Class, Race, Ethnicity, and Justice in Safe Drinking Water Compliance*

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Objective. Past research yields inconsistent evidence of disparities in environmental quality by socioeconomic status (SES), race, and/or ethnicity. Since the political significance of race/ethnicity may be contingent upon SES, this study advances environmental justice research by examining interactively the effects of race, ethnicity, and SES on environmental quality. *Methods.* We match 2010–2013 Safe Drinking Water Act (SDWA) compliance records with demographic and economic data for U.S. local government water utilities serving populations greater than 1,000. Statistical regression isolates direct and interactive relationships between communities' racial/ethnic populations, SES, and SDWA compliance. *Results.* We find that community racial/ethnic composition predicts drinking water quality, but also that SES conditions the effect; specifically, black and Hispanic populations most strongly predict SDWA violations in low-SES communities. *Conclusions.* Our findings highlight the importance of analyzing race, ethnicity, and SES interactively in environmental justice research. Results also carry troubling implications for drinking water quality in the United States.

Since its emergence as a subject of inquiry, environmental justice (EJ) research has focused on racial, ethnic, and socioeconomic inequalities in the distribution of environmental risks and benefits. This study takes up a question of perennial interest and longstanding controversy to EJ researchers: when racial and/or ethnic environmental inequities occur, are they due to systemic bias, or are they corollaries to socioeconomic status (SES) disparities? To date, the evidence in favor of race, ethnicity, or SES as a major determinant of environmental inequity has been mixed, depending on the environmental hazard studied and on the type of analysis used to study it (Mohai, Pellow, and Timmons Roberts, 2009).

But what if the effects of race, ethnicity, and SES interact in ways that affect the distribution of environmental quality? Race and ethnicity might have different effects on environmental conditions at varying levels of SES. That is, environmental conditions in heavily black or Hispanic communities might be different if those communities are also poor. Failure to account for such intersectional effects may miss important aspects of EJ or underestimate the substantive relationships between race, ethnicity, SES, and environmental quality.

This study analyzes drinking water quality compliance in the United States at the intersection of race/ethnicity with SES. The recent crisis in Flint, Michigan—a predominantly black, high-poverty American city—has made drinking water quality an EJ issue in the national political conversation. To summarize our main results, we find that a utility's compliance with the Safe Drinking Water Act (SDWA) varies according to the racial

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and/or ethnic composition of its service population. But critically, we find that the negative relationship between race/ethnicity and SDWA compliance is strongest in communities with very low SES. As SES increases, the relationships of race and ethnicity with SDWA violations decline and eventually disappear. Additionally, comparative analysis of multiple statistical models shows that including the interactions between SES and race/ethnicity yields a model fit superior to models with direct effects only, providing more evidence that EJ models should account for such potential conditional relationships. Our empirical results carry troubling implications for EJ in a drinking water regulatory system that relies upon local government compliance for success. Moreover, our findings cast new light on the relationships between class, race, ethnicity, and environmental regulation, paving the way for more careful analysis of EJ.

Environmental (In)Justice: Race/Ethnicity or Socioeconomic Status?

Empirical research on EJ has developed in two distinct ways, each of which addresses the question of whether race or SES is the better predictor of environmental inequity. The majority of studies focus on the inequitable distribution of risk on racial, ethnic, and socioeconomic lines. More recent research has dealt with the inequitable enforcement of environmental laws by the state and federal government.

The early literature on the inequitable distribution of environmental risk focused on the location of toxic waste facilities, investigating the location of firms that produced potential environmental harms. Beginning with a 1987 study by the United Church of Christ's Commission on Racial Justice, these studies have attempted to investigate whether toxic waste sites are disproportionately located around poor and minority communities. Hundreds of studies have investigated this question, with a great deal of debate over the nature of the biases (see Mohai, Pellow, and Timmons Roberts, 2009; Mohai and Saha, 2006; Bowen, 2002; Bowen and Wells, 2002; Williams, 1999; Brulle and Pellow, 2006; Brown, 1995 for reviews of the literature). A meta-analysis of 49 previous studies found evidence that the placement of hazards is ubiquitously related to race, but little evidence of a relationship between socioeconomic class and risk (Ringquist, 2005).

Additional studies have investigated other measures of environmental quality. One study investigated 29 different measures of environmental quality—air pollution, water pollution, and hazardous waste—finding that race and ethnicity were negatively associated with environmental quality across many different variables, while finding little evidence of an association between environmental quality and income (Hird and Reese, 1998). More recently, studies have investigated an association of race, ethnicity, and class with higher levels of contaminants in drinking water, finding evidence of inequity in the distribution of drinking water hazards (Balazs et al., 2011; Balazs and Ray, 2014).

A second and more recent focus of the EJ literature is on potential inequities in implementation and enforcement of environmental regulations. Studies have investigated whether the judicial and administrative penalties handed out for violations of the major pieces of U.S. environmental legislation have disadvantaged poor and minority communities. The results of these studies have been mixed, with some finding evidence for enforcement bias, while others have found no discrimination in enforcement (Lavelle and Coyle, 1992; Ringquist, 1998; Atlas, 2001; Konisky, 2009; Konisky and Schario, 2010; Spina, 2015; Liang, 2016).

A consistent question throughout the development of the EJ literature has been whether race and ethnicity or SES is a better predictor of environmental inequities (Downey, 1998; Mohai, Pellow, and Timmons Roberts, 2009; Konisky, 2009; Ringquist, 2005). Some have argued that environmental inequities come from intentional or unintentional biases against minority populations (Bullard, 2000), while others have argued that any perceived racial biases are the result of minority populations generally living in poorer communities (Been, 1994; Foreman, 1998).

The "class versus race" debate is far from settled. Some have noted that considering SES and race separately may be a mistake (Downey, 1998). Since the political significance of race/ethnicity may be contingent upon SES, it might be more fruitful to analyze the potential additive or interactive effects of race/ethnicity and SES as determinants of environmental quality, rather than analyzing them separately (Mohai, Pellow, and Timmons Roberts, 2009). To this point, the studies that have considered the relationship have been case studies (Bullard, 2000; Capek, 1993), or purely conceptual (Di Chiro, 2008; Holifield, Porter, and Walker, 2009). A rich literature has built on work from feminist theories of intersectionality (Collins, 1998) that consider how different identities, including race, ethnicity, and social class, as well as gender, are interconnected in building frames of environmental justice (e.g., Di Chiro, 2008; Holifield, Porter, and Walker, 2009; Buckingham and Kulcur, 2009). But despite calls for the consideration of the conditional nature of the relationship between race, ethnicity, SES, and environmental inequity, and the extensive qualitative and theoretical literature on the topic, we are unaware of any research that analyzes the interaction quantitatively across large numbers of communities. Local government compliance with federal environmental regulations offers one avenue for such analysis.

Hypotheses

Here, we lay out a series of simple hypotheses about the effects of race, ethnicity, and SES on local compliance with environmental regulation. In the present analysis, "compliance" means adherence to SDWA regulations, and so violations of the SDWA reflect a compliance failure by a local government utility. Our expectations follow directly from research on EJ that predicts a positive relationship between environmental quality and SES, as well as a negative relationship between environmental quality and minority population:

- H1: *SES and compliance*: as the SES of a local government's population increases, its environmental compliance also increases.
- H2: *Ethnicity and compliance*: as the percentage of a local government's population that is Hispanic increases, its environmental compliance decreases.
- H3: *Race and compliance*: as the percentage of a local government's population that is black increases, its environmental compliance decreases.

However, it is also possible that SES conditions or masks the effects of race and ethnicity on environmental quality. Political science research has long established that SES is an important contributor to citizen participation (Brady, Verba, and Schlozman, 1995), and that the resources necessary for political participation are inequitably distributed across ethnic and racial lines (Verba et al., 1993). Crucially, the potential for community mobilization has a large effect on environmental inequities (Konisky and Reenock, 2013). Consequently, more affluent minority communities might be less vulnerable to poor environmental outcomes due to their greater potential for political mobilization. With this being the case, we would expect that the effects of race and ethnicity on environmental quality depend on SES: in low-SES communities, race and ethnicity affect environmental compliance, but in middle-class and more affluent communities, race and ethnicity will have less effect on compliance. In this way, any implicit or explicit racial or ethnic bias in environmental outcomes will be dependent on communities' SES, and by extension, their potential for collective action. Two additional hypotheses follow:

H4: *SES, ethnicity, and compliance*: as the SES of a local government's population increases, the effect of its percent Hispanic population on environmental compliance decreases.
H5: *SES, race, and compliance*: as the SES of a local government's population increases, the effect of its percent black population on environmental compliance decreases.

Hypotheses H4 and H5 reflect the idea that apparent racial and/or ethnic biases in environmental compliance or enforcement are exacerbated or ameliorated by SES, and that the environmental significance of race and ethnicity disappears as communities become more affluent. Just so, it is possible that the negative effects of SES on environmental quality depend on race and/or ethnicity. For purposes of the present analysis, these two ways of thinking about intersectionality are analytically equivalent. If either dependency is true, then studies that analyze any of these variables in isolation risk missing underlying intersectionalities, and thus understating their relationships with environmental quality.

In addition to our hypotheses about the conditionality between SES, race, and ethnicity, we also anticipate that the inclusion of the interactions in the models will result in models that predict EJ outcomes more accurately. Through statistical testing, we can examine whether the inclusion of the interaction terms significantly improves on statistical model fit of traditional EJ analyses that do not take into account potential interaction between SES and race/ethnicity.

Data

Our empirical subject is local government compliance with the SDWA. About 85 percent of the U.S. population receives its drinking water from local government utilities. Beyond the recent popular attention that it has received, drinking water quality is an excellent subject for EJ research. While there is great variation among utilities in terms of size, number of employees, the type of water that they use, and other characteristics, they all are subject to SDWA regulation. Importantly for our purposes, the populations served by utilities vary widely in education, income, and poverty, as well as racial and ethnic composition. These uniform standards of performance, coupled with variation in demographic characteristics, present an excellent opportunity to explore how race, ethnicity, and SES interact in the distribution of environmental risks.

The SDWA requires utilities to perform tasks related to both the removal of contaminants from the water and to monitoring and reporting. Unlike other major environmental programs, the SDWA has no formal inspection regime. Rather, utilities must collect water samples according to specified procedures. Samples are sent to a certified laboratory, which tests them for the presence of contaminants or treatment byproducts. Because we are primarily concerned with environmental risk, we focus on *health violations*. Included in this category are the core elements of the SDWA's public health mission: maximum contaminant limit violations (when the utility fails to keep contaminants below allowed limits, as occurred in Flint), and treatment technique violations (when a utility does not use EPA-approved treatment methods).[1]

[1]The SDWA also requires utilities to follow certain protocols with regard to testing of water, filing reports, and public communication. The same analysis with these *management violations* yielded nearly identical results.

Sources

We obtained data on water utility characteristics and SDWA compliance from the Safe Drinking Water Information System (SDWIS) (USEPA, 2015). The SDWIS includes data on utility size, water source, and regulatory compliance for all public water systems in the United States. We evaluate all local government water utilities serving populations of 1,000 or more from the years 2010–2013, including municipal water utilities, special districts, and county-owned utilities. We exclude utilities owned by state or federal agencies, as well as private, investor-owned utilities, since these organizations face different kinds of incentives and constraints (Konisky and Teodoro, 2016). Importantly, while both privately owned utilities and utilities owned and operated by local governments are accountable to state-level environmental agencies, public utilities are accountable to local governments, and thus, local constituents, as well. Consequently, there is good reason to believe that public utility performance will depend on local-level factors in a way that private performance does not. Demographic data were obtained from the American Community Survey (ACS) (U.S. Census Bureau, 2015). After excluding 660 cases with incomplete data, our analysis includes 12,972 utilities over four years. The unit of analysis in the present study is the utility year.

Dependent Variable

The dependent variable in our models of environmental risk is health violations of the SDWA in each utility year. Health violations are relatively rare, with utilities committing an average of 0.19 health violations per year.

Race, Ethnicity, and SES

Most EJ studies use percent black and percent Hispanic population within a given geographic area as their measure of minority population. We do the same here, using percent black population and percent Hispanic population of the primary municipality served by the water utility, as identified in the SDWIS.

The EJ literature has been less consistent with respect to measures of SES. Rather than use any one measure to represent SES, we created a variable using factor analysis that incorporates median household income, percent high school educated, percent college educated, and percent below poverty line. Factor analysis is a statistical technique that can be used for data reduction. It assumes that multiple observed variables are the results of unobserved latent variables, and so estimates the extent to which each of the observed variables can be explained by the underlying factors (Zwick and Velicer, 1982). Using eigenvalues, it is possible to identify the number of factors underlying the observed data. Generally, when a single factor has a high eigenvalue and no other factors have eigenvalues higher than 1, then we can assume that there is a single factor underlying the observed data. Our analysis of local levels of education, poverty, and income revealed a single factor with an eigenvalue of 2.77, accounting for 70 percent of the variance. We believe that this factor more fully represents SES than any single measure of income, education, or poverty. Factor analysis generated a standardized, regression-based factor score ranging from –4.06 to +5.77 about mean of 0, each unit representing one standard deviation in SES.[2] In other

[2]We also fitted models with community median income, education, and poverty rate entered separately, rather than as elements of a factor score. The results were similar to the estimates reported here.

TABLE 1

Descriptive Statistics

	Percentage	Mean	Standard Deviation	Minimum	Maximum
Binary variables					
Groundwater supply	53.97				
Purchased water supply	28.08				
New system	11.61				
Continuous variables					
Health violations		0.19	1.11	0	75
Socioeconomic status		0	1	–4.06	5.77
% w/High school diploma		83.44	9.62	19.1	100
% w/Bachelor's degree		21.44	13.09	0	100
% Below poverty		17.61	9.81	0	85.1
Median household income (1,000s)		45.79	19.05	2.5	250.00
% Hispanic		11.64	17.28	0	100
% Black		10.53	16.94	0	100
Population served (1,000s)		17.99	109.96	10.01	8,271

words, a SES of 0 represents a socioeconomically average community, a value of +1.0 is one standard deviation higher than average in SES, and a value of –1.0 is one standard deviation below average SES.

Controls

We included a number of control variables in the analysis to account for common causes of SDWA violations: primary water source (ground or surface), whether the utility purchased wholesale water, whether the system existed prior to 1981 (a proxy for age of the utility system), and a logged measure of the population served by the utility (a proxy for size). Table 1 offers a descriptive summary of our data.

Models

In order to evaluate our compliance hypotheses, we estimated a statistical model with the following form for health violations:

$$V_{it} = \alpha_1 + \beta_1 S_{it} + \beta_2 H_{it} + \beta_3 B_{it} + \beta_4 S_{it} H_{it} + \beta_5 S_{it} B_{it} + \beta_6 U_{it} + \beta_7 E_{it} + \beta_8 T_{it} + \beta_9 V_{it-1} + \varepsilon_{it},$$

where V represents the number of violations for a given utility i in year t, S represents SES, H and B represent Hispanic and black populations, U is utility-level characteristics, E is a vector of state fixed effects, and T represents a vector of year fixed effects. We follow the typical approach to analyzing environmental compliance (Konisky and Schario, 2010; Konisky and Teodoro, 2016) by including a lagged dependent variable, and α and ε are constant and error terms, respectively.

TABLE 2

Negative Binomial Regression Predicting SDWA Violations 2010–2013

	(1)		(2)	
	Coefficient	Standard Error	Coefficient	Standard Error
Lagged violations	0.800**	(0.016)	0.800**	(0.016)
SES	–0.121**	(0.023)	–0.059*	(0.027)
% Hispanic	0.004**	(0.001)	–0.001	(0.002)
% Black	0.000	(0.001)	–0.002	(0.002)
Hisp × SES			–0.004**	(0.001)
Black × SES			–0.003*	(0.001)
Logged population served	–0.123**	(0.016)	–0.112**	(0.017)
Groundwater supply	–0.665**	(0.043)	–0.660**	(0.043)
Purchased water supply	–0.583**	(0.046)	–0.573**	(0.046)
New system	–0.246**	(0.058)	–0.229**	(0.059)
Constant	–1.108**	(0.155)	–1.112**	(0.156)
Observations	51,889		51,889	
AIC	36,819.194		36,802.909	
Log likelihood	–18,348.970		–18,338.455	
LR-test (χ^2)		20.28**		

NOTE: Models also include state and year fixed effects. Significance levels: ** <0.01; * <0.05.
LR-test of whether interactive model improves on no interaction model.

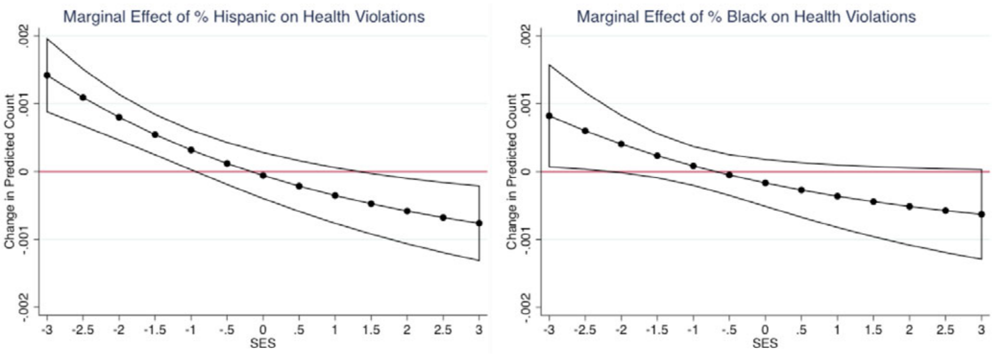
Our dependent variable is a count of SDWA health violations, meaning linear regression is not an appropriate modeling strategy. Additionally, while Poisson models are most commonly used to model counts, they make a strong assumption that the mean and variance of the distribution are equal. When data are overdispersed (i.e., the variance of the dependent variable is larger than its mean), the Poisson model may lead to biased results (King, 1998). Statistical testing showed evidence of overdispersion in the count of violations, and so we estimate pooled time series negative binomial models, which relax the assumption of equal mean and variance (King, 1998). We estimated models with and without the interaction terms. Allowing the effect of a variable x on y to depend on a third variable z, interactive models provide for a deeper understanding of the relationship between x and y. By advancing a model that allows for the effects of race and ethnicity to depend on SES, we are able to gain a clearer understanding of where environmental injustice occurs. Further, estimating a model with direct effects only alongside our interactive models, it is possible to see what (if any) information is gained by including the interaction terms and whether SES-race or SES-ethnicity interactions improve estimation significantly.

Results

Table 2 reports the results of our two models of SDWA health violations: the traditional noninteractive model is reported as Model (1); the interactive model is reported as Model (2). These estimates provide strong evidence for a conditional relationship between SES and race/ethnicity. The traditional EJ Model (1) provides support for H1 and H2, but little support for H3: increasing SES has a strong negative effect on the number of health violations, and utilities serving areas with higher Hispanic populations committed

FIGURE 1

Marginal Effect of Race/Ethnicity on Health Violations



NOTE: Figure depicts 95 percent confidence intervals.

more violations. Contrary to expectations, percent black population is not statistically or substantively significant in Model (1).

The results of the interactive Model (2) show that the effects of percent Hispanic and black on health violations are both conditional on SES. Both interaction terms are substantively and statistically significant, showing that the effects of increasing Hispanic and black population on SDWA violations decline as SES increases and supporting H4 and H5.

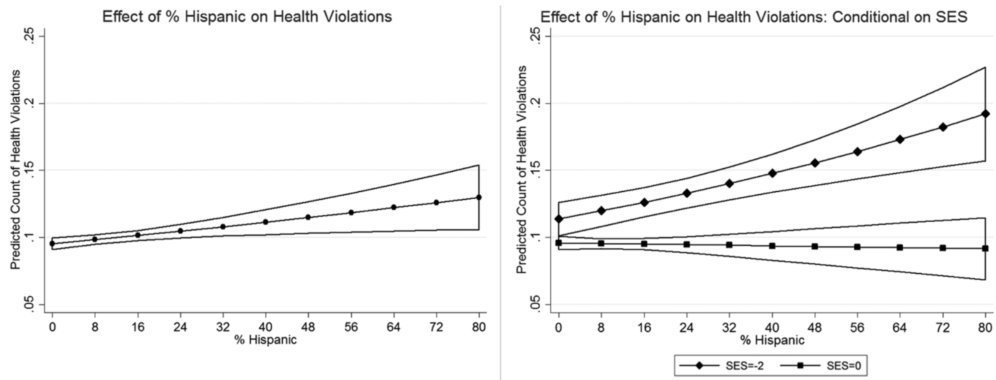
Figure 1 illustrates the marginal effects of Hispanic and black population, conditional on SES. In other words, Figure 1 shows how a 1 percent increase in the percent Hispanic or black population changes the expected number of SDWA violations at various levels of SES. The conditional relationship between Hispanic population and SES is quite clear in the left panel of Figure 1: percent Hispanic has a positive and significant relationship with the number of health violations in areas where SES is one standard deviation below the mean or lower, but this effect becomes small and statistically indistinguishable from zero as SES increases. Indeed, in very high SES communities, higher levels of Hispanic population are actually associated with fewer violations, although highly affluent areas with high Hispanic populations are uncommon and the effect is relatively small.

The right panel of Figure 1 depicts the marginal effect of percent black population on SDWA compliance. Black population has a positive and significant effect on health violations only in the very poorest of areas, 2.15 standard deviations below mean SES or lower. In areas any more affluent than this, there is no statistically significant relationship between a community's racial composition and SDWA violations.

Comparison of the predicted counts of the two models illustrates how noninteractive models may misestimate EJ effects. Figure 2 shows predicted counts of health violations by percent Hispanic population, with estimates based on the noninteractive Model (1) in the left panel and estimates from the interactive Model (2) in the right panel. With direct effects only, the left panel of Figure 2 shows that there is a modestly positive correlation between percent Hispanic and violations at average SES. The right panel of Figure 2 shows the predicted counts of health violations based on the interactive model for a community with average SES and a community with SES two standard deviations below average. For a utility serving an area with an SES of –2, an increase in the Hispanic population

FIGURE 2

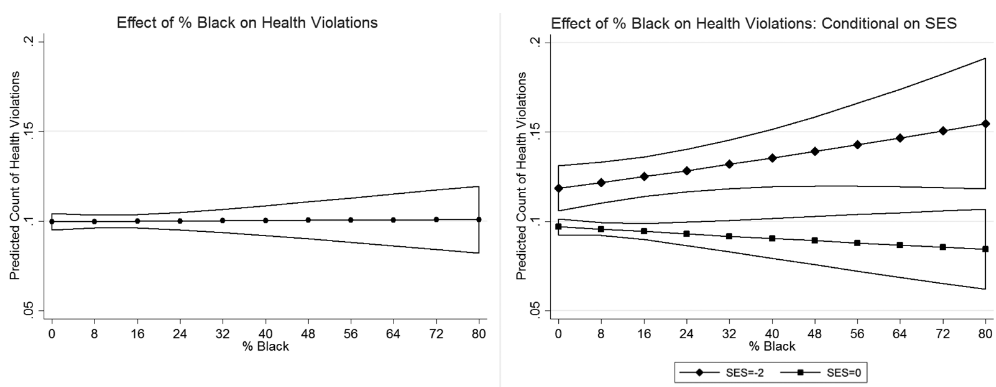
Hispanic Population and Predicted SDWA Health Violations—Direct and Interactive Effects



NOTE: Figure depicts 95 percent confidence intervals.

FIGURE 3

Black Population and Predicted SDWA Health Violations—Direct and Interactive Effects



NOTE: Figure depicts 95 percent confidence intervals.

from 0 percent to 80 results in a 0.08 (or 70 percent) increase in predicted violations. At average SES, the same increase in Hispanic population results in a statistically insignificant 4 percent *decrease* in the predicted number of health violations. That is, the interactive model shows that in communities with low SES, the effect of Hispanic population on the number of violations is much higher, while there is no significant effect of ethnicity in more affluent areas.

The same comparison for race can be seen in Figure 3, again with the noninteractive Model (1) estimates in the left panel and the interactive Model (2) in the right panel. While the noninteractive model showed no significant correlation between percent black population and health violations, the interactive model finds that at very low levels of SES, black population positively predicts SDWA health violations. For a utility in a community with an average SES, the effect of increasing black population results in a very small, statistically insignificant decrease in predicted health violations. For a poor community with

SES two standard deviations below the mean, however, the increase in black population from 0 percent to 80 percent correlates with a 30 percent increase in health violations. Based on the noninteractive models alone, we would have concluded that percent black population has no relationship with drinking water health violations. Once the potential conditional relationship with SES is considered, however, we find evidence of racial inequities in the poorest of communities. We should note that while only about 1.5 percent of all utilities serve populations with an SES lower than –2 standard deviations below the mean, 28 percent of these cases are majority black communities, which further highlights the need to consider the interactive relationship.

From an EJ perspective, the noninteractive Model (1) both over- and underestimates the effect of race/ethnicity on environmental outcomes. For poor communities, a noninteractive model greatly underestimates the relationship between Hispanic and black population and drinking water quality, while for more affluent communities it significantly overestimates the relationship.

Comparative Fit

As expected, the inclusion of interactions between SES and race/ethnicity greatly improved the fit of our model predicting health violations. Both penalized fit statistics and statistical testing showed that Model (2) was a significant improvement on Model (1), suggesting that EJ analyses with interactions may offer greater explanatory power than the noninteractive analyses that are most common in EJ research.

Beginning with fit statistics, the inclusion of the interaction term in Model (2) greatly improved both the log likelihood and the Akaike information criterion (AIC) score of our model: including the interaction terms results in a 10.2 increase in log likelihood and a 16.4 decrease in AIC. The decrease in AIC is especially important, since the AIC penalizes the estimate for inclusion of each additional variable. Since Model (1) is nested within Model (2) (the interaction terms are the only differences in specification), a simple likelihood ratio test allows us to evaluate formally the hypothesis that the interactive model improves on the noninteractive model. The likelihood ratio test tests whether an unrestricted model (in this case the interactive Model (2)), improves on the restricted model (noninteractive Model (1)). The likelihood ratio test yields a χ^2 of 20.28, meaning that we can reject the null hypothesis of no improved fit, and provides substantial evidence that the inclusion of the interaction terms is appropriate when predicting SDWA health violations. Put simply, for SDWA compliance, modeling interactions between race/ethnicity and SES results in markedly superior estimates compared with a traditional noninteractive model. Future environmental justice models should take into account these potential conditional relationships.

Conclusion

By examining race, ethnicity, SES, and their interactions simultaneously, this research takes an important step toward understanding how each of these variables can affect environmental policy implementation alone and in combination with each other. The improvements in model fits and correlations unveiled through interactive modeling are useful advances that we hope to extend to other environmental programs; we encourage other EJ researchers to do the same. Interestingly, the interaction of SES is larger with percent Hispanic population than with percent black population, a finding that warrants further investigation.

The substantive results of our analysis carry disturbing implications for public health in poor communities, where members of racial and ethnic minorities face greater risk of unsafe drinking water. That the significance of race is most pronounced in the very poorest communities is particularly striking—from a welfare-maximizing perspective, these communities' experiences might be dismissed as outliers; from an environmental justice perspective, they are alarming. The challenge of providing safe drinking water to America's poorest communities takes on a troubling racial and ethnic cast that resonates well beyond Flint, Michigan.

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