Public Health Impacts of the Opioid Epidemic: Vulnerability to Bloodborne Infections and Overdose Death

Bureau of Epidemiology

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Executive Summary

After a 2015 HIV outbreak associated with unsterile injection drug use occurred in Scott County, Indiana, the Centers for Disease Control and Prevention (CDC) conducted a nation-wide vulnerability assessment to identify other U.S. counties at risk of a similar outbreak. Hepatitis C, another bloodborne infection, causes concern in these types of outbreaks as well. Three of the top 220 counties identified through the CDC assessment are within Pennsylvania. Therefore, Pa. conducted an instate vulnerability assessment with more recent, census tract-level data to determine which Pa. communities are at the highest risk of bloodborne infections associated with unsterile drug use and drug overdose deaths.

The most recent, complete HCV case data (from the Pa. National Electronic Diseases Surveillance System or PA-NEDSS) and overdose death data (from the Bureau of Health Statistics and Registries) were used to compare with CDC's original predictions. Two multivariable Poisson logistic regressions were performed at the census tract level, one with HCV case counts for those under age 40 as the outcome, a proxy for bloodborne infections associated with unsterile injection drug use, and another with overdose death counts as the outcome. Indicator variables were obtained from the U.S. census and various programs within the Department of Health, and final variables were selected via a multi-step, dimension reduction process. The predicted probabilities from the Poisson models were used to assign census tract vulnerability to bloodborne infections or drug overdose deaths.

Pa. counties with the highest crude rates of HCV cases were different from the three counties CDC had predicted in 2015 were at greatest risk of bloodborne infections: Luzerne, Cambria and Crawford. HCV case hot spots fall along the Appalachian Mountain Range as well as in York and Philadelphia counties. Overdose death hot spots are focused around Pa.'s large urban centers.

The HCV case outcome model contained premature death rate, rural category (1=all urban, 2=some or all rural), teen birth rate, and syphilis rate as indicator (independent) variables. The overdose death outcome model contained premature death, rural category, syphilis rate and percent of vacant housing as indicator variables. Model results indicate the top 25 percent of census tracts vulnerable to high overdose death rates are concentrated around Philadelphia and Pittsburgh. Meanwhile, the top 25% of census tracts vulnerable to high HCV infection rates are more evenly spread across the state in both urban and rural areas.

This census tract-level assessment has provided valuable granular detail otherwise missed using only county-level data to predict vulnerability to bloodborne infections and drug overdose deaths. These results provide a starting point from which Pa. can work towards more efficient allocation of health-related resources and targeted interventions that will prevent the spread of infectious disease and further decrease Pa. drug overdose deaths in both the short and long term.

Background

In 2015, needle-sharing for the use of injection drugs in Scott County, Indiana resulted in an HIV outbreak with 235 individuals infected,[1] a number 47 times greater than the average annual incidence of HIV for the county.[2] Hepatitis C (HCV) was another bloodborne infectious disease of concern during the outbreak; over 90% of those infected with HIV were coinfected with HCV.[3] Such a devastating outbreak earned national attention, and shortly after, the CDC developed a vulnerability index with which they identified counties in the United States at risk of a similar outbreak. Three of Pennsylvania's counties were identified as "at high risk" in the CDC assessment: Cambria, Crawford and Luzerne.[4]

CDC also identified 41 Tennessee counties as "at high risk." In response, the Tennessee Department of Health conducted an instate vulnerability assessment. One of the limitations of the original national CDC assessment was data availability; CDC could only use data available to all 50 states. The Tennessee Department of Health had access to more extensive, and sometimes more detailed, data which allowed them to incorporate other important indicators in their assessment and ultimately produce more robust results. Their instate results were similar to CDC's country-wide assessment, but there were some significant discrepancies.[5] Therefore, using lessons learned from Tennessee and supported by funding from CDC, several states that have been impacted by the opioid epidemic (including Pennsylvania) are conducting their own in-depth assessments to identify potential high-risk areas at a more granular level so appropriate resources and interventions can be efficiently allocated. In this report, the methods and results of the Pennsylvania instate vulnerability assessment are presented.

Objectives

1. Determine the current burden and distribution of HCV cases and overdose deaths in Pa.
2. Compare Pa.'s HCV and overdose death rates by county to the original CDC vulnerability assessment predictions.
3. Incorporate updated, Pa.-specific data into a regression model and rank census tracts by risk of overdose deaths and HCV/other bloodborne infections associated with unsterile injection drug use.

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Methods

Outcome Data

The vulnerability assessment includes two statistical models, one with HCV case counts as the outcome and another with overdose death counts as the outcome. HCV cases were used as a proxy for bloodborne infections associated with unsterile drug use. A separate model was developed for overdose deaths, as Pennsylvania is a large state with widely divergent counties and communities, and it was thought that communities with the highest rates of HCV cases may not be the same communities that have the highest rates of overdose deaths. Early hot spot mapping of HCV and overdose death rates lent support to this hypothesis (see supplemental **Figure S1** and **S2**).

HCV Outcome Data

Individual non-Philadelphia HCV case data were collected from Pa.'s electronic disease reporting database, PA-NEDSS. Philadelphia HCV case data were obtained from the Philadelphia Department of Public Health. Confirmed HCV cases (i.e., persons with a positive HCV RNA test) first reported in 2017 and 2018 were included. Because hepatitis C is often asymptomatic (and was thus unidentified for many years), time of first report is not a reliable proxy for time of infection. To limit HCV cases to those that were infected relatively recently, HCV cases in persons 40 years of age and older were excluded from these analyses. In addition, because the purpose of the vulnerability assessment was to identify geographic areas that were at risk for increases in bloodborne infections, we also excluded cases that were incarcerated in state prisons. The Pennsylvania state prison system screens all inmates upon admission; because the prevalence of screening and HCV infection is much higher in inmates than in the non-incarcerated population, including prisoners in the vulnerability assessment would have skewed results toward counties and census tracts containing a state prison. A total of 12,347 cases meeting the inclusion criteria were identified.

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 ArcMap® 10.4.1, and a spatial join was performed to obtain the number of cases falling within each county or census tract. Cases with either exact or zip code centroid address matches were used for county-level maps, but only cases with exact matches (10,535, or 85% of the total) were used for census tract-level maps and assessment.

Overdose Death Outcome Data

Overdose death data for 2017 was obtained from the Pennsylvania Department of Health (DOH) Bureau of Health Statistics and Registries. The most recent year of death certificate data available was 2017. The Bureau of Epidemiology obtained death certificate data related to overdose through the DOH Prescription Drug Monitoring Program (PDMP). PDMP defines overdose deaths using the following steps:

1. A literal text search tool based on guidance from the Council of State and Territorial Epidemiologists (CSTE) Overdose Subcommittee was run to identify deaths of interest, with minor modifications, including the removal of the Cause of Death coding restrictions, as Pennsylvania has found a portion of drug overdose deaths get miscoded.[6]

2. Literal cause of death text fields and cause of death codes (International Classification of Diseases, Tenth Revision, or ICD-10) fields were reviewed to identify cases where drug toxicity was included as a cause of death.
3. An expanded CDC Enhanced State Opioid Overdose Surveillance (ESOOS) grant case definition was applied,[7] eliminating "drug-related" deaths where some other illness of external injury caused the death (i.e., sepsis, endocarditis, drownings, falls, motor vehicle accidents, etc.).

Overdose deaths with the following codes for cause of death were included: Accidental (X40-44, X47 when substance indicated is difluoroethane, alone or in combination with other drugs, X49 when the literal cause of death is Mixed or Combined or Multiple "Substance Toxicity," as these are likely drug overdoses), Suicide (X60-64), Undetermined (Y10-14), accidental/undetermined overdose deaths marked as Homicide for prosecution purposes (X85), as well as Pending (R99), and unknown manners when the Injury Description or coroner/medical examiner records indicated an overdose as the cause of death.[7,8] True homicide overdose deaths were excluded.

Overdose deaths from all drug types were included in this vulnerability assessment, except for alcohol-only overdoses. A total of 5,490 overdose deaths in 2017 were identified using the methods outlined above, with 4,653 (85%) having an assigned census tract. Only the 4,653 overdose deaths with an assigned census tract were used for the census tract-level maps and assessment.

Indicator Data

Upon review and consideration of the variables used in other vulnerability assessments by CDC,[3] Tennessee,[5] and Illinois,[9] a list of 32 potential variables were assembled. These variables, accessible in Pa., are potentially associated with the risk of bloodborne infections and overdose. Data were collected from the American Community Survey 2017 five-year estimates, County Health Rankings Report by the Robert Wood Johnson Foundation, DOH PDMP, DOH Sexually Transmitted Diseases (STD) Program, DOH HIV/AIDS Surveillance and Epidemiology Program, and the Philadelphia Department of Public Health (PDPH).

Discussions were held with subject area specialists from CDC and Pennsylvania's Bureau of Epidemiology, PDMP, STD and HIV/AIDS programs to reduce overlap and further narrow the variable list. Their expert consensus resulted in a final list of 12 indicators thought likely to be associated with overdose deaths or HCV cases: percent unemployed, percent without a high school diploma, percent vacant housing, teen birth rate (per 1,000 women), Gini index (measure of income inequality across a population), percent rural area, percent reporting poor/fair health, premature death rate (years of potential life lost before age 75 per 100,000 population, age-adjusted), rate of average daily morphine milligram equivalents (MME) > 90mg (per 10,000), opioid (excluding buprenorphine) prescription rate (per 10,000 population), syphilis rate (per 100,000 population), and HIV incidence rate (per 100,000 population). Further details on all 32 variables considered can be found in Appendix B **Supplemental Table S1**. The distributions of the 12 variables remaining after subject area expertise reduction were evaluated, and only one variable was altered: "percent rural" was transformed from a continuous variable into a bivariate variable (completely urban vs. some or all rural). Data from the PDMP and County health rankings were unavailable at the census tract-level (Appendix B **Table S1**). For these fields, the county value was applied to all census tracts falling within that county.

Statistical Analyses

All statistical analyses were completed using SAS® 9.4. After the census tract data were prepared, a principal components analysis was completed for further dimension reduction and to eliminate some possibly collinear variables. The rotated factor pattern, or the analysis tool produced to compare components for inclusion, was evaluated to determine when appropriate groupings were reached.[10] This occurred with four components. Any variables that grouped into more than one component were removed. The variable with the heaviest weight from each component of the unrotated factor pattern was then incorporated into a multivariable Poisson regression model with the log of the population as the offset. Predicted rates from the model results were used to assign final rankings and classify risk.

Mapping

All maps were made using ArcMap® 10.4.1 by Esri. Basic choropleth maps were produced for 2017-2018 HCV case counts and rates, as well as 2017 overdose death counts and rates by county and census tract for baseline evaluation. Hotspot maps were created with the optimized hotspot analysis tool with census tract data as an input feature. The Poisson model predicted rates were then mapped by both quartile and Jenks method. The Quartile method organizes data into four distinct categories, each representing 25% of the data. 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.[11] The Jenks method HCV case model was classified into four categories rather than three, because only seven tracts were categorized in the top, most vulnerable tier.

Results

Hepatitis C Case Rates and Overdose Death Rates by County

To compare with CDC's original predictions, Appendix A **Tables 1** and **2** display Pa.'s counties by their 2017 – 2018 crude rate of HCV cases and overdose deaths per 10,000 population, respectively. Counties identified in CDC's original vulnerability assessment are starred. Blair, Union and Tioga counties were the top three counties with the highest crude rates of HCV cases per 100,000 population under 40 years of age; Cambria ranked seventh, Luzerne 13th and Crawford 22nd. Meanwhile, Montour, Philadelphia and Allegheny counties had the top three highest crude rates of overdose deaths per 10,000 population.

In addition, the corresponding county maps (Appendix A **Figures 1** and **2**) should be reviewed when considering these ranks. These maps display county-level HCV or overdose death crude rates classified using Jenks method, with an overlain layer showing hotspots of HCV cases or overdose deaths by count.

Poisson Regression Results

Final variables included in the overdose death outcome model at the census tract-level were premature death rate, rural category, percent vacant housing and syphilis rate. Final variables for the HCV case outcome model at the census tract-level were premature death rate, rural category, teen birth rate and syphilis rate. Again, all variables were retained ($p<0.05$).

Census data was missing for some census tracts and resulted in missing predicted values. Missing data was a result of no sample observations or too few sample observations to compute a census estimate. More than 98% (3,153 / 3,217) of tracts had complete data for the variables used in the HCV case model, and more than 99% (3,196 / 3,217) of tracts had complete data for the variables used in the overdose death model.

For both HCV case and overdose death models, the scaled Pearson statistics were close to 1.0 (0.89-0.92), indicating that overdispersion/underdispersion was not an issue. The specified Poisson models fit both Pennsylvania's HCV and overdose data well. Final ranks by census tract, according to the HCV model, are displayed using Jenks method (Appendix A **Figure 3**) and using quartiles (Appendix A **Figure 5**). Final ranks by census tract, according to the overdose death model, are displayed using Jenks method (Appendix A **Figure 4**) and using quartiles (Appendix A **Figure 6**). Enlarged maps for individual counties can be found in the associated County Map Packet.

Discussion

The original 2015 vulnerability assessment completed by CDC identified 220 counties nationwide that were considered to be the most vulnerable (i.e., ranked in the top 5%) for rapid dissemination of bloodborne infections resulting from unsterile injection drug use within the context of the current opioid epidemic. Three Pennsylvania counties were in the top 5%: Luzerne, which ranked 38th; Cambria, at 131; and Crawford, at 188. In comparison, our instate, county-level evaluations resulted in somewhat different rankings. Luzerne, Cambria and Crawford were in the top third of counties with the highest crude rates but were not in the top 5% (Appendix A **Tables 1 and 2**). Instead, Blair, Union and Tioga counties had the highest crude HCV case rates, all relatively rural counties. In contrast, the crude rate of overdose deaths was highest in Montour, Philadelphia and Allegheny counties. Philadelphia and Allegheny counties represent Pa.'s two largest urban centers. The differences with CDC's assessment may reflect changes from 2015 to 2017-18 and may also reflect differences in data fields included in the model.

Predictive Modeling

The Poisson logistic regression model results at the census tract-level were consistent with initial predictions that areas of Pa. at risk of bloodborne infections (the HCV case outcome model) differ from those at risk of overdose death (Appendix A **Figures 3 – 6**). Overall, census tracts at greater risk of overdose deaths tend to be located around Pa.'s urban centers, especially Philadelphia and Pittsburgh (Appendix A **Figures 4, 6**). Though some tracts at greater risk of bloodborne infections also surround those urban areas, in general, they are more scattered, rural and are frequently located in the Appalachian regions of the state (Appendix A **Figures 3, 5**).

The census tract model results by quartile clearly depict those trends, as the census tracts within the top quartile for overdose death vulnerability are heavily concentrated around Philadelphia and Pittsburgh (Appendix A **Figure 6** displays many red tracts around Philadelphia and Pittsburgh, but mostly gray tracts everywhere else). The census tracts within the top quartile for bloodborne infection vulnerability (the HCV case outcome model) are prevalent in the Philadelphia and Pittsburgh areas, but there are also top quartile tracts throughout the state (Appendix A **Figure 5** displays some red tracts around urban centers, a more even mix of red and gray everywhere else).

The maps displayed by quartile are useful for comparing the two models' predicted outcomes, since each color or shade represents 25% of the data, regardless of the model. However, this also means that two (or more) census tracts could fall under different quartiles, but they may only have a minor difference in actual values. For example, a census tract ranked 799th with a predicted rate of 4.866 per 10,000 would be in the top quartile, while a census tract ranked 837th with a predicted rate of 4.876 per 10,000 would be in the second top quartile. Ultimately, the two census tracts have a difference in predicted rate of 0.01, but they are displayed differently because of the quartile they fall into.

This issue is mostly resolved when model results are presented using Jenks method, since the method maximizes the difference between group means,[11] so one can conclude the classes created are as distinct as possible. However, this method is not meant to be used for the comparison of different maps. The census tracts deemed "more vulnerable" by the Jenks method can provide precise representation of those areas at greatest risk. However, it is also possible that areas with significant risk, yet not in the most vulnerable classification group, could be overlooked.

Strengths and Limitations

Performing the assessment at census tract-level has provided Pa. with valuable granular detail that would have been missed using only county-level data. It is more efficient to target specific communities for interventions and health resources, because even within a county, communities can be quite diverse. For example, in a county-level analysis, Allegheny County would be deemed "more vulnerable," but upon evaluation at the census tract-level, it becomes clear certain interventions or health resources would be inefficient if allocated across the whole county. Instead, there are specific communities that could benefit from targeted intervention.

It is important to again recognize that only 85% of the overdose death data and only 85% of the HCV case data had census tract information and were used in the Poisson models. Over 97% of Philadelphia HCV data supplied by PDPH had census tract information; however, it should be noted that cases associated with the Philadelphia Department of Prisons were not removed from the analysis as were cases associated with the state correctional system. Pennsylvania jails are not uniformly testing for HCV like the state correctional system. Nevertheless, the Philadelphia Department of Prisons is conducting more HCV testing than most jails. The inclusion of these cases likely led to the jail-associated census tract in northeast Philadelphia being identified as at-risk for bloodborne infections.

Data to Action

Non-urban areas, particularly those in the Appalachian region that have been identified as "more vulnerable" to bloodborne infections, would likely benefit from the expansion of mobile clinics and syringe exchange programs, as well as increased community outreach and education. Although syringe exchange programs are not currently legal in Pennsylvania, local regulations in Philadelphia and Pittsburgh permit them, and each city has a functioning program. Syringe exchange services have been well established as strategies for reducing the risk of bloodborne infections among persons who inject drugs.[12-16] Communities in Pittsburgh and Philadelphia identified as "more vulnerable" to bloodborne infections would also likely benefit from further expansion of existing syringe service programs. Communities that have been identified as "more vulnerable" to overdose deaths could benefit from the continued distribution of naloxone and use of fentanyl test strips, establishment of warm handoff case management teams, improved access to addiction treatment and rehabilitation, and public education on drug dosing and tolerance. The "best" interventions will be location-specific, and it is important that the results of this assessment be distributed to local and regional health departments, which have the greatest understanding of the culture and norms of the communities they serve. The lessons learned from the 2015 outbreak in Scott County, Indiana underscore these points.

As new data emerges about the resurgence of methamphetamines, it is crucial that, while deciding which interventions are best suited to a certain area, public health institutions also consider which health resources and intervention programs will transfer across drug types. For example, a syringe exchange program helps to reduce risk of bloodborne infections regardless of the drug being injected by providing sterile equipment, as well as potentially reducing risk of overdose, by connecting clients to local addiction treatment and/or medication-assisted therapy programs. Public education, community engagement (such as workforce preparation and alternative pain management programs), and increased awareness and access to mental health services are other examples of transferable interventions.

Although Pa. is beginning to see a decrease in opioid-related overdose, the epidemic is not over, and we must keep up with an ever-changing drug market. This statewide, granular assessment of Pa.'s overdose death and bloodborne infection risk provides a starting point from which Pa. can work towards more efficient allocation of health-related resources and targeted interventions that will prevent the spread of infectious disease and further decrease Pa. drug overdose deaths in both the short and long term.

Appendix A:
Figures and Tables

Table 1: Pennsylvania 2017 – 2018 County-level HCV Crude Rates per 100,000.

County	Rate	County	Rate	County	Rate	County	Rate	County	Rate
Blair	710.1	Somerset	290.5	Butler	235.6	Indiana	182.0	Franklin	138.1
Union	582.1	Lawrence	287.3	Potter	234.3	Huntingdon	180.5	Clarion	138.0
Tioga	455.6	Forest	280.3	Carbon	228.6	Bucks	175.3	Sullivan	125.1
Armstrong	419.6	McKean	278.5	York	220.8	Jefferson	167.7	Juniata	124.9
Cameron	398.6	Beaver	273.0	Erie	218.8	Pike	164.0	Delaware	123.4
Fayette	386.3	Fulton	268.9	Clearfield	216.5	Bedford	161.8	Northampton	117.3
Cambria*	377.8	Lackawanna	268.6	Elk	214.8	Lehigh	157.6	Berks	112.1
Wayne	364.3	Crawford*	263.6	Philadelphia	214.2	Snyder	157.6	Adams	108.5
Washington	338.0	Bradford	259.0	Mercer	208.4	Clinton	157.4	Montgomery	89.0
Greene	314.7	Wyoming	256.0	Allegheny	205.5	Monroe	153.3	Chester	61.6
Schuylkill	310.3	Mifflin	247.5	Perry	197.6	Dauphin	146.7	Centre	51.3
Columbia	299.4	Susquehanna	244.6	Lycoming	196.4	Lebanon	141.5		
Luzerne*	293.7	Westmoreland	244.3	Venango	183.5	Cumberland	141.5		
Montour	291.6	Northumberland	237.0	Warren	182.4	Lancaster	141.4		

*Counties identified through the original 2015 CDC vulnerability assessment as the most vulnerable for rapid dissemination of bloodborne infections resulting from unsterile injection drug use.[4]
Source: PA-NEDSS confirmed, acute and chronic hepatitis C cases first identified in 2017 and 2018 in those under age 40 and not in prison

Table 2: Pennsylvania 2017 county-level overdose crude death rates per 100,000.

County	Rate	County	Rate	County	Rate	County	Rate	County	Rate
Montour	87.4	Erie	42.8	Greene	32.1	Crawford*	25.3	Susquehanna	12.0
Philadelphia	75.8	Armstrong	42.0	Lancaster	30.9	Franklin	22.9	Union	11.1
Allegheny	69.5	Lackawanna	40.6	Monroe	30.5	Elk	22.7	Clearfield	9.9
Cambria*	63.3	Somerset	39.7	Lycoming	29.5	Jefferson	20.3	Snyder	9.9
Lawrence	57.8	Wyoming	39.6	Wayne	29.0	Schuylkill	20.1	Clinton	7.6
Fayette	56.3	York	38.7	Huntingdon	28.5	Columbia	19.5	Venango	7.6
Westmoreland	52.7	Bucks	38.3	Mifflin	28.0	Adams	17.7	Centre	7.5
Beaver	50.5	Indiana	38.1	Chester	27.8	Potter	17.6	Warren	7.4
Butler	48.4	Blair	37.7	Pike	26.9	Lebanon	17.4	Fulton	6.8
Lehigh	48.2	Cumberland	35.4	Northumberland	26.9	Tioga	16.8	Juniata	4.1
Washington	45.3	Dauphin	35.1	Berks	26.7	Sullivan	16.1	Cameron	0.0
Delaware	44.6	Bedford	34.8	Perry	26.2	Clarion	15.5		
Carbon	43.8	Northampton	34.6	Bradford	26.0	McKean	14.3		
Luzerne*	43.1	Mercer	32.6	Montgomery	25.9	Forest	13.5		

*Counties identified through the original 2015 CDC vulnerability assessment as the most vulnerable for rapid dissemination of bloodborne infections resulting from unsterile injection drug use.[4]
Source: Bureau of Health Statistics and Registries and PDMP overdose death cases reported in 2017

Figure 1: Pa. county-level HCV case Crude Rates for 2017-18 Overlaid with Hot Spots.

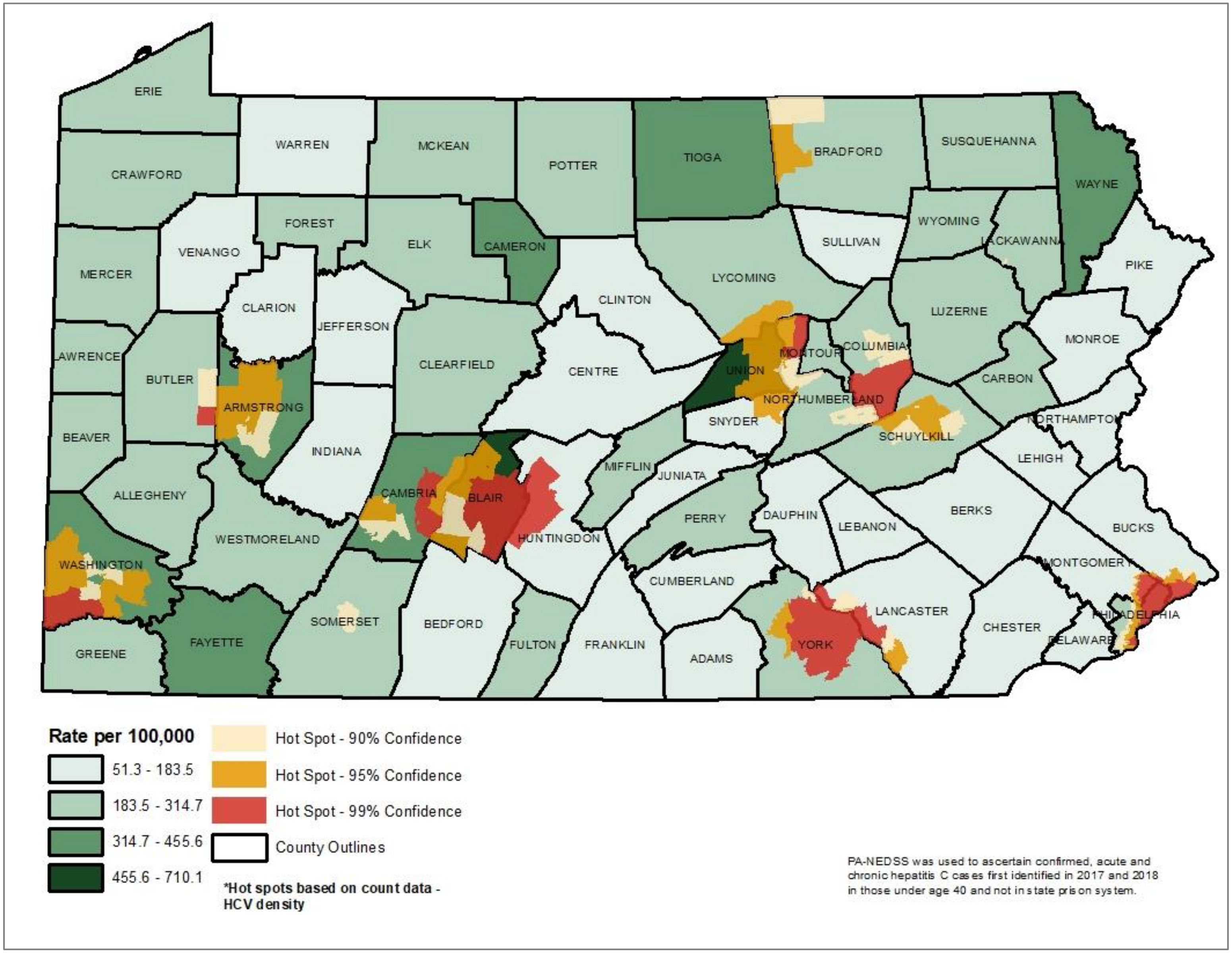


Figure 2: Pa. County-level Overdose Death Crude Rates for 2017 Overlaid with Hot Spots.

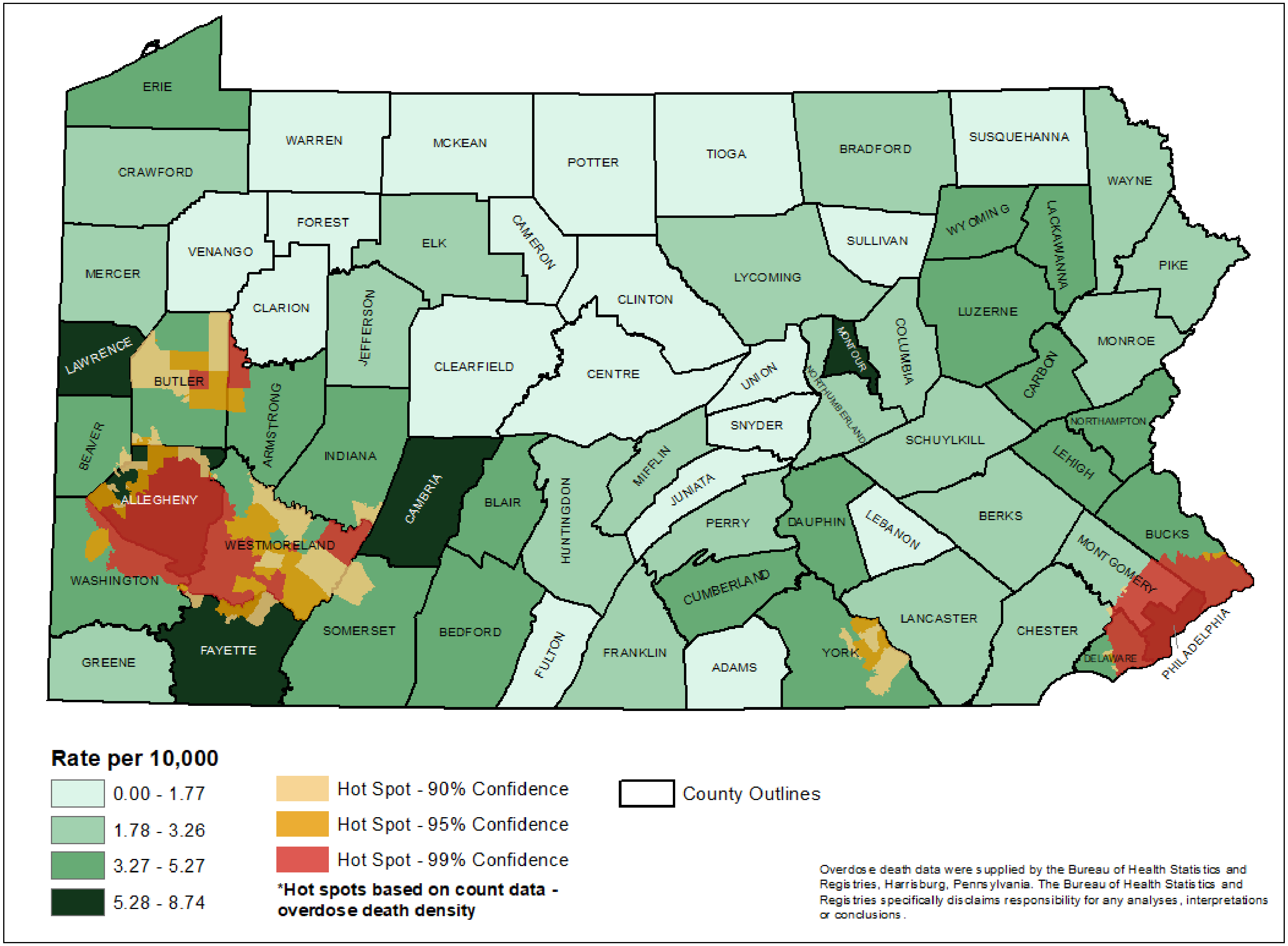


Figure 3: Predicted Census Tract Vulnerability to Bloodborne Infections by the HCV Case Model using Jenks Method.

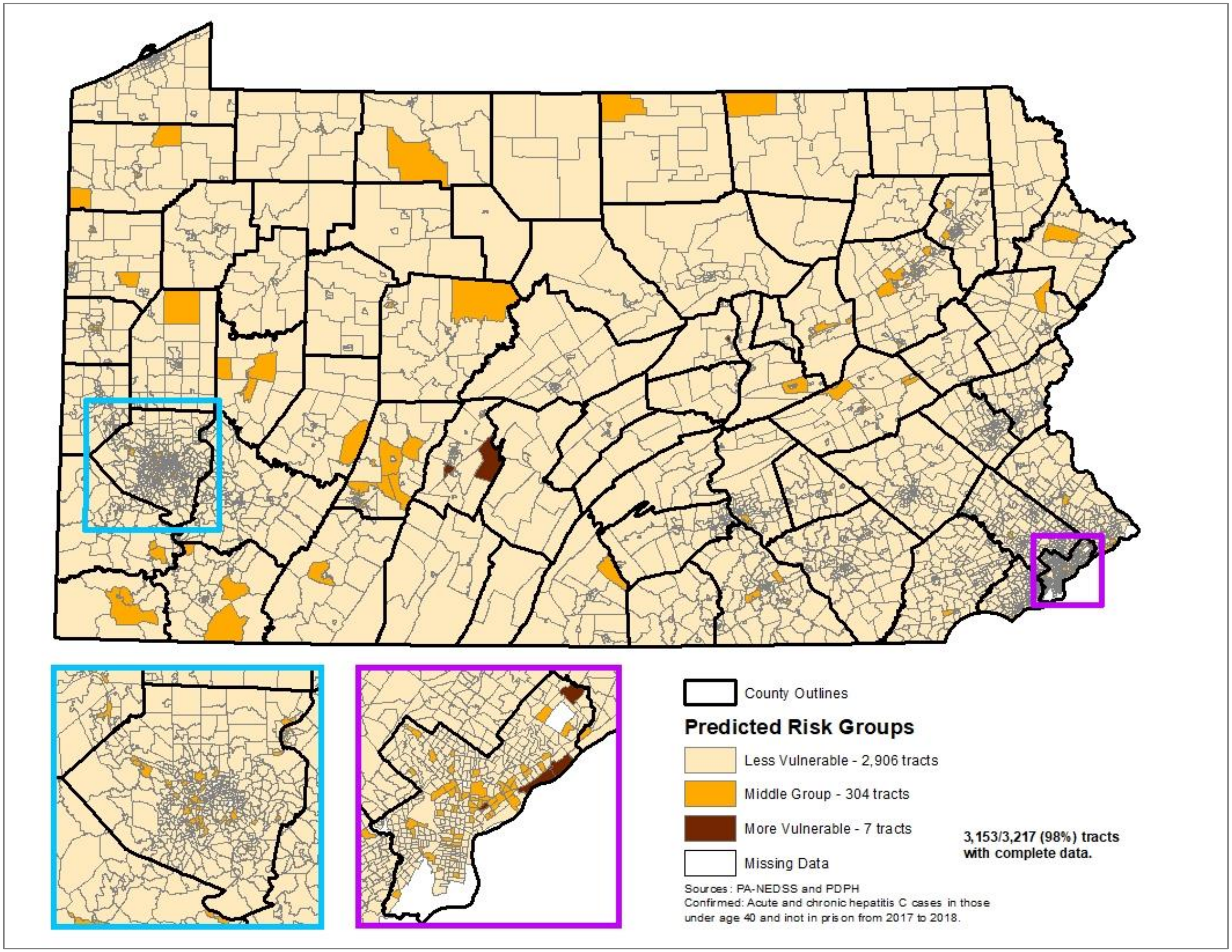


Figure 4: Predicted Census Tract Vulnerability to Overdose Deaths by the Overdose Death Model Using Jenks Method.

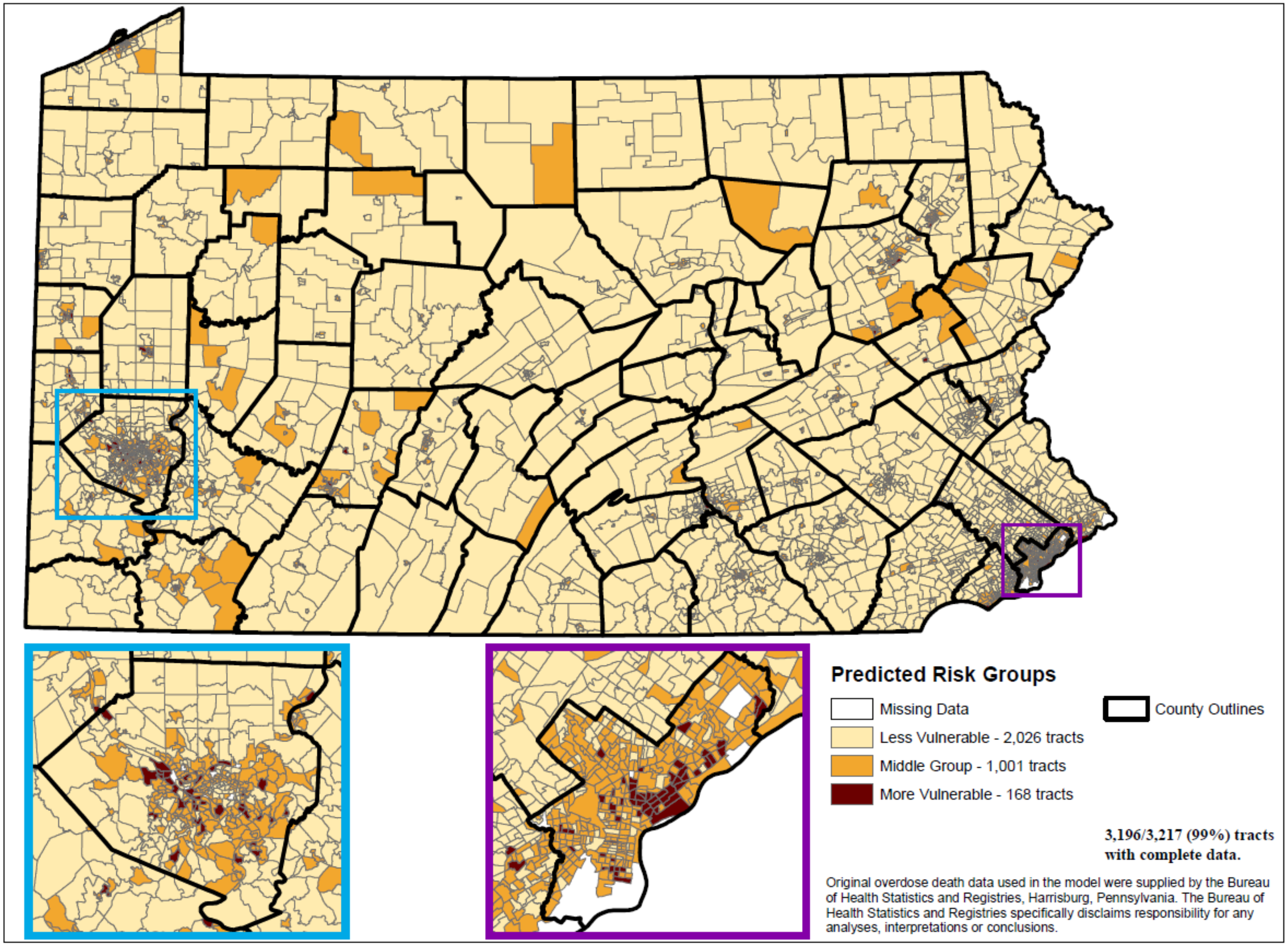


Figure 5: Predicted Census Tract Vulnerability to Bloodborne Infections by the HCV Case Model Using Quartiles.

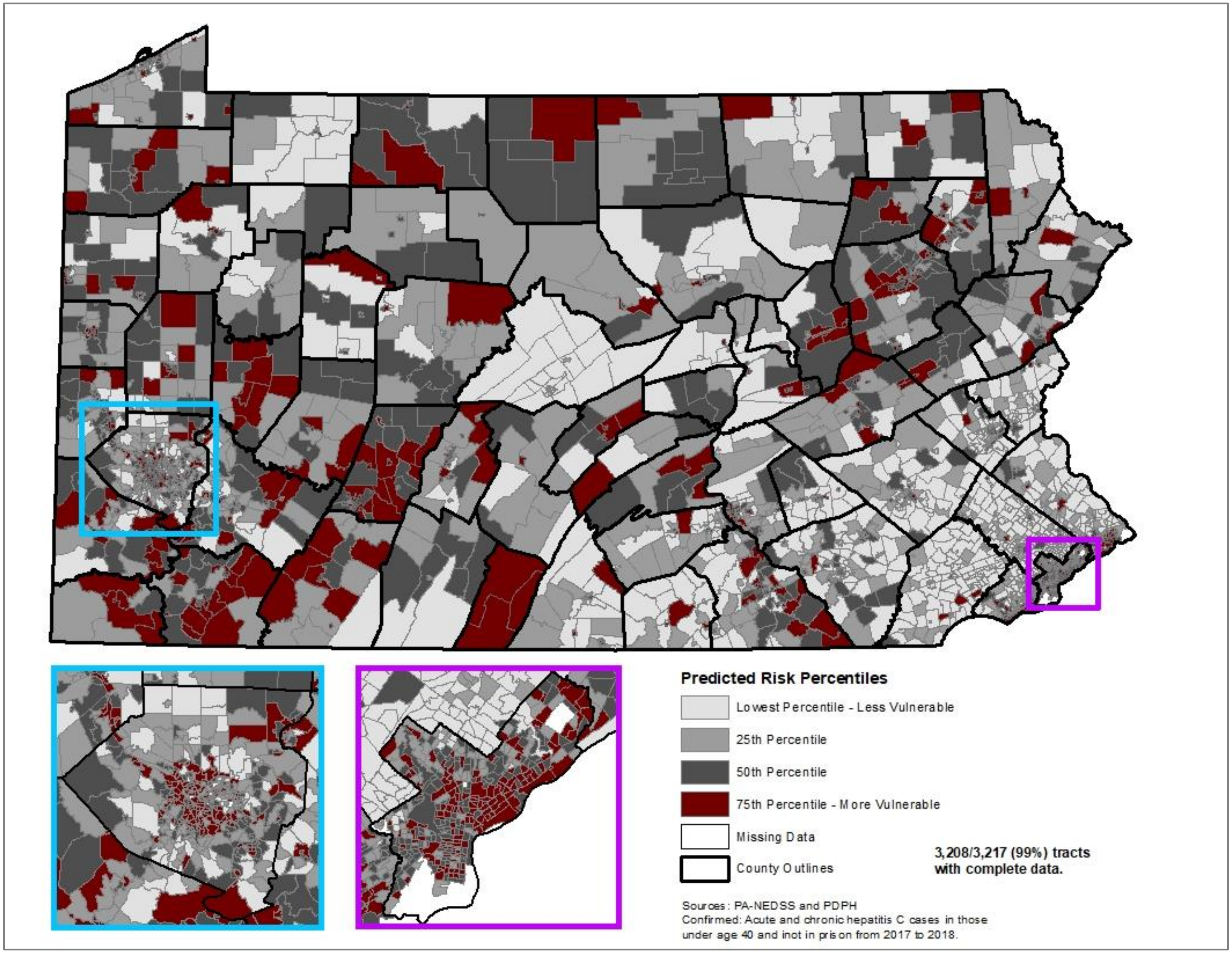
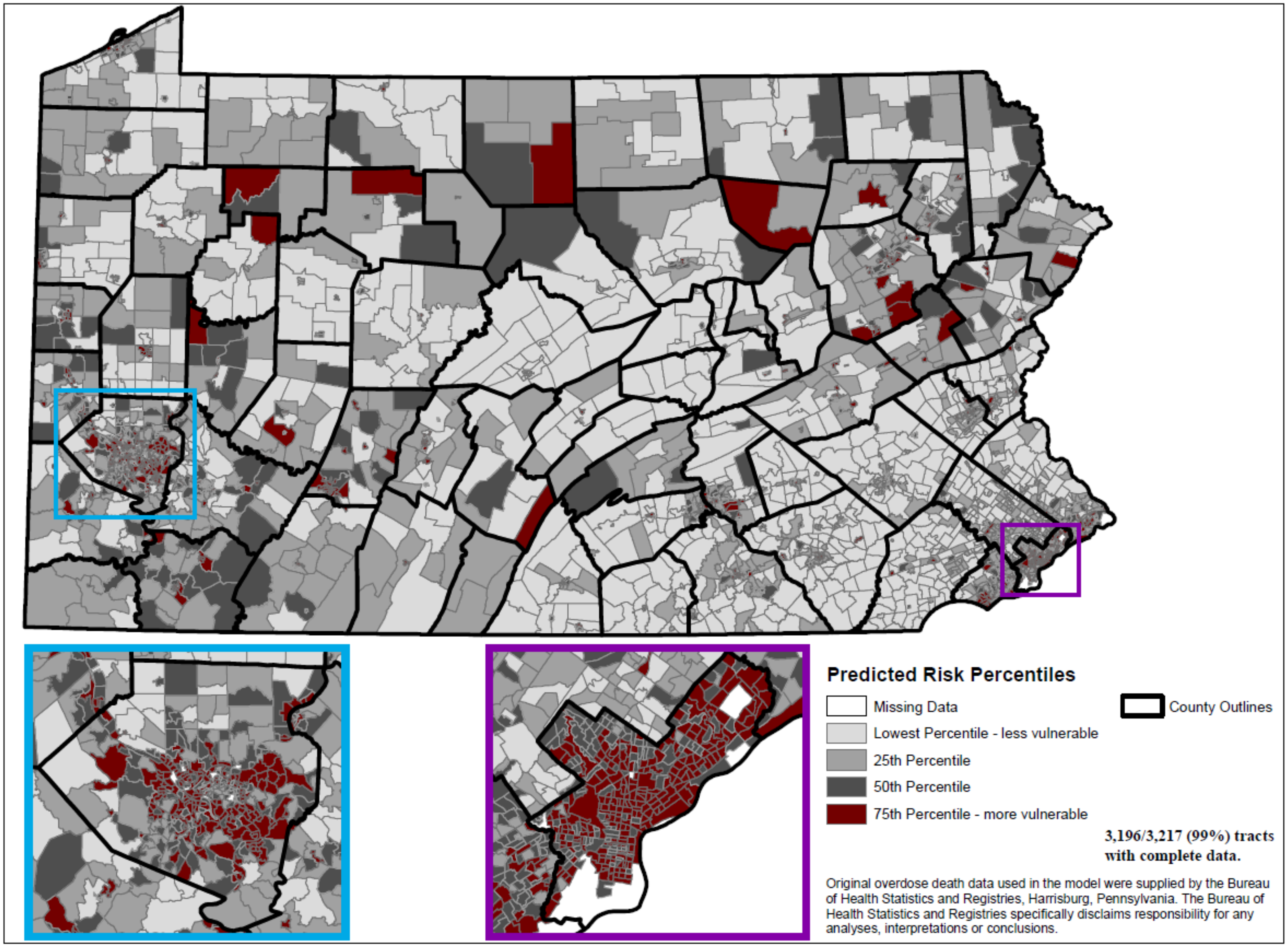


Figure 6: Predicted Census Tract Vulnerability to Overdose Deaths by the Overdose Death Model Using Quartiles.



Appendix B:
Supplementary Figures and Tables

Table S1: List of Indicator Variables Considered for Use in Pa.'s assessment.

Variable	Source	Year(s)
Population decline (y/n)	American Community Survey (ACS)	2010-2017
Percent unemployed ♦	ACS	2017
Percent uninsured	ACS	2017
Percent without a high school diploma ♦	ACS	2017
Percent non-Hispanic white	ACS	2017
Percent vacant housing ♦	ACS	2017
Percent crowded housing	ACS	2017
Percent of households without vehicle access	ACS	2017
Per capita income	ACS	2017
Log per capita income	ACS	2017
Teen birth rate (per 1,000) ♦	ACS	2017
Gini index ♦	ACS	2017
Percent rural ♦	ACS	2010
Rural/Urban classification	National Center for Health Statistics	2013
Overall social vulnerability index (SVI) score	Agency for Toxic Substances and Disease Registry (ATSDR)	2016
SVI theme 1 score (socioeconomics)	ATSDR	2016
SVI theme 2 score (household composition & disability)	ATSDR	2016
SVI theme 3 score (minority status & language)	ATSDR	2016
SVI theme 4 score (housing & transportation)	ATSDR	2016
Average number of poor physical health days (age-adjusted)	County Health Rankings (CHR) Report	2016
Average number of poor mental health days (age-adjusted)	CHR Report	2016
Percent reporting poor/fair health (age-adjusted) ♦	CHR Report	2016
Premature death rate (YPLL before age 75 per 100,000; age-adjusted) ♦	CHR Report	2015-2017
Rate of average daily MME > 50 (per 10,000)	PDMP Information Data Report (IDR)	2017
Rate of average daily MME > 90 (per 10,000) ♦	PDMP IDR	2017
Rate of average daily MME > 120 (per 10,000)	PDMP IDR	2017
Opioid (excluding buprenorphine) dispensation rate (per 10,000)	PDMP IDR	2017
Opioid (excluding buprenorphine) prescription rate (per 10,000) ♦	PDMP IDR	2017
Chlamydia rate (per 100,000)	PA STD Program	2017
Gonorrhea rate (per 100,000)	PA STD Program	2017
Syphilis rate (per 100,000) ♦	PA STD Program	2017
HIV incident rate (per 100,000) ♦	PA HIV/AIDS Surveillance and Epidemiology	2017

♦ indicates inclusion in the principal components analysis

ACS 2017 5-year estimates used

Figure S1: Hot spot map of HCV case rates per 100,000.

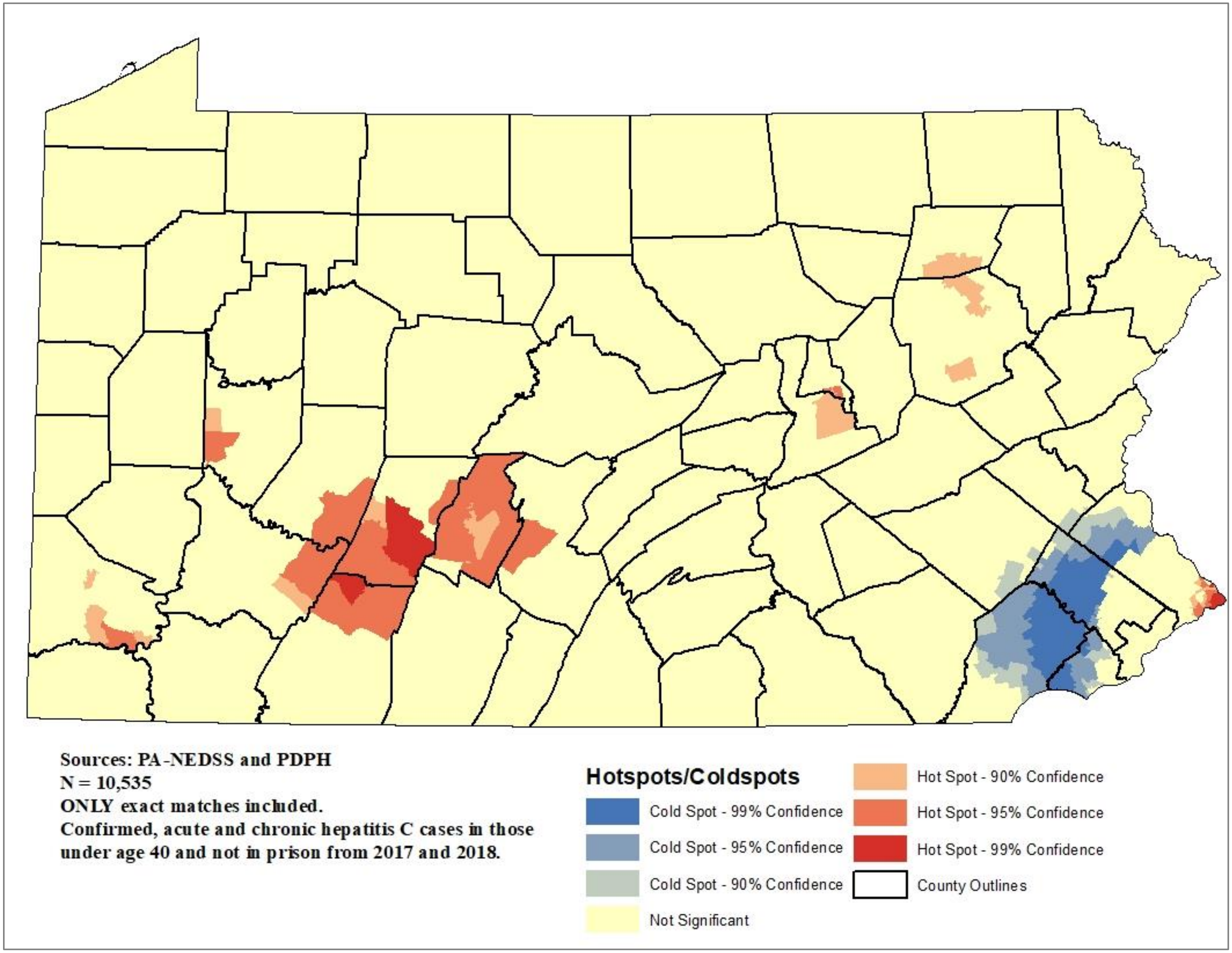
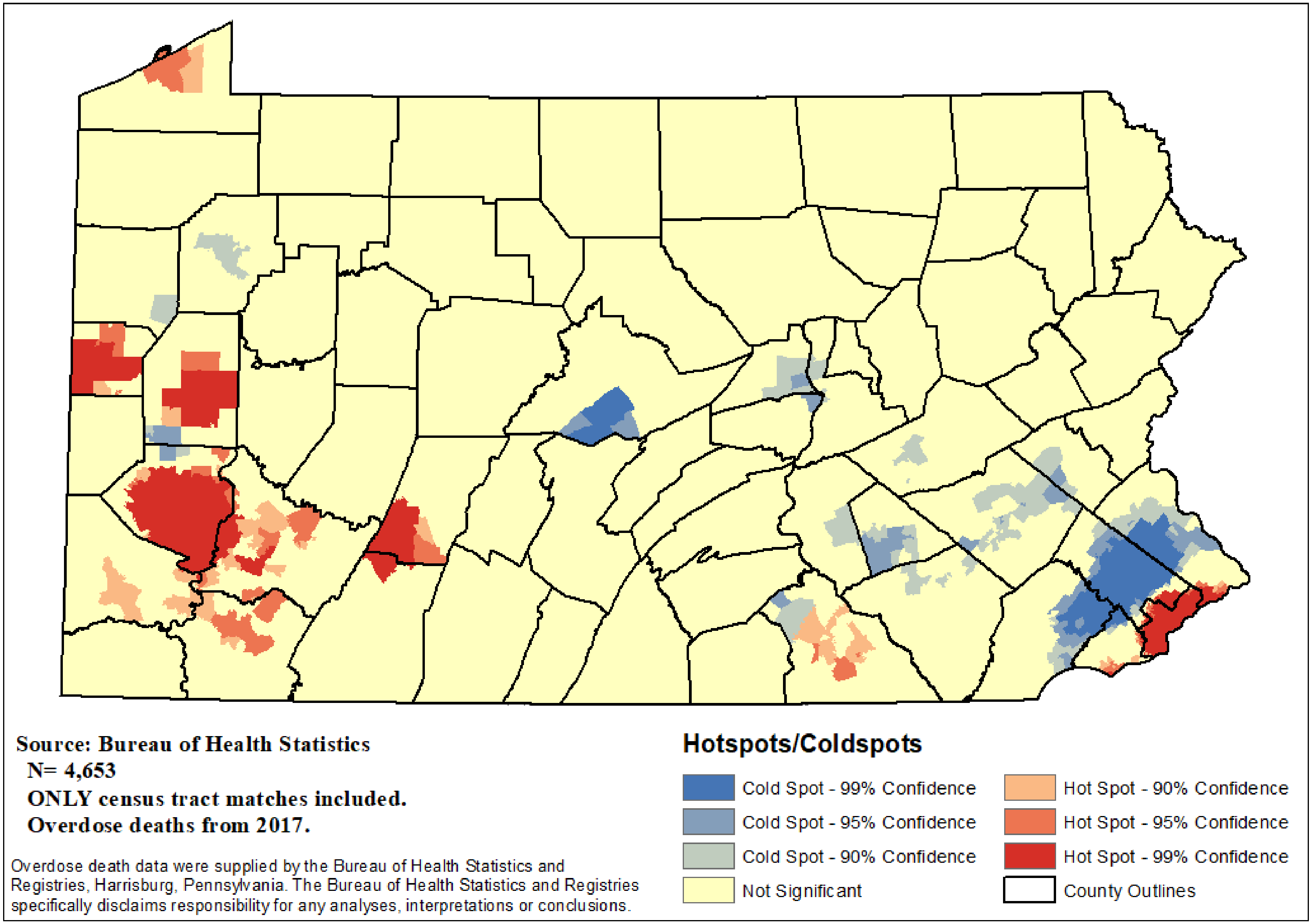


Figure S2: Hot spot map of overdose death rates per 100,000.



Citations

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