Water System Service Areas and Environmental Justice Analysis of Drinking Water Quality

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Internal, deliberative.

Motivation

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

Research Question: How significant is the selection of service area boundary in shaping the conclusions of environmental justice analyses of drinking water?

- **Related objective:** Provide new evidence on the extent of disparities in drinking water quality and cumulative environmental burdens.

Research Methods

To answer our primary research question, we take five primary steps.

1. Apply population areal apportionment techniques to service area boundaries to calculate public water system demographic information according to the specific boundary type.
2. Generate five indicators of drinking water quality for every public water system.
3. Produce demographic-specific population weighted average drinking water quality indicators for each boundary type.
4. Compute relative risks from a population of environmental justice concern to an exclusive comparison group.
5. Compare how the relative risks differ according to the service area product employed.

The Service Boundary Products

Four service area boundary products:

1. Primary **county served** according to the Safe Drinking Water Information System (SDWIS).
2. The **zipcode served** according to UCMR3, UCMR4, UCMR5, and SDWIS. Where multiple zipcodes are served by the same system, these are dissolved into one shape.
3. Environmental Policy Innovation Center **(EPIC) Hydroshare boundaries** v3.0. For main analysis we include all tiers, but this is relaxed in sensitivity tests.
4. The **Hall and Murray (2023)** boundaries.

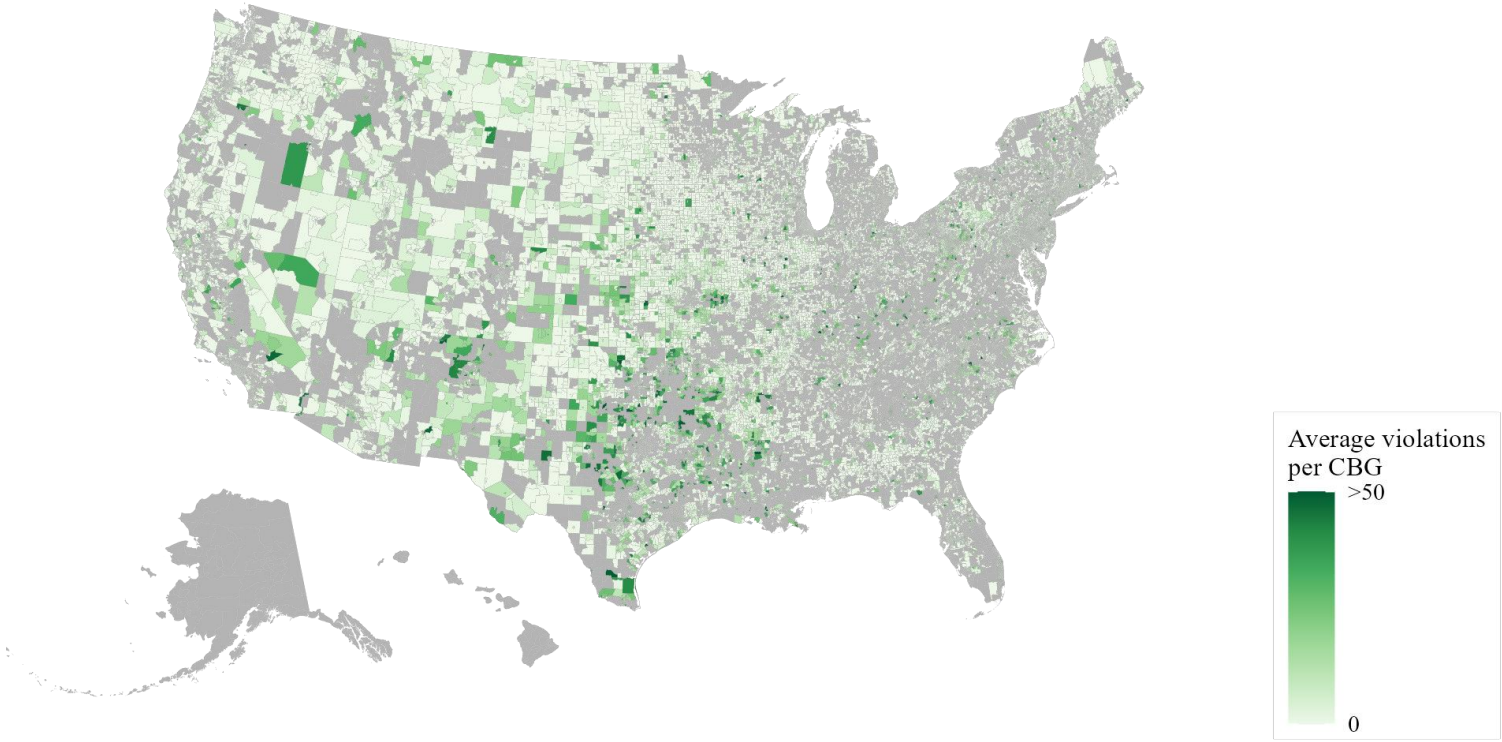
These boundaries are areally apportioned to 2021 census block group population information using a modified version of the EJSCREENbatch package in R.

The Drinking Water Quality Indicators

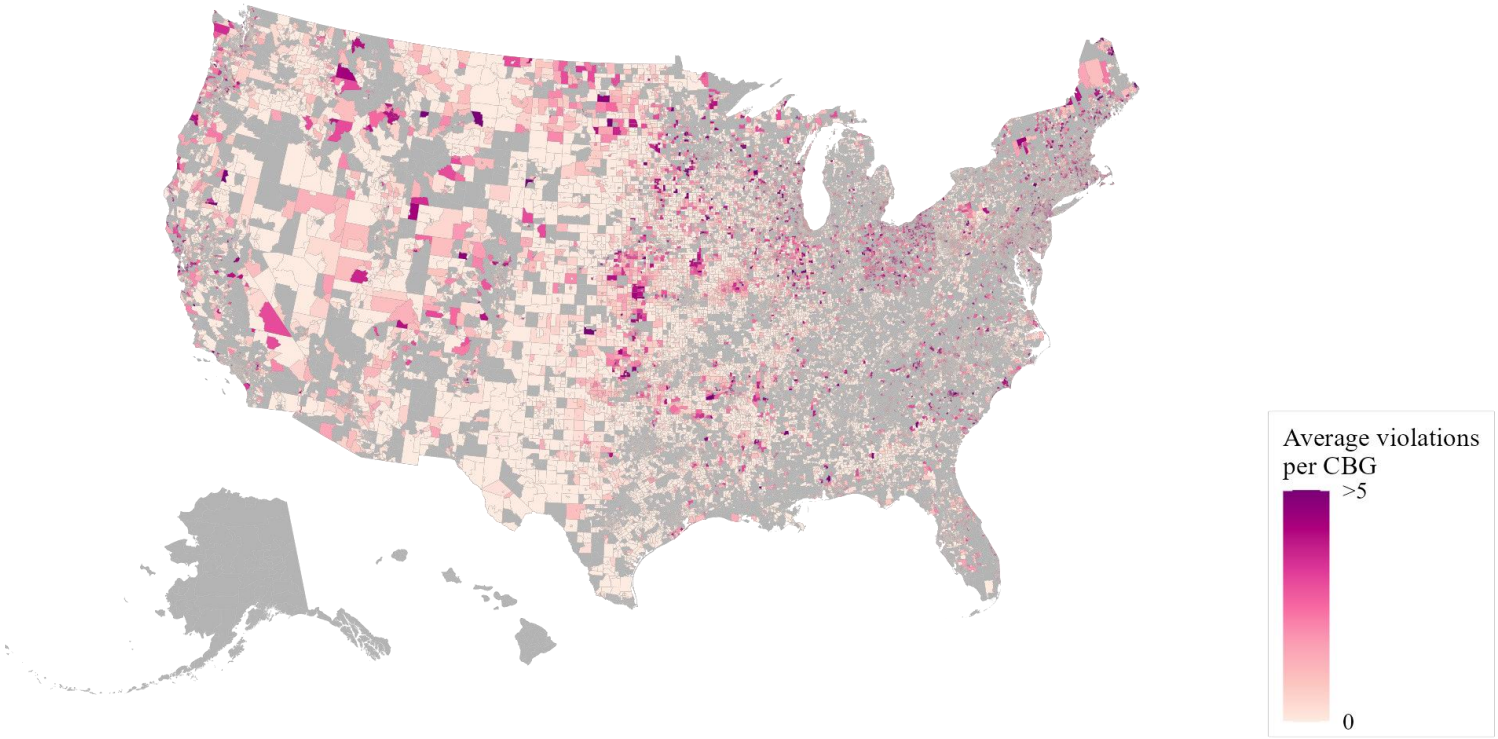
We selected five transparent and comprehensible drinking water indicators that are intended to represent the types of drinking water quality metrics EPA might investigate in an EJ analysis.

1. Health-based violations of the Safe Drinking Water Act (2015-2023).
2. Lead action level exceedences under Lead and Copper Rule (1991-2023).
3. Detections of any PFAS (2013-2023) over 1 million samples across 14,846 systems.
4. Disinfectant byproducts average total concentration of TTHM + HAA5 (2006-2019) according to 13 million samples.
5. Total Coliform detection share (2006-2019) according to 18 million samples.

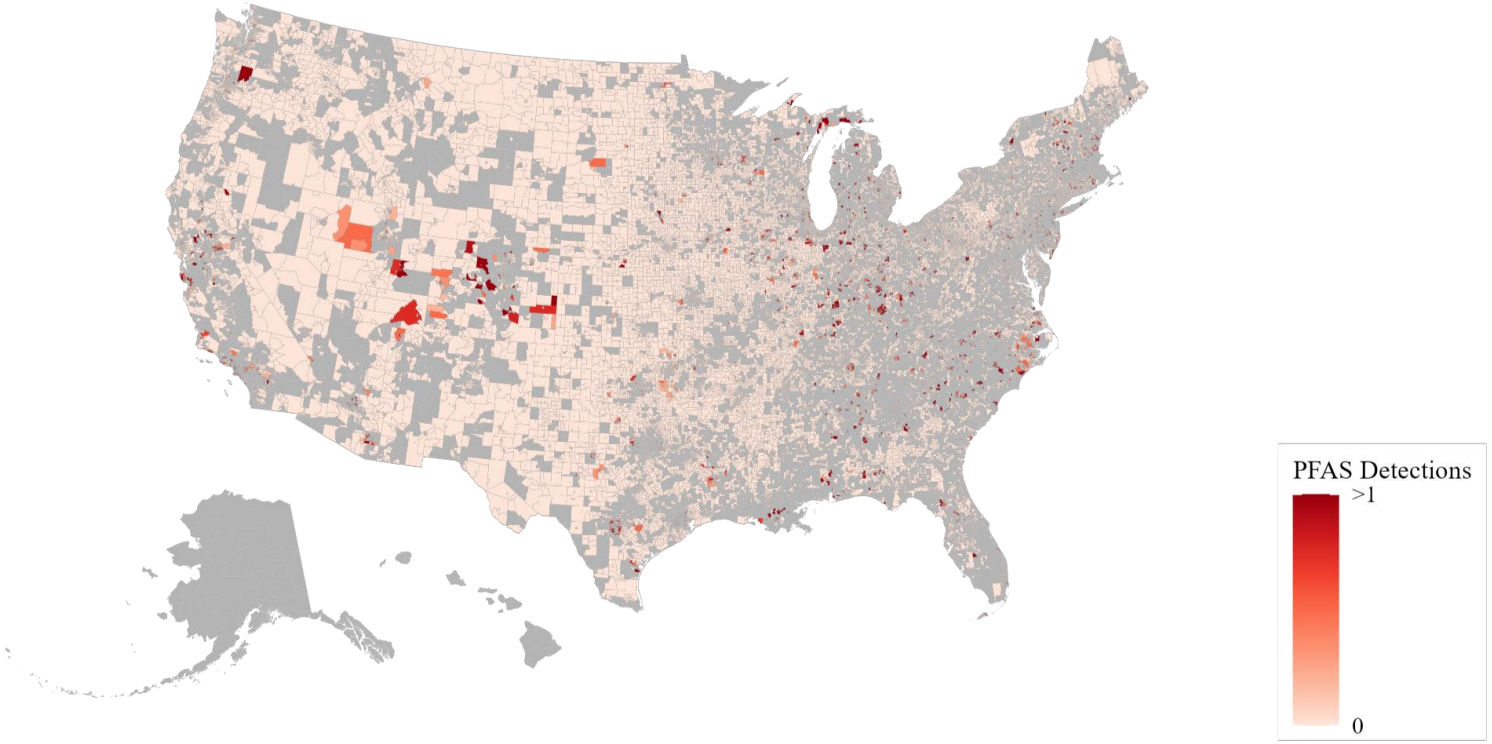
Health-based Violations of SDWA (2015-2023)



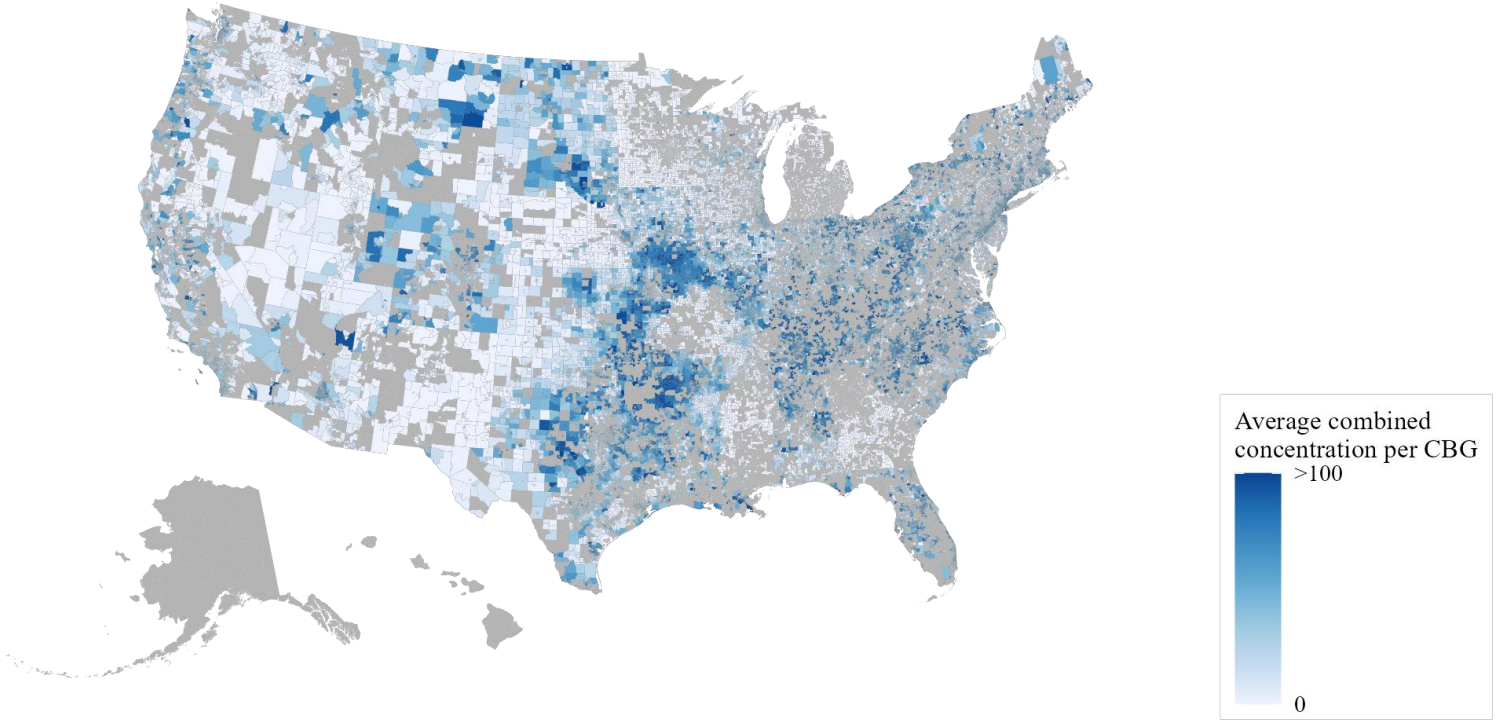
Lead Action Level Exceedences (1991-2023)



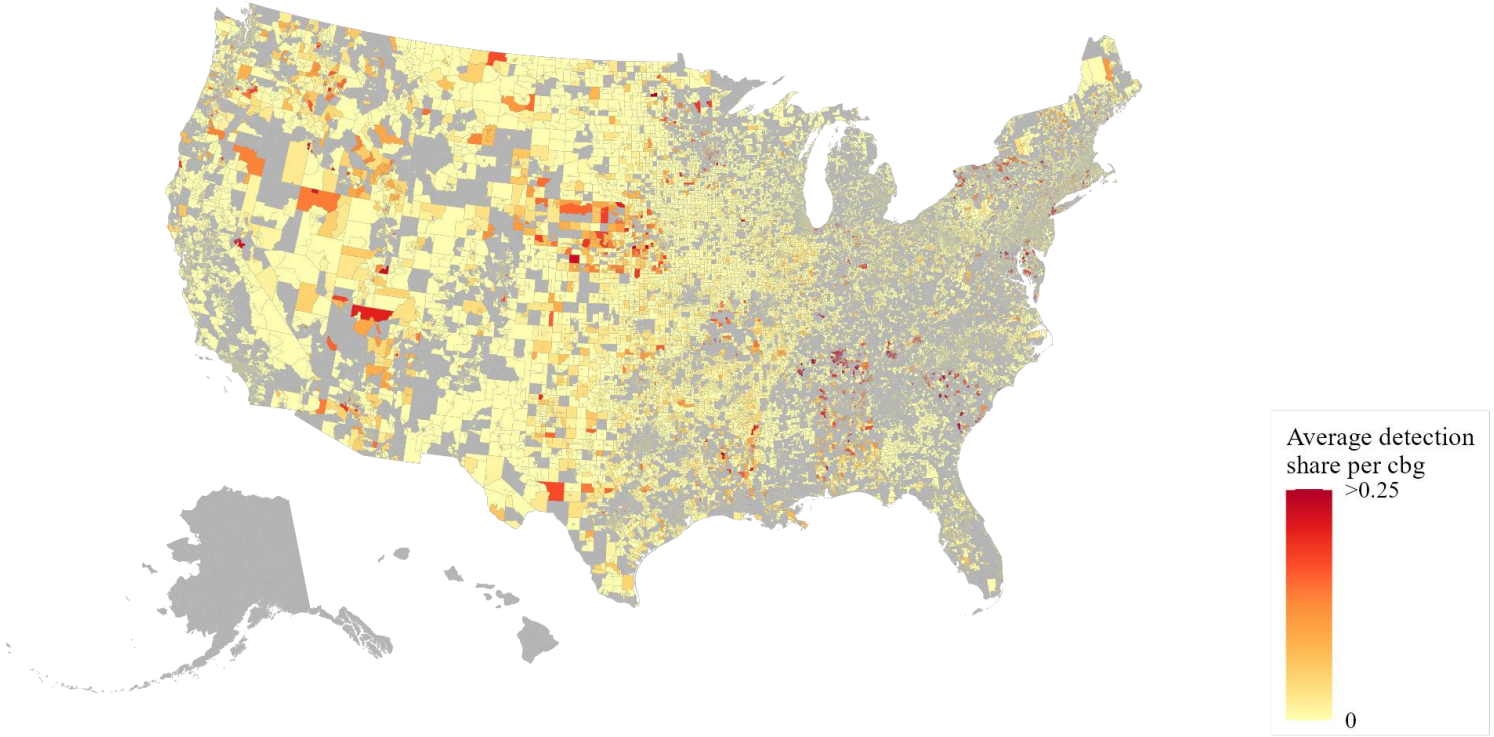
PFAS Detections (2013-2023)



Average Combined TTHM and HAA5 Concentration (2006-2019)



Total Coliform Detection Share (2006-2019)



Construction of a Relative Risk Metric for all DW Indicators

For each drinking water indicator *i* and for the demographic information associated with each service area boundary product, we compute:

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

In words, the average population-weighted exposure to the drinking water quality risk factor for a specific group *j*. We then construct relative risk metrics that compare the risk for an EJ population group of concern to the risk of a comparison group.

$$Relative\ Risk_i = \frac{Indicator_{iu}}{Indicator_{iv}}$$

Comparing Relative Risk Metrics Across Boundary Products

How to interpret these values:

- 1 → No disparate risk
- >1 → potential EJ concern
- <1 → lower risk for EJ communities

	County	Zipcode	EPIC	Hall and Murray
Health-based Violations (2015-2022)				
POC & NH White	0.93	1.07	1.03	
Below & Above 2X Poverty Level	1.13	1.10	1.27	
Lead Action Level Exceedences				
POC & NH White	0.84	1.03	0.95	
Below & Above 2X Poverty Level	0.93	0.96	0.93	
PFAS Detected (2013-2023)				
POC & NH White	1.01	1.40	1.38	
Below & Above 2X Poverty Level	0.89	1.00	0.98	
Average TTHM & HAA5 Concentrations (2006-2019)				
POC & NH White	0.94	0.92	0.99	
Below & Above 2X Poverty Level	1.01	1.02	1.01	
Average Total Coliform Detection Share (2006-2019)				
POC & NH White	0.70	1.07	0.99	
Below & Above 2X Poverty Level	0.93	1.02	1.07	
PWS Observations	45,934	16,394	45,372	

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Relative Risk by DW Indicator – Subgroup Analysis using EPIC Boundaries

	Black	American Indian	Asian	Pacific Islander	Hispanic
Health-based Violations (2015-2022)	1.16	2.29	0.49	0.53	1.06
Lead Action Level Exceedences	1.07	0.72	1.24	0.97	0.78
PFAS Detected (2013-2023)	1.08	1.09	1.64	1.35	1.56
Average TTHM & HAA5 Concentrations (2006-2019)	1.08	0.95	0.99	0.91	0.94
Average Total Coliform Detection Share (2006-2019)	1.39	0.82	1.38	0.99	0.93
Observations	44,199				

Cumulative Risks – EJSCREEN Pollution Indicators

	Dependent variable:				
	Total Violations		Detection	Combined DBP	Detection Share
	negative binomial		*probit*	*OLS*	*OLS*
	Health-Based	LCR	PFAS	DBP	TCR
	(1)	(2)	(3)	(4)	(5)
Lead	0.444***	0.938***	0.326***	17.248***	−0.006***
	(0.103)	(0.061)	(0.051)	(1.037)	(0.002)
Ozone	0.037***	0.001	0.010***	−0.364***	−0.0002***
	(0.003)	(0.002)	(0.002)	(0.033)	(0.0001)
$PM_{2.5}$	0.141***	−0.074***	−0.045***	1.269***	−0.002***
	(0.012)	(0.007)	(0.006)	(0.132)	(0.0002)
TSD Facility	−0.225***	0.068***	0.103***	−0.114	0.002***
	(0.019)	(0.010)	(0.007)	(0.164)	(0.0003)
Wastewater discharge	−0.001**	−0.00000	−0.00001	−0.0004	−0.00000
	(0.0002)	(0.00003)	(0.00003)	(0.0004)	(0.00000)
Superfund Site	−0.317***	0.098	0.591***	−5.357***	−0.002
	(0.123)	(0.069)	(0.045)	(1.216)	(0.002)
Constant	−1.053***	−0.007	−1.932***	32.611***	0.050***
	(0.156)	(0.094)	(0.081)	(1.729)	(0.003)
Observations	45,195	45,195	45,195	30,547	34,780
R^2				0.014	0.004

Heterogeneity Analysis

	Dependent variable:				
	Total Violations		Detection	Combined DBP	Detection Share
	negative binomial		*probit*	*OLS*	*OLS*
	Health-Based	LCR	PFAS	DBP	TCR
	(1)	(2)	(3)	(4)	(5)
% Black	0.025	−0.329***	0.079	−9.759***	0.033***
	(0.144)	(0.089)	(0.081)	(1.599)	(0.003)
% Hispanic	1.235***	−1.191***	−0.200***	−25.477***	−0.019***
	(0.126)	(0.082)	(0.075)	(1.274)	(0.002)
% Pacific Islander	−15.883***	0.794	−9.961***	−65.801*	0.173***
	(3.334)	(1.856)	(3.109)	(36.191)	(0.055)
% Asian	−7.912***	0.347	0.712***	−27.383***	−0.034***
	(0.543)	(0.294)	(0.213)	(4.866)	(0.010)
% American Indian	3.523***	−0.322*	−1.097***	−4.706*	0.010**
	(0.276)	(0.175)	(0.356)	(2.692)	(0.004)
% Low income	1.892***	−0.512***	−0.871***	31.277***	0.002
	(0.144)	(0.088)	(0.084)	(1.462)	(0.002)
Medium system	0.250**	−0.150**	−0.279***	−4.925***	−0.008***
	(0.098)	(0.059)	(0.037)	(0.882)	(0.002)
Small system	0.279***	−0.163***	−0.751***	−10.041***	−0.011***
	(0.084)	(0.050)	(0.034)	(0.762)	(0.001)
Large system	−0.312	0.126	0.425***	8.953***	0.027***
	(0.223)	(0.131)	(0.072)	(1.959)	(0.004)
Very small system	0.248***	−0.325***	−1.087***	−20.860***	−0.004***
	(0.078)	(0.046)	(0.032)	(0.719)	(0.001)
Constant	0.635***	0.301***	−0.619***	40.108***	0.027***
	(0.087)	(0.052)	(0.037)	(0.822)	(0.002)
Observations	45,195	45,195	45,195	30,547	34,780
R^2				0.068	0.011

Some next steps…

- Incorporate Hall and Murray (2023) boundaries.
- Draw comparisons when using the same set of water systems.
- Other configurations of PWSs such as just tier 1 and tier 2 EPIC systems, combined zipcode and county datasets, etc.
- Additional formulations of the DW indicators.
- Bivariate mapping to identify hotspots of EJ concern.
- Outreach

Thank you for listening.
Questions/comments?

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