Disparities in community water systems:

[[1]](#footnote-1)Conduct a cross-method spatial analysis to determine the overlap and disparities between different characterizations of community water systems.

Find that, in Pennsylvania, there was no evidence of SDWA violations disparities (based on number of health-violations) across racial groups or socio-economic status. Comparing areal weighting, dasymetric mapping, areal interpolation, and county-level analysis, the authors also find that the methods used to determine service water boundaries when compared to socio-demographic factors could affect the ultimate results of some statistical analyses.

**Prior cases of CWS spatial analysis:**

Balazs: Social Disparities in Nitrate Contaminated Drinking water in San Joaquin Valley[[2]](#footnote-2)

Analyze the relationship between nitrate concentrations in Community Water Systems and the socio-demographic composition of their customers in the San Joaquin Valley of California. The authors find a positive but non-statistically significant relationship between the percent Latino and a water system’s estimated nitrate concentration. They also look at the difference between bigger and smaller systems, finding that smaller systems with a higher percent Latino had higher estimated nitrate concentrations. While the authors mention that the limitations of previous studies have included identifying system-level disparities based on population-specific demographic information, their use of the ACS for population demographic highlights the difficulty for researchers to find finer-grain socio-demographic data to establish concrete correlations. As such, the authors employ an areal weighted technique using digitized CWS boundaries (which are available in California), which they compare with an approach joining the spatial coordinates for the water sources for each CWS to those of census block groups. They then derive population-based averages at the census block group level. While they do not explicitly compare the values derived from each method, this demonstrates the inherent complications associated with conducting spatially determined analyses using incongruent spatial categories.

Water affordability and human right to water implications in California[[3]](#footnote-3)

The authors use an aerial-household weighting method intersecting CWS boundaries in California with census block groups from the ACS, which were then aggregated to the CBG level to estimate the number of households served by a CWS in each water system. The household income data was then extrapolated to each CWS to estimate MHI.

Digitizing a Statewide Map of Community Water System Service Areas[[4]](#footnote-4)

A team of students at Duke University developed a report on the benefits of collecting and digitizing information on the boundaries of publicly owned water systems across North Carolina, while noting the challenges associated with this task. The authors note that 20% of water systems do not map their spatial extent, whereas service systems with maps do not always have interpretable or usable formats. The authors also find that smaller water systems often overlap geographically when mapped onto Census TIGER lines, rendering spatial analysis more difficult.

Approximating Community Water System Service Areas to Explore the Demographics of SDWA Compliance in Virginia[[5]](#footnote-5)

Marcillo et al. ({cite}) conduct a spatial analysis of previously geocoded community water systems in Virginia using a zip code level matching approach to study environmental justice implications associated with service boundary identification. The authors find that the proportion of Black individuals served by a water system was positively correlated with more health-based violations. Notably, a number of CWS were omitted from the final dataset due to systems not being geocoded, and the availability of existing boundaries allowed the researchers to employ public datasets to conduct their analysis.

Assessing Water Affordability: A Pilot Study of Two Regions of California[[6]](#footnote-6)

Christian-Smith et al. study water affordability metrics in two regions—one rural, one urban—in California, using both mapped system boundaries and extrapolating boundary extents based on general knowledge of service areas for smaller water providers. The authors note that the relative size of service areas and Census Block groups are inversely related in urban versus rural areas, where urban locations may have CBGs which are smaller than their associated CWSs, and rural areas seeing CBGs much larger than the extent of an associated water system’s service area. The authors use spatial weighting to calculate the average MHI for a CWS, assuming a homogeneously-distributed socio-demographic characteristics within a block group.

Community-Level Analysis of Drinking Water Data Highlights the Importance of Drinking Water Metrics for the State, Federal Environmental Health Justice Priorities in the United States[[7]](#footnote-7)

Using drinking water datasets for California and Texas, both of which document and publish CWS boundaries, the authors use drinking water violations data to analyze spatial and sociodemographic patterns[[8]](#footnote-8). The authors match weighted populations defined within census boundaries to CWSs to outline their sociodemographic composition, relying on percentage overlap between the CWS and census tracts.[[9]](#footnote-9)

Disparities in drinking water compliance: Implications for incorporating equity into regulatory practices[[10]](#footnote-10)

Study on disparities in health-based drinking water violations in California from 2000 to 2018. Controlling for system size, type of source water, and ownership type, the authors intersect CWS boundaries with zip code tabulation areas (ZTCAs) from the US Census Bureau, using areal weighting to assign demographic characteristics to each CWS. Using their calculated demographics, the authors create categorical variables for water systems serving low income and communities of color. The latter are designated as CWSs serving African American or Latino populations depending on the relative proportion to the statewide average.

National trends in drinking water quality violations[[11]](#footnote-11)

Allaire et al. employ violations records and CWS characteristics from the SDWIS to study historical trends in drinking water violations based on system characteristics. Their approach uses the CWSs’ address in the SDWIS to match water systems to counties and the associated sociodemographic information obtained from the US Census. While their work, spanning over three decades (1982-2015), represents a national panel study on drinking water violations, their unit of analysis (county) and the use of CWS addresses (rather than geographic boundaries) may obscure the variation across systems and their populations served, while possibly misattributing population characteristics to systems for which their geographic extents are poorly captured by county matching. The median county has a population of 26,551 (2022 Census), whereas the median CWS serves a population of only 216. The drastic difference in the relative size of CWSs and counties renders their direct analytical comparison potentially erroneous.

\*Recognizing the different spatial boundaries for water systems and reported socio-demographic data means necessarily imperfect analysis for the environmental justice implications of SDWA violations and non-regulated water contaminant hazards. The additional problem of imperfect knowledge of the boundaries of CWSs themselves complicates researchers’ ability to track and assess disproportionate drinking water quality issues for more vulnerable populations\*. Past studies on water quality have been focused on states and regions where spatial boundaries already exist, such as California, Texas, and Virginia. The lack of data in a great number of states hinders systematic, national analysis on drinking water system violations across the United States.

# Background information

1. Statman-Weil, Nanus, and Wilkinson, “Disparities in Community Water System Compliance with the Safe Drinking Water Act.” [↑](#footnote-ref-1)
2. “Social Disparities in Nitrate-Contaminated Drinking Water in California’s San Joaquin Valley.” [↑](#footnote-ref-2)
3. “Water Affordability and Human Right to Water Implications in California | PLOS ONE.” [↑](#footnote-ref-3)
4. Gonsenhauser et al., “Digitizing a Statewide Map of Community Water System Service Areas.” [↑](#footnote-ref-4)
5. Marcillo, Krometis, and Krometis, “Approximating Community Water System Service Areas to Explore the Demographics of SDWA Compliance in Virginia.” [↑](#footnote-ref-5)
6. Christian-Smith et al., “Assessing Water Affordability: A Pilot Study in Two Regions of California.” [↑](#footnote-ref-6)
7. Uche et al., “Community-Level Analysis of Drinking Water Data Highlights the Importance of Drinking Water Metrics for the State, Federal Environmental Health Justice Priorities in the United States.” [↑](#footnote-ref-7)
8. Test results reported in the original state data sets as “non-detects” were assigned a value of zero and included in the overall data array for the calculation of arithmetic averages [↑](#footnote-ref-8)
9. An illustrative example presents a calculation of demographic variable Y for the population served by a community water system (YCWS) where the water system service area covers x%, y%, and z% of tracts A, B, and C by area, respectively, with the following equation: (YCWS) = [(YA \_ x%) + (YB \_ y%) + (YC \_ z%)] [↑](#footnote-ref-9)
10. Allaire and Acquah, “Disparities in Drinking Water Compliance.” [↑](#footnote-ref-10)
11. Allaire, Wu, and Lall, “National Trends in Drinking Water Quality Violations.” [↑](#footnote-ref-11)