



# Comparative Analysis of Service Area Boundaries and Drinking Water Quality Disparities

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# Background and Motivation

**Background:** Executive Orders 12898 and 14096 direct EPA to identify disproportionate impacts of its rules and policies on minority and low-income populations.

**Motivation:** We have limited evidence on how our conclusions in regulatory impact analyses might be affected by the selection of service area boundary type.

## Research Objectives:

1. Provide evidence on the extent of disparities in drinking water quality.
2. Test the sensitivity of environmental justice analyses to the selection of service area boundary representation.



# Research Methods

We take five steps to answer our primary research question.

1. Generate seven metrics of drinking water quality for every public water system.
2. Estimate public water system demographic shares according to each specific boundary type.
3. Calculate demographic-specific population-weighted average drinking water quality metrics.
4. Compute relative risk ratios from a population of EJ concern to an exclusive comparison group.
5. Compare how the relative risks differ according to the service area representation for groups of EJ concern.



# The Drinking Water Quality Metrics

We construct **7 metrics of drinking water quality** for each public water system:

Metric	Year Range	Population-Weighted Average	System Count
<a href="#">Count of Health-based SDWA Violations</a>	2015-2023	1.354	45,492
<a href="#">Lead Action Level Exceedances</a>	1991-2023	0.455	45,492
<a href="#">Disinfection Byproduct Concentrations</a>	2006-2019	29.1 (ug/l)	34,413
<a href="#">Count of Unique PFAS detected</a>	2013-2023	0.884	9,885
<a href="#">Total Coliform Detection Share</a>	2006-2019	0.022	35,085
<a href="#">Arsenic Concentrations</a>	2006-2019	0.001 (mg/l)	37,627
<a href="#">Nitrate Concentrations</a>	2006-2019	1.06 (mg/l)	30,297



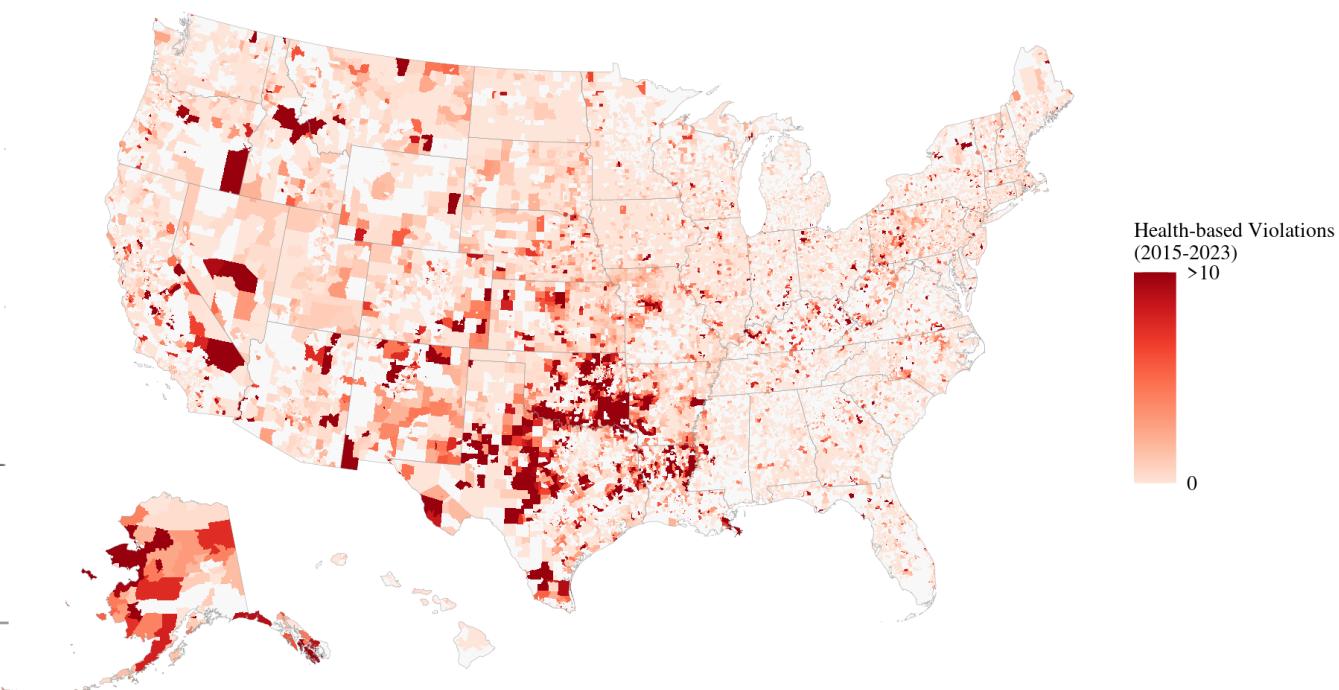
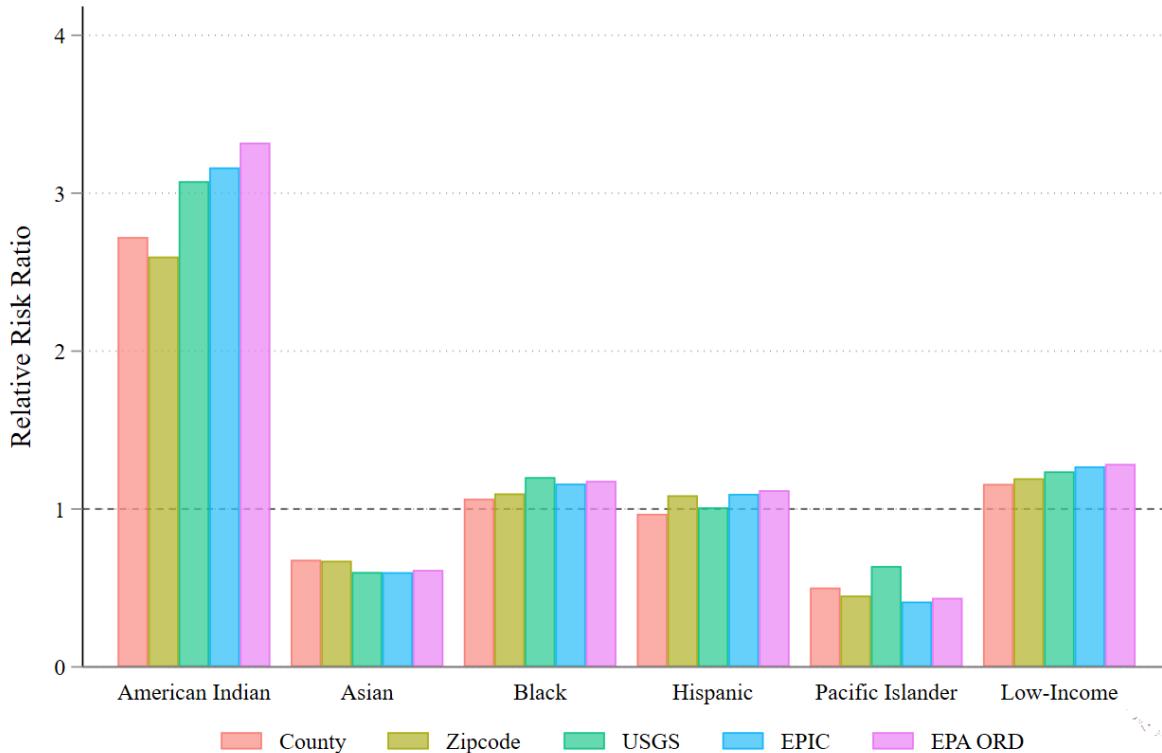
# The Service Area Boundaries

We compare 5 approaches for approximating service area boundaries nationally:

- County served
- Zip code served
- United States Geological Survey (USGS)
- Environmental Policy Innovation Center (EPIC)/SimpleLab boundaries
- Hall & Murray (EPA/ORD) boundaries

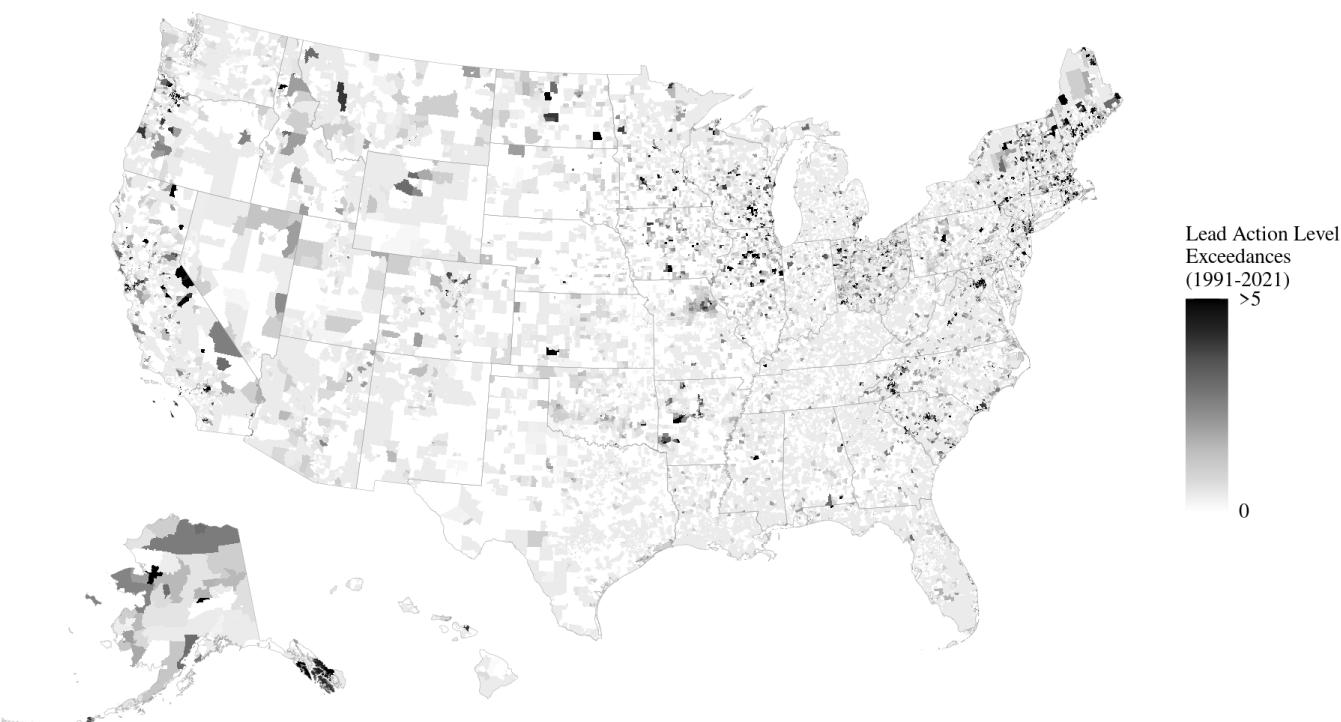
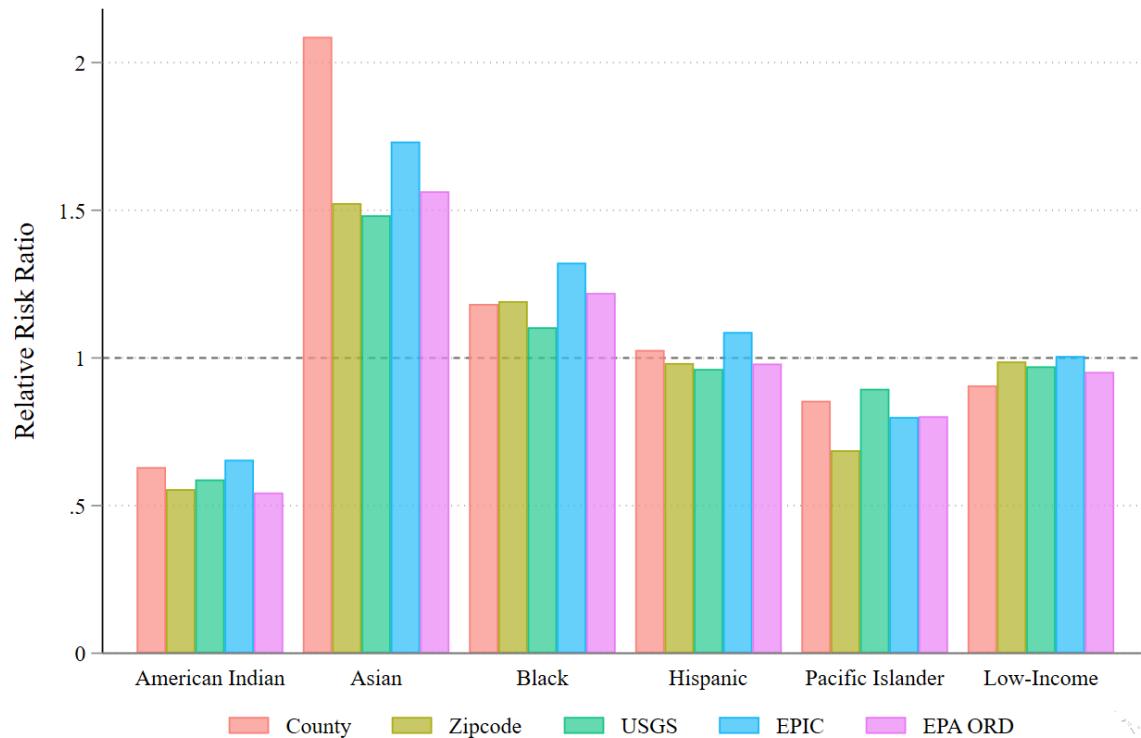
# Health-based SDWA Violations

Notes: The comparison group for each relative risk ratio is non-Hispanic White individuals except for the low-income ratio, where the reference category is all individuals with income above twice the federal poverty limit.



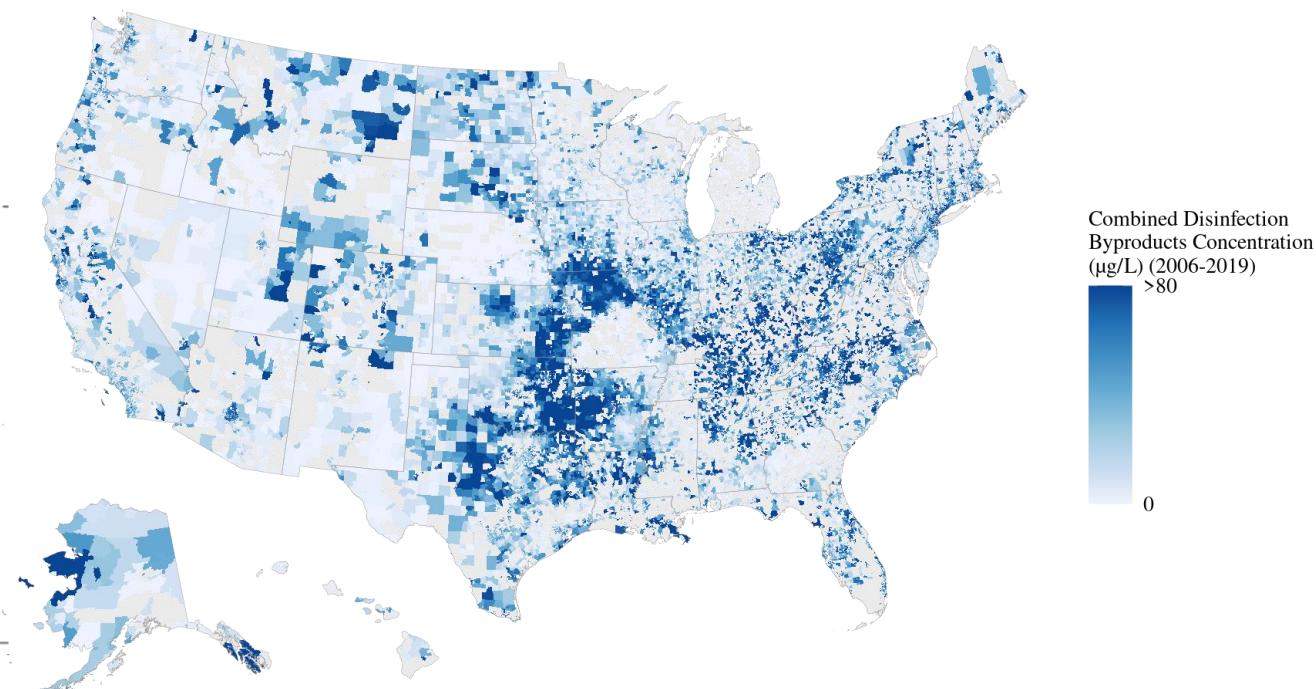
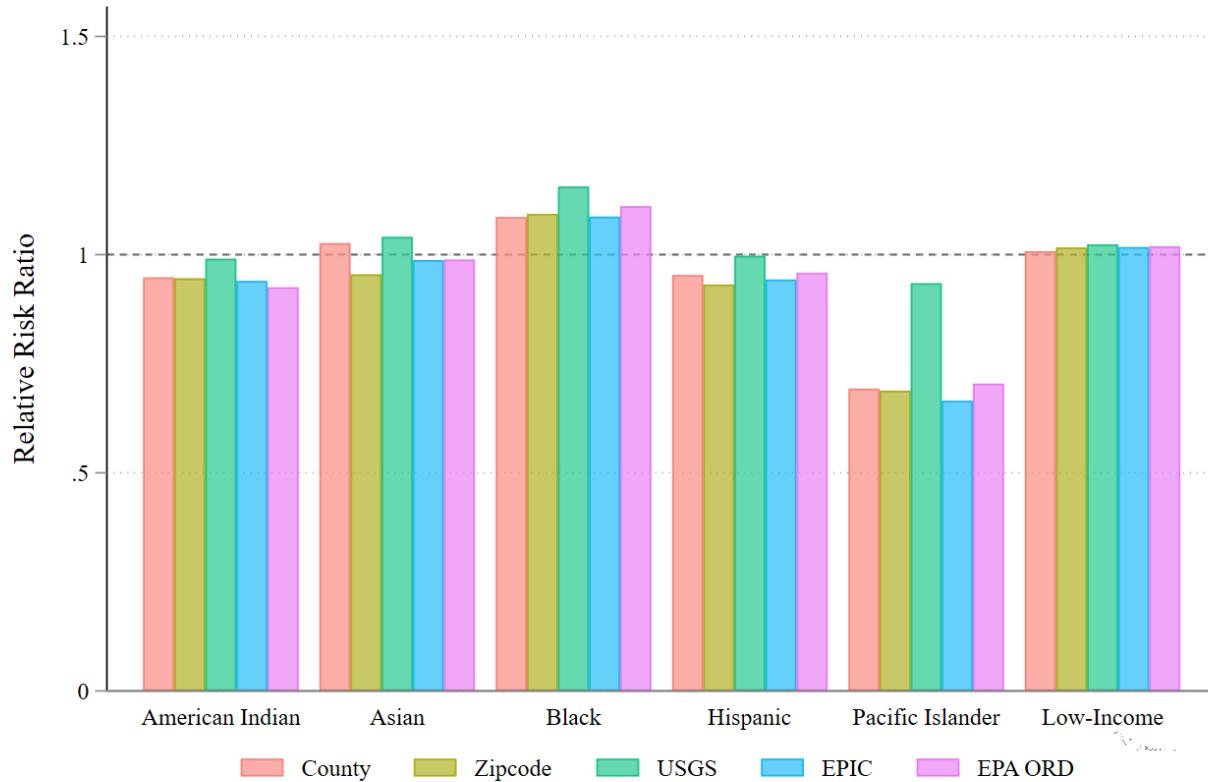


# Lead Action Level Exceedances



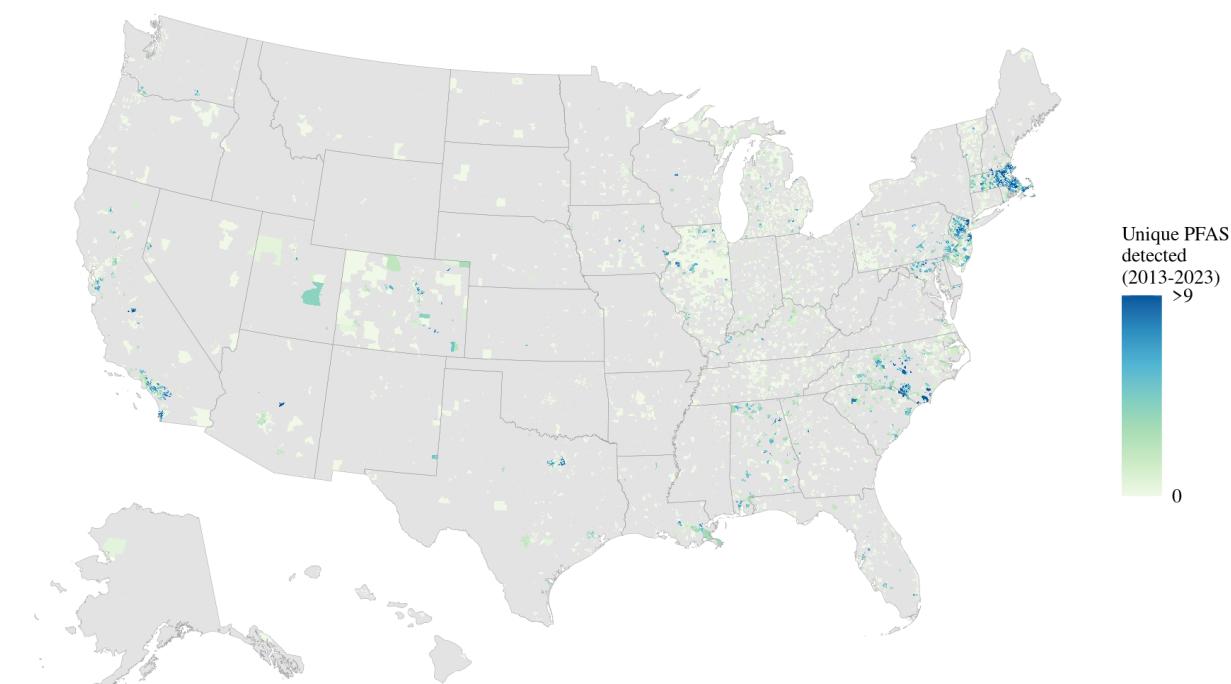
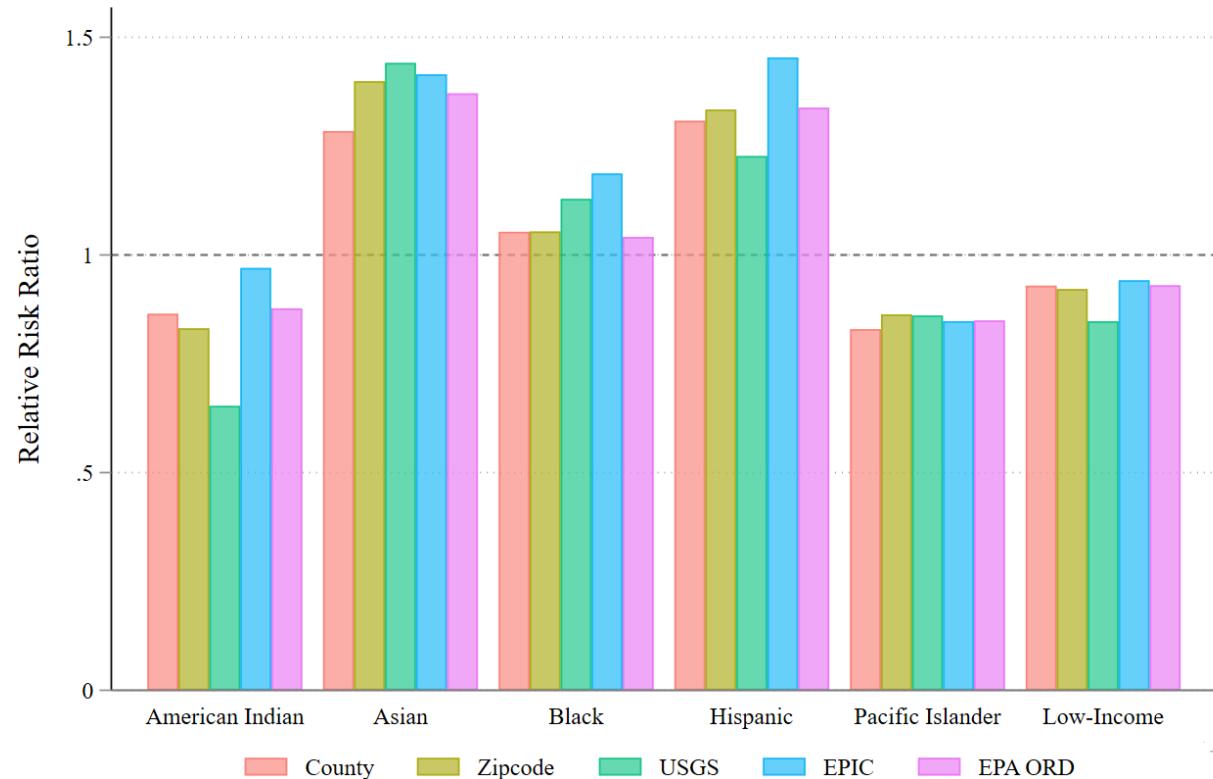


# Disinfection Byproduct Concentrations



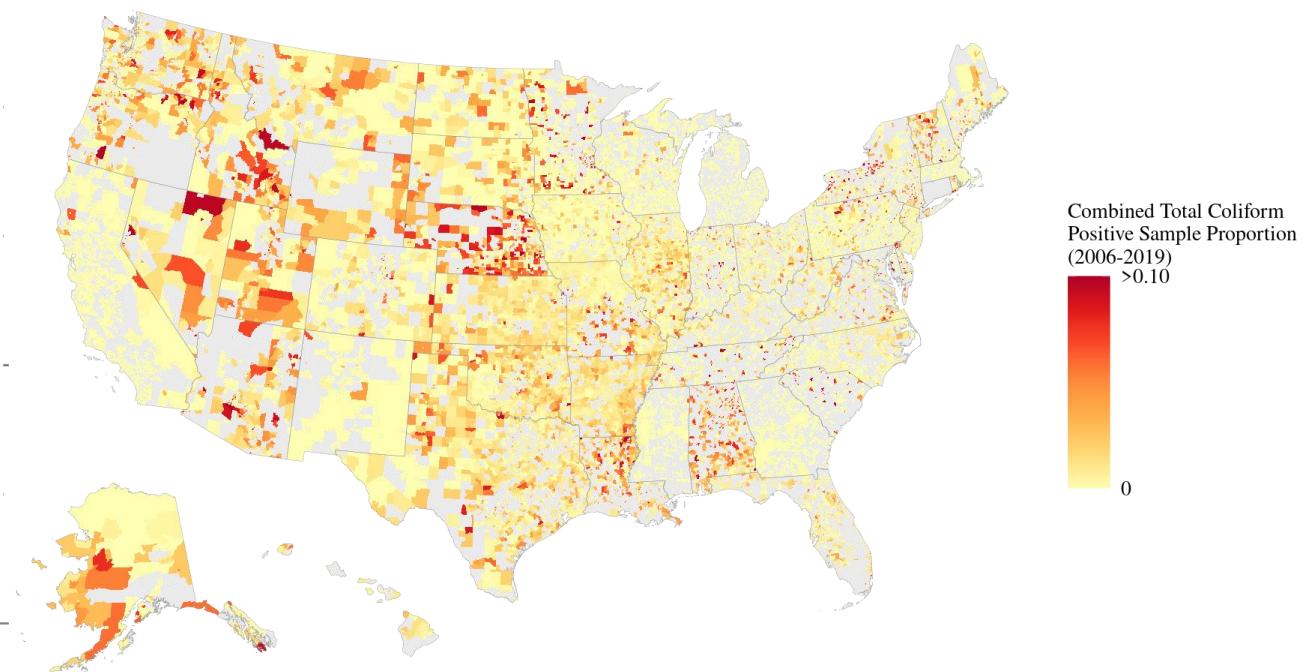
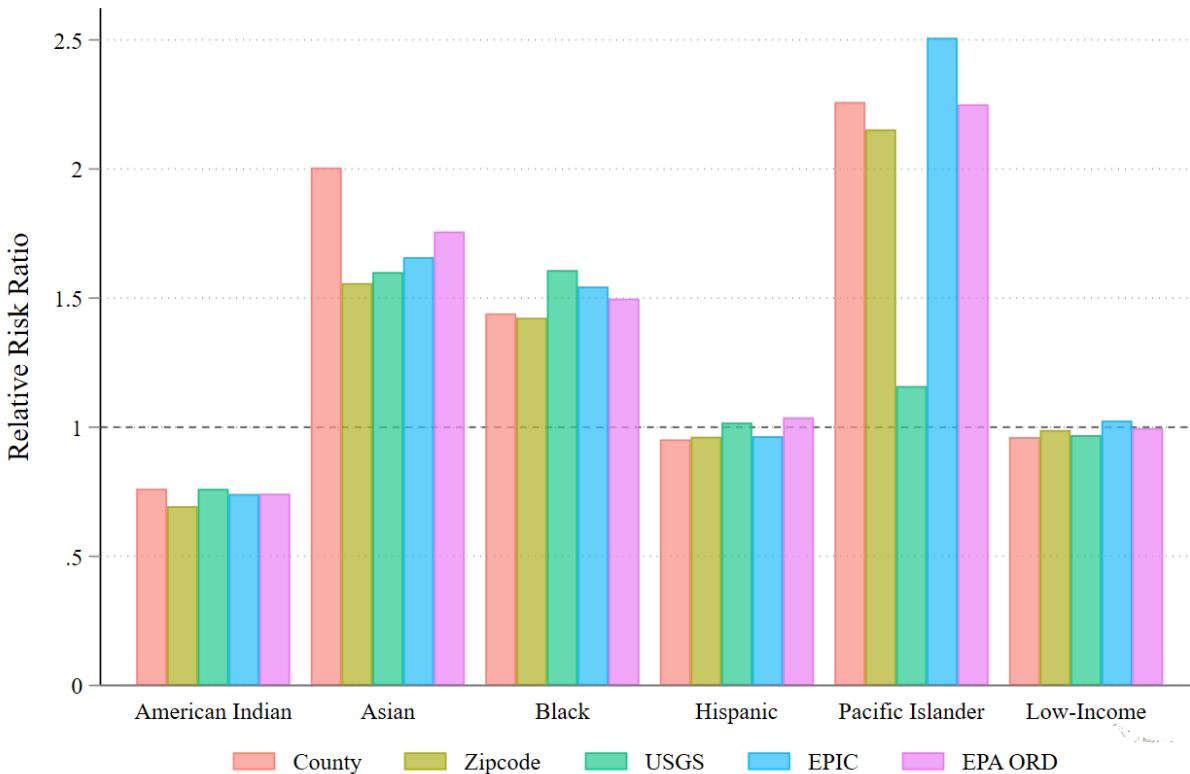


# Count of Unique PFAS Detected



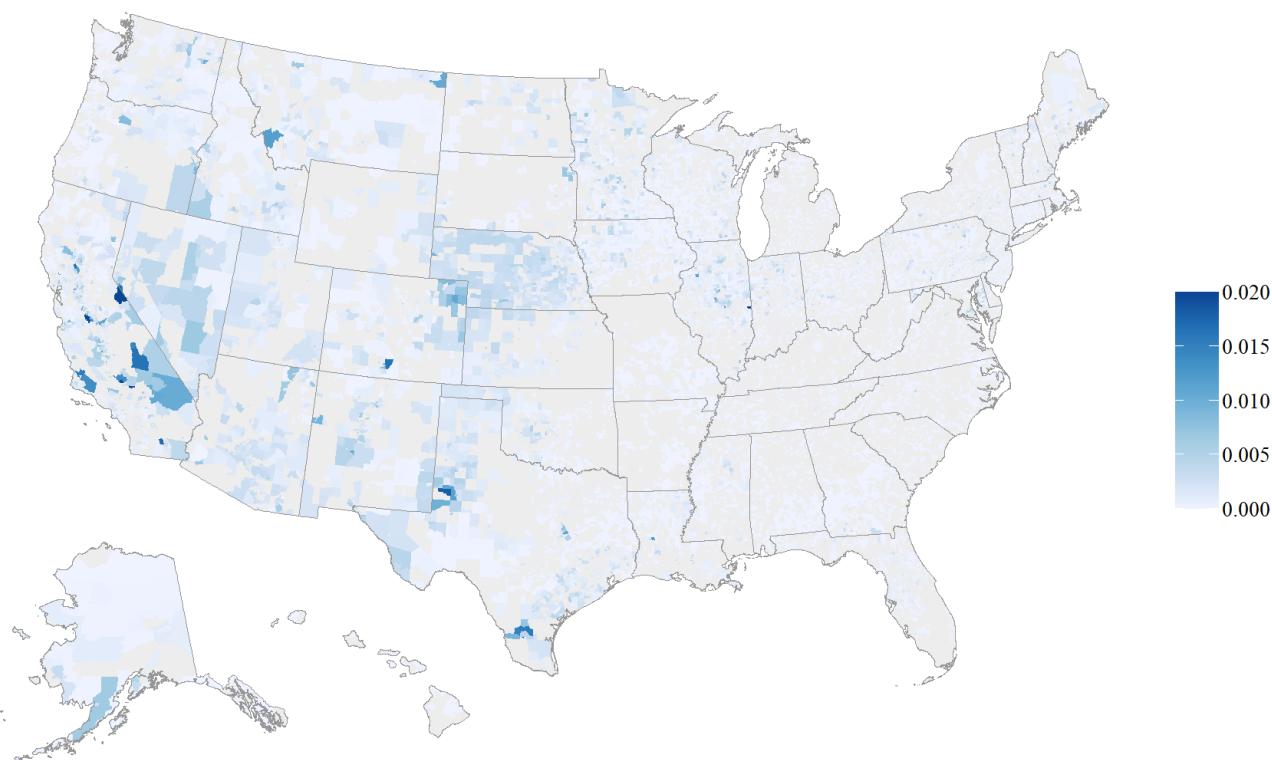
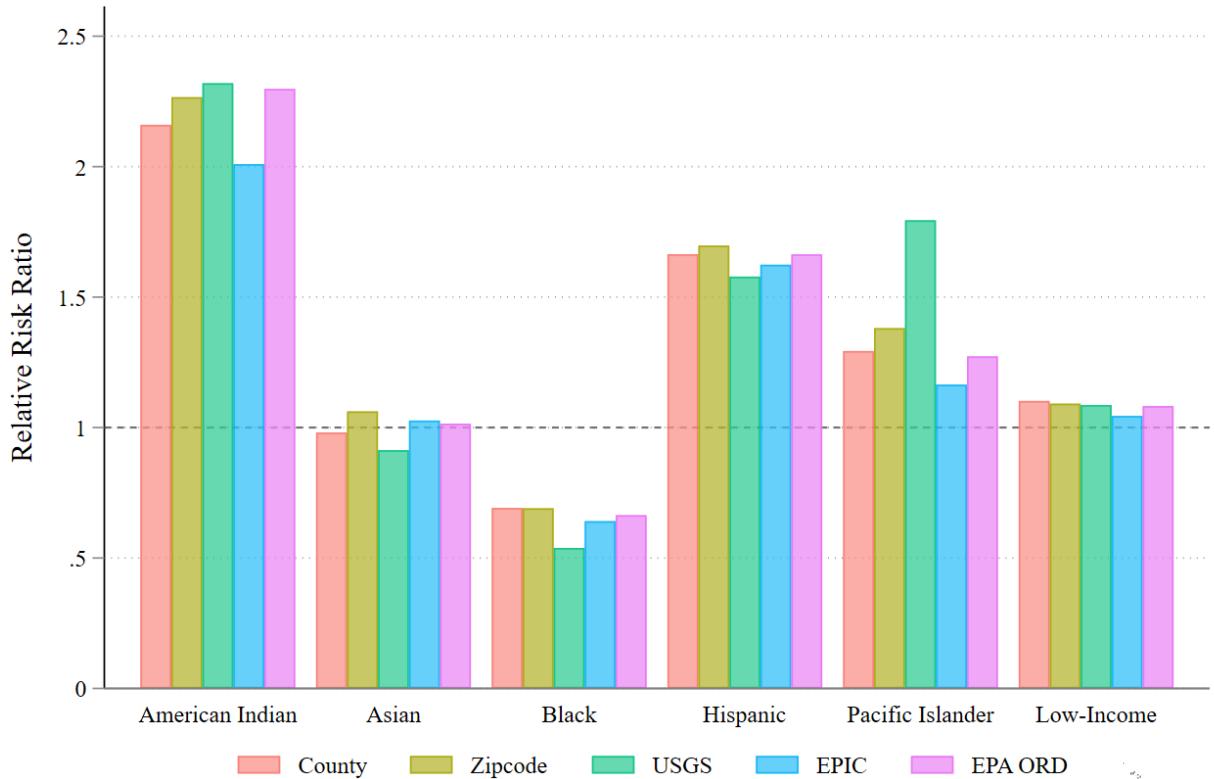


# Total Coliform Detection Share



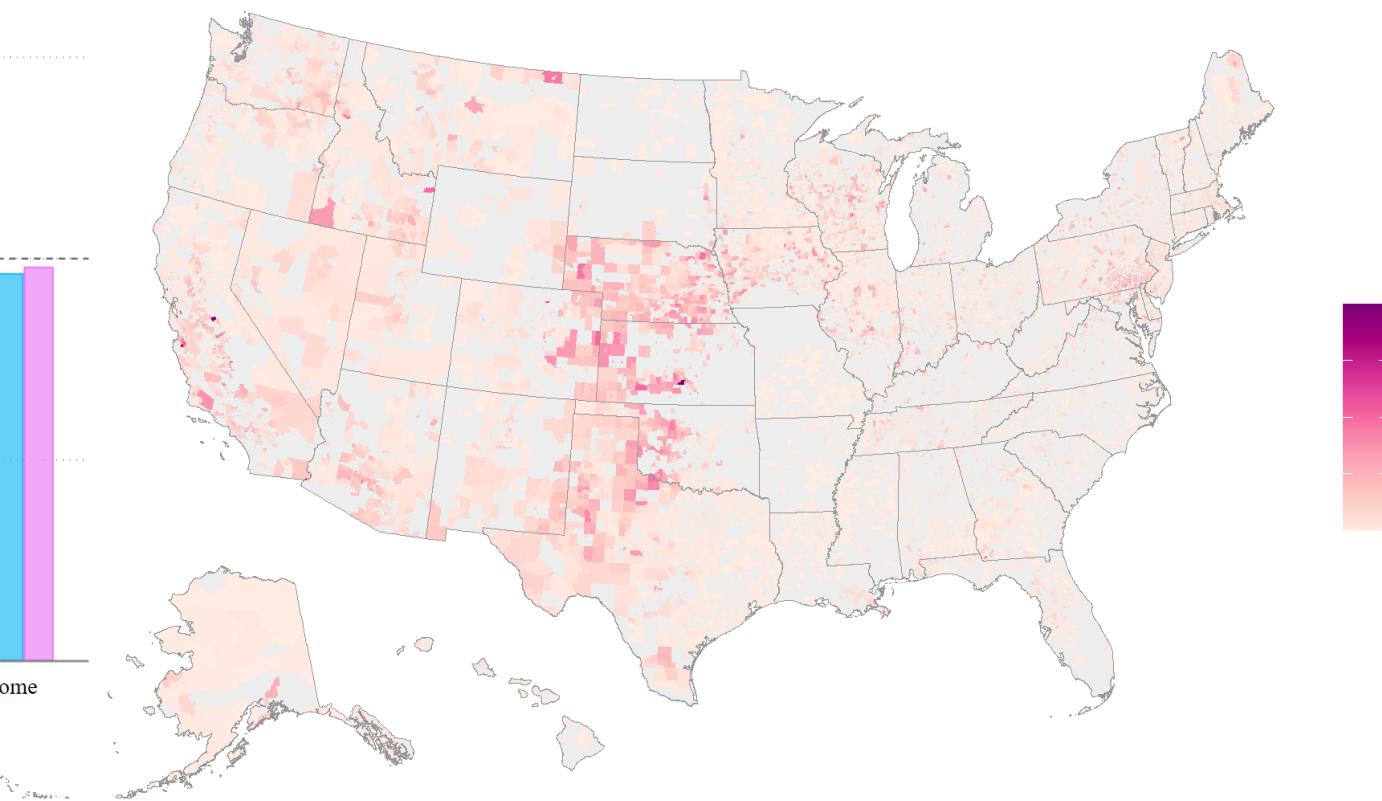
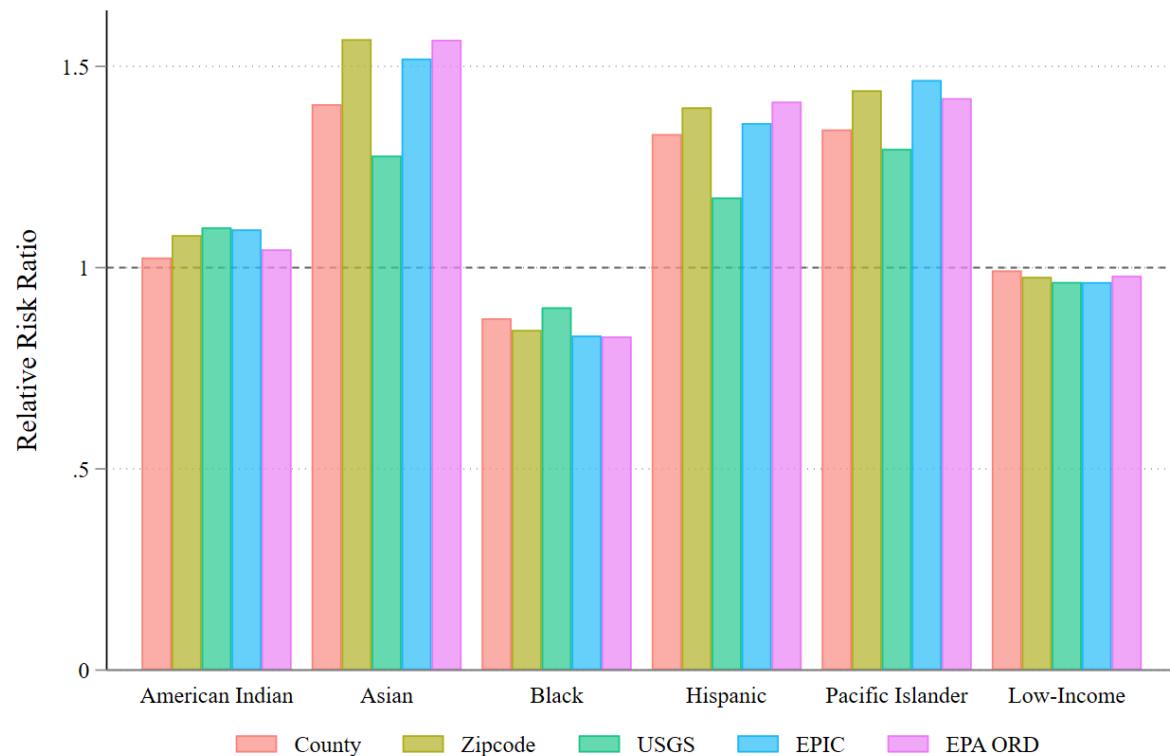


# Arsenic Concentrations (mg/l)





# Nitrate Concentrations (mg/l)





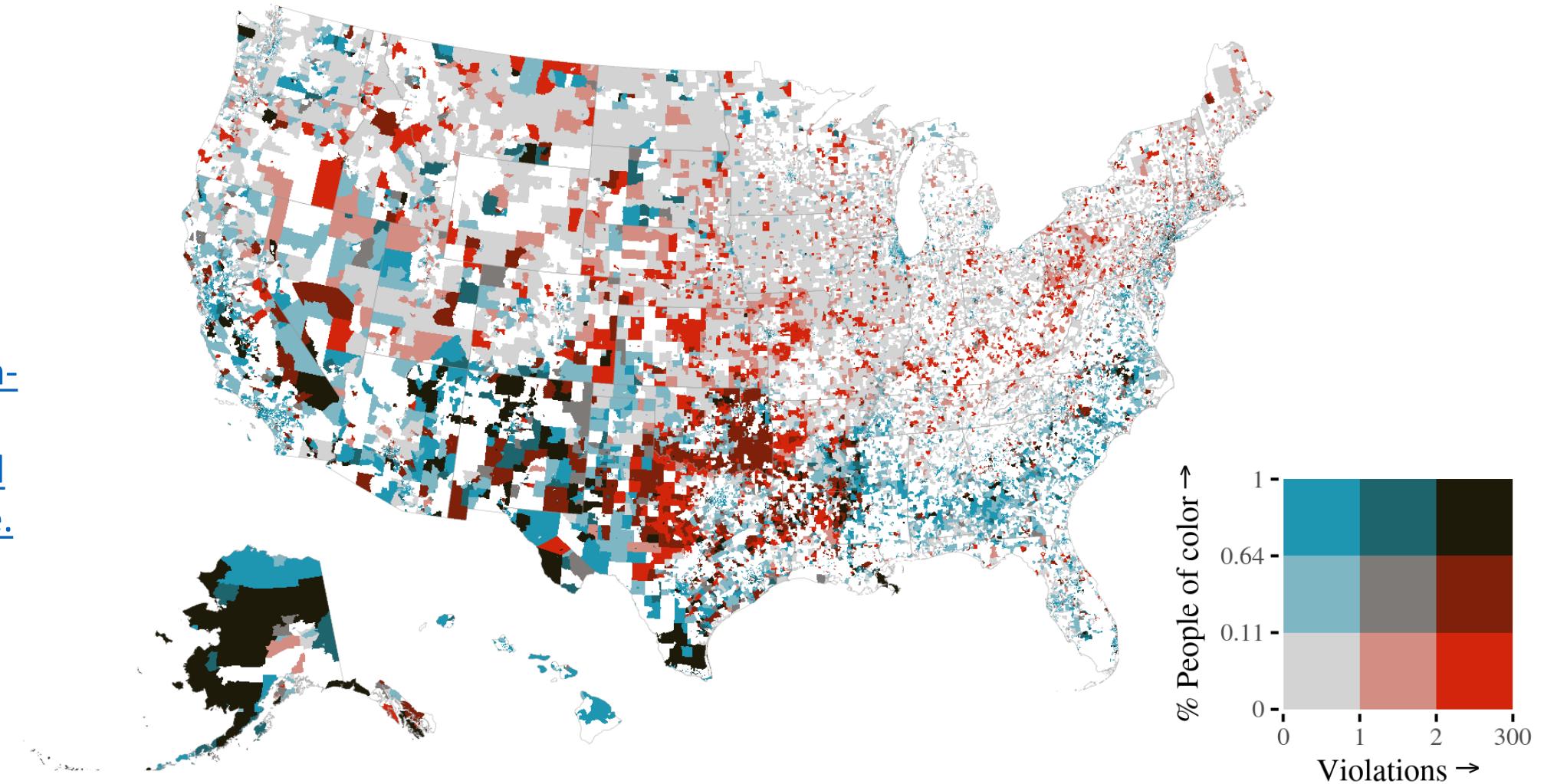
# Bivariate Maps of DW Quality

Produce bivariate national and state maps at the Census block group level:

- Highlights patterns in drinking water quality across a wide geographic region
- Illustrates disparities with respect to race and income across indicators
- Helps to identify hotspots of environmental justice concern

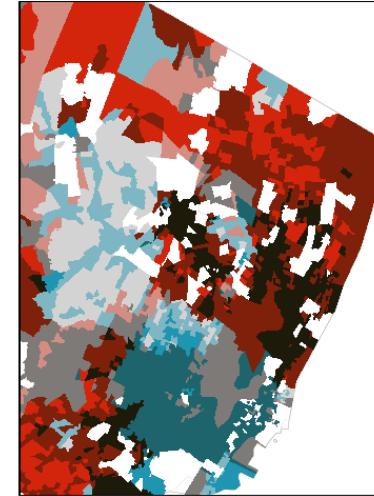
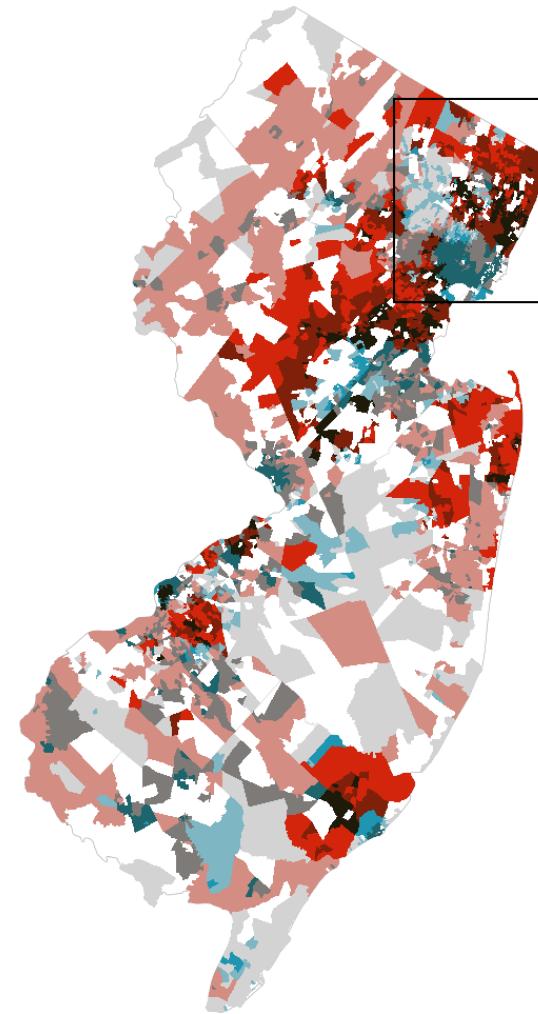
# Health-based violations and % POC

See bivariate  
map of health-  
based  
violations and  
% low income.

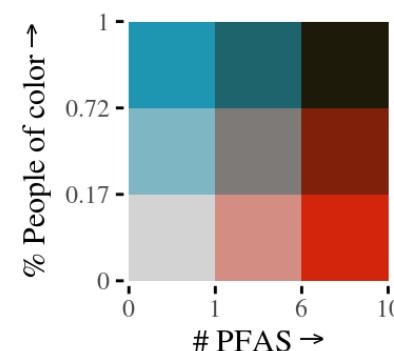




# New Jersey: PFAS detected

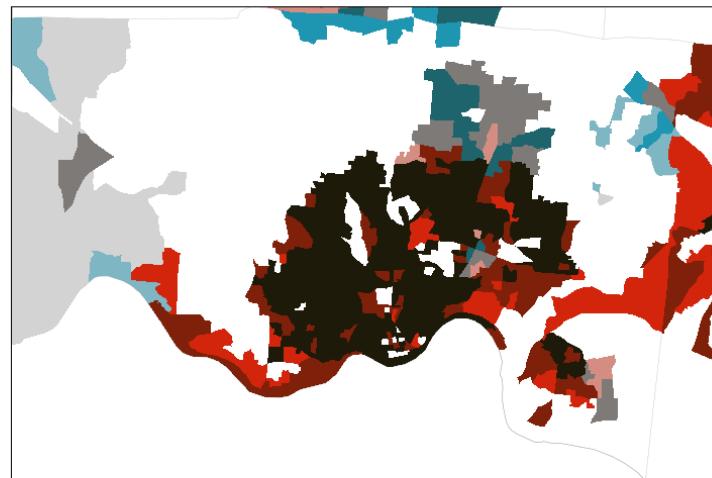
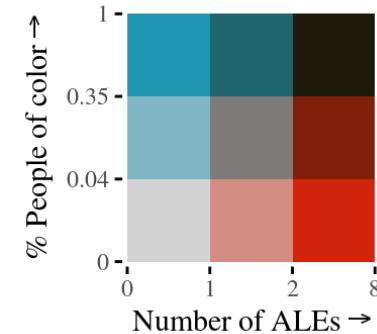


Essex, NJ

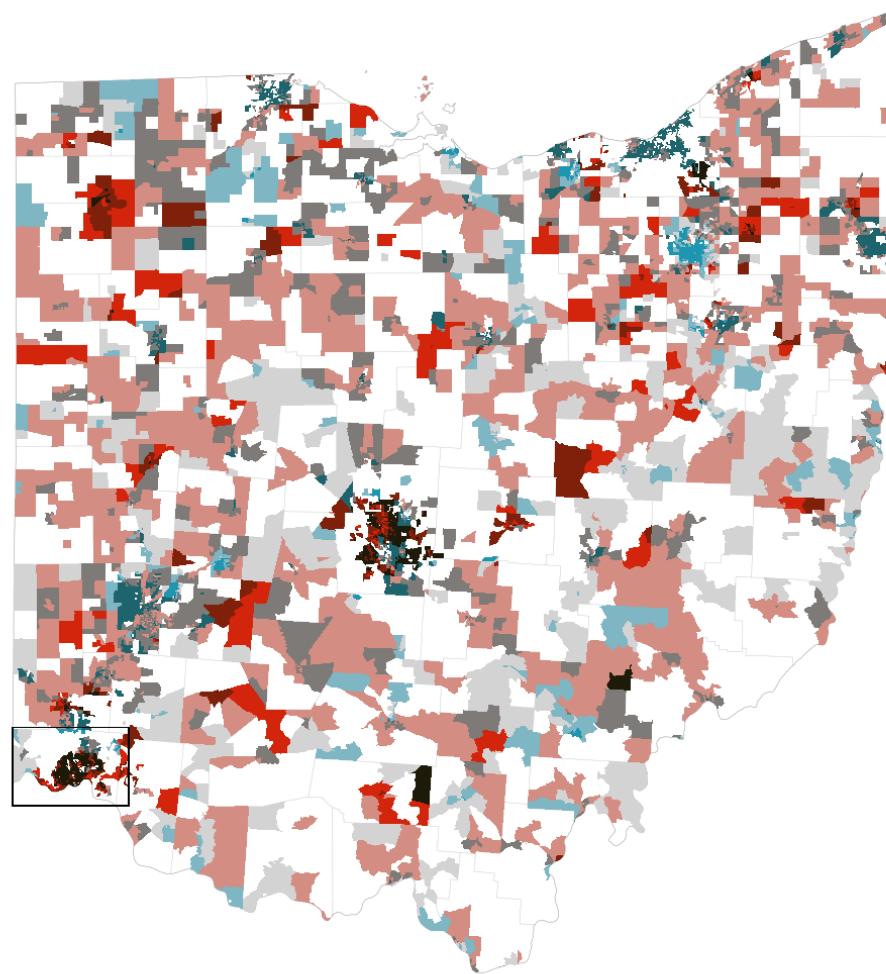




# Ohio: Lead Action Level Exceedances

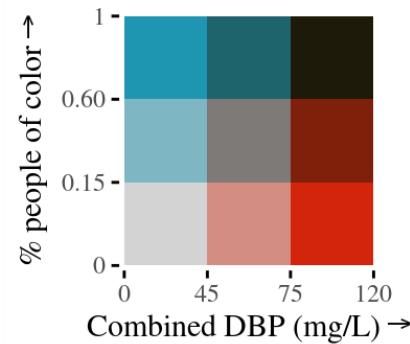


Hamilton County, OH





# North Carolina: Disinfectant Byproducts



Forsyth, NC





# Thank you for listening.

Questions/comments?

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# Appendix Slides

# Computing Indicators by Demographic Group

For each drinking water indicator  $i$  and service area boundary representation, we compute the **average population-weighted drinking water indicator** for group  $j$ :

$$Indicator_{ij} = \frac{\sum_{k \in PWS}^K PopulationShare_{ijk} * PopulationServed_{ijk} * Indicator_{ijk}}{Total Population Served_j}$$

- $PopulationShare_{ijk}$  variables are determined using areal apportionment over the service area boundary representation and multiplied by the population served according to SDWIS,  $PopulationServed_{ijk}$ .
- The total population per system remains constant while the total population of each demographic group varies across service area boundary representations.

# Constructing Relative Risk Metrics

We then construct **relative risk ratios** that compare the relative exposure for an EJ population group of concern  $u$  to the exposure of a comparison group  $v$ .

$$\text{Relative Risk}_i = \frac{\text{Indicator}_{iu}}{\text{Indicator}_{iv}}$$

Two general type of comparisons:

- Compare minority populations to non-Hispanic white individuals.
- Compare individuals with income below twice the federal poverty limit to those with incomes above twice the federal poverty limit.

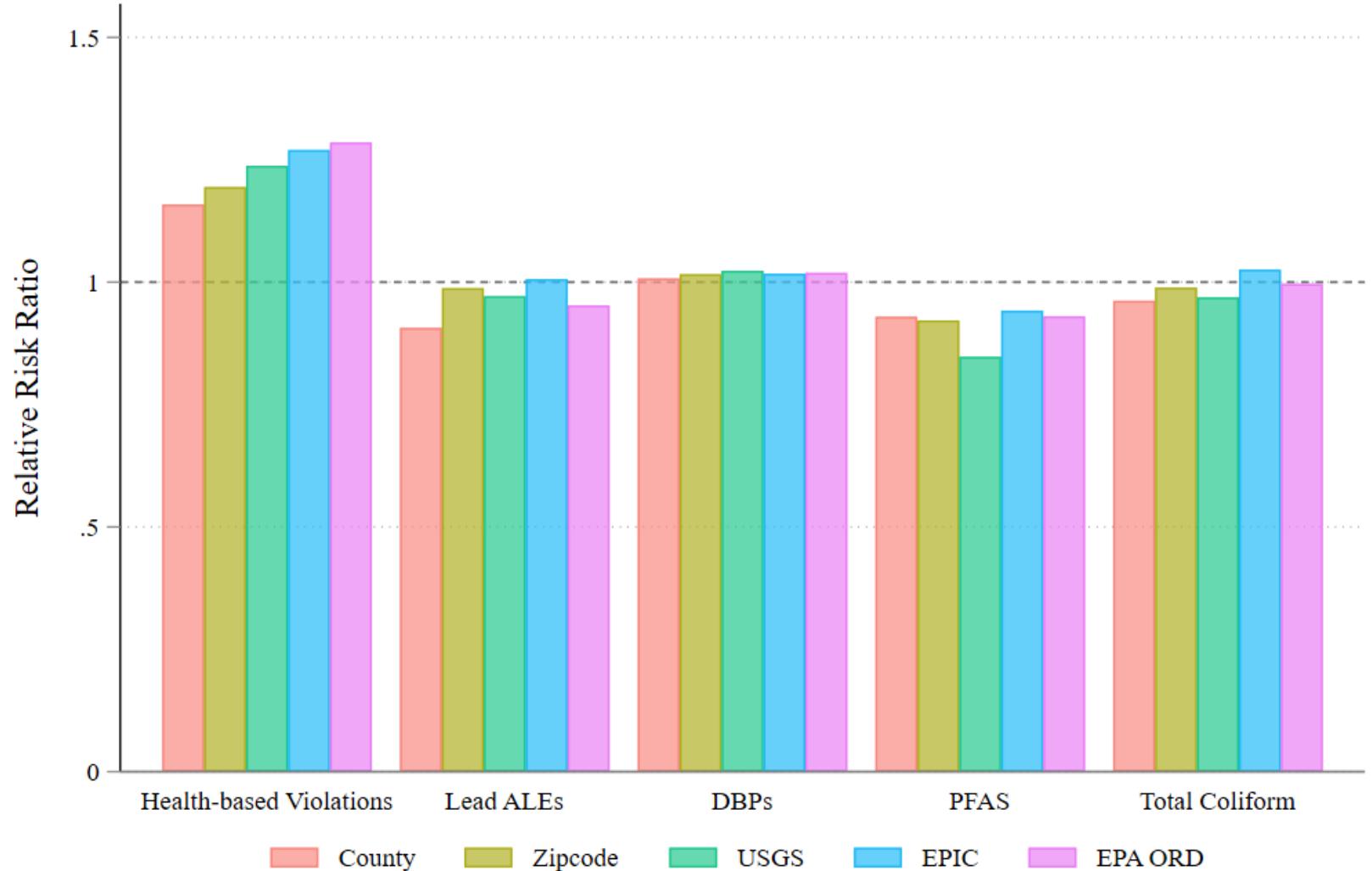
# Relative Risk for Low-Income Individuals

- Interpretation:

- $1 \rightarrow$  No disparate risk
- $RR > 1 \rightarrow$  potential EJ concern
- $RR < 1 \rightarrow$  lower risk for EJ communities

- See in table format.

- Comparison by race and ethnicity.



# Relative Risk by Race/Ethnicity

All relative risks ratios compare People of Color to non-Hispanic White populations.





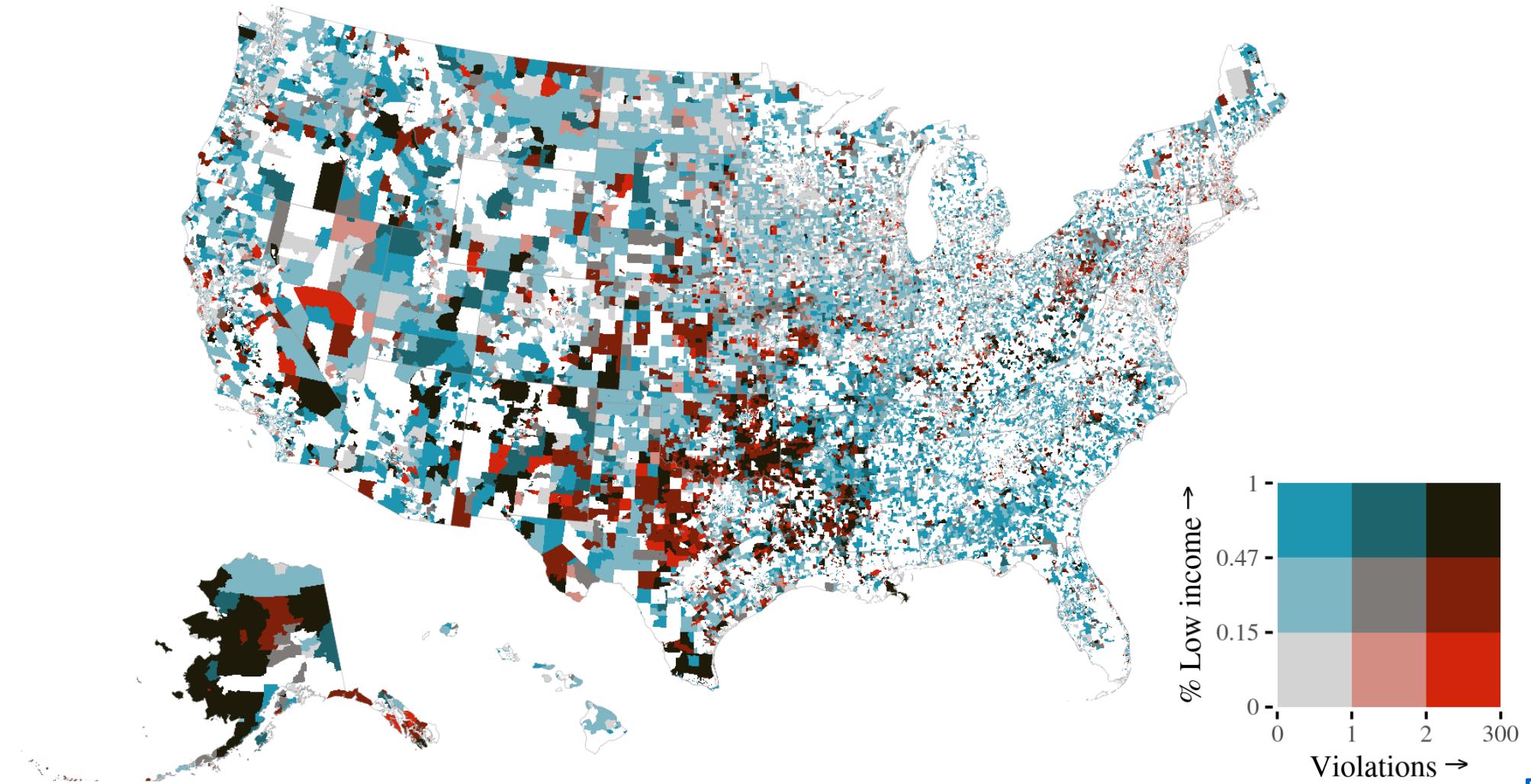
# Relative Risks by Boundary Type

	County	Zip code	USGS	EPIC	EPA ORD
<b>Health-based Violations (2015-2022)</b>					
People of Color & Non-Hispanic White	0.98	1.04	1.04	1.07	1.09
Below & Above 2X Poverty Level	1.16	1.19	1.24	1.27	1.29
<b>Lead Action Level Exceedances (1991-2021)</b>					
People of Color & Non-Hispanic White	1.24	1.13	1.09	1.25	1.14
Below & Above 2X Poverty Level	0.91	0.99	0.97	1.01	0.95
<b>PFAS Detected (2013-2023)</b>					
People of Color & Non-Hispanic White	1.20	1.22	1.20	1.33	1.22
Below & Above 2X Poverty Level	0.93	0.92	0.85	0.94	0.93
<b>TTHM &amp; HAA5 Concentrations (2006-2019)</b>					
People of Color & Non-Hispanic White	1.01	0.99	1.06	1.00	1.01
Below & Above 2X Poverty Level	1.01	1.02	1.02	1.02	1.02
<b>Total Coliform Detection Share (2006-2019)</b>					
People of Color & Non-Hispanic White	1.28	1.22	1.31	1.28	1.30
Below & Above 2X Poverty Level	0.96	0.99	0.97	1.03	1.00
PWS Observations	45,934	16,394	18,806	45,372	42,300
Population Served	308m	283m	269m	313m	307m

[Return](#)



# HB Violations and %Low income



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## Next Steps

Some possible next steps with the study:

- Explore reasons why different service area boundaries can lead to different conclusions.
- Additional measures related to income and affordability concerns.