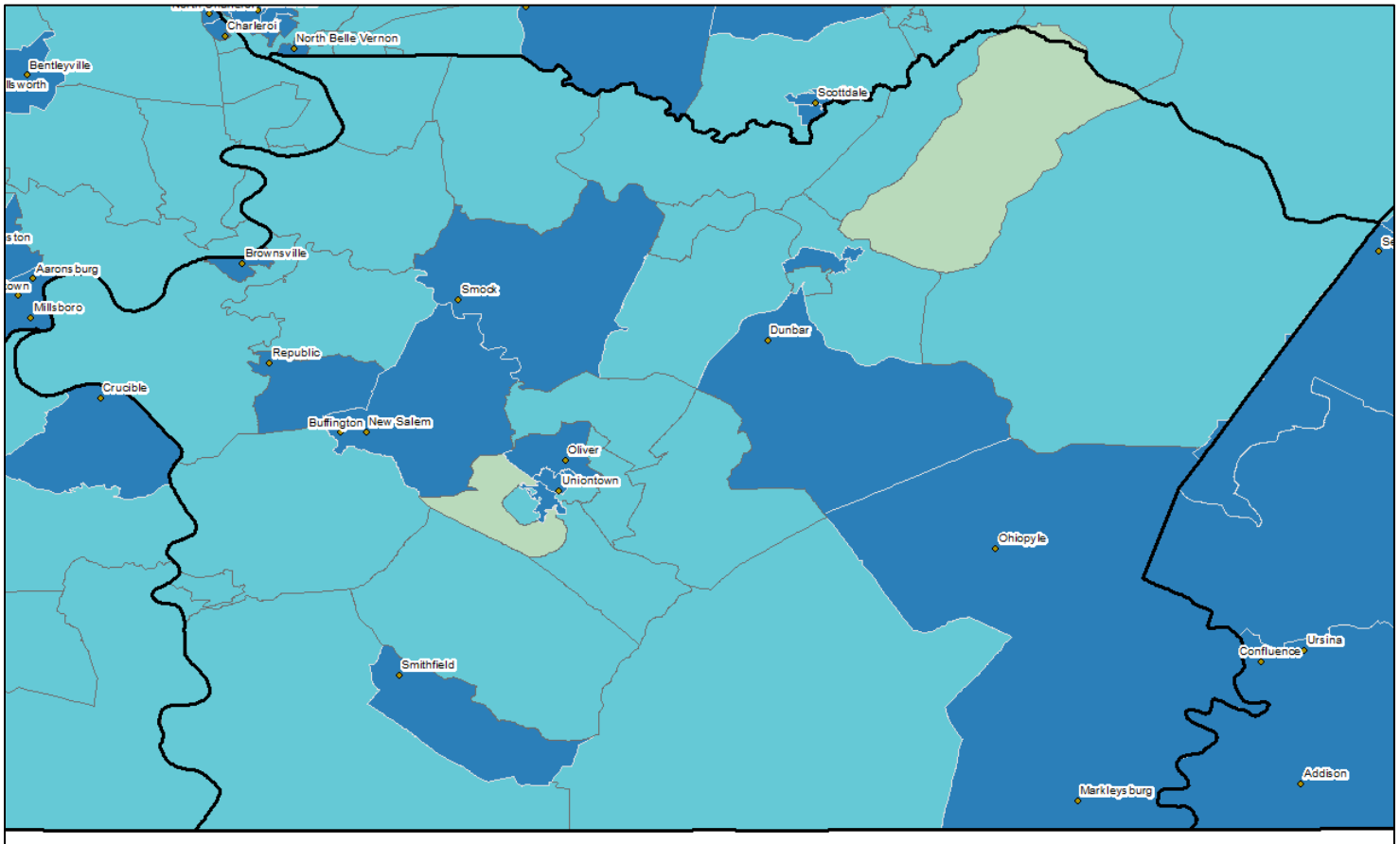

HCV Predicted Rate (per 100,000 population)

- Vulnerability Level 1 (1.72 - 4.22)
- Vulnerability Level 2 (4.22 - 4.54)
- Vulnerability Level 3 (4.54 - 4.94)
- Vulnerability Level 4 (4.94 - 7.20)
- Vulnerability Level 5 (7.20 - 13.17)
- Missing data

Predicted HCV Vulnerability – Washington County

For the HCV model, **vulnerability levels 4 and 5** are considered to be highly vulnerable to HCV infections related to injection drug use.

- **6%** (12/207) of high-vulnerability census tracts **across the state** are found in Washington County.
- **19%** (12/62) of census tracts **within Washington County** are high vulnerability.
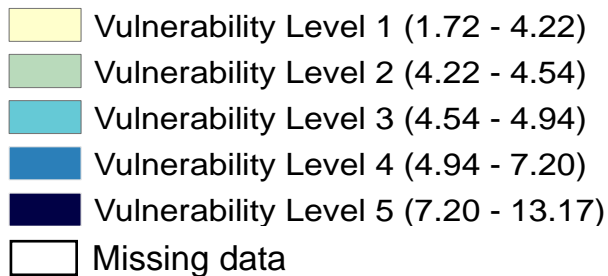

HCV Predicted Rate (per 100,000 population)

- Vulnerability Level 1 (1.72 - 4.22)
- Vulnerability Level 2 (4.22 - 4.54)
- Vulnerability Level 3 (4.54 - 4.94)
- Vulnerability Level 4 (4.94 - 7.20)
- Vulnerability Level 5 (7.20 - 13.17)
- Missing data

Predicted HCV Vulnerability – Fayette County

For the HCV model, **vulnerability levels 4 and 5** are considered to be highly vulnerable to HCV infections related to injection drug use.

- **5%** (11/207) of high-vulnerability census tracts **across the state** are found in Fayette County.
- **30%** (11/36) of census tracts **within Fayette County** are high vulnerability.
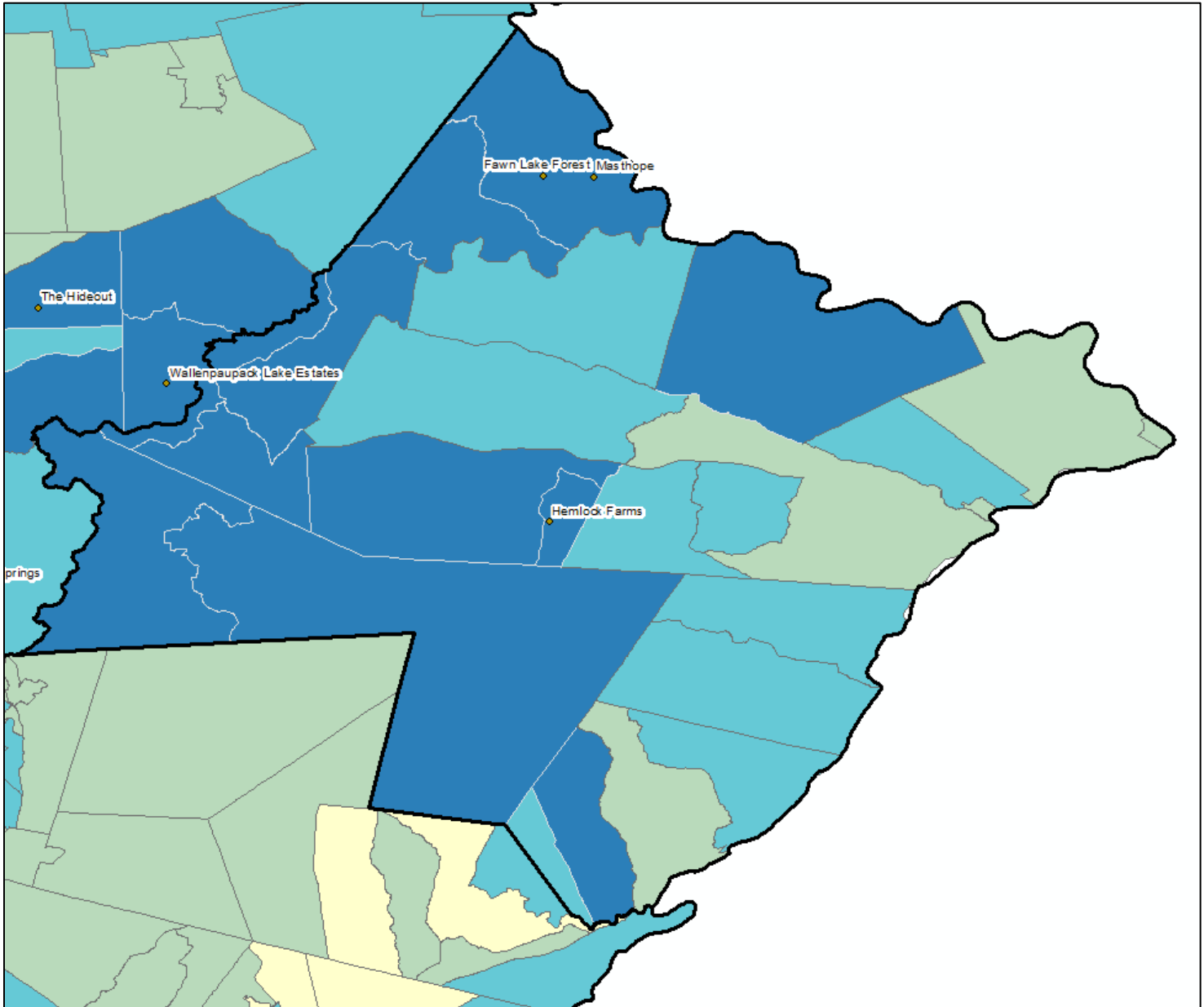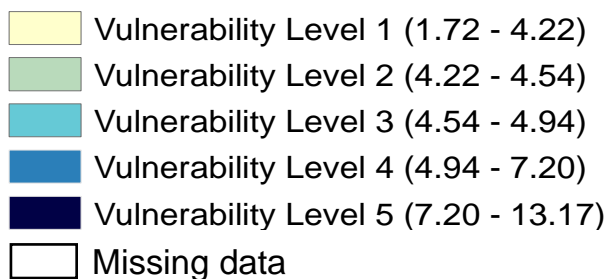

HCV Predicted Rate (per 100,000 population)

- Vulnerability Level 1 (1.72 - 4.22)
- Vulnerability Level 2 (4.22 - 4.54)
- Vulnerability Level 3 (4.54 - 4.94)
- Vulnerability Level 4 (4.94 - 7.20)
- Vulnerability Level 5 (7.20 - 13.17)
- Missing data

Predicted HCV Vulnerability – Pike County

For the HCV model, **vulnerability levels 4 and 5** are considered to be highly vulnerable to HCV infections related to injection drug use.

- **5%** (11/207) of high-vulnerability census tracts **across the state** are found in Pike County.
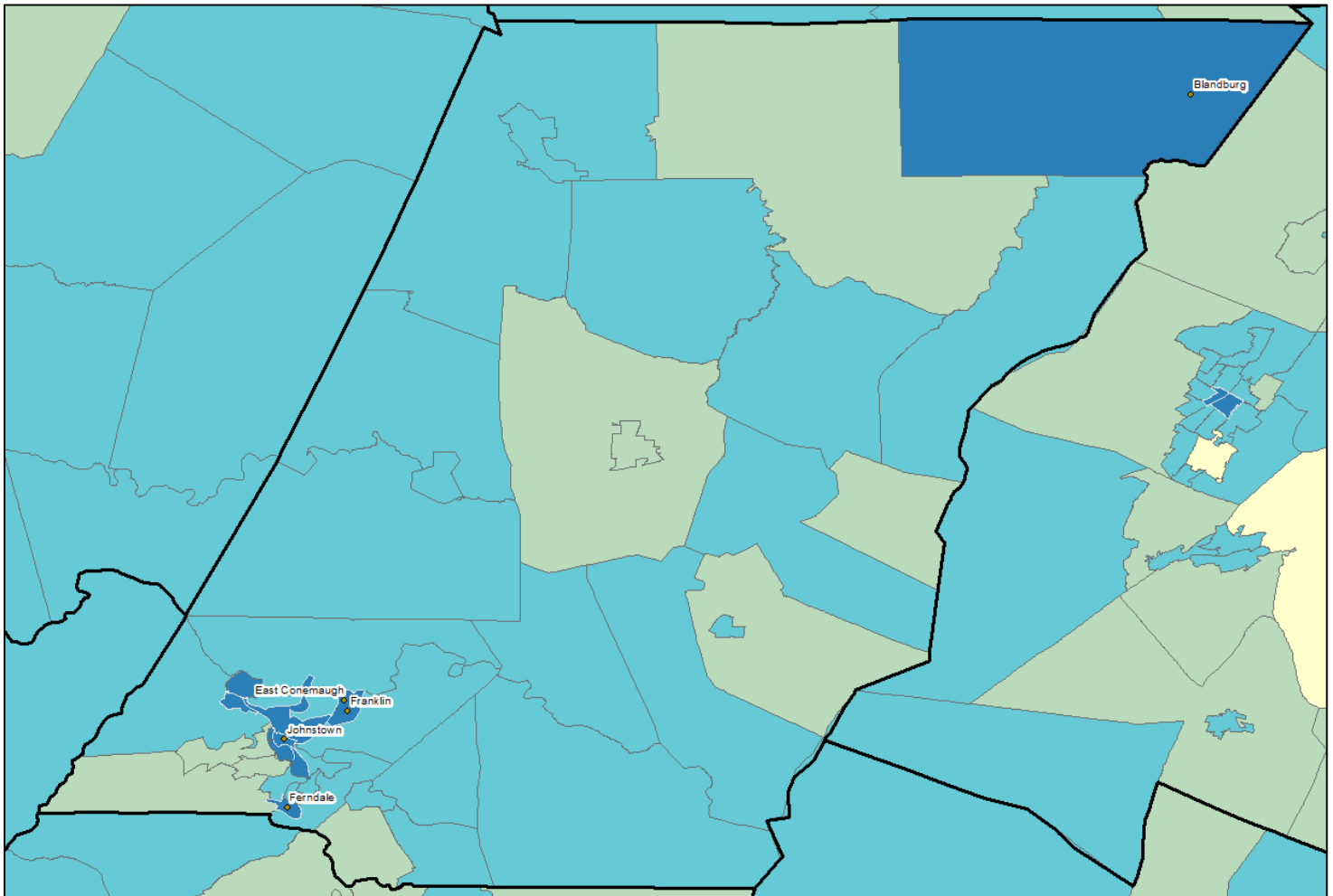- **44%** (11/25) of census tracts **within Pike County** are high vulnerability.

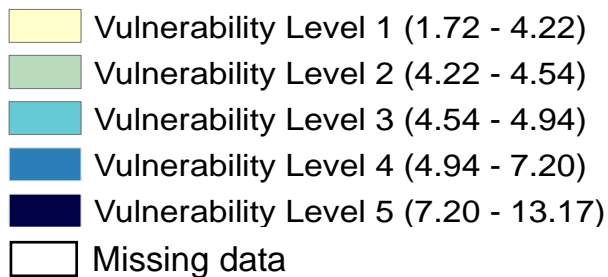## HCV Predicted Rate (per 100,000 population)

- Vulnerability Level 1 (1.72 - 4.22)
- Vulnerability Level 2 (4.22 - 4.54)
- Vulnerability Level 3 (4.54 - 4.94)
- Vulnerability Level 4 (4.94 - 7.20)
- Vulnerability Level 5 (7.20 - 13.17)
- Missing data

Predicted HCV Vulnerability – Cambria County

For the HCV model, **vulnerability levels 4 and 5** are considered to be highly vulnerable to HCV infections related to injection drug use.

- **4%** (9/207) of high-vulnerability census tracts **across the state** are found in Cambria County.
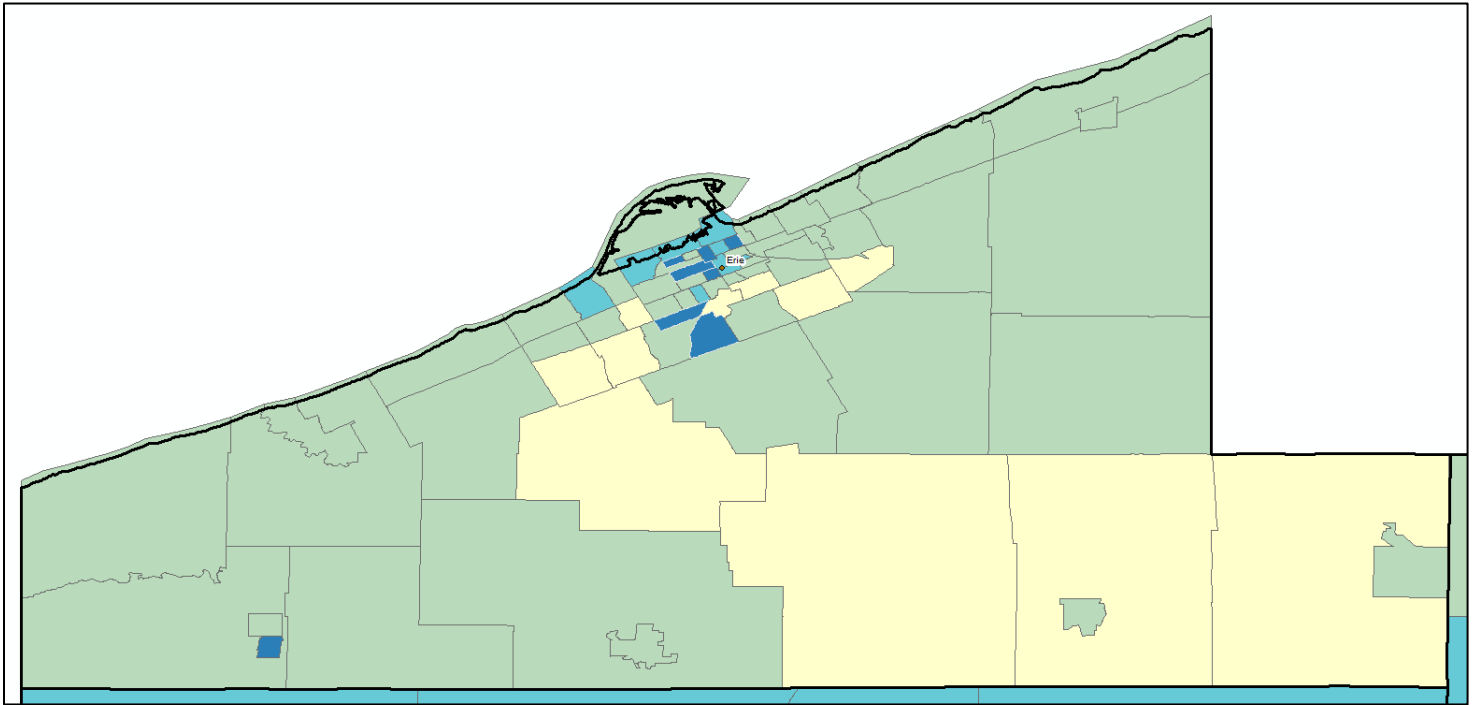- **21%** (9/42) of census tracts **within Cambria County** are high vulnerability.
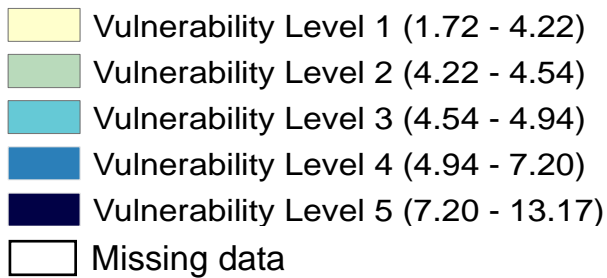

HCV Predicted Rate (per 100,000 population)

Vulnerability Level 1 (1.72 - 4.22)
Vulnerability Level 2 (4.22 - 4.54)
Vulnerability Level 3 (4.54 - 4.94)
Vulnerability Level 4 (4.94 - 7.20)
Vulnerability Level 5 (7.20 - 13.17)
Missing data

Predicted HCV Vulnerability – Erie County

For the HCV model, **vulnerability levels 4 and 5** are considered to be highly vulnerable to HCV infections related to injection drug use.
- **4%** (8/207) of high-vulnerability census tracts **across the state** are found in Erie County.
- **11%** (8/73) of census tracts **within Erie County** are high vulnerability.
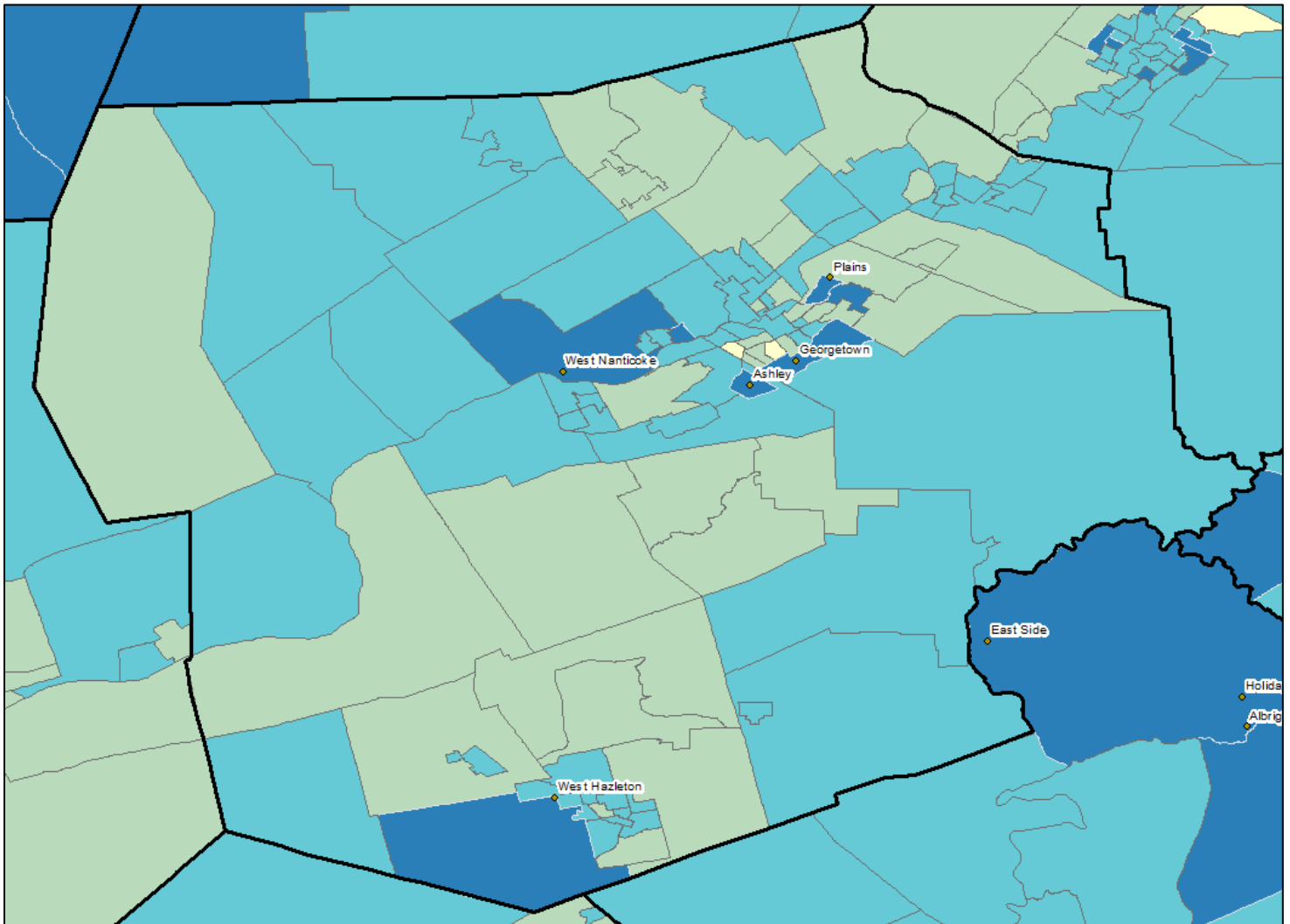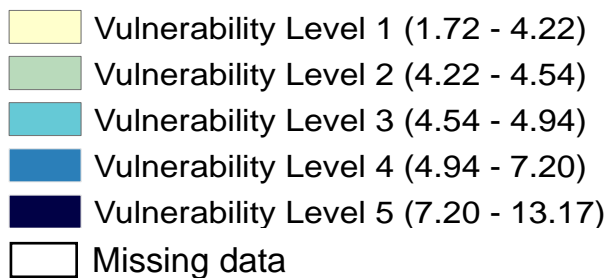

HCV Predicted Rate (per 100,000 population)

- Vulnerability Level 1 (1.72 - 4.22)
- Vulnerability Level 2 (4.22 - 4.54)
- Vulnerability Level 3 (4.54 - 4.94)
- Vulnerability Level 4 (4.94 - 7.20)
- Vulnerability Level 5 (7.20 - 13.17)
- Missing data

Predicted HCV Vulnerability – Luzerne County

For the HCV model, **vulnerability levels 4 and 5** are considered to be highly vulnerable to HCV infections related to injection drug use.

- **3%** (7/207) of high-vulnerability census tracts **across the state** are found in Luzerne County.
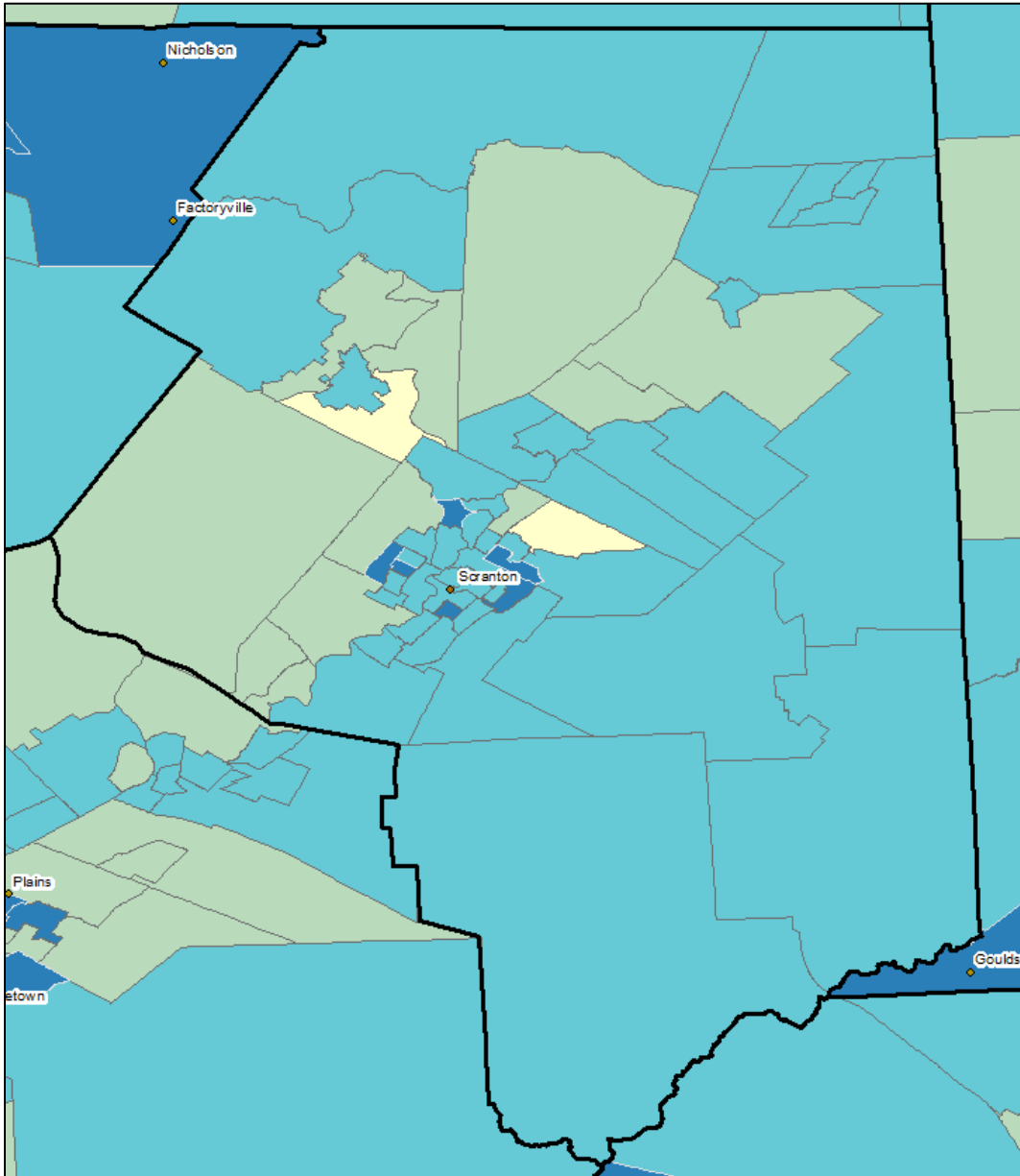- **7%** (7/101) of census tracts **within Luzerne County** are high vulnerability.
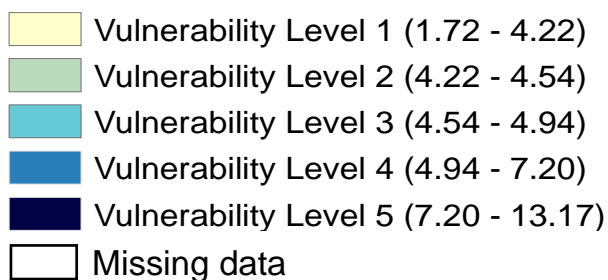

HCV Predicted Rate (per 100,000 population)

- Vulnerability Level 1 (1.72 - 4.22)
- Vulnerability Level 2 (4.22 - 4.54)
- Vulnerability Level 3 (4.54 - 4.94)
- Vulnerability Level 4 (4.94 - 7.20)
- Vulnerability Level 5 (7.20 - 13.17)
- Missing data

Predicted HCV Vulnerability – Lackawanna County

For the HCV model, **vulnerability levels 4 and 5** are considered to be highly vulnerable to HCV infections related to injection drug use.

- **3%** (6/207) of high-vulnerability census tracts **across the state** are found in Lackawanna County.
- **10%** (6/60) of census tracts **within Lackawanna County** are high vulnerability.
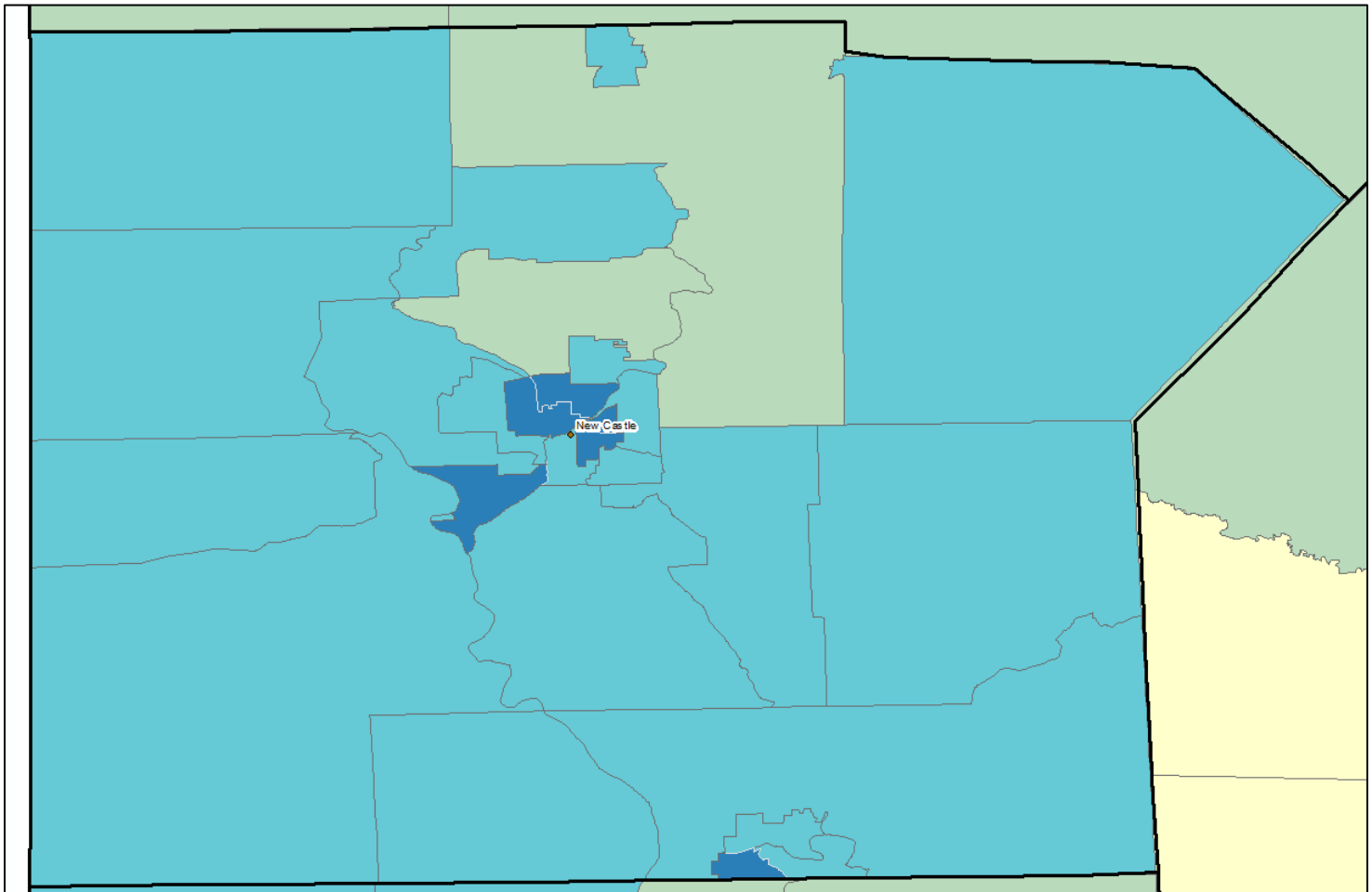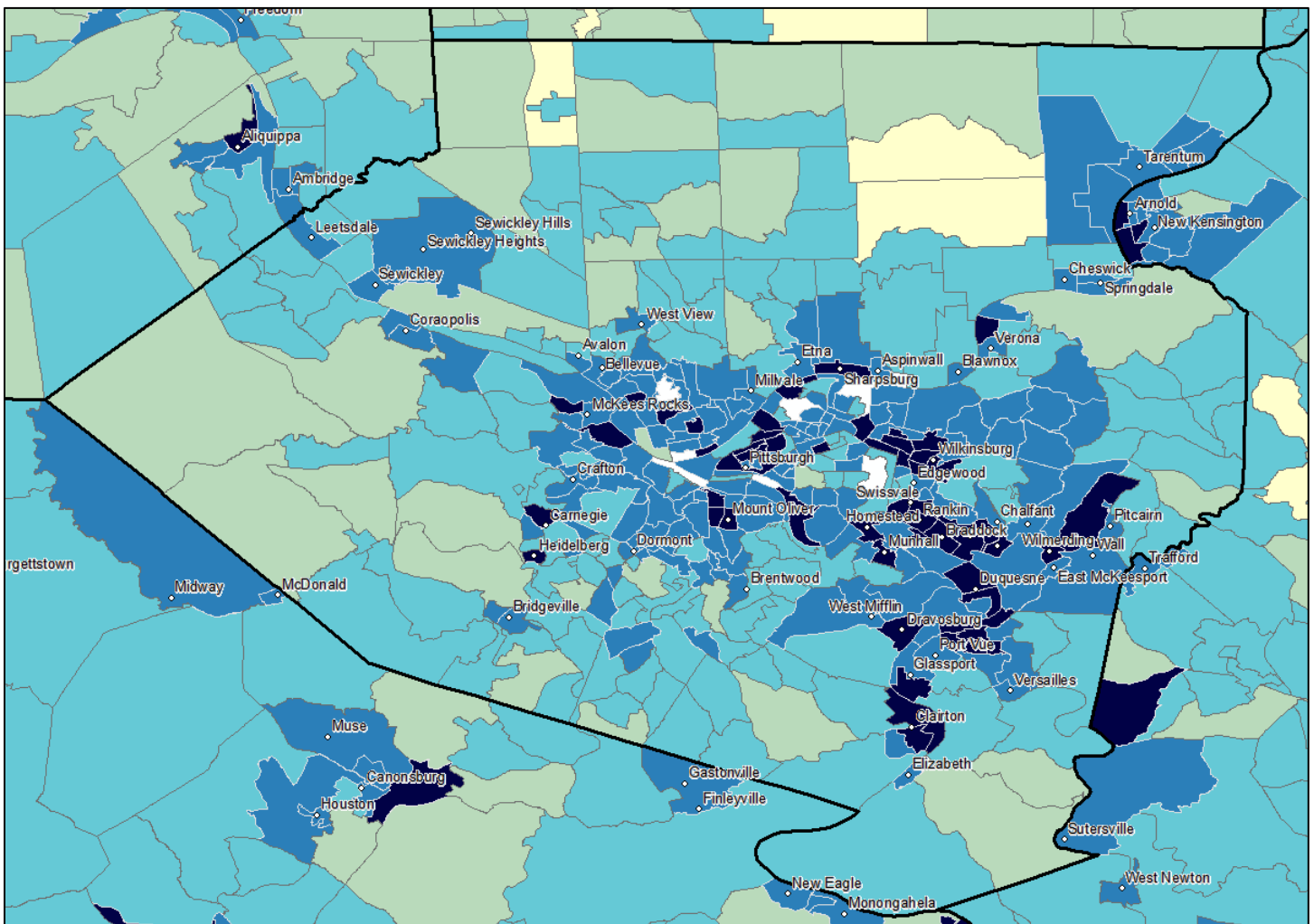

HCV Predicted Rate (per 100,000 population)

- Vulnerability Level 1 (1.72 - 4.22)
- Vulnerability Level 2 (4.22 - 4.54)
- Vulnerability Level 3 (4.54 - 4.94)
- Vulnerability Level 4 (4.94 - 7.20)
- Vulnerability Level 5 (7.20 - 13.17)
- Missing data

Predicted HCV Vulnerability – Lawrence County

For the HCV model, **vulnerability levels 4 and 5** are considered to be highly vulnerable to HCV infections related to injection drug use.

- **3%** (6/207) of high-vulnerability census tracts **across the state** are found in Lawrence County.
- **21%** (6/28) of census tracts **within Lawrence County** are high vulnerability.
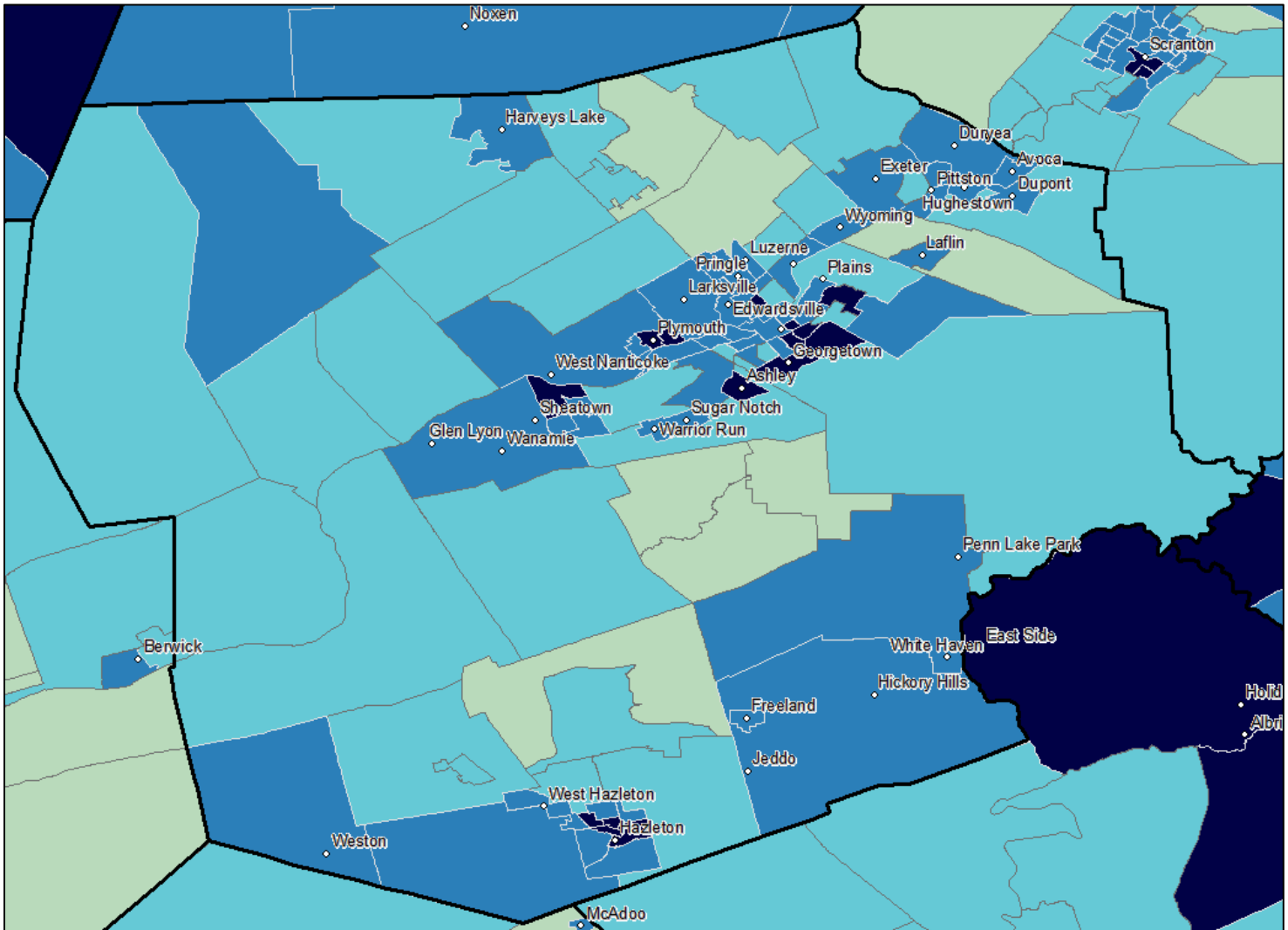

HCV Predicted Rate (per 100,000 population)

- Vulnerability Level 1 (1.72 - 4.22)
- Vulnerability Level 2 (4.22 - 4.54)
- Vulnerability Level 3 (4.54 - 4.94)
- Vulnerability Level 4 (4.94 - 7.20)
- Vulnerability Level 5 (7.20 - 13.17)
- Missing data

Figure S2: Predicted Overdose Death Rates and Vulnerability Levels by Census Tracts – Top 10 Counties

Predicted OD Vulnerability – Allegheny County

For the overdose death model, **vulnerability levels 4 and 5** are considered to be highly vulnerable to overdose death related to injection drug use.
- **28%** (218/776) of high-vulnerability census tracts **across the state** are found in Allegheny County
- **57%** (218/385) of census tracts **within Allegheny County** are high vulnerability.

Overdose Death Predicted Rate (per 100,000 population)

- Vulnerability Level 1 (1.40 - 3.41)
- Vulnerability Level 2 (3.41 - 3.73)
- Vulnerability Level 3 (3.73 - 4.06)
- Vulnerability Level 4 (4.06 - 4.48)
- Vulnerability Level 5 (4.48 - 8.82)
- Missing data

Census tracts labeled in white are not included in the HCV model given a population under 40 years old was not represented in the census tract in 2020.
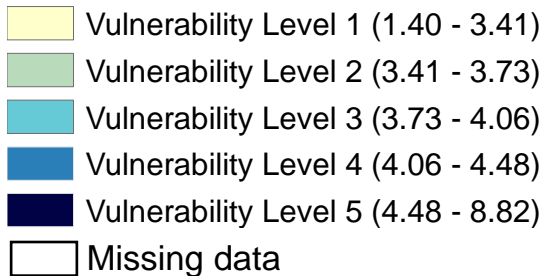
Predicted OD Vulnerability – Luzerne County

For the overdose death model, **vulnerability levels 4 and 5** are considered to be highly vulnerable to overdose death related to injection drug use.
- **8%** (62/776) of high-vulnerability census tracts **across the state** are found in Luzerne County
- **61%** (62/101) of census tracts **within Luzerne County** are high vulnerability.

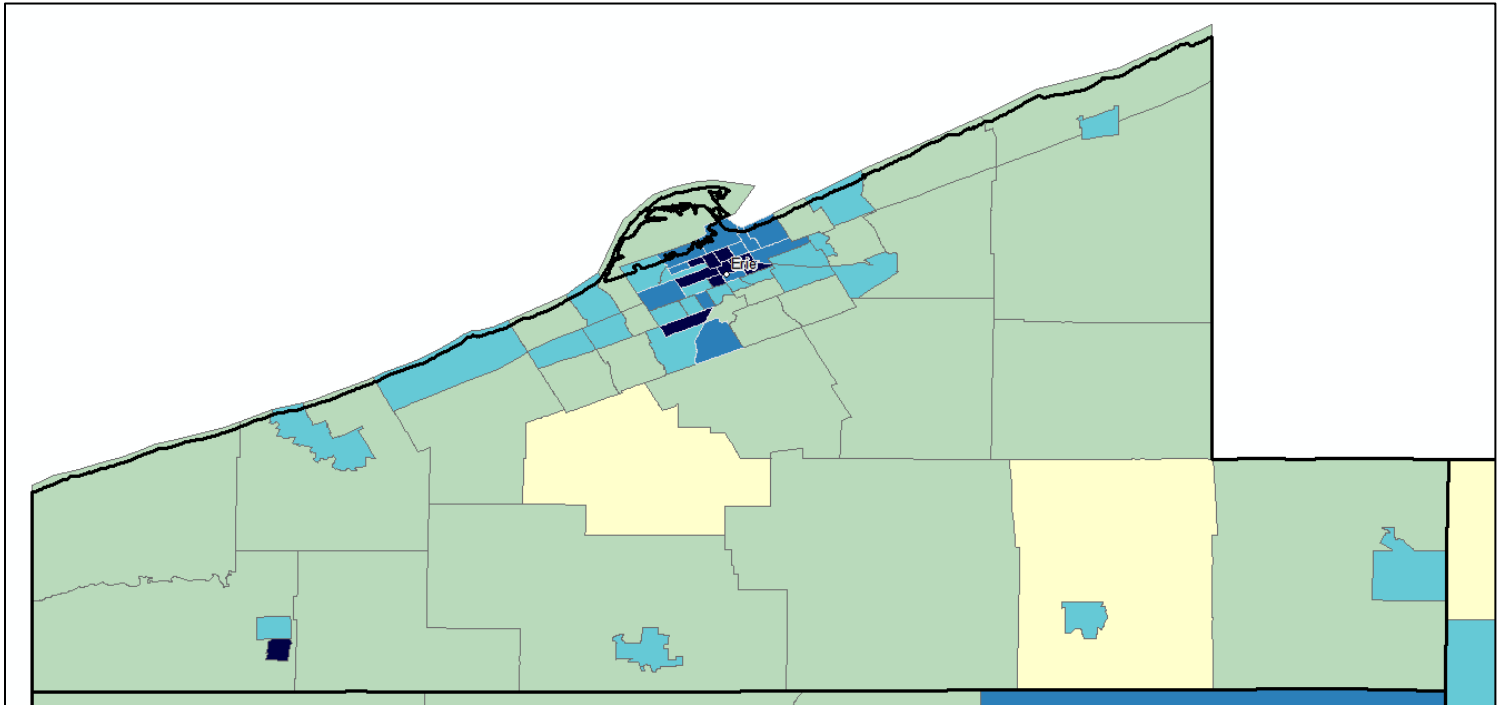## Overdose Death Predicted Rate (per 100,000 population)

- Vulnerability Level 1 (1.40 - 3.41)
- Vulnerability Level 2 (3.41 - 3.73)
- Vulnerability Level 3 (3.73 - 4.06)
- Vulnerability Level 4 (4.06 - 4.48)
- Vulnerability Level 5 (4.48 - 8.82)
- Missing data

Predicted OD Vulnerability – Erie County

For the overdose death model, **vulnerability levels 4 and 5** are considered to be highly vulnerable to overdose death related to injection drug use.
- **3%** (21/776) of high-vulnerability census tracts **across the state** are found in Erie County
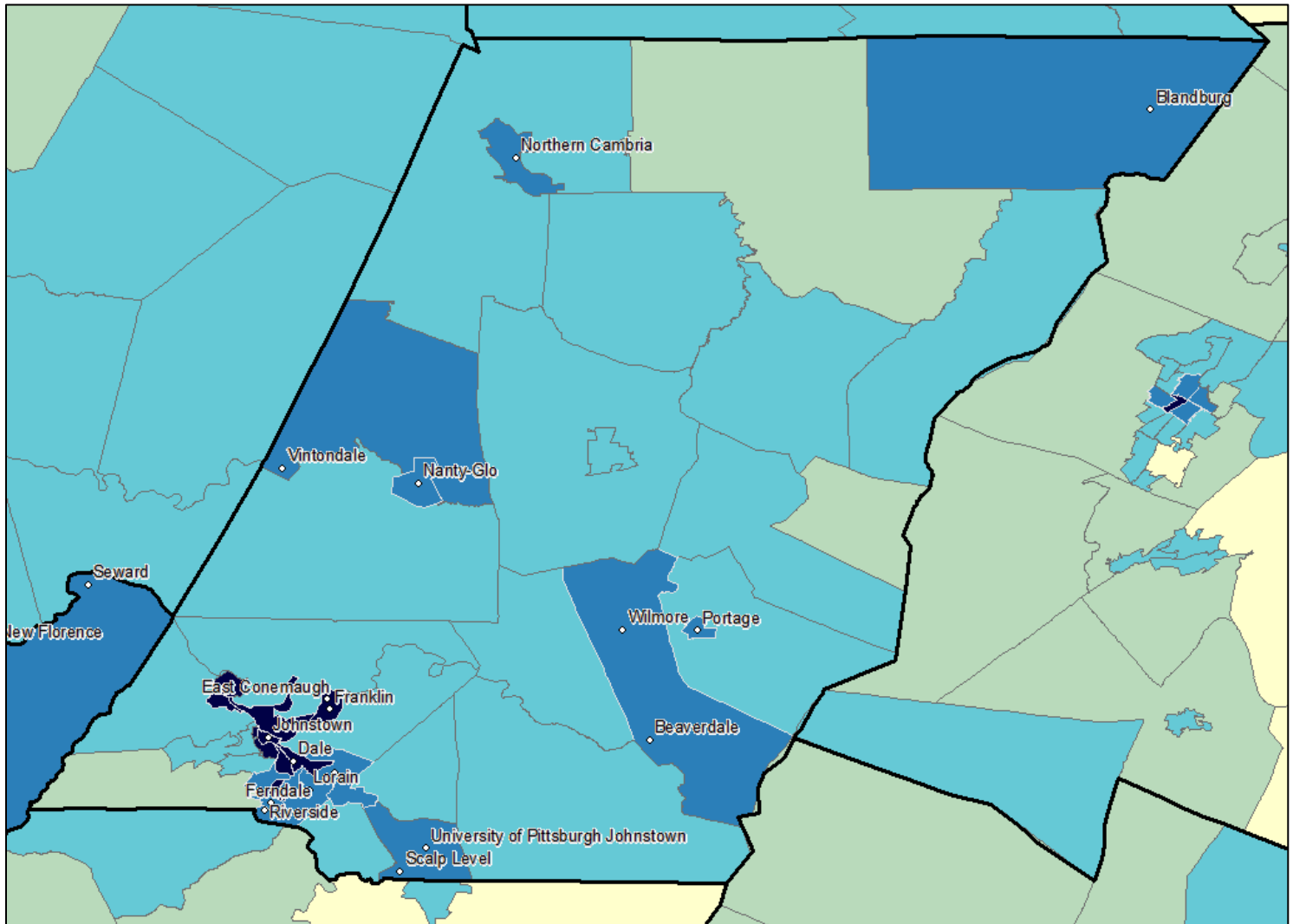- **29%** (21/73) of census tracts **within Erie County** are high vulnerability.

Overdose Death Predicted Rate (per 100,000 population)

- Vulnerability Level 1 (1.40 - 3.41)
- Vulnerability Level 2 (3.41 - 3.73)
- Vulnerability Level 3 (3.73 - 4.06)
- Vulnerability Level 4 (4.06 - 4.48)
- Vulnerability Level 5 (4.48 - 8.82)
- Missing data

Predicted OD Vulnerability – Cambria County

For the overdose death model, **vulnerability levels 4 and 5** are considered to be highly vulnerable to overdose death related to injection drug use.
- **3%** (21/776) of high-vulnerability census tracts **across the state** are found in Cambria County
- **50%** (21/42) of census tracts **within Cambria County** are high vulnerability.
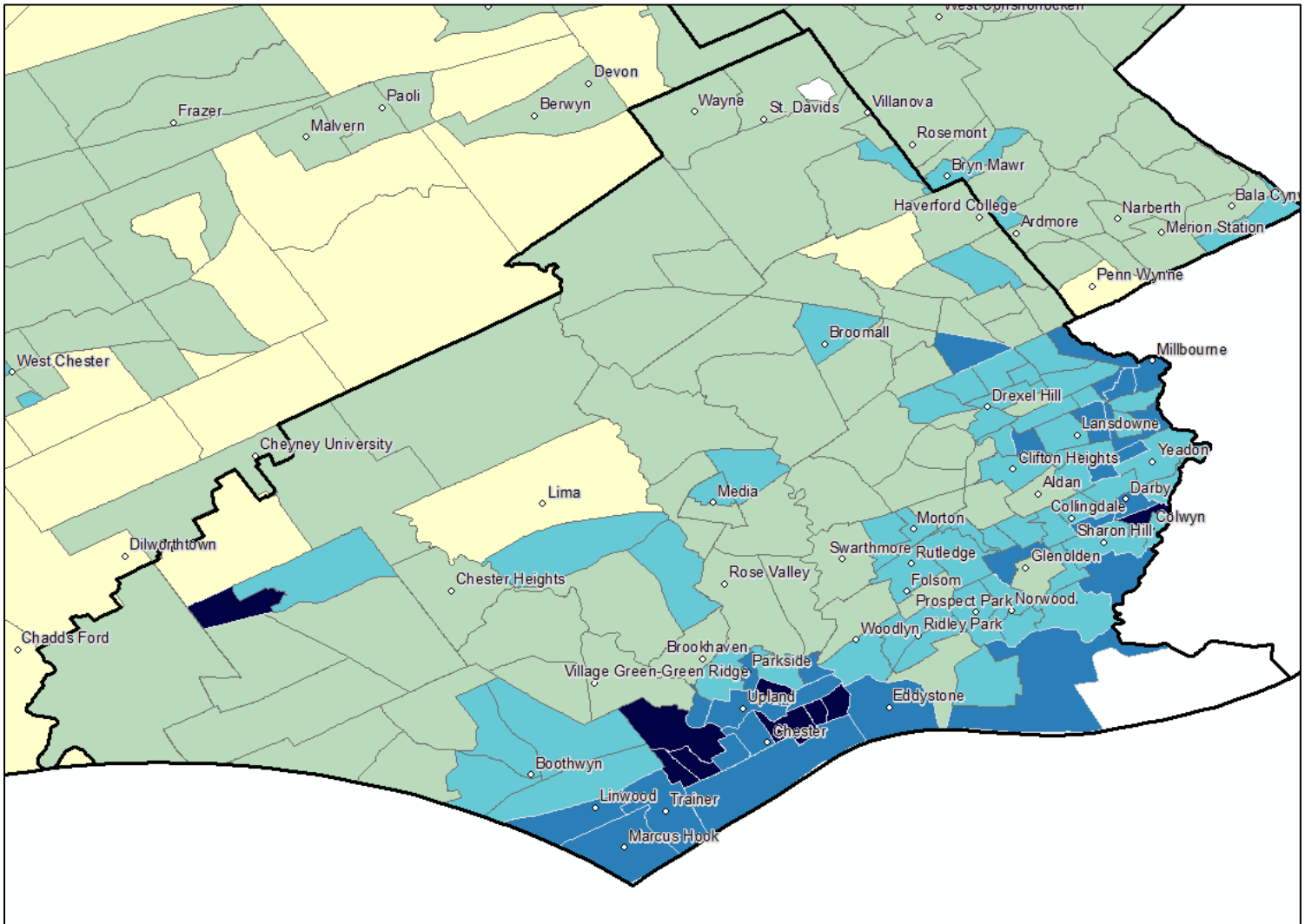

Overdose Death Predicted Rate (per 100,000 population)

- Vulnerability Level 1 (1.40 - 3.41)
- Vulnerability Level 2 (3.41 - 3.73)
- Vulnerability Level 3 (3.73 - 4.06)
- Vulnerability Level 4 (4.06 - 4.48)
- Vulnerability Level 5 (4.48 - 8.82)
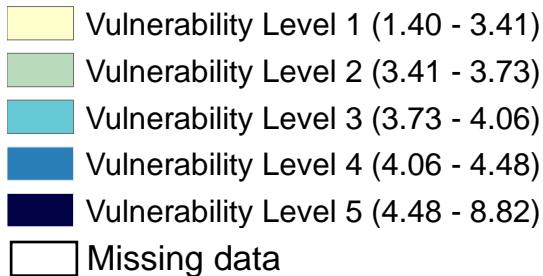- Missing data

Predicted OD Vulnerability – Delaware County

For the overdose death model, **vulnerability levels 4 and 5** are considered to be highly vulnerable to overdose death related to injection drug use.
- **4%** (35/776) of high-vulnerability census tracts **across the state** are found in Delaware County
- **23%** (35/150) of census tracts **within Delaware County** are high vulnerability.
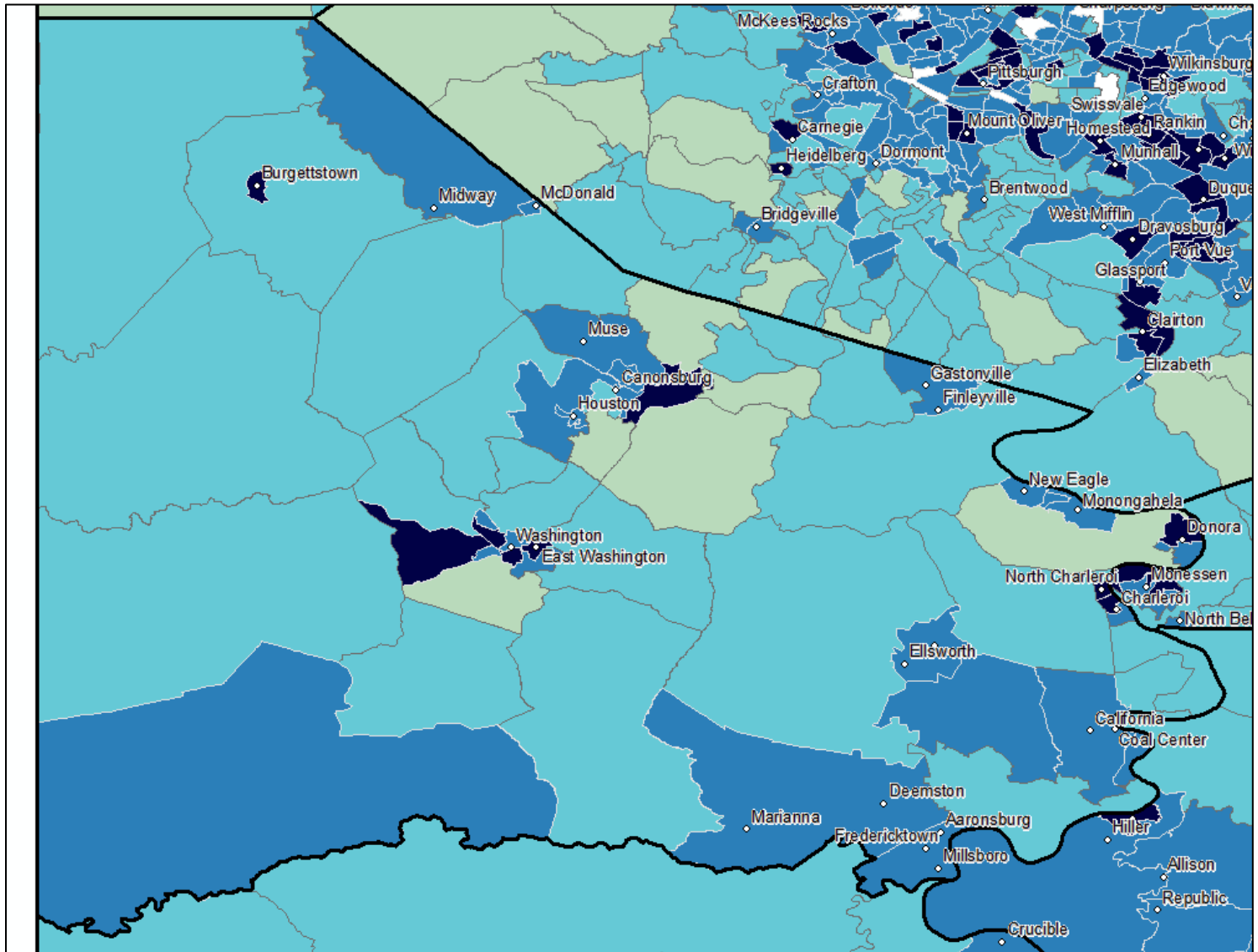

Overdose Death Predicted Rate (per 100,000 population)

- Vulnerability Level 1 (1.40 - 3.41)
- Vulnerability Level 2 (3.41 - 3.73)
- Vulnerability Level 3 (3.73 - 4.06)
- Vulnerability Level 4 (4.06 - 4.48)
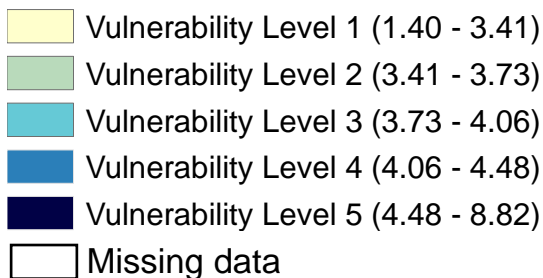- Vulnerability Level 5 (4.48 - 8.82)
- Missing data

Predicted OD Vulnerability – Washington County

For the overdose death model, **vulnerability levels 4 and 5** are considered to be highly vulnerable to overdose death related to injection drug use.

- **4%** (33/776) of high-vulnerability census tracts **across the state** are found in Washington County
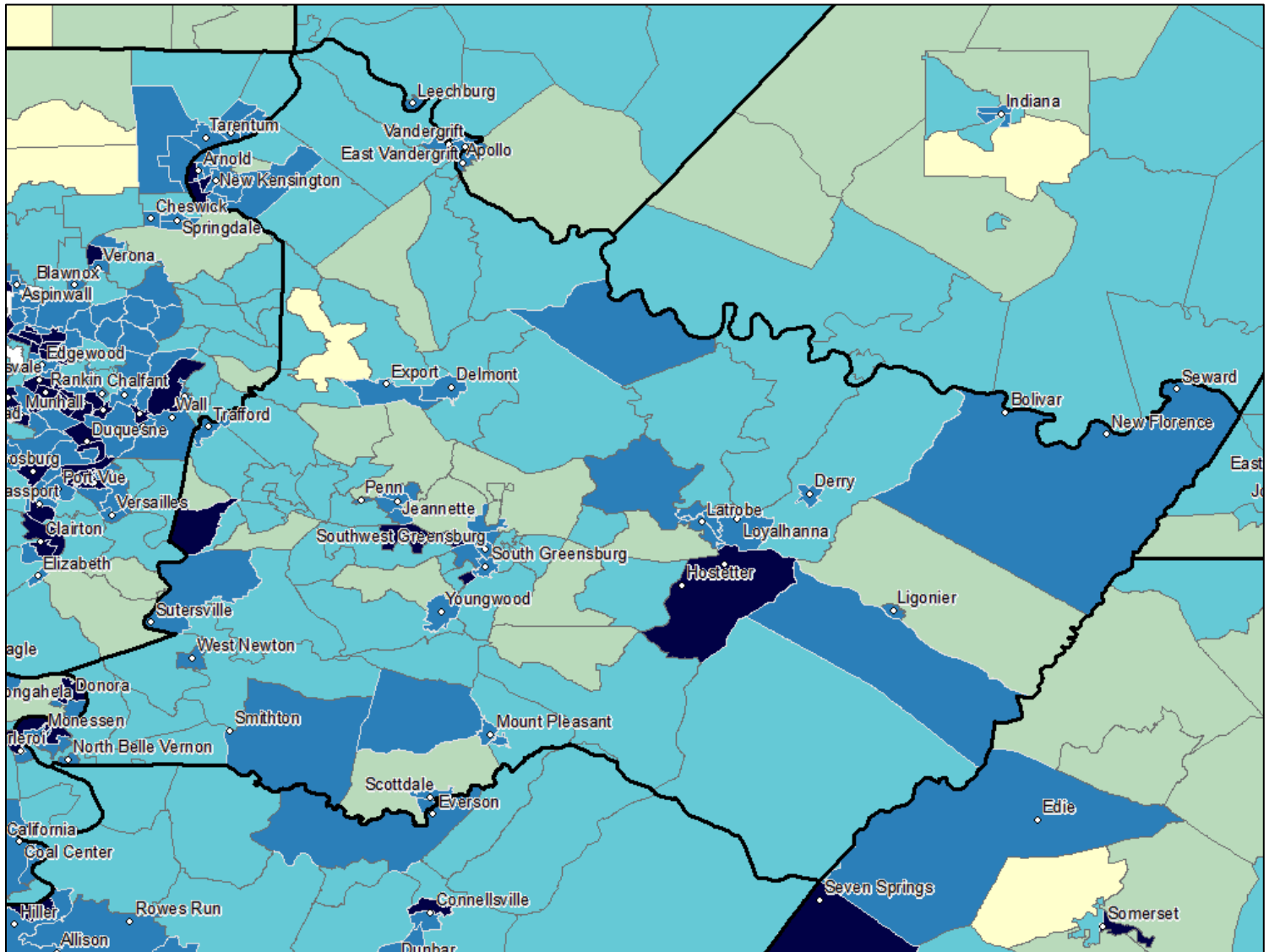- **53%** (33/62) of census tracts **within Washington County** are high vulnerability.

Overdose Death Predicted Rate (per 100,000 population)

- Vulnerability Level 1 (1.40 - 3.41)
- Vulnerability Level 2 (3.41 - 3.73)
- Vulnerability Level 3 (3.73 - 4.06)
- Vulnerability Level 4 (4.06 - 4.48)
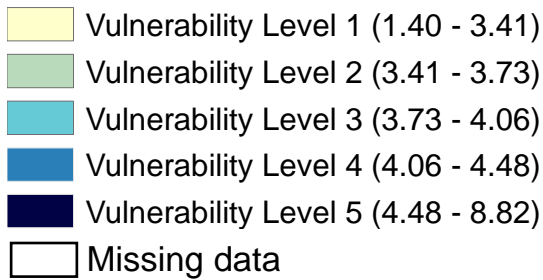- Vulnerability Level 5 (4.48 - 8.82)
- Missing data

Predicted OD Vulnerability – Westmoreland County

For the overdose death model, **vulnerability levels 4 and 5** are considered to be highly vulnerable to overdose death related to injection drug use.

- **7%** (53/776) of high-vulnerability census tracts **across the state** are found in Westmoreland County
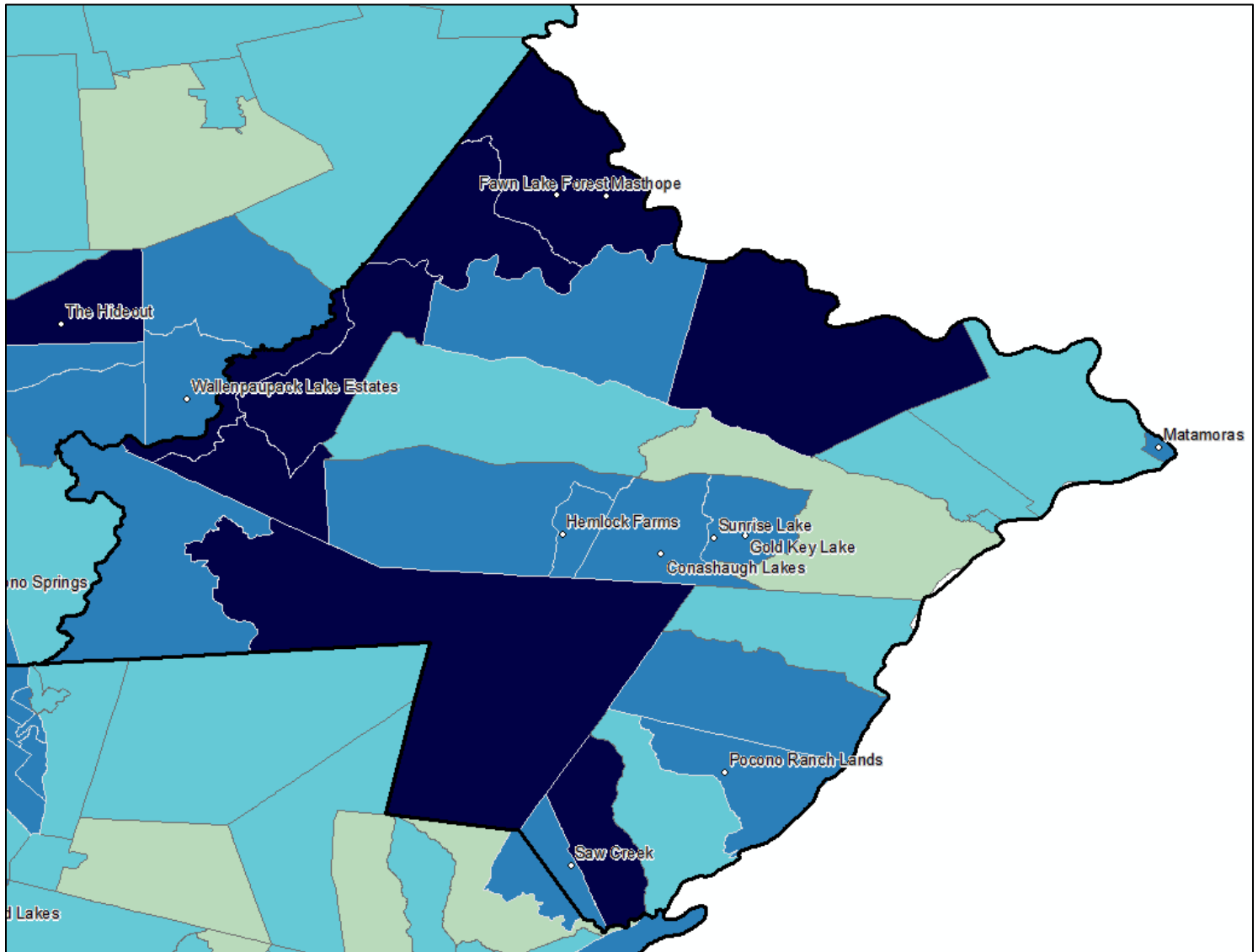- **47%** (53/113) of census tracts **within Westmoreland County** are high vulnerability.

Overdose Death Predicted Rate (per 100,000 population)

- Vulnerability Level 1 (1.40 - 3.41)
- Vulnerability Level 2 (3.41 - 3.73)
- Vulnerability Level 3 (3.73 - 4.06)
- Vulnerability Level 4 (4.06 - 4.48)
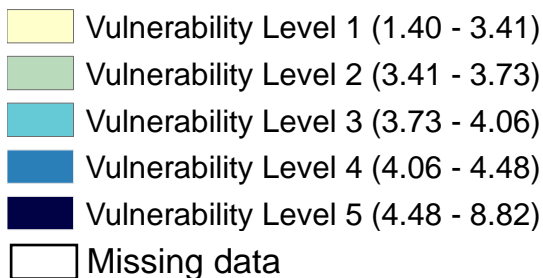- Vulnerability Level 5 (4.48 - 8.82)
- Missing data

Predicted OD Vulnerability – Pike County

For the overdose death model, **vulnerability levels 4 and 5** are considered to be highly vulnerable to overdose death related to injection drug use.

- **2%** (18/776) of high-vulnerability census tracts **across the state** are found in Pike County
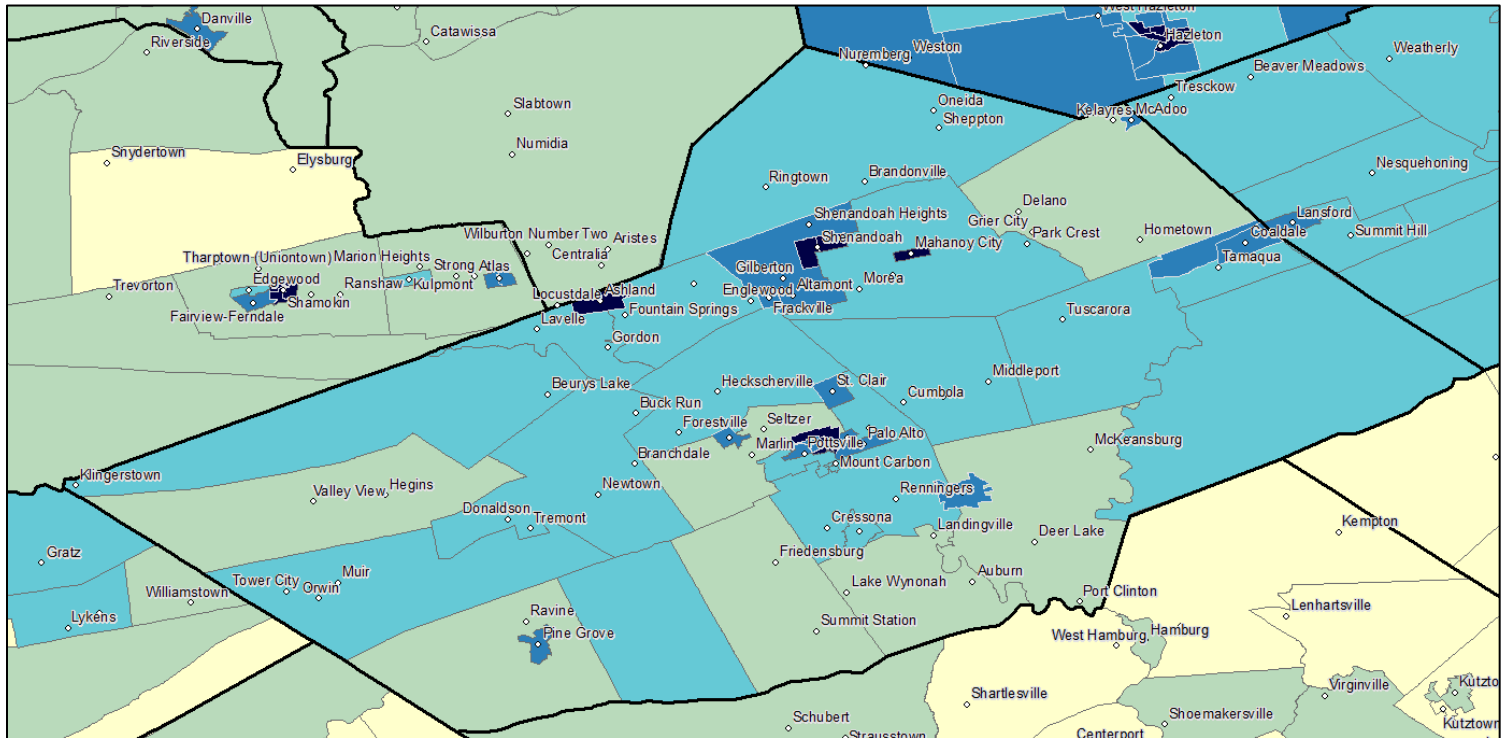- **72%** (18/25) of census tracts **within Pike County** are high vulnerability.

Overdose Death Predicted Rate (per 100,000 population)

- Vulnerability Level 1 (1.40 - 3.41)
- Vulnerability Level 2 (3.41 - 3.73)
- Vulnerability Level 3 (3.73 - 4.06)
- Vulnerability Level 4 (4.06 - 4.48)
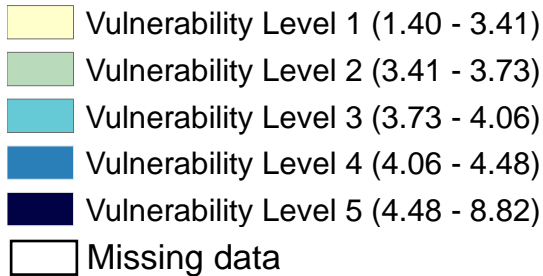- Vulnerability Level 5 (4.48 - 8.82)
- Missing data

Predicted OD Vulnerability – Schuylkill County

For the overdose death model, **vulnerability levels 4 and 5** are considered to be highly vulnerable to overdose death related to injection drug use.

- **2%** (18/776) of high-vulnerability census tracts **across the state** are found in Schuylkill County
- **43%** (18/42) of census tracts **within Schuylkill County** are high vulnerability.

Overdose Death Predicted Rate (per 100,000 population)

- Vulnerability Level 1 (1.40 - 3.41)
- Vulnerability Level 2 (3.41 - 3.73)
- Vulnerability Level 3 (3.73 - 4.06)
- Vulnerability Level 4 (4.06 - 4.48)
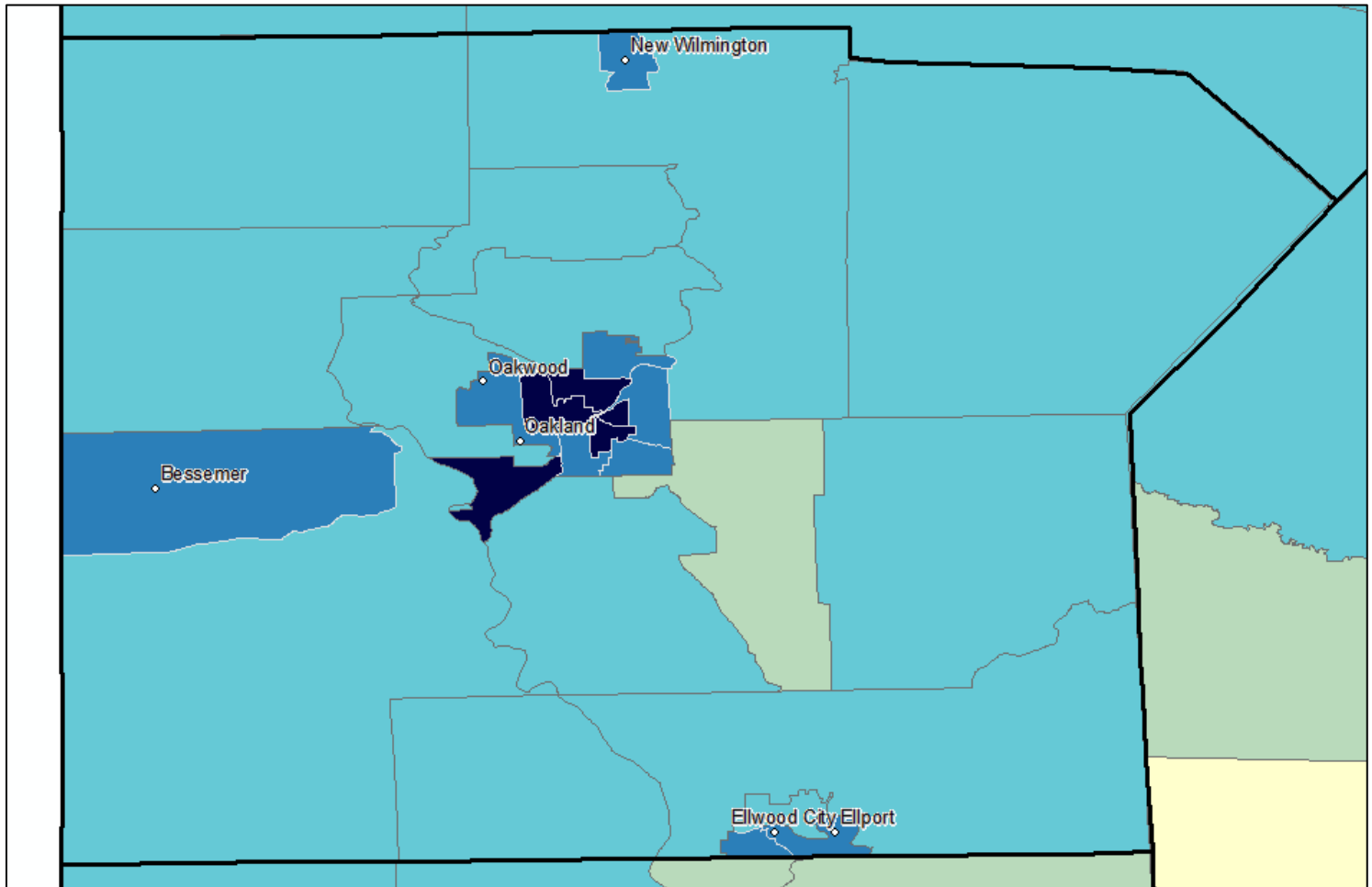- Vulnerability Level 5 (4.48 - 8.82)
- Missing data

Predicted OD Vulnerability – Lawrence County

For the overdose death model, **vulnerability levels 4 and 5** are considered to be highly vulnerable to overdose death related to injection drug use.
- **2%** (14/776) of high-vulnerability census tracts **across the state** are found in Lawrence County
- **50%** (14/28) of census tracts **within Lawrence County** are high vulnerability.

Overdose Death Predicted Rate (per 100,000 population)

- Vulnerability Level 1 (1.40 - 3.41)
- Vulnerability Level 2 (3.41 - 3.73)
- Vulnerability Level 3 (3.73 - 4.06)
- Vulnerability Level 4 (4.06 - 4.48)
- Vulnerability Level 5 (4.48 - 8.82)
- Missing data

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