

EXAMINING THE DISPARITIES IN PUBLIC WATER SYSTEMS: SPATIAL DISTRIBUTION OF WATER HEALTH VIOLATIONS AND THEIR IMPACT ON HEALTH OUTCOMES IN MARGINALIZED COMMUNITIES.

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Keywords

Water violations, cancer, water quality, public water systems, sociodemographic characteristics

RESEARCH PROBLEM

Harmful contaminants in drinking water pose significant risks to public health, including increased cancer incidence (Ward et al., 2018; Hrudey et al., 2015), negative mental health outcomes (Gibson et al., n.d.), obesity (Mosites et al., 2020), and type 2 diabetes (Mosites et al., 2020). Although the Environmental Protection Agency (EPA) monitors drinking water quality, frequent violations occur (Allaire et al., 2019; Allaire, Wu, and Lall, 2018a, 2018b). Marginalized communities, characterized by social, economic, or political exclusion, are disproportionately affected by water violations (Du, Xie, and Waycott, 2020). However, limited studies have emphasized the disparities and heightened risks marginalized communities face regarding detrimental health outcomes linked to inadequate water quality. This study aims to investigate the relationship between health violations and adverse health outcomes, such as cancer, in marginalized communities.

Water quality health violations impact communities differently based on demographics, socioeconomic status, and environmental exposure. Latino farmworkers in California's Central Valley face high pesticide and nitrate exposure (Ayotte, Nolan, and Gronberg, 2016; Burow et al., 2013), while low-income communities, like Flint, Michigan, suffer from lead contamination due to aging infrastructure and lack of oversight (Kruger et al., 2011, 2017). Indigenous communities, such as the Standing Rock Sioux Tribe, experience water quality violations due to historical displacement and inadequate government infrastructure (Allaire et al., 2018a; Martinez-Morata et al., 2022; Ravalli et al., 2022). Inadequate infrastructure, limited financial resources, and political power contribute to these disparities (Aiyetan and Das, 2021; Vanderslice, 2011).

Although literature recognizes the disproportionate burden on marginalized communities, few epidemiological studies comprehensively examine the association between water violations and cancer rates in these communities. Research often focuses on individual contaminants or specific incidents, necessitating population-level studies evaluating long-term health impacts of chronic exposure to multiple water contaminants. Therefore, this study seeks to answer two research questions: *1) What is the prevalence and distribution of water health violations across U.S. counties? 2) To what extent do sociodemographic characteristics mediate the relationship between water health violations and health outcomes at the county level?* We hypothesize that the relationship between water quality violations and health outcomes is stronger in marginalized communities due to limited access to healthcare and resources. By analyzing comprehensive county-level data on violations, cancer rates, and other health outcomes, along with demographic and socioeconomic data, we employ geospatial models and ordinary linear regression to establish correlations between health violations and outcomes.

In conclusion, this research aims to address the knowledge gap regarding the disparities in water quality health violations and the associated health outcomes in marginalized communities. By examining the relationship between violations and adverse health outcomes, this study will contribute to identifying the factors contributing to inadequate water quality and guide the development of targeted interventions to promote health equity in water access and quality across the United States.

BRIEF RESEARCH METHODOLOGY AND APPROACH

The aim of this study is to examine disparities in public water systems across the United States and investigate the effect of marginalization on the relationship between water health violations and health

outcomes. Our analysis focuses on county-level data, aiming to provide insights into the associations between water violations, health outcomes, and sociodemographic characteristics. Water violations data for n=2,831 counties in the United States were obtained from the EPA SDWA database, which reports health violations from public water systems. This dataset includes the total number of violations for each county from 2013 to 2021. Sociodemographic characteristics such as income, age, poverty level, education level, and the Gini Index were collected from the American Community Survey spanning from 2013 to 2021. These characteristics were recorded as continuous variables for robust statistical analysis at the county level. Cancer incidence rates, including various types of cancer, were obtained from state cancer profiles provided by the National Cancer Institute and Centers for Disease Control and Prevention. Health outcome data, including mental and physical distress, were extracted from the County Health Rankings & Roadmaps program of the University of Wisconsin Population Health Institute. This data was collected at the county level from 2013 to 2021. The available data covered the period of 2015-2019 and was used for analysis. Pooled Ordinary Linear Regression (OLS) was employed to investigate potential associations between water violations and health outcomes at the county level, while controlling for sociodemographic characteristics. Pooled OLS is a statistical technique used for analyzing panel data, combining data from different entities (counties in this case) into a single dataset. This approach assumes that the relationship between the dependent variable (health outcomes) and the independent variables (water violations and sociodemographic characteristics) is consistent across all counties in the panel. The use of pooled OLS allows for estimation of regression coefficients using the combined data, although it ignores potential heterogeneity or differences among the counties. This analysis will provide insights into the relationships between water violations and health outcomes while considering sociodemographic factors, contributing to our understanding of the impact of marginalization on water quality and public health.

KEY FINDINGS AND IMPLICATIONS

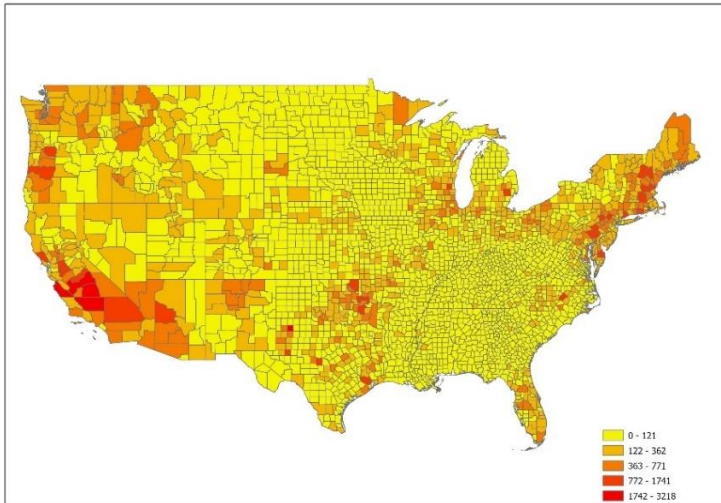


Figure 1 A map of county-level health violations in 2021

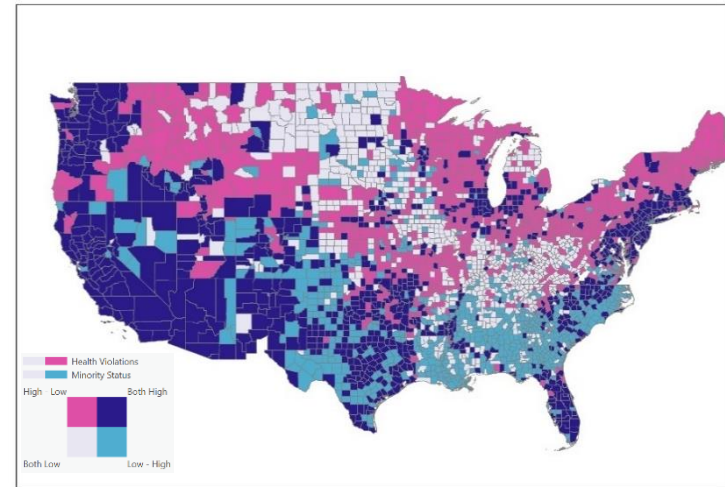


Figure 2 Bivariate map of Health Violations vs Minority Status

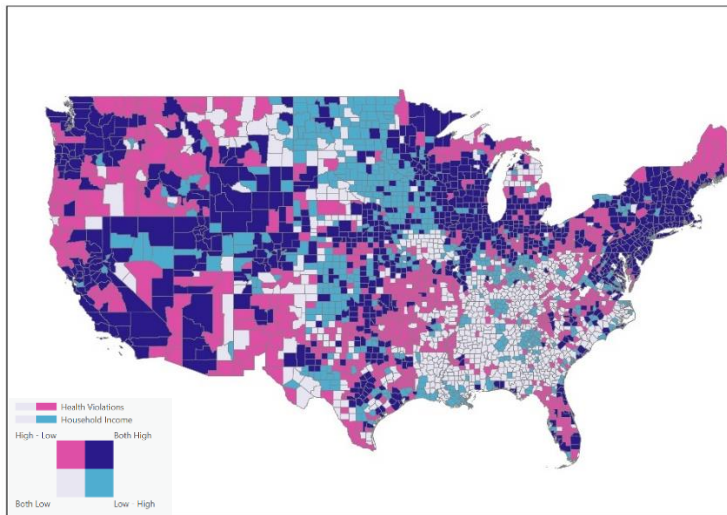


Figure 1 A bivariate map of health violations vs household income

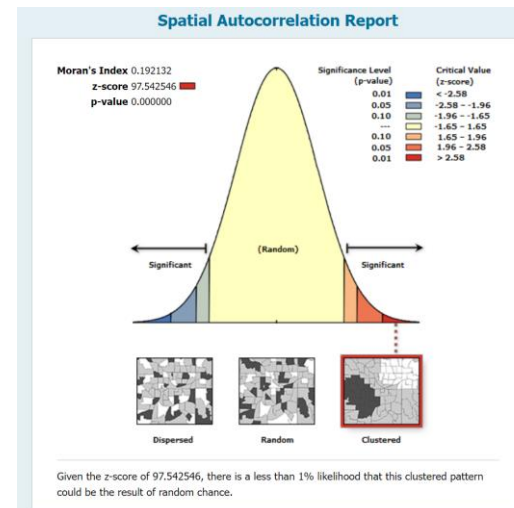


Figure 4 Spatial Autocorrelation Report for Health Violations

This study examined the spatial distribution of water health violations in the United States and investigated their association with health outcomes, specifically cancer incidence rates and mental distress. The key findings and implications are summarized as follows:

1. *Spatial Distribution of Water Health Violations*: The analysis revealed significant clustering of water health violations at the county level, suggesting the presence of spatial patterns or geographic factors contributing to these violations. Rural regions, including counties in Alabama, Alaska, Arkansas, and California, exhibited a higher concentration of water violations compared to neighboring counties.
2. *Associations Between Water Violations and Health Outcomes*: Pooled Ordinary Linear Regression analysis demonstrated that water health violations were significant predictors of health outcomes, including lung, kidney, and colon cancer incidence rates, as well as frequent mental distress. The findings highlighted the potential health risks associated with poor water quality.
3. *Influence of Sociodemographic Factors*: Median household income and minority status were significant predictors for all health outcomes, with higher income levels associated with lower cancer incidence rates and mental distress. Minority status was positively associated with cancer incidence rates, except for mental distress. These results underscored the influence of sociodemographic factors on health outcomes.
4. *Moderating Effect of Race/Ethnicity*: The interaction effects revealed that the relationship between water violations and health outcomes was moderated by race/ethnicity. The associations between health violations and kidney cancer incidence rates were stronger among African Americans, while the associations between health violations and lung cancer incidence rates were more pronounced among Hispanic populations. Alaska Native populations were particularly at risk of developing kidney cancer due to poor water quality.
5. *Implications for Environmental Justice*: The findings highlighted the disproportionate burden of water health violations and their consequences on marginalized communities. The study emphasized the need for targeted interventions to address water quality disparities, particularly in rural areas and among racial/ethnic minority populations, ensuring equitable access to safe and clean drinking water.
6. *Policy and Research Recommendations*: The results called for further investigation into the underlying factors contributing to the disparities in health outcomes related to water health violations, focusing on Hispanic and Alaska Native populations. Additional research is needed to understand the mechanisms and drivers of environmental injustice in public water systems and its impact on cancer and mental distress outcomes. Policy interventions should be considered to mitigate disparities, promote environmental justice, and protect public health.

In conclusion, this study provides important insights into the spatial distribution of water health violations and their implications for health outcomes. The findings underscore the need for comprehensive approaches to address disparities in public water systems, considering sociodemographic factors and the specific vulnerabilities of marginalized communities. Policy interventions and further research efforts are necessary to promote environmental justice, improve water quality, and safeguard public health.

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