Published in final edited form as:

Sociol Spectr. 2006 ; 26(1): 21–41. doi:10.1080/02732170500256716.

ENVIRONMENTAL INEQUALITY IN METROPOLITAN AMERICA IN 2000

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Abstract

This article compares black and Hispanic environmental inequality levels across 14 of the largest metropolitan areas in the United States and asks how conclusions regarding the existence of environmental inequality differ when different definitions of environmental inequality are employed. Using census tracts as the unit of analysis, industrial pollution data from the Toxic Release Inventory, and demographic data from the U.S. census, tobit regression analysis is used to determine whether two types of environmental racial inequality—disparate social impacts inequality and relative distribution inequality—existed in each metropolitan area in 2000. Results show that black and Hispanic environmental inequality were fairly widespread throughout the 14 metropolitan areas, that Hispanic environmental inequality was more widespread than black environmental inequality, and that conclusions vary depending upon which definition of environmental inequality is employed. This latter findings suggests that the conclusions researchers draw are likely to be inaccurate if they do not properly specify the definitions of environmental inequality they are using and the types of environmental inequality they are studying.

In recent years, academic interest in environmental inequality has grown dramatically, with researchers in fields as diverse as economics, sociology, geography, epidemiology, political science, and legal studies attempting to determine whether minority and low income neighborhoods are disproportionately burdened by environmental hazards (Anderton et al. 1994a, b; Been 1994; Bowen et al. 1995; Bryant and Mohai 1992; Chakraborty and Armstrong 1997; Hamilton 1995; Liu 2001; Pastor et al. 2002; Szasz and Meuser 1997). Although researchers have found income and poverty to be consistently associated with hazard presence in the expected direction, findings regarding the existence of environmental racial inequality have been mixed (Bowen 2002; Pastor et al. 2001).

Whether these mixed findings accurately reflect the distribution of minority groups around different hazards in different locations or are the result of methodological variation across studies is not clear. Nevertheless, it is likely that methodological variation has played at least some role in affecting research findings (Anderton et al. 1994a, b; Mohai 1995).

Thus, rather than examining a single study area or pooling data from multiple study areas, as most environmental inequality studies have done, this study uses a single methodological approach to compare Hispanic and black environmental inequality levels in 14 U.S. metropolitan areas in the year 2000. Such an approach will not allow me to determine why prior research findings have varied or whether the results presented here would have differed if my methodological approach and choice of hazard indicator had differed. It will allow me

to determine whether the existence of black and Hispanic environmental inequality varies from one study area to another when the unit of analysis (census tracts), type of hazard (toxic release inventory emissions), type of region (metropolitan areas), comparison population (all non-emission tracts in each metropolitan area), and statistical test (tobit analysis) are held constant across study areas.

In addition to using a single methodological approach to examine environmental racial inequality in multiple study areas, I also examine how the conclusions drawn from the findings reported below differ when I use an alternate definition of environmental inequality in addition to the standard definition used in virtually all environmental inequality research. My goal in doing this is not to argue that one definition of environmental inequality is superior to another definition, but rather to argue that our conclusions are likely to be inaccurate if we do not properly specify the definition of environmental inequality we are using and the type of environmental inequality we are studying.

LITERATURE REVIEW

Environmental inequality is a relatively new concept that gained national attention in the late 1980s and early 1990s due to the efforts of grassroots environmental justice activists and professional researchers. Calling into question the mainstream environmental movement's assumption that environmental degradation affects everyone equally, early environmental justice activists and researchers argued that the poor, the working class, and people of color are disproportionately burdened by environmental hazards, that environmental inequality is inseparable from other forms of inequality, and that environmental thought and activism need to be broadened to include all the different environments in which people live, work, and play (Bryant and Mohai 1992; Szasz and Meuser 1997; Taylor 2000).

Sometimes explicit, but often implicit, in early environmental justice thinking was the idea that subordinate social groups are triply harmed by their subordinate social and economic status: not only are they disproportionately burdened by industrial pollution, they also (1) receive relatively few of the benefits deriving from the capitalist production and distribution process and (2) have relatively few resources with which to protect their health. Thus they face a triple bind: not only do they benefit least from capitalist social relations, they are also the most burdened by capitalism's toxic externalities and the least able to protect their health once they are so burdened (Bullard 1990, 1994; Bryant and Mohai 1991, 1992; Hofrichter 1993; Taylor 2000).

This extraordinary set of claims spurred the growth of a new field of study, environmental inequality research. Environmental inequality researchers have studied the distribution of social groups around a variety of environmental hazards including hazardous waste sites, manufacturing facilities, superfund sites, chemical accidents, and air pollutants (Bowen 2002; Derezinski et al. 2003; Morello-Frosch et al. 2001; Szasz and Meuser 1997). Researchers have found income and poverty to be consistently associated with hazard presence in the expected direction: as environmental hazard presence increases, incomes decrease and poverty rates increase (Been 1994; Charkraborty and Armstrong 1997; Derezinski et al. 2003; Hamilton 1995; Kreig 1995; Lester et al. 2001; McMaster et al. 1997; Mohai and Bryant 1992; Morello-Frosch et al. 2001; Oakes et al. 1996; Ringquist 2000; Stretesky and Hogan 1998; Szasz and Meuser 1997). However, findings regarding the existence of environmental racial inequality have been mixed. Many studies have found strong evidence of environmental racial inequality (Been 1994; Downey 1998, 2003; Hamilton 1995; Krieg 1995; Mohai and Bryant 1992; Morello-Frosch et al. 2001; Ringquist 1997; Stretesky and Hogan 1998; Stretesky and Lynch 2002), some have found evidence of environmental racial inequality for some minority groups but not others (Brown et al. 1997;

Pastor et al. 2002; Sadd et al. 1999a), and some have found only weak evidence of environmental racial inequality or none at all (Anderton et al. 1994a, b; Atlas 2002; Bowen et al. 1995; Clark et al. 1995; Derezinski et al. 2003; Oakes et al. 1996; Yandle and Burton 1996).

Although it is quite possible that environmental racial inequality levels really do vary from one location, hazard, and minority group to another, it is also possible that the contradictory research findings noted above are due, at least in part, to the fact that environmental inequality researchers use a variety of methodological approaches in their work. Among other things, researchers use different units of analysis, different comparison populations, different hazard indicators, and different statistical tests; and disagreements over proper research methodology have received a fair amount of attention (Anderton et al. 1994a, b; Bowen et al. 1995; Downey 1998; Mohai 1995; Sadd et al. 1999a, b).

While it is unlikely that these methodological disagreements will be resolved any time soon, most researchers acknowledge the methodological debate, defend their methodological choices, and recognize the empirical implications of using different research methodologies. This is in stark contrast to disagreements over the definition of environmental inequality, the empirical implications of which often go unacknowledged despite the existence of several articles highlighting these implications (Downey 1998; Pulido 1996; Stretesky and Hogan 1998).

Thus, in the following section, I set forth three definitions of environmental inequality, all of which are drawn from the broader environmental inequality literature and each of which refers to a different type of environmental inequality. I then use two of these definitions to demonstrate the empirical implications of restricting our attention to a single type of environmental inequality.

DEFINITIONS

Definitions of environmental inequality fall into two broad categories, those that focus on racially discriminatory intent and those that focus on inequitable environmental outcomes (Cutter 1995; Downey 1998; Pulido 2000; Stretesky and Hogan 1998). *Intentional racism* definitions, which focus solely on facility siting decisions, hold that environmental racial inequality occurs only when companies intentionally place environmental hazards in minority neighborhoods (Been 1994; Hamilton 1995).

Outcome definitions focus on a variety of environmental outcomes including, but not limited to, disparate exposure, disparate health impacts, disparate social impacts, and what I call “the relative distribution of burdens versus benefits.” However, because this article only tests for the existence of disparate social impacts inequality and relative distribution inequality, these are the only two forms of environmental inequality defined below (see Downey 2005a for definitions of disparate exposure inequality and disparate health impacts inequality).

The *disparate social impacts* definition holds that environmentally hazardous neighborhoods are socially and economically undesirable places to live. Research shows, for example, that environmental hazard presence has a negative impact on local economic activity and property values (Ihlanfeldt and Taylor 2003; Liu 2001) and that, regardless of race or income, people prefer living in pollution-free and industry-free neighborhoods (Mohai and Bryant 1998).¹ Moreover, the dramatic increase in recent decades in the number of grassroots environmental justice organizations dedicated to removing or banning environmental hazards from their neighborhoods indicates that access to clean residential environments has become an important social value for many individuals (Austin and Schill

1994; Bullard 1994; Environmental Justice Resource Center 2000; Hofrichter 1993; Taylor 2000).

Given the economic advantages and social desirability of living in pollution-free and hazard-free neighborhoods, the *disparate social impacts* definition holds that environmental inequality exists when members of a specific social group are more likely to live in environmentally hazardous neighborhoods than we would expect if group members were randomly distributed across residential space. As a result, disparate social impacts inequality can be said to exist when, for a given set of analysis units, researchers find a statistically significant positive correlation or association between subordinate group presence and hazard presence. Conversely, a negative or nonsignificant correlation or association between subordinate group presence and hazard presence is evidence that disparate social impacts inequality does not exist in a study area.²

The *relative distribution of burdens versus benefits* definition holds that environmental inequality exists when those who receive greater benefits than others from the capitalist production and distribution process do not bear a greater share of the burdens of this process than do others. In this formulation, benefits refer to the overall distribution of rewards arising from capitalist social relations rather than to the immediate benefits a neighborhood receives due to the existence of a specific industrial facility in that neighborhood (Downey 1994; Bullard 1994b). Thus, one cannot determine whether environmental inequality exists in a study area by focusing solely on outcomes such as disparate social impacts (or disparate exposure or disparate health impacts). Instead, one must ask whether groups that receive greater benefits from capitalist social relations (whites, the middle and upper classes) are more burdened by industrial pollution than are groups that receive fewer benefits from capitalist social relations (people of color, the poor, the working class). If not, *relative distribution inequality* exists.

Given this definition, relative distribution inequality can be said to exist when, for a given set of analysis units, there is *not* a statistically significant negative correlation or association between subordinate group presence and hazard presence or a statistically significant positive correlation or association between dominant group presence and hazard presence.

DATA

In order to determine whether environmental racial inequality exists in each of the 14 metropolitan areas included in this study, I merged industrial facility pollution data drawn from the Environmental Protection Agency's year-2000 Toxic Release Inventory (TRI) with tract-level demographic data drawn from the 2000 U.S. census. The census data is used to calculate *percent black* and *percent Hispanic* in each census tract. The TRI data is used to calculate the tract-level pollution proximity indicator used in this study.³

The TRI records the number of pounds of specified toxic chemicals released into the environment each year by industrial facilities that employ the equivalent of ten or more full-time workers and manufacture, process, or otherwise use the specified chemicals in

¹Although activists and researchers have argued that environmental hazard presence is likely to be associated with declining neighborhood incomes, increased neighborhood poverty, increased minority presence, and increased residential segregation, few studies have investigated these claims and those that have done so have produced contradictory findings (Downey 2005b; Been 1994; Oakes et al. 1996; Pastor et al. 2001; Pulido 2000; Yandle and Burton 1996).

²Strictly speaking, of course, a negative correlation between subordinate group presence and hazard presence suggests that dominant groups may live in closer proximity to some set of environmental hazards than we would expect if dominant group members were randomly distributed across residential space.

³Environmental inequality researchers generally use pollution proximity indicators rather than pollution exposure indicators because exposure data is extremely difficult to obtain.

specified quantities.⁴ TRI facilities were located on a map using an automated geographic information system (GIS) procedure called geocoding.⁵

Although used by many environmental inequality researchers, TRI data have several limitations. First, only those industrial facilities meeting the requirements listed above are included in the dataset. As a result, the toxic chemical emissions reported in the database represent only a small fraction of the toxic chemicals released into the environment each year by U.S. industrial facilities (Sadd et al. 1999a). Second, TRI emissions are self-reported estimates and noncompliance rates are unknown. Third, the database does not record actual or estimated exposure rates (Sadd et al. 1999a; Szasz and Meuser 1997). Thus, we do not know whether people who live near TRI facilities are more highly exposed to TRI releases than are people who live further away from these facilities (this, of course, is not problematic when we are testing for the existence of disparate social impacts inequality).

Despite these limitations, TRI-based studies make up a significant proportion of the environmental inequality literature (for example, see Bowen 2002; Bowen et al. 1995; Brown et al. 1997; Downey 1998; Pastor et al. 2001; Sadd et al. 1999a; Szasz and Meuser 1997). Researchers continue to use the TRI because the limitations described in the preceding paragraph are not as serious as they first appear. For example, although we do not know actual reporting compliance rates, companies that fail to comply with TRI reporting requirements face stiff civil and criminal penalties. Thus, it is likely that compliance rates are high (Sadd et al. 1999a). In addition, regardless of its limitations, the TRI is still the most comprehensive and detailed national record of industrial facility pollution available to researchers. Finally, because of the difficulty of obtaining or deriving exposure and risk estimates, few of the datasets environmental inequality researchers currently use report such estimates (Bowen 2002). Thus, while it is important to acknowledge the limits of the TRI, it is also important to recognize that the TRI is as good a database for environmental inequality research as most of the other databases used by environmental inequality researchers.

MEASURING PROXIMITY

Environmental inequality researchers generally create pollution proximity indicators by summing the pounds of pollutants released in each of their study area analysis units, summing the number of environmental hazards located in each of their study area analysis units, or creating a dummy variable set equal to one if a study area analysis unit contains an environmental hazard and zero otherwise. In addition, researchers sometimes consider analysis units adjacent to hazardous units to be hazardous as well (for example, see Anderton et al. 1994a, b), but usually they do not.

These approaches are problematic in a number of respects. First, they force us to assume that environmental hazards are distributed evenly within analysis units. However, environmental hazards are not distributed evenly across space. Industrial facilities, for example, generally cluster near major transportation routes (Northam 1979), routes that often serve as census

⁴In 2000, the list of TRI chemicals included over 600 chemicals and chemical categories. 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.

⁵Geocoding, which can be done in batch or interactive mode, is an automated process that requires a table of observations with known street addresses and a corresponding GIS street theme. Street theme streets are divided into segments and each segment is linked to a record that lists the odd and even street numbers at either end of the segment. Thus, the location of each observation is determined by matching the observation to the correct street segment and interpolating its placement along the segment based on its street number and the segment endpoint numbers. For example, if a facility's street address is 150 West 5th Street and it is matched to a street segment that runs from 100–200 West 5th Street, it will be placed midway along the segment. Since streets often serve as census tract boundaries, it is crucial that facilities are placed on the correct side of the street. Thus, you must specify an offset distance before running the procedure. Otherwise, the software places the facility directly on the street.

tract boundaries. Second, they force us to assume that environmental hazards either (1) do not impact people residing in adjacent analysis units or (2) impact every square inch of their home unit and specified adjacent units equally (Anderton et al. 1994a, b). Third, simple summing fails to take analysis unit size into account. However, analysis units generally become larger as you move away from the urban core. In the Detroit metropolitan area, for example, distance from the central business district is significantly correlated with percent black and census tract area. As a result, in the Detroit metropolitan area percent black is significantly and negatively correlated with tract area, a potentially important determinant of the number of facilities and pounds of emissions in a tract.

In order to overcome these problems, I converted each metropolitan area census tract map into a rectangular grid composed of 25-meter resolution square cells and then calculated the total pounds of TRI pollutants emitted within a one-quarter-kilometer radius of the center of each grid cell. Thus, all cells located within a one-quarter-kilometer radius of a TRI facility, including cells in a different tract from that facility, are considered to be polluted, and all cells in *each* tract that are outside a one-quarter-kilometer radius of any facility are considered to be unpolluted.

Finally, for each census tract, I took the sum of the values of all the cells in that tract and divided this sum by the number of cells in that tract. The resulting variable, the *average pounds of TRI emissions in a tract* (average emissions), takes facility location and tract size into account. It also allows facilities located within one-quarter of a kilometer of a tract boundary to affect people living on the other side of that boundary without affecting every square inch of the adjacent tract. As a result, it is a more accurate indicator of pollution proximity than is “the total pounds of TRI pollutants emitted in a tract” (see Downey 2003 for a more detailed discussion of this variable construction technique).⁶

STUDY AREA

Although this study only uses year-2000 census and TRI data, the data used in this study are drawn from a larger dataset I have compiled that includes 1990 and 2000 U.S. census and TRI data. Because it is more difficult to geocode 1990 TRI data than it is to geocode 2000 TRI data (due to improvements in street network maps from 1990 to 2000),⁷ the 14 metropolitan areas included in the dataset were selected using criteria shaped by the limitations of the 1990 data (the metropolitan areas are listed in Table 1). The metropolitan areas were chosen by (1) dividing the United States into seven regions, the northwest, southwest, northern Midwest, southern Midwest, northeast, southeast, and mid-Atlantic, (2) allocating each of the 50 most populous metropolitan areas in the United States in 1990 to one of these regions, (3) ranking the metropolitan areas in each region, from highest to lowest, according to the total pounds of TRI pollutants emitted in each metropolitan area, and (4) moving down each list until I found two metropolitan areas in each region with a successful TRI facility geocoding rate of at least 75 percent.⁸ Unfortunately, only one

⁶Like most proximity indicators used in environmental inequality research, including the total pounds of emissions in a tract, the average emissions indicator is limited in at least four respects. First, it assumes that all chemical pollutants are equally hazardous. Second, it assumes an even dispersal of pollutants around each facility. Third, it assumes there is no emissions decay within the one-quarter-kilometer pollution radius. In other words, if a facility emits 500 pounds of TRI pollutants, this approach assumes it contributes a value of 500 to each cell within a one-quarter-kilometer radius of it. Fourth, it assumes that industrial facilities are more hazardous (or damaging) to those who live close to them than to those who live further away.

Although these assumptions are all problematic, they underlie nearly all environmental inequality research. Moreover, the “no decay” assumption is less problematic in this case than it is in the case of the three most commonly used proximity indicators in the literature, “the total pounds of emissions in an analysis unit,” “the total number of facilities in an analysis unit,” and “this analysis unit hosts a hazardous facility,” all of which assume that there is no emissions, pollution, or risk decay within the entire analysis unit that houses the hazard, regardless of how big that analysis unit is or where the hazard is located within it. Thus, *average emissions* relies on a less limited set of assumptions than do the pollution proximity indicators most commonly used by environmental inequality researchers.

⁷The 1990 TRI data were geocoded prior to the release of the 2000 street network data.

metropolitan area in the southern Midwest (Houston) met these criteria. I made up for this by selecting an additional metropolitan area from the southwest (Phoenix). I chose Phoenix based on its relatively high geocoding rate.

Successful geocoding rates for the 2000 TRI data used in this article were much better: approximately 94% of the TRI facilities in the 14 metropolitan areas were successfully geocoded.

While a random sample of major metropolitan areas would have been preferable to the sample used in this study, I was unable to generate a random sample because so many of the 50 largest metropolitan areas had successful geocoding rates below 75 percent in 1990. As a result, the findings reported in this article cannot be generalized to the 50 largest U.S. metropolitan areas or to a broader set of U.S. metropolitan areas. This is true, however, of all the regional and metropolitan area environmental inequality studies with which I am familiar, none of which use random sampling for case selection and almost all of which focus on a *single* region or metropolitan area. Thus, while not random, this study offers much broader metropolitan area coverage than virtually all previous urban environmental inequality research.

RESULTS

In order to determine whether black disparate social impacts and relative distribution inequality existed in each metropolitan area in 2000, I regress average emissions on percent black and its squared term using tobit regression analysis (Table 2). I include the squared term because the urban poverty and spatial mismatch literatures suggest that there is relatively little industrial activity in extremely poor, highly segregated, urban minority neighborhoods (Small and Newman 2001; Wilson 1987). Thus, it is possible that industrial environmental hazards tend to be located in neighborhoods with high percentages of minorities, but not in neighborhoods with the highest percentages of minorities, a curvilinear relationship that is well captured by the inclusion of the squared term.

I use tobit regression analysis rather than ordinary least squares (OLS) regression analysis because average emissions is heavily censored at zero, making OLS regression inappropriate (Long 1997). Finally, I employ bivariate and trivariate regression models rather than more complex multivariate models because I am interested in determining whether black environmental inequality existed in each metropolitan area in 2000, not why it existed, and complex multivariate models are not needed to make such a determination.⁹

⁸While many of the metropolitan areas included in this study had successful geocoding rates well above 75% in 1990, several did not. Nevertheless, in my experience, 75% is a very good geocoding rate for 1990 data.

⁹Determining whether environmental inequality exists and, if so, why it exists are both important tasks. However, these tasks require different types of analyses. Determining whether environmental inequality exists requires researchers to compare the spatial distributions of specific hazards and specific social groups to each other. Determining why environmental inequality exists requires that researchers explain why these spatial distributions take the form that they do. Thus, if researchers want to know whether black environmental inequality exists in a specific study area, all they need to do is compare the distributions of blacks and environmental hazards to each other. Controlling for other factors, such as neighborhood income levels or neighborhood unemployment rates, may help researchers explain why black environmental inequality exists, but it will not help them determine whether it exists because, once researchers control for these other factors, they are no longer making a simple comparison between the spatial distribution of an environmental hazard and the spatial distribution of a single demographic group. For example, if I were to regress *average emissions* on percent black and its squared term controlling for neighborhood income levels, and neither percent black nor its squared term were significantly associated with *average emissions*, this could mean that black environmental inequality does not exist or that it exists because blacks tend to live in low income neighborhoods and low income neighborhoods tend to house environmental hazards (and the only way to differentiate between these two conclusions is to run a model that does not control for income). Since the goal of this article is to determine whether black and Hispanic environmental inequality existed in each of the 14 metropolitan areas included in the study, and not to determine why it existed, I do not include control variables in the regression analyses.

Table 2, column 1 lists the metropolitan areas in alphabetical order, with the model coefficients listed to the right of each metropolitan area. Table 2 shows that the association between percent black and average emissions is statistically insignificant in Baltimore, Detroit, Houston, Los Angeles, and Seattle; linear and negative in Boston, Chicago, and Philadelphia; linear and positive in Phoenix; and curvilinear in Atlanta, Greensboro, Hartford, Oakland, and Portland. In the latter five metropolitan areas, the association between average emissions and percent black is positive until the percentage of blacks in a tract reaches a turning point value, at which point the association becomes negative.¹⁰

The last two columns in Table 2 list the turning point for each of these five metropolitan areas as well as the percentage of tracts in each of the five metropolitan areas that falls below the turning point. For example, the next to last column in Table 2 tells us that in the Atlanta metropolitan area the association between percent black and average emissions is positive until the percentage of blacks in a tract reaches 46.55%, at which point the association becomes negative. The last column tells us that 70.9% of the tracts in the Atlanta metropolitan area fall below the 46.55% turning point. The percentage of tracts below the turning point equals 85.9% in Greensboro, 95.5% in Hartford, 87.3% in Oakland, and 97.1% in Portland.

Table 3 uses tobit regression analysis to regress average emissions on percent Hispanic and percent Hispanic squared. Table 3 shows that the association between percent Hispanic and average emissions is statistically insignificant in Baltimore, Boston, Hartford, and Philadelphia; linear and positive in Chicago, Houston, Phoenix, Portland, and Seattle; and curvilinear in Atlanta, Detroit, Greensboro, Los Angeles, and Oakland. In each of the latter five metropolitan areas, the association between average emissions and percent Hispanic is positive until the percentage of Hispanics in a tract reaches a turning point value, at which point the association becomes negative. The percentage of tracts below the turning point equals 96.4% in Atlanta, 98.5% in Detroit, 97.7% in Greensboro, 88.9% in Los Angeles, and 95.07% in Oakland.

Table 4 tells us whether the results listed in Tables 2 and 3 support the hypothesis that disparate social impacts inequality and relative distribution inequality existed in each of the 14 metropolitan areas in 2000. As noted earlier, the hypothesis that disparate social impacts inequality exists in a study area is supported if there is a statistically significant positive association between subordinate group presence and hazard presence. The hypothesis that relative distribution inequality exists in a study area is supported as long as there is *not* a statistically significant negative association between subordinate group presence and hazard presence.

Table 4 shows that in 2000, black disparate social impacts inequality existed in six of the metropolitan areas included in this study—Atlanta, Greensboro, Hartford, Oakland, Phoenix, and Portland—and that black relative distribution inequality existed in 11 of the metropolitan areas included in the study (the three exceptions were Philadelphia, Boston, and Chicago). The metropolitan areas with black disparate social impacts inequality were located primarily in the southeast and west (the one exception is Hartford) while the metropolitan areas without black relative distribution inequality were located in the mid-Atlantic, the northeast, and the northern Midwest.

Hispanic disparate social impacts and relative distribution inequality were more widespread in this sample than were black disparate social impacts and relative distribution inequality.

¹⁰Turning point refers to the value of x_i at which the slope of the regression line equals zero. Thus, it refers to the transition point at which a positive slope is about to become negative or a negative slope is about to become positive.

Hispanic relative distribution inequality existed in all 14 metropolitan areas included in the study and Hispanic disparate social impacts inequality existed in 10 of the metropolitan areas included in this study: the exceptions—Baltimore, Philadelphia, Boston, and Hartford—comprised all 4 mid-Atlantic and northeastern metropolitan areas included in the study.

DISCUSSION

In this article, I have attempted to increase our understanding of environmental inequality by (1) testing for the existence of two distinct forms of environmental inequality, disparate social impacts inequality and relative distribution inequality, and (2) comparing the results of these tests for blacks and Hispanics in 14 of the largest metropolitan areas in the United States. As with any study, caution must be taken in interpreting the findings reported here. I noted earlier, for example, that the metropolitan areas included in this study were not selected randomly, preventing me from generalizing these findings to a broader set of metropolitan areas. Likewise, because this study focuses on a single type of environmental hazard, its findings cannot be generalized to a broader set of environmental hazards. Finally, like virtually all proximity indicators employed in the literature, the proximity indicator used in this article is limited in several respects.

These caveats notwithstanding, this study demonstrates that in this sample of metropolitan areas, disparate social impacts inequality and relative distribution inequality are both fairly widespread. However, Hispanic disparate social impacts and relative distribution inequality are more widespread than black disparate social impacts and relative distribution inequality.

Results also indicate that when a consistent methodological approach is applied across multiple study areas, the presence of disparate social impacts inequality and relative distribution inequality still varies across study areas and regions of the country: black disparate social impacts inequality is found primarily in the southeastern and western metropolitan areas included in this study; Hispanic disparate social impacts inequality is found in all the southeastern, Mid-western, and western metropolitan areas included in this study, but in none of the mid-Atlantic or northeastern metropolitan areas included in this study; and black relative distribution inequality exists in most, but not all, of the metropolitan areas included in this study. Whether such variation exists for other environmental hazards and social groups and whether the presence of regional variation is merely an artifact of the case selection procedure employed in this article cannot be determined here. Nevertheless, these findings clearly merit further investigation.¹¹

Finally, the evidence reported in this article demonstrates that the definitions of environmental inequality we employ affect the conclusions we draw regarding the existence of environmental inequality. While one could argue that this is a fairly basic methodological

¹¹In an attempt to determine whether I could replicate the pattern of results found here for a broader sample of metropolitan areas, I conducted a similar study of all 62 U.S. metropolitan areas that had more than one million residents in the year 2000, using the total pounds of TRI chemicals emitted in a census tract in the year 2000 as my hazard indicator (these 62 metropolitan areas included the 14 metropolitan areas that were included in this study). I used *total TRI emissions* rather than *average emissions* because it would have been too time consuming to calculate average emissions for all 62 metropolitan areas (average emissions is, of course, the preferred hazard indicator). The results for the 62 metropolitan areas were roughly similar to the results presented here. Hispanic disparate social impacts and relative distribution inequality were more widespread than black disparate social impacts and relative distribution inequality, results varied across metropolitan areas, and conclusions varied depending upon which definition of environmental inequality was employed. The results for the 62 metropolitan areas showed somewhat less regional variation than the results presented here, and black and Hispanic disparate social impacts inequality existed in a smaller percentage of the 62 metropolitan areas than they did in the results presented here. It is not entirely clear whether these differences were the result of including more metropolitan areas in the analysis or using a different hazard proximity indicator. However, a comparison of results for the 14 metropolitan areas for which I calculated both *total TRI emissions* and *average emissions* shows that results differed considerably across hazard indicators, suggesting that the differences noted above are likely due to using *total TRI emissions* rather than *average emissions* in the larger study.

point, the fact of the matter is that few studies examine more than one type of environmental inequality and few researchers note that their conclusions might differ if they used a different definition of environmental inequality. Moreover, despite its centrality in early environmental justice debates, no empirical study I am aware of asks whether relative distribution inequality exists.

Thus, it is likely that when faced with results comparable to those presented here for Baltimore and Philadelphia, most researchers would conclude that environmental racial inequality did not exist in either of these metropolitan areas in 2000, despite the fact that in 2000, Hispanic relative distribution inequality existed in both metropolitan areas and black relative distribution inequality existed in the Baltimore metropolitan area.

My point is not that the relative distribution definition is superior to other definitions of environmental inequality or that relative distribution inequality is more important or serious than other forms of environmental inequality; nor am I arguing that researchers should always test for the existence of multiple forms of environmental inequality at the same time. Rather, I am arguing that our understanding of environmental inequality will remain incomplete if we do not study multiple forms of environmental inequality, and that it is incorrect to conclude that environmental inequality does not exist in a particular study area if researchers have only searched for evidence of one or two types of environmental inequality in that area. In other words, our conclusions are likely to be inaccurate if we do not properly specify the definitions of environmental inequality we are using and the types of environmental inequality we are studying.

Acknowledgments

This research was supported by a grant to Liam Downey from The American Sociological Association's Fund for the Advancement of the Discipline Award supported by the American Sociological Association and the National Science Foundation.

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Table 1

Metropolitan areas included in the analysis

Metropolitan areas	Number of tracts
Southeast	
Atlanta	660
Greensboro	263
Mid-Atlantic	
Baltimore	625
Philadelphia	1,329
Northeast	
Boston	1,176
Hartford	421
Northern Midwest	
Chicago	1,875
Detroit	1,275
Southern Midwest	
Houston	886
Southwest	
Los Angeles	2,786
Oakland	489
Phoenix	696
Northwest	
Portland	421
Seattle	527

N = 13,429.

Table 2

Tobit analysis of average emissions regressed on percent black and percent black squared

Metropolitan areas	% Black	% Black squared	Constant	Model X ²	Turning point (%)	Percentage of tracts below turning point (%)
Atlanta	-1.96	—	-5732.27***	0.04		
	127.56**	-1.37**	-7004.71***	10.21**	46.55	70.90
Baltimore	-39.19	—	-25368.93***	0.95		
	114.49	-1.66	-26483.21***	1.82		
Boston	-120.57**	—	-6120.39***	14.33***		
	140.29	-9.64†	-6590.72***	19.70***		
Chicago	-24.03***	—	-4950.72***	14.55***		
	-44.20	0.21	-4864.73***	14.95***		
Detroit	-10.09	—	-8089.41***	1.20		
	64.44	-0.81	-8342.41***	3.34		
Greensboro	19.24*	—	-2584.03***	4.47*		
	122.53***	-1.21**	-3532.91***	17.31***	50.84	85.90
Hartford	31.30*	—	-3932.57***	4.05*		
	114.44**	-1.20*	-4196.58***	7.93*	47.80	95.50
Houston	-42.70	—	-20229.37***	0.95		
	137.17	-2.30	-21395.28***	2.71		
Los Angeles	-17.76	—	-26398.02***	0.14		
	95.22	-1.85	-26771.96***	1.09		
Oakland	33.40	—	-10773.09	1.05		
	207.20*	-2.81†	-11617.34***	3.91	36.87	87.30
Philadelphia	-37.77*	—	-9606.82***	6.50*		
	24.63	-0.74	-9943.98***	7.97*		
Phoenix	98.46***	—	-2982.97***	16.24***		
	163.79***	-1.99	-3169.12***	18.35***		

Metropolitan areas	% Black	% Black squared	Constant	Model X ²	Turning point (%)	Percentage of tracts below turning point (%)
Portland	48.23	—	−3603.46***	2.32		
	214.27*	−4.54*	−3783.57***	6.12*	23.61	97.10
Seattle	−73.50	—	−11506.98***	0.38		
	406.65	−21.25	−12421.48***	3.03		

$\bar{r}^2 < .10;$

* $p < .05;$

** $p < .01;$

*** $p < .001.$

Table 3

Tobit analysis of average emissions regressed on percent Hispanic and percent Hispanic squared

Metropolitan areas	% Hispanic	% Hispanic squared	Constant	Model X ²	Turning point (%)	Percentage of tracts below turning point (%)
Atlanta	71.02 [*]	—	-6278.30 ^{***}	4.25 [*]		
	220.40 [*]	-3.80 [†]	-6776.51 ^{***}	7.63 [*]	28.97	96.40
Baltimore	8.34	—	-26487.55 ^{***}	0.00		
	3803.39 [†]	-556.87	-29912.46 ^{***}	4.28		
Boston	14.47	—	-6786.09 ^{***}	0.46		
	-52.49	1.13	-6533.63 ^{***}	2.31		
Chicago	59.33 ^{***}	—	-6575.49 ^{***}	47.35 ^{***}		
	101.87 ^{***}	-0.54	-6850.54 ^{***}	49.55 ^{***}		
Detroit	61.94	—	-8540.74 ^{***}	1.91		
	319.33 [*]	-4.90 [*]	-9005.93 ^{***}	5.82 [*]	32.56	98.50
Greensboro	207.10 ^{***}	—	-3281.62 ^{***}	31.27 ^{***}		
	419.64 ^{***}	-9.62 [*]	-3865.54 ^{***}	35.89 ^{***}	21.81	97.70
Hartford	23.12	—	-3842.36 ^{***}	1.53		
	77.60	-0.94	-4040.60 ^{***}	2.77		
Houston	194.59 ^{***}	—	-27167.65 ^{***}	21.97 ^{***}		
	370.03 [*]	-1.98	-29564.17 ^{***}	23.30 ^{***}		
Los Angeles	161.03 ^{***}	—	-33891.00 ^{***}	52.98 ^{***}		
	390.79 ^{***}	-2.33 [*]	-37458.85 ^{***}	59.18 ^{***}	83.79	88.90
Oakland	148.92 ^{***}	—	-13148.15 ^{***}	13.87 ^{***}		
	372.97 ^{***}	-3.72 [†]	-15233.30 ^{***}	16.79 ^{***}	50.09	95.07
Philadelphia	13.91	—	-10366.31 ^{***}	0.13		
	26.04	-0.21	-10397.29 ^{***}	0.14		
Phoenix	29.46 ^{***}	—	-3387.94 ^{***}	32.78 ^{***}		
	57.55 ^{***}	-0.34	-3701.95 ^{***}	34.95 ^{***}		

Metropolitan areas	% Hispanic	% Hispanic squared	Constant	Model X ²	Turning point (%)	Percentage of tracts below turning point (%)
Portland	68.09 [*]	—	−3984.03 ^{***}	3.76 [*]		
	173.52 [†]	−3.29	−4435.32 ^{***}	5.60		
Seattle	342.85 [*]	—	−13639.71 ^{***}	4.81		
	440.38	−4.16	−13971.91 ^{***}	4.92		

[†] < .10;

^{*} p < .05;

^{**} p < .01;

^{***} p < .001.

Table 4

Black and Hispanic disparate social impacts and relative distribution inequality by region

Metropolitan areas	Association: percent Black— average exposure	Black social impacts inequality	Black relative distribution inequality	Association: percent Hispanic — average exposure	Hispanic social impacts inequality	Hispanic relative distribution inequality
Southeast						
Atlanta	Curvilinear Positive	Yes	Yes	Curvilinear Positive	Yes	Yes
Greensboro	Curvilinear Positive	Yes	Yes	Curvilinear Positive	Yes	Yes
Mid-Atlantic						
Baltimore	Insignificant	No	Yes	Insignificant	No	Yes
Philadelphia	Negative	No	No	Insignificant	No	Yes
Northeast						
Boston	Negative	No	No	Insignificant	No	Yes
Hartford	Curvilinear Positive	Yes	Yes	Insignificant	No	Yes
Northern Midwest						
Chicago	Negative	No	No	Positive	Yes	Yes
Detroit	Insignificant	No	Yes	Curvilinear Positive	Yes	Yes
Southern Midwest						
Houston	Insignificant	No	Yes	Positive	Yes	Yes
Southwest						
Los Angeles	Insignificant	No	Yes	Curvilinear Positive	Yes	Yes
Oakland	Curvilinear Positive	Yes	Yes	Curvilinear Positive	Yes	Yes
Phoenix	Curvilinear Positive	Yes	Yes	Positive	Yes	Yes
Northwest						
Portland	Curvilinear Positive	Yes	Yes	Positive	Yes	Yes
Seattle	Insignificant	No	Yes	Positive	Yes	Yes