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RACE, INCOME, AND ENVIRONMENTAL INEQUALITY IN THE UNITED STATES

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Abstract

This article asks whether the relationship between neighborhood and household income levels and neighborhood hazard levels varies according to neighborhood and household racial composition. Using a national, census tract-level data set, the authors find that black, white, and Hispanic households with similar incomes live in neighborhoods of dissimilar environmental quality, that the association between neighborhood and household income levels and neighborhood hazard levels varies according to neighborhood and household racial composition, and that increases in neighborhood and household income levels are more strongly associated with declining hazard levels in black neighborhoods and households than in white neighborhoods and households. These findings contradict Wilson's claim that the significance of race has declined in the modern industrial period and demonstrate that environmental racial inequality is not the product of racial income inequality. In addition, these findings suggest that the impact of higher incomes on black/white proximity to environmental hazards has less to do with increases in white geographic mobility (relative to black geographic mobility) than with the ability of higher income blacks to escape the highly polluted, disorganized, and deteriorated neighborhoods to which so many low-income blacks are confined.

Keywords

environmental inequality; environmental justice; environmental hazards; race

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Since the early 1990s, a growing number of researchers have attempted to determine whether environmental inequality exists in the United States (Bowen 2002; Brulle and Pellow 2005; Downey 2007). These researchers have focused much of their attention on three questions: Are racial minorities disproportionately burdened by environmental hazards? If so, is this because of their racial status or because minorities tend to have lower incomes than whites? And is neighborhood racial composition a stronger predictor than neighborhood income levels of neighborhood environmental hazard levels?

We expand on this research, and on arguments set forth by Pulido (1996, 2000) and Downey (1998), by arguing that rather than comparing the predictive power of race and income, it would be more fruitful to ask whether these factors interact to produce environmentally inequitable outcomes. Thus, this study addresses questions such as the following: Does the association between neighborhood income levels and neighborhood hazard levels vary according to neighborhood racial composition? Are increases in neighborhood income levels more strongly associated with declining hazard levels in minority neighborhoods or white neighborhoods?

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Questions such as these have not been posed in prior environmental inequality research. Thus, this article extends prior research by (a) developing a theoretical explanation for why race and income should interact to produce environmentally inequitable outcomes and (b) testing neighborhood- and household-level hypotheses derived from this explanation.

In order to test these hypotheses, we merge industrial air pollutant concentration data drawn from the Environmental Protection Agency's (EPA) year-2000 Risk-Screening Environmental Indicators (RSEI) project with demographic data drawn from the 2000 U.S. census (data are merged for every census tract in the continental United States). We then divide U.S. households into different race/income categories and test our household-level hypotheses by comparing neighborhood pollution levels for households in these different categories. Finally, we run a set of regression analyses that allow us to determine whether the relationship between neighborhood income levels and neighborhood hazard levels varies according to neighborhood racial composition. Although these analyses do not allow us to determine why or how race and income interact to produce environmentally inequitable outcomes, they do allow us to determine whether they interact to produce environmentally inequitable outcomes. As we hope to demonstrate below, this increases our understanding of environmental inequality in the United States in several important ways.

Literature Review

The environmental inequality literature is very broad, with researchers studying topics ranging from the public health implications of residing in polluted neighborhoods (Berry and Bove 1997; Brulle and Pellow 2005; Croen et al. 1997; Downey and Van Willigen 2005; Environmental Health Perspectives 2002; Evans and Kantrowitz 2002; Evans and Marcynyszyn 2004) to global environmental inequality (Clapp 2001; Roberts and Parks 2007; Smith, Sonnenfeld, and Pellow 2006; Washington, Rosier, and Goodall 2006) to qualitative examinations of environmental justice organizations and environmental justice communities (Bullard 2005; Pellow and Brulle 2005; Roberts and Toffolon-Weiss 2001). Researchers have debated the relative merits of different research methodologies (Bowen 2002; Downey 2006, 2007; Mohai and Saha 2006; Pastor, Sadd, and Morello-Frosch 2004) and different definitions of environmental inequality (Downey 1998, 2005a; Holif-ield 2001; Pulido 1996; Stretesky and Hogan 1998) and have conducted extensive quantitative analyses to determine whether environmental racial inequality exists, whether racial minorities are disproportionately burdened by environmental hazards because of their racial status or income status, and whether neighborhood racial composition is a stronger predictor than neighborhood income levels of neighborhood environmental hazard levels (the race versus income debate).

These quantitative studies have produced mixed results. Although several studies have found that the association between neighborhood racial composition and neighborhood hazard levels persists after controlling for neighborhood income levels and other neighborhood characteristics (Ash and Fetter 2004; Brulle and Pellow 2005; Lester, Allen, and Hill 2001; Mennis and Jordan 2005; Morello-Frosch, Pastor, and Sadd 2001; Sadd et al. 1999; Stretesky and Hogan 1998), several other studies have found that this association either does not exist or is no longer statistically significant after including control variables in the analysis (Anderton et al. 1994; Atlas 2002; Bowen 2002; Bowen et al. 1995; Derezinski, Lacy, and Stretesky 2003; Oakes, Anderton, and Anderson 1996). Moreover, the findings in some of the former studies only hold under certain model specifications or when certain pollution variables are used but not others.

In addition to producing mixed results, these studies have also drawn criticism from researchers, who argue that the "race versus income debate" masks much of the complexity that underlies the relationship between race and class in the United States (Downey 1998;

Pulido 1996, 2000; Stretesky and Hogan 1998). These researchers note, for example, that racial income inequality is largely the product of racial discrimination in educational institutions and housing and labor markets (Massey and Denton 1993; Waldinger 1996). Thus, it is likely that racial discrimination plays an important role in shaping environmental racial inequality even when regression models indicate that environmental racial inequality is due solely to racial income inequality.

In addition, Pulido (1996) and Downey (1998) argue that comparing the relative predictive power of race and income is unproductive because "it implies that the one factor that is found to be 'right' has to be so at the expense of the other" (Downey 1998: 774). This is problematic, they contend, because (a) race and income work together, not separately, to produce racially and environmentally inequitable outcomes and (b) the role income and class play in shaping environmental outcomes likely differs for different racial and ethnic groups (Pulido 2000).

Given this argument and the fact that racial and ethnic groups vary in their ability to translate income gains into residential mobility (Crowder and South 2005; Massey and Denton 1993), we hypothesize that (a) the relationship between household income levels and neighborhood hazard levels should vary according to household racial composition and (b) the relationship between neighborhood income levels and neighborhood hazard levels should vary according to neighborhood racial composition.

As noted earlier, these hypotheses have not been tested in prior research.[1] The most likely reason for this is that theoretical explanations of environmental inequality generally ignore the possibility that race and income may interact to produce environmentally inequitable outcomes. For example, the most common explanations of environmental inequality hold that poor and minority neighborhoods are more likely than other neighborhoods to house environmental hazards because (a) poor and minority communities lack the political power to keep hazardous facilities out of their neighborhoods (Hamilton 1995); (b) housing market racism confines minorities to undesirable neighborhoods shunned by whites (Mohai and Bryant 1992); (c) housing costs are relatively low in environmentally hazardous neighborhoods, making them more attractive to lower income people who are, in turn, disproportionately nonwhite (Hamilton 1995;Mohai and Bryant 1992); or (d) environmentally hazardous facilities are intentionally sited in minority neighborhoods (Downey 2005c).

Although few researchers have directly tested these explanatory models (exceptions include Downey 2005c; Hunter et al. 2003; Pastor, Sadd, and Hipp 2001), researchers have used these models to predict that statistical associations between neighborhood racial composition and neighborhood hazard levels either should (Models B and D) or should not (Models A and C) persist after controlling for neighborhood income levels and other factors associated with environmental hazard presence. As a result, these models have provided theoretical justification for much quantitative environmental inequality research.

What these models have failed to do is provide researchers with any reason for expecting that race and income should interact to produce environmentally inequitable outcomes. Thus, in developing a theoretical explanation for why race and income should interact to produce environmental inequality, and in testing hypotheses drawn from this explanation, this study fills an important theoretical and empirical gap in the literature.

[1]Downey (2003) tests the hypothesis that black and white households with similar incomes live in neighborhoods of dissimilar environmental quality, but he does not test other "interaction" hypotheses and his study is confined to the Detroit metropolitan area.

Why Race and Income Should Interact

Although generally unacknowledged in the environmental inequality literature (Downey 2003), the race versus income debate bears a striking similarity to broader sociological debates surrounding Wilson's (1978) declining significance of race thesis. According to Wilson, blacks' life chances are now determined more by their economic status than their racial status. Thus, differences between blacks and whites across a whole range of social indicators are the result not of racial discrimination but of income differences between blacks and white.

If Wilson is correct, then the life chances and experiences of blacks and whites with similar incomes should be relatively similar to each other, and as a result, blacks and whites with similar incomes should live in neighborhoods of similar environmental quality (Downey 2003). In other words, if Wilson is correct, the relationship between neighborhood and household income levels and neighborhood pollution levels should not vary according to neighborhood and household racial composition.

Empirically, Wilson's thesis has not fared well (Feagin and Sikes 1994; Massey and Denton 1993; Sugrue 1996; Waldinger 1996). For example, research demonstrates that white housing preferences and discriminatory real estate and lending practices place blacks and whites in different housing markets (Galster and Godfrey 2005; Massey and Denton 1993; Oliver and Shapiro 2006). Racial and ethnic groups also vary in their ability to translate income and human capital gains into residential mobility into more desirable neighborhoods (Charles 2003; Crowder and South 2005; Logan and Alba 1993; South, Crowder, and Chavez 2005). These findings not only contradict Wilson's argument, they also suggest that blacks, whites, and Hispanics with similar incomes are likely to live in neighborhoods of dissimilar environmental quality. Thus, the relationship between neighborhood and household income levels and neighborhood pollution levels is likely to vary according to neighborhood and household racial composition.

But even if this relationship does vary according to neighborhood and household racial composition, it is not clear what the nature of this variation will be. On the one hand, because higher incomes tend to increase residential mobility for whites more than for minorities (Charles 2003; Crowder and South 2005; South et al. 2005), it seems likely that increases in income levels across neighborhoods and households will be more strongly associated with declining hazard levels in white neighborhoods and households than in minority neighborhoods and households. On the other hand, because low-income minority neighborhoods and households are more likely than low-income white neighborhoods and households to experience neighborhood disorganization and neighborhood deterioration (Sampson, Morenoff, and Gannon-Rowley 2002; Small and Newman 2001; Wilson 1987), it seems likely that increases in income levels across neighborhoods and households will be more strongly associated with declining hazard levels in minority neighborhoods and households than in white neighborhoods and households.

Thus, in the analyses presented below, we test the following hypotheses:

> *Hypothesis 1*: Blacks, whites, and Hispanics with similar incomes live in neighborhoods of dissimilar environmental quality.
>
> *Hypothesis 2*: The association between neighborhood and household income levels and neighborhood hazard levels varies according to neighborhood and household racial composition.
>
> *Hypothesis 3*: Increases in neighborhood and household income levels should be more strongly associated with declining hazard levels in white neighborhoods and households than in minority neighborhoods and households.

> *Hypothesis 4*: Increases in neighborhood and household income levels should be more strongly associated with declining hazard levels in minority neighborhoods and households than in white neighborhoods and households.

Before proceeding, we should note that Hypotheses 3 and 4 refer to variation in income levels across neighborhoods and households at a single point in time rather than to variation over time in income levels within neighborhoods and households. We should also note that the argument from which Hypothesis 4 is derived is potentially consistent with Wilson's (1987) argument that poor blacks live in much more highly disorganized and deteriorated neighborhoods than do poor whites due to middle-class black flight from poor black neighborhoods. However, Hypothesis 4 can be supported even if middle-class blacks and whites live in neighborhoods of dissimilar environmental inequality, whereas Wilson's argument is inconsistent with such an outcome.

Pollution Data

The pollution data used in this study are derived from the EPA's RSEI project. The RSEI model from which the pollution data are derived models the toxicity-weighted concentration of air pollutants released from every facility listed in the EPA's year-2000 Toxics Release Inventory (TRI). The TRI records the number of pounds of specified toxic chemicals released into the environment each year by industrial facilities that fall into one of seven industrial categories (manufacturing, metal mining, coal mining, electric generating facilities that combust coal or oil, chemical wholesale distributors, petroleum terminals, and bulk storage), employ the equivalent of ten or more full-time workers, and manufacture, process, or otherwise use the specified chemicals in specified quantities. In 2000, the specified quantities were 25,000 pounds for facilities that manufactured or processed TRI chemicals and 10,000 pounds for facilities that otherwise used TRI chemicals (Rtknet 2004). The TRI chemical list included over 600 chemicals and chemical categories in 2000.

The RSEI estimates a 101-kilometer square pollution plume model (made up of one-kilometer square grid cells) for each air pollutant released by each TRI facility in a calendar year. Incorporating factors such as wind speed, wind direction, air turbulence, smokestack height, exit gas velocities, and rate of chemical decay and deposition, the RSEI model estimates a yearly, average air pollutant concentration value for each one-kilometer square grid cell in each plume model. Each grid cell value in each plume model is then multiplied by the toxicity weight of the modeled air pollutant, and the toxicity-weighted grid cell values for each plume model in the United States are then summed together to create a toxicity-weighted air concentration grid (also made up of one-kilometer square grid cells) for the entire nation (see EPA 2004a for technical details on the RSEI model).

For example, if we placed a grid consisting of one-kilometer square grid cells across the entire continental United States, and each grid cell in this national grid had a value of zero, then (a) each of the grid cells in each of the air pollutant plume models would directly correspond to one of the cells in the national grid and (b) we could add the value of each plume model grid cell to the value of its corresponding grid cell in the national grid. The RSEI data used in this article are thus created by successively adding cell values from each air pollutant plume model to the appropriate cell values in the national grid, such that some cell values in the national grid are calculated using information from multiple plume models and multiple TRI facilities and other cell values retain a value of zero because they do not correspond with any of the plume model grid cells.

Finally, in order to estimate the toxicity-weighted air pollutant concentration level in each census tract in the continental United States, we calculated the proportion of each census tract covered by each grid cell that overlapped it. We then calculated the weighted average of each tract's overlapping grid cells using the proportion overlap as our weighting variable. For example, if Grid Cells 1 and 2 covered 40 percent and 60 percent of Tract A, respectively, and if the toxicity-weighted concentration values of these grid cells were 10 and 20, respectively, then the toxicity-weighted concentration value of Tract A would equal [(10 ×.4) + (20 ×.6)].

Before proceeding, it is important to note that the data used in this study were obtained directly from the EPA and are not included in the public release data set. The main difference between our data and the public release data is that the public release data provide facility-specific hazard and risk scores for each facility in the TRI database, while the data used here provide an estimated air pollutant concentration value for each one-kilometer square grid cell in the United States, with each cell value potentially incorporating information from multiple facilities. Unlike the data used here, the public release data also incorporate information on water and ground pollution.

It is also important to note that RSEI data are not exposure estimates. They are unitless measures that (a) allow researchers to "assess the relative hazard and risk of chemicals, facilities, regions, and industries" and (b) are only meaningful in relation to other RSEI data values (EPA 2004b). Thus, the tract-level, toxicity-weighted, air pollutant concentration data used in this study provide estimates of the relative risk of each census tract in the study area in relation to every other census tract in the study area (see Downey 2007 for a discussion of the strengths and weaknesses of the RSEI data).

Demographic Data

Demographic data for every census tract in the continental United States were obtained from the 2000 U.S. Census. Demographic variables include percent His-panic, percent non-Hispanic black, percent non-Hispanic white, median household income (in thousands of dollars), the percentage of tract residents twenty-five years old and older who have completed at least one year of college (percent some college), median property value (in thousands of dollars), median housing unit age, the number of tract residents per square mile divided by 1,000 (population density), the percentage of tract housing units that are vacant (percent vacant), and the percentage of employed tract residents sixteen years old and older who are engaged in manufacturing occupations (percent manufacturer). Table 1 lists the means and standard deviations of these variables and of the toxicity-weighted air pollutant concentration variables, toxic concentration and toxic concentration logged.

The race and income variables are included in the analysis in order to test the hypotheses listed above and because environmental inequality researchers have focused their attention primarily on blacks, whites, and Hispanics. The remaining demographic variables were selected based on their importance in prior quantitative research, most of which asks whether racial minorities are disproportionately burdened by environmental hazards because of their racial status, their income status, or some other theoretically relevant, but supposedly "nonracial," factor. Thus, most regression models found in the literature include income and other control variables in the analysis in order to examine their impact on the association between neighborhood racial composition and neighborhood hazard levels.

As we argued earlier, this methodological approach is potentially problematic because racial discrimination can play an important role in shaping environmental racial inequality even when regression models indicate that environmental racial inequality is due solely to racial income inequality or to factors such as neighborhood workforce composition, neighborhood education levels, and neighborhood property values, all of which are strongly influenced by race and racial discrimination (Charles 2003; Crowder and South 2005; Massey and Denton 1993; Waldinger 1996; Western and Pettit 2005). Nevertheless, we include these and other control variables in our regression models in order to be consistent with prior research and to show that even after controlling for these variables, race and income still interact to produce environmentally inequitable outcomes.

Thus, percent manufacturer is included in the analysis because researchers have hypothesized that industrial facilities and industrial workers tend to locate near each other (Anderton et al. 1994); median property value is included because researchers have hypothesized that industrial facilities and low-income individuals are both attracted to neighborhoods with low property values (Downey 2005c); percent some college is included because neighborhood education levels have been significantly associated with environmental risk levels in prior research (Ash and Fetter 2004); and population density is included because (a) industrial facilities are often located in areas with plenty of open space (Downey 2005c) and (b) some researchers have argued that local officials work to reduce pollution levels in areas with high population densities (Ash and Fetter 2004). Finally, median housing unit age and percent vacant are included because it is likely that industrial facilities are overrepresented in older, somewhat run-down neighborhoods.

RESULTS

In order to determine whether blacks, whites, and Hispanics are overrepresented in environmentally hazardous neighborhoods, Table 2 compares the neighborhood toxic concentration values of the average Hispanic, non-Hispanic black, non-Hispanic white, non-Hispanic Pacific Islander, non-Hispanic Native American, and non-Hispanic Asian American in the continental United States. These values were calculated using census tract data and represent weighted averages taken by multiplying the number of group members in each census tract by the toxic concentration value in each tract, summing these products across all tracts, and then dividing this sum by the number of group members in the entire continental United States. For example, if we were studying three census tracts, with twenty, thirty, and fifty Hispanics, respectively, and toxic concentration levels of zero, five, and ten, respectively, the average Hispanic person in these tracts would live in a tract with a toxic concentration value equal to $[(20 \times 0) + (30 \times 5) + (50 \times 10)]/(20 + 30 + 50)$.

Table 2 shows that in the continental United States, the average non-Hispanic black person lives in a census tract that has a toxic concentration value of 732.9. This value is significantly different from the average toxic concentration value of each of the other racial/ethnic groups listed in Table 2, ranging from 1.45 times as great as the value for non-Hispanic whites to 2.52 times as great as the value for non-Hispanic Asian Americans. Non-Hispanic whites have the second highest average toxic concentration value found in the table, followed by Hispanics and non-Hispanic Pacific Islanders, whose values are not significantly different from each other. Finally, non-Hispanic Native Americans and non-Hispanic Asian Americans have the lowest average toxic concentration values found in Table 2.

Thus, Table 2 shows that in the continental United States, non-Hispanic blacks are more highly overrepresented in environmentally hazardous census tracts than are any of the other racial/ethnic groups included in the table. Non-Hispanic whites are also overrepresented in environmentally hazardous census tracts but not to nearly the same degree as non-Hispanic blacks. Finally, Hispanics and non-Hispanic Pacific Islanders are overrepresented in environmentally hazardous tracts when compared to non-Hispanic Native Americans and non-Hispanic Asian Americans but not when compared to non-Hispanic blacks and non-Hispanic whites.

Table 3 divides U.S. households into different race/income groups and compares the average neighborhood toxic concentration values of Hispanic, black, and white households that fall into the same income category, allowing us to determine whether black, white, and Hispanic households with similar incomes live in neighborhoods of dissimilar environmental quality. The income categories, which are provided by the U.S. Census, are listed in the first column of the table, and the average toxic concentration values for black, Hispanic, and white households are listed in Columns 2 through 4. Because categorical household income data are unavailable for non-Hispanic black and non-Hispanic white households, the black and white toxic concentration values are calculated using data that include black and white Hispanic households. Although we cannot be entirely certain about how this affects the toxic concentration values, a comparison of all Hispanic- and non-Hispanic black individuals and all Hispanic- and non-Hispanic white individuals suggests that including data for Hispanic households in our calculations lowers the black and white toxic concentration averages, possibly a bit more for white households than for black households. This is unfortunate but unavoidable.

The last three columns in Table 3 list, for each income category, a black/white, black/Hispanic, and white/Hispanic toxic concentration ratio that is calculated by dividing the toxic concentration value of the first racial/ethnic group in the ratio pair by the toxic concentration value of the second racial/ethnic group in the ratio pair. For example, the first black/white ratio in Table 3 (Column 5) shows that the average black household with an income below $10,000 lives in a neighborhood with a toxic concentration value that is significantly different from and 1.51 times as great as the average white household in the same income category.

Table 3 shows that there are only three pairs of "within-income category" toxic concentration values that are not significantly different from each other (those for the wealthiest three groups of Hispanic and white households). Thus, Table 3 provides strong support for Hypothesis 1, which holds that blacks, whites, and Hispanics with similar incomes live in neighborhoods of dissimilar environmental quality. These results also demonstrate that in the continental United States, environmental racial inequality cannot be explained by income differences between blacks, whites, and Hispanics, at least when toxic concentration data are used to indicate environmental quality.

Table 3 also provides some initial evidence with which to evaluate Hypotheses 2 through 4. Restricting our attention to the black/white toxic concentration ratios (Column 5), we see that as household incomes increase, the black/white ratio declines from a high of 1.51 when household incomes are less than $10,000 to a low of 1.22 when household incomes reach the $50,000 to $60,000 income range. The black/white ratio then holds steady until household incomes reach the $125,000 to $150,000 income range, at which point the ratio begins to increase (the black/white ratio increases dramatically when household incomes reach the $200,000 and above range).

Thus, the black/white ratio data suggest that increases in household income levels are more strongly associated with declining hazard levels for black households than for white households, at least when household incomes are below $60,000 (79.93 percent of black households and 64.77 percent of white households have incomes below $60,000). This is consistent with Hypothesis 4, which holds that increases in household income levels should be more strongly associated with declining hazard levels for minority households than for white households, but inconsistent with Hypothesis 3, which holds that the opposite should be true. This is also consistent with Hypothesis 2, which holds that the association between household income levels and neighborhood hazard levels should vary according to household racial composition.

Directing our attention to Column 4, we see that unlike increases in black and white household income, increases in Hispanic household income appear to have no consistent effect on toxic concentration values until Hispanic household incomes reach approximately $45,000, at which point income increases appear to be associated with declining toxic concentration levels. This is consistent with Hypothesis 2 because it suggests that the association between household income levels and neighborhood hazard levels varies according to household racial composition.

Finally, the white/Hispanic ratio data found in Column 7 contradict Hypotheses 3 and 4 because they show that increases in household incomes do not result in a steadily increasing or decreasing white/Hispanic ratio at any point along the income category range. (The white/Hispanic ratio does decline from 1.32 to 1.22 as household incomes increase from approximately $25,000 to approximately $45,000. However, this is a very narrow income range and a very narrow ratio range.)

Testing the Race/Income Interactions

Although Table 3 presents evidence with which to tentatively evaluate Hypotheses 2 through 4, these hypotheses cannot be fully evaluated without conducting significance tests of the interaction between race and income and without controlling for other factors associated with environmental hazard presence. Thus, Table 4, Model 1 regresses toxic concentration logged on percent non-Hispanic black, median household income, an interaction term created by multiplying percent non-Hispanic black and median household income, and a set of control variables that were discussed earlier in the article. Model 2 inserts percent Hispanic and a “Percent Hispanic × Median Household Income” interaction term into the equation in place of percent non-Hispanic black and its interaction term, and Model 3 inserts percent non-Hispanic white and a “non-Hispanic White × Median Household Income” interaction term into the equation in place of percent Hispanic and its interaction term.

Several points must be made before discussing the regression results. First, the regression models use neighborhood-level demographic data rather than household-level demographic data because the decennial U.S. Census does not provide demographic data for individual households. Second, the dependent variable is logged because it is highly and positively skewed. This means that model coefficients cannot be interpreted directly. Thus, in addition to providing untransformed model coefficients, we also provide transformed coefficients that indicate the percentage change in the dependent variable that results from a one standard deviation change in the independent variable.

Third, fixed effects regression models are employed rather than Ordinary Least Squares (OLS) regression models because average pollution levels and other factors vary greatly across metropolitan areas and across metropolitan and nonmetropolitan areas, making it difficult to disentangle the effects of census tract variation from the effects of regional variation. Fixed effects regression models solve this problem by controlling for unobserved regional variation, thereby providing identical results to those that would have been obtained had we run OLS models that included a dummy variable for each metropolitan area in the United States, with nonmetropolitan area census tracts as the reference category.

Table 4 shows that after controlling for other neighborhood covariates, all three sets of Race, Income, and Race × Income interaction terms are significantly associated with toxic concentration logged. In Model 1, toxic concentration logged is positively associated with percent non-Hispanic black and negatively associated with median household income and the Race × Income interaction term; in Model 2, toxic concentration logged is negatively associated with percent Hispanic and median household income and positively associated with the Race × Income interaction term; and in Model 3, toxic concentration logged is negatively associated with percent non-Hispanic white and median household income and positively associated with the interaction term.

Figure 1 graphs these significant associations, holding all the statistically significant control variables constant at their means and the statistically insignificant control variables constant at zero. Median household income is held constant at $25,000, $75,000, and $125,000 in Graphs 1 through 3, respectively, and neighborhood racial composition is held constant at various levels in Graphs 4 through 6. In Graphs 1 through 3, neighborhood racial composition is allowed to vary along the x-axis; in Graphs 4 through 6, median household income is allowed to vary along the x-axis; and in all six graphs, the y-axis represents unlogged toxic concentration values.

The statistically significant interaction terms in Table 4, and the graphs in Figure 1, support Hypothesis 2 by demonstrating that the association between neighborhood income levels and neighborhood hazard levels does vary according to neighborhood racial composition. To contradict this hypothesis, the interaction terms would have to be statistically insignificant and the lines in the last three graphs would all have to follow the exact same path. The statistically significant interaction terms and Graphs 1 through 3 also indicate that the relationship between neighborhood racial composition and neighborhood toxic concentration levels varies according to neighborhood income levels. For example, in low-income neighborhoods (Graph 1), the association between percent non-Hispanic black and toxic concentration levels is strongly positive, but in high-income neighborhoods (Graph 3), the association is negative.

Figure 1 also allows us to test Hypotheses 3 and 4. In order to do this, Graph 4 examines the relationship between median household income and toxic concentration, holding percent non-Hispanic white constant at 0 percent, 50 percent, and 100 percent. If Hypothesis 3 is correct, increases in neighborhood income levels should be more strongly associated with declining hazard levels in white neighborhoods than in minority neighborhoods. If Hypothesis 4 is correct, the opposite should be true.

As Graph 4 demonstrates, the negative slopes of the graphed lines are steepest in neighborhoods with no whites and the least steep in neighborhoods that are all white, thus supporting Hypothesis 4 and contradicting Hypothesis 3.

Because the relationship between neighborhood income levels and neighborhood toxic concentration levels differs for blacks and Hispanics, we also graph the relationship between these variables for black and nonblack neighborhoods (Graph 5) and Hispanic and non-Hispanic neighborhoods (Graph 6). In Graph 5, the negative slopes of the graphed lines are steepest in neighborhoods that are 100 percent non-Hispanic black and the least steep in neighborhoods that are 0 percent non-Hispanic black. This is consistent with Hypothesis 4 and with the findings presented in Graph 4.

In Graph 6, however, the slopes of the graphed lines range from negative to positive, with the steepest negative slope in neighborhoods that are 0 percent Hispanic and the steepest positive slope in neighborhoods that are 100 percent Hispanic.[2] This is inconsistent with the findings illustrated in Graphs 4 and 5.

Finally, we ran a set of unreported fixed effects regression models, each of which included median household income, one of the race variables, and a Race Income interaction term but none of the other covariates. These models show that in census tracts with median household incomes below $25,000, the average all-black neighborhood has a pollution burden that is between 2.6 and 3.3 times greater than the pollution burden of the average all-white neighborhood. However, as neighborhood incomes increase, the pollution burden in all-black

[2]Ninety-nine percent of the tracts in the continental United States that are 50 percent or more Hispanic have median household incomes of less than $62,000. Thus, the important point to keep in mind when looking at Graph 6 is not the toxic concentration values found at higher median household income levels but the trend in the slopes of the lines as percent Hispanic increases.

and all-white neighborhoods converges, becoming virtually identical once neighborhood incomes reach approximately $120,000. These findings are consistent with Hypothesis 4 and with Wilson's argument concerning middle-class black flight but inconsistent with Wilson's declining significance of race thesis.

Because these findings control for regional variation (unlike the household-level findings in Table 3), they suggest that the reason higher income black households experience a greater pollution burden than higher income white households (Table 3) may be because higher income black households reside in more polluted regions of the country than do higher income white households. However, these findings also suggest that regional variation in pollution levels does not explain the difference in pollution burden experienced by low- and medium-income black households and low- and medium-income white households.

DISCUSSION

The analyses presented in the previous section demonstrate that black, white, and Hispanic households with similar incomes live in neighborhoods of dissimilar environmental quality, that the association between neighborhood and household income levels and neighborhood hazard levels varies according to neighborhood and household racial composition, and that increases in neighborhood and household income levels are more strongly associated with declining toxic concentration levels in black neighborhoods and households than in white neighborhoods and households.

As with the results of any study, these results must be interpreted with caution. For example, this study examines a single environmental hazard, and as a result, its findings cannot be generalized to other environmental hazards. This study is also restricted to a detailed examination of black, Hispanic, and white environmental inequality. Thus, we do not know if the interactive relationships uncovered here hold for Asian Americans, Native Americans, and Pacific Islanders or whether results would vary if we compared Puerto Rican Americans with Mexican Americans, Cuban Americans, and other Hispanic Americans. This study may also mask important regional variation in black, white, and Hispanic environmental inequality and, therefore, important regional variation in the relationship between race, income, and neighborhood toxic concentration. Finally, this study does not test causal hypotheses. As a result, we do not know how or why race and income interact to produce environmental inequality.

These caveats notwithstanding, this study makes several important contributions to the environmental inequality literature. This study also has several important implications for public policy and future sociological research. First, with the exception of Pulido (1996, 2000) and Downey (1998), environmental inequality researchers have largely ignored the possibility that race and income may interact to produce environmental inequality. Thus, in setting forth a theoretical explanation for why this should occur and in providing empirical support for this explanation, this study fills an important theoretical and empirical gap in the literature. It also confirms Pulido's and Downey's claim that rather than comparing the relative predictive power of race and income, researchers should investigate how race and income work together to produce environmental inequality.

Second, this study demonstrates that environmental racial inequality is not the product of racial income inequality. If it were, black, white, and Hispanic households with similar incomes would live in neighborhoods of similar environmental quality, the association between neighborhood income levels and neighborhood hazard levels would not vary according to neighborhood racial composition, and whites would not be the second most highly burdened racial or ethnic group included in the study.

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Third, the fact that increases in income levels are more strongly associated with declining toxic concentration levels in black neighborhoods and households than in white neighborhoods and households suggests that the impact of higher incomes on black/white proximity to environmental hazards has less to do with increases in white geographic mobility (relative to black geographic mobility) than with the ability of higher income blacks to escape the highly polluted, disorganized, and deteriorated neighborhoods to which so many low-income blacks are confined. Determining whether this is true is clearly beyond the scope of this article. Nevertheless, it is an important topic for further research, the results of which will contribute greatly to our theoretical understanding of racial inequality in general and environmental inequality in particular.

Fourth, in demonstrating that the relationship between income and toxic concentration differs not only for whites and minorities but for Hispanics and blacks as well, this study suggests that researchers are not going to be able to develop a single explanation of environmental racial inequality that can be applied to all racial and ethnic groups. Instead, researchers will likely need to develop group-specific explanations that focus on different explanatory factors for different racial and ethnic groups or that explain how a common set of explanatory factors interact in different ways to shape the distribution of different racial and ethnic groups around different hazards. Developing such explanations will not be easy, but doing so will greatly increase our understanding of the roles that race, income, and other factors play in producing environmental inequality.

Fifth, in demonstrating that the associations between neighborhood and household income levels and neighborhood hazard levels vary according to neighborhood and household racial composition, this study (a) contradicts Wilson's claim that the significance of race has declined in the modern industrial period and (b) provides indirect support for the argument that racial and ethnic groups vary in their ability to translate income and human capital gains into residential mobility into more desirable neighborhoods (Charles 2003; Crowder and South 2005; South et al. 2005). In order to provide a more direct test of this residential mobility argument, researchers could merge household-level residential mobility data with neighborhood-level environmental hazard data to examine racial differences in residential mobility into and out of environmentally hazardous neighborhoods. Such data would allow researchers to directly test causal hypotheses regarding the determinants of environmental inequality and would shed light on general processes of neighborhood attainment and on the environmental consequences of racially differentiated patterns of residential mobility.

Sixth, this study uncovers several surprising findings that defy simple explanation. Perhaps the two most surprising findings are that whites are the second most highly burdened racial or ethnic group included in the study and that results differ so greatly for blacks and Hispanics. For example, whites experience neighborhood toxic concentration levels that are higher on average than those experienced by Hispanics, Pacific Islanders, Native Americans, and Asian Americans; and the association between median household income and toxic concentration is positive in neighborhoods that are predominantly Hispanic but strongly negative in neighborhoods that are predominantly black. In addition, in low-income neighborhoods, the association between percent non-Hispanic black and toxic concentration is strongly positive, while the association between percent Hispanic and toxic concentration is strongly negative.

Explaining these findings is clearly beyond the scope of this article. Nevertheless, Ash and Fetter (2004: 441) provide one possible explanation for why His-panics experience a lower pollution burden, on average, than do whites. In their study of urbanized areas, Ash and Fetter found that although Hispanics are overrepresented in polluted neighborhoods within cities, they tend to "live in less polluted cities on average." Thus, their findings suggest that whites live in more polluted regions of the country than do Hispanics. This pattern of Hispanic settlement may also help explain why results differ so greatly for blacks and Hispanics.

Finally, and perhaps most importantly, this study demonstrates that in the continental United States, blacks are more highly represented in census tracts with high toxic concentration levels than are any other major racial/ethnic group in the country (Table 2), experiencing neighborhood toxic concentration levels that are on average 1.45 times as great as those experienced by the second most highly burdened group included in the study and 2.52 times as great as those experienced by the least burdened group included in the study. Moreover, low-income black neighborhoods and households experience a much higher pollution burden than do any other neighborhood or household type included in the study (Table 3 and Figure 1). In fact, blacks experience such a high pollution burden that black households with incomes between $50,000 and $60,000 live in neighborhoods that are, on average, more polluted than the average neighborhood in which white households with incomes below $10,000 live (Table 3; the unreported fixed effects regression analyses provide similar neighborhood-level results).

Regardless of why blacks are so overburdened, these findings have potentially important public health implications and may help to explain some of the significant health disparities that exist between blacks, whites, and Hispanics (Evans and Kantrowitz 2002; Gee and Payne-Sturges 2004). These findings also suggest that poor blacks are not only more likely than other groups to live in highly disorganized and extremely poor neighborhoods with high rates of welfare dependency, crime, joblessness, and violence (Wilson 1987), they are also more likely to live in neighborhoods with high levels of industrial pollution. Thus, poor blacks likely experience a greater range and intensity of social and environmental stressors than do members of other racial/income groups.

Exposure to multiple social and environmental stressors is likely to have serious psychological, physical, educational, and labor market consequences (Boardman 2004; Downey 2005b; Downey and Van Willigen 2005; Evans and Kantrowitz 2002; Troutt 2006). However, most theoretical and empirical work linking socioeconomic status, environmental quality, and health focus on one environmental risk factor at a time (Evans and Kantrowitz 2002), and few neighborhood effects studies ask whether industrial environmental hazards negatively affect mental and physical health, educational outcomes, or labor market success (Downey and Van Willigen 2005). Thus, this study suggests that sociologists need to identify those communities that experience excessively high numbers of social and environmental stressors, determine whether these communities share specific socioeconomic and racial characteristics, and compare the psychological, physical, educational, and labor market outcomes of people in these communities to those of people in other communities. Such research will allow us to better understand the human, social, and economic consequences of living in neighborhoods that are highly disorganized, extremely poor, and highly polluted and will enable us to devise public policies that better address the serious problems that people in these communities face.

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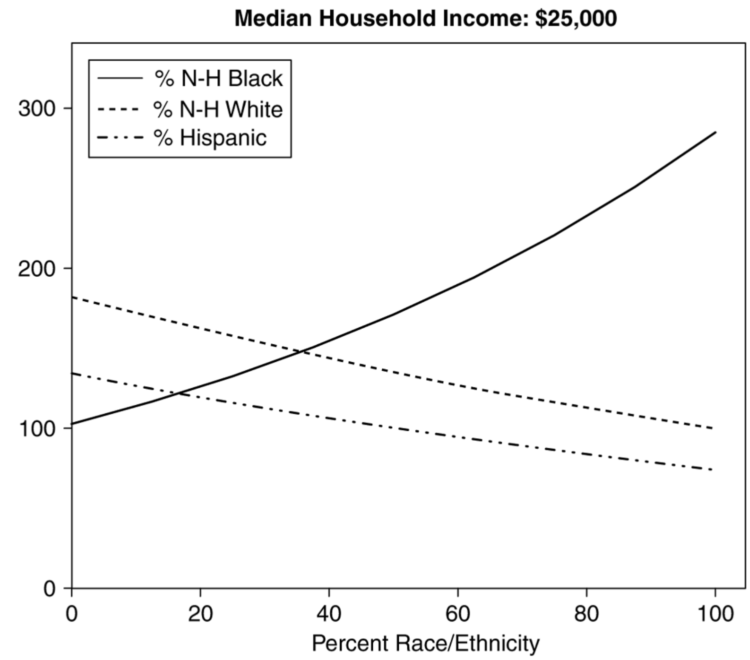
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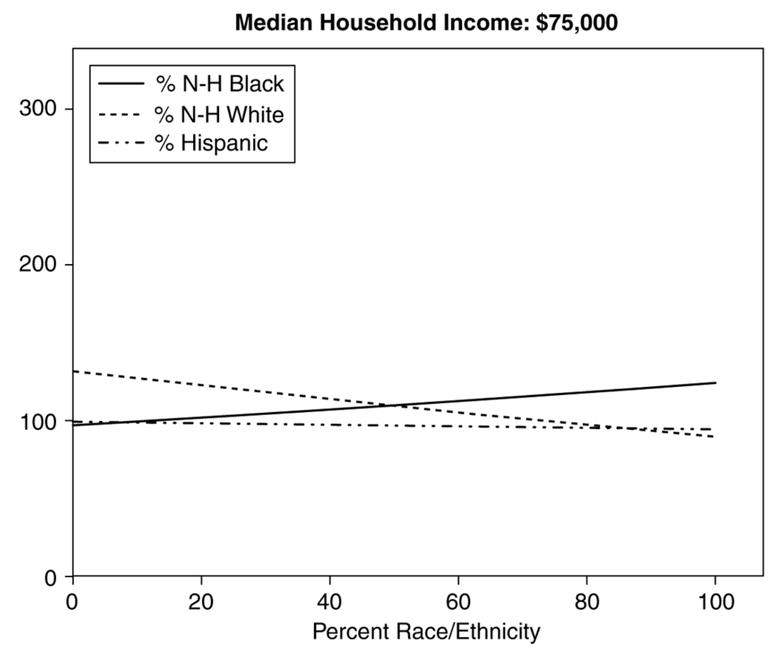
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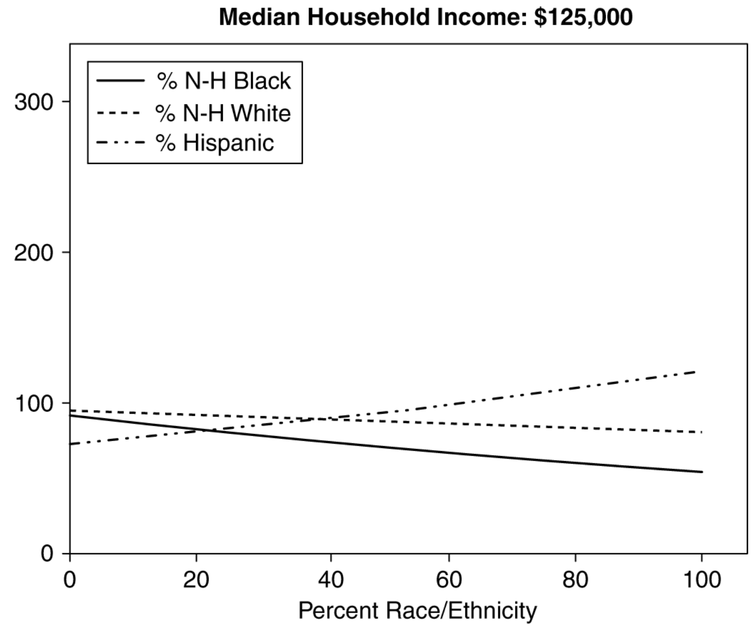
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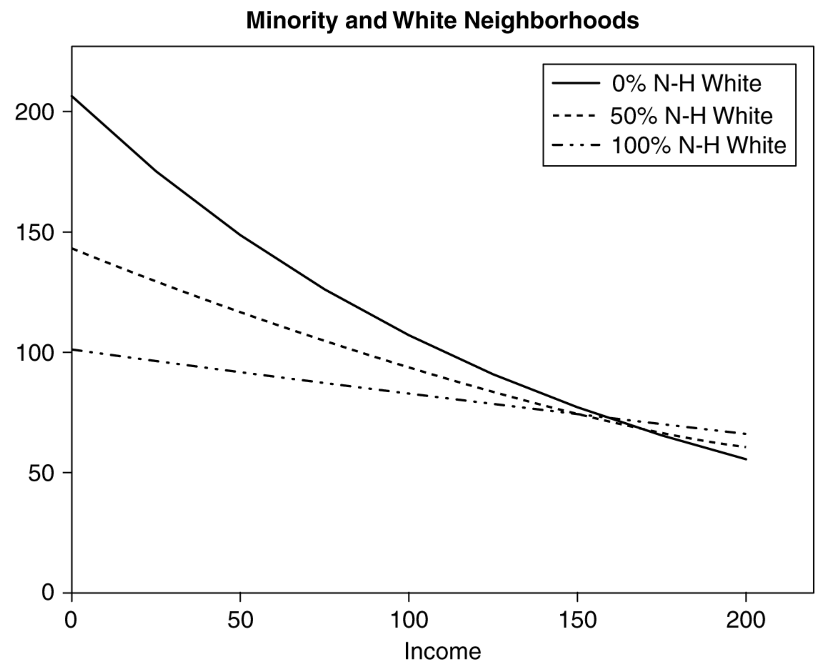
Minority and White Neighborhoods
0% N-H White
50% N-H White
100% N-H White
200
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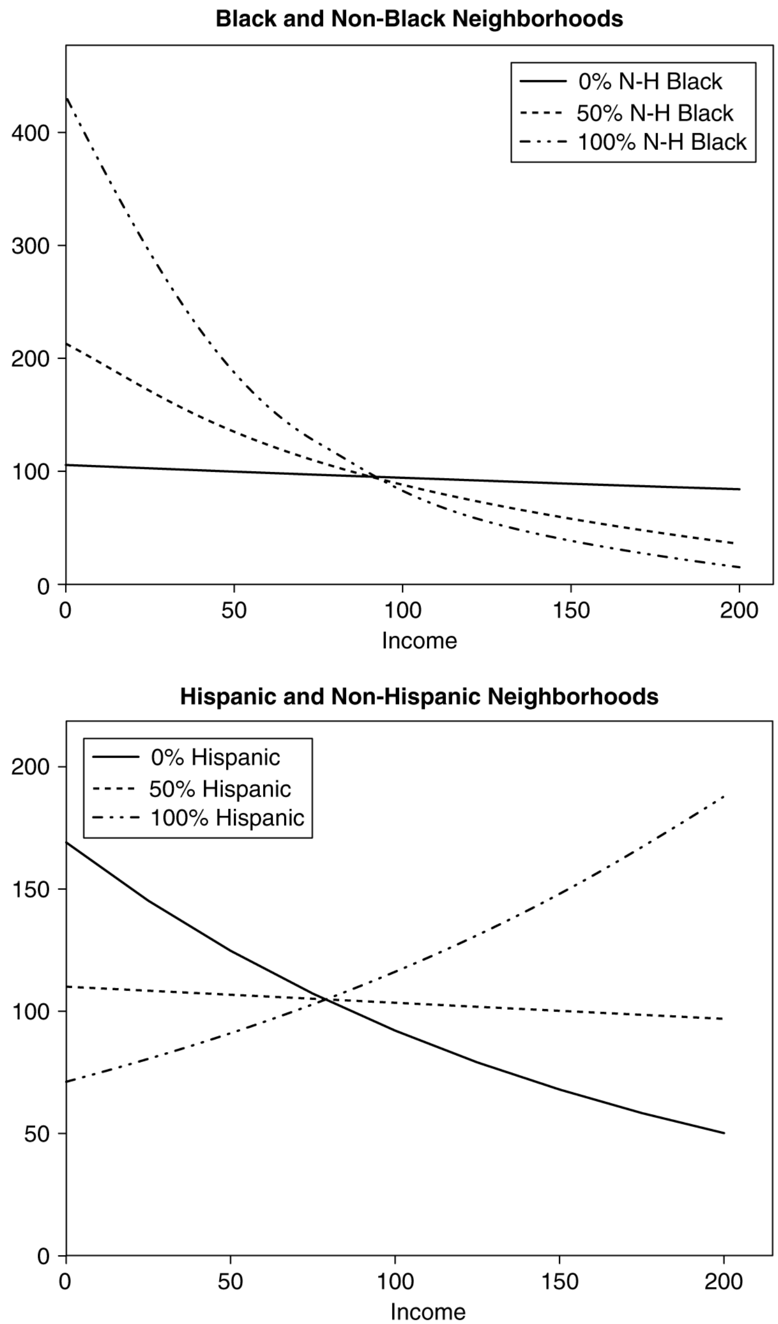

FIGURE 1.
Graphed Income/Race Interactions
Note: N–H = non-Hispanic.

TABLE 1

Descriptive Statistics for Variables Used in the Analyses

	M	**SD**
Dependent variables		
Toxic concentration	590.71	2,825.40
Toxic concentration logged	4.74	1.87
Independent variables		
% Hispanic	11.53	19.03
% non-Hispanic black	13.49	23.57
% non-Hispanic white	69.03	30.32
Median household income (in thousands of dollars)	44.20	20.77
% some college	43.05	19.04
Population density (divided by 1,000)	5.31	12.07
% manufacturer	15.52	8.70
% vacant	8.54	8.78
Median property value (in thousands of dollars)	136.64	109.90
Median house age	34.10	15.05

TABLE 2

Average Neighborhood Toxic Concentration Values by Race and Hispanic Ethnicity, the Continental U.S. 2000[a]

	Black	**White**	**Hispanic**	**Pacific Islander**	**Native American**	**Asian**
Black	732.90[b]					
White	1.45***	503.73				
Hispanic	1.70***	1.17***	430.36			
Pacific Islander	1.77***	1.22***	1.04	413.20		
Native American	2.27***	1.56***	1.33***	1.28***	322.65	
Asian	2.52***	1.73***	1.48***	1.42***	1.11***	290.51

[a] All five racial categories include non-Hispanics only.

[b] These are analysis of variance results. A Scheffe's test was conducted to determine whether each group mean is significantly different from every other group mean in the table (Scheffe's test controls for multiple comparisons). Thus, significant results indicate significantly different means rather than ratios that are significantly different from one.

*** $p < .001$.

TABLE 3

Average Neighborhood Toxic Concentration Values by Race/Income Category, the Continental U.S. 2000

(1)	(2)	(3)	(4)	(5)	(6)	(7)
Income	**Black**	**White**	**Hispanic**	**Black/White Ratio**	**Black/Hispanic Ratio**	**White/Hispanic Ratio**
Less than $10,000	916.33	605.72	484.29	1.51***	1.89***	1.25***
$10,000 to $15,000	876.86	601.61	449.69	1.46***	1.95***	1.34***
$15,000 to $20,000	848.43	595.90	469.06	1.42***	1.81***	1.27***
$20,000 to $25,000	786.16	584.97	463.81	1.34***	1.70***	1.26***
$25,000 to $30,000	751.17	571.43	433.81	1.31***	1.73***	1.32***
$30,000 to $35,000	720.27	557.40	430.67	1.29***	1.67***	1.29***
$35,000 to $40,000	703.06	548.99	432.13	1.28***	1.63***	1.27***
$40,000 to $45,000	677.30	533.84	438.42	1.27***	1.54***	1.22***
$45,000 to $50,000	663.82	527.60	431.70	1.26***	1.54***	1.22***
$50,000 to $60,000	623.54	511.91	419.75	1.22***	1.49***	1.22***
$60,000 to $75,000	592.95	482.11	395.00	1.23***	1.50***	1.22***
$75,000 to $100,000	529.33	435.42	368.57	1.22***	1.44***	1.18***
$100,000 to $125,000	468.44	383.37	323.09	1.22***	1.45***	1.19***
$125,000 to $150,000	448.24	349.30	308.12	1.28***	1.45***	1.13
$150,000 to $200,000	445.33	325.09	291.21	1.37***	1.53***	1.12
More than $200,000	593.45	325.34	328.94	1.82***	1.80***	0.99

*** $p < .001$.

TABLE 4

Fixed Effects Models Regressing Toxic Concentration Logged on Neighborhood Racial Composition, Median Household Income, and Other Covariates

	Model 1	% Δ for a 1 SDΔ	Model 2	% Δ for a 1 SDΔ	Model 3	% Δfor a 1 SD Δ
% non-Hispanic black	0.01407***	39.32%				
% Hispanic			−0.00863***	−15.14%		
% non-Hispanic white					−0.00711***	−19.39%
Median household income (in $1,000s)	−0.00114*	−2.33%	−0.00608***	−11.85%	−0.00656***	−12.74%
Race × Income interaction	−0.00015***	−10.89%	0.00011***	7.44%	0.00004***	10.38%
% some college	0.00769***	15.76%	0.00429***	8.51%	0.00795***	16.34%
Population density (in 1,000s)	0.00639***	8.02%	0.00913***	11.64%	0.00413***	5.12%
% manufacturer	0.07051***	55.97%	0.06836***	53.87%	0.06835***	53.87%
% vacant	−0.03016***	−23.27%	−0.02747***	−21.43%	−0.02833***	−22.02%
Median property value (in $1,000s)	0.00052***	5.84%	0.00058***	6.59%	0.00065	7.37%
Median house age	0.01390***	23.27%	0.01508***	25.49%	0.01458***	24.55%
Constant	3.38190***		3.85132***		4.05258***	
R^2	.1611		.1178		.1214	
N	63,614		63,614		63,614	

* p <.05;

** p <.01;

*** p <.001.