Risk-Based Targeting: Identifying Disproportionalities in the Sources and Effects of Industrial Pollution

Mary B. Collins, MA

Objectives. I assessed the distribution of relative health risk from industrial air pollution in Milwaukee, Wisconsin, and the extent to which risk was disproportionately attributable to a minority of facilities.

Methods. I spatially linked data on airborne emissions, health risk, and sociodemographics by census tract, coupling disproportionality measurements from 2 perspectives: the health risk borne by communities and the harms produced by individual polluters.

Results. Of Milwaukee's 307 census tracts, 90 warranted the highest environmental justice concern. Striking variations in risk production existed between industrial polluters. Of 299 facilities with reported emissions, 30 (10%) contributed 90% of all health risk.

Conclusions. This research adds to an emerging body of work connecting environmental health risk, environmental justice, and corporate responsibility. Findings support the hypothesis that relatively few heavy polluters create most environmental health risk. Environmental policy often devotes insufficient attention to such outliers, in part because of the questionable assumption that pollution is economically necessary for jobs or essential products. Increased emphasis on risk-based targeting of the worst polluters could significantly improve environmental quality and health in overburdened communities. (*Am J Public Health.* 2011;101:S231–S237. doi:10.2105/AJPH.2011.300120)

It is widely acknowledged that, in the United States, profound health disparities exist between the rich and the poor, between White people and people of color, and between powerful and marginalized populations. Specifically, racial and ethnic minorities and people of low socioeconomic status have higher morbidity and mortality from many chronic diseases, including asthma, cardiovascular disease, diabetes, and certain cancers.[1] The life expectancy gap between the best-off and the worst-off population groups is estimated to be 15.4 years for men and 12.8 years for women.[2] Although the reasons for such disparities are poorly understood, public health researchers have recently begun to explore environmental pollution as an important contributor to health disparities.

The environmental justice movement developed in response to concerns about unequal exposure to environmental toxins in poor and minority communities. Although methodological debates remain, most studies have supported the contention that racial and ethnic minorities and people of low socioeconomic status are disproportionately exposed to environmental hazards. Mohai et al.[3] reviewed 2 decades of literature with the clear conclusion that inequities in exposure to environmental toxins continue to be pervasive throughout the United States. Maantay et al.[4] reviewed studies on proximity to environmental hazards in relation to health outcomes, concluding that, although results were mixed, some studies found significant relationships between living close to environmental hazards and adverse health conditions such as poor pregnancy outcome; cancer among children; increased hospitalization for asthma and other chronic respiratory symptoms; death from stroke; polychlorinated biphenyl toxicity; end-stage renal disease; and diabetes. Although such findings cannot be taken to mean that the environmental hazards in question caused the adverse outcomes, they do suggest that links may exist and should be addressed.

Air pollution from both stationary and mobile sources is a primary source of environmental health risk, particularly in urban areas. Low-income, high-minority-population communities, which can be highly segregated, tend to be closer to industrial sources of pollution, including chemical plants, steel mills, oil refineries, and hazardous waste incinerators. Mohai et al.[5] found that Blacks, the poor, and people with low educational attainment were substantially more likely to live within 1 mile of a polluting facility and that, within urban areas, racial disparities were particularly evident in the Midwest and West. Faber and Krieg[6] reviewed some of the key literature on the health effects of industrial air pollutants, finding substantial evidence of associations between air pollution and acute effects such as eye irritation, nausea, difficulty breathing, asthma, or death as well as chronic effects including respiratory, reproductive, or nervous system damage; birth defects; and cancer. They also reported estimates that industrial air pollution, exacerbated by motor vehicle exhaust, may lead to more than 60 000 deaths per year and a 15% to 17% greater risk of death for half a million people who live in the nation's most polluted cities. Again, a limitation of such studies is that they provide evidence of associations between proximity to hazards and adverse public health outcomes but do not establish a cause-and-effect relationship.

I had 3 central and interrelated goals for this research; 2 were policy oriented and 1 was more theoretical. The first 2 goals were aimed at demonstrating a new perspective and analytic approach to using publicly available data to support Environmental Protection Agency (EPA) targeting and enforcement for environmental justice. The third goal was to draw attention to the high level of variation in pollution levels generated by industrial producers, its social meanings, and its implications for environmental equity and public health. Taken together, findings could drive policy improvements while emphasizing the socially

structured nature of the distribution of environmental benefits and harms.

My hypothesis was that most health risk from industrial air pollution in Milwaukee, Wisconsin, is caused by relatively few heavy industrial polluters, or outliers, that disproportionately affect spatially identifiable low-income, high-minority communities. The Risk Screening Environmental Indicators (RSEI) model provided an ideal tool with which to test this, because it enabled assignment of relative health risk by census tract and individual facility. This framework also advanced the central EPA goals of promoting environmental justice, public right to know, and corporate accountability.

The first and second goals had immediate regulatory relevance. Managers at the EPA Region 5 Office of Enforcement and Compliance Assurance (OECA) were actively seeking new approaches to help them geographically prioritize regional environmental justice communities to guide pollution reduction efforts. In Milwaukee, Wisconsin, the site of this research, existing EPA screening tools identified the entire city as an area of concern, a region far too large for focused regulatory action. Milwaukee is the most highly segregated city in the nation and ranks lower than all but 1 Wisconsin county in health determinants.[7] EPA managers were seeking a universal approach to identify the most vulnerable areas. I aimed to provide such a method. Second, I sought to put forth a paradigm for analysis aimed at promoting community empowerment and corporate accountability by connecting pollution sources with geographically specific health risk information. Several of the data sources I used were designed as right-to-know tools; if widely noticed, such information could be more effective in driving environmental protection than command-and-control regulation alone.

My third goal was to draw attention to another side of environmental inequity that often escapes scrutiny. As coined by Freudenburg[8] in relation to the creation of environmental harm, the disproportionality hypothesis posits that relatively few heavy polluters drive environmental degradation and the overuse of natural resources. Moreover, such overuse is often not proportional to economic output (despite prevailing worldviews that pit economic performance against environmental quality). Freudenburg found that, among industrial polluters, a small number of firms, sometimes termed *outliers,* reported emissions far above average for their group and that differences remained after controlling for facility size, number of employees, and productive output. He found that

> major polluters tend to be inefficient producers of low-value commodities, and rather than being major employers, they can have emissions-to-jobs ratios a thousand times worse than the economy as a whole.[8(p. 89)]

The ability to pollute disproportionately, without societal sanction or other compensation to the public, constitutes what Freudenburg termed *privileged access* to environmental rights and resources.Although more work is needed to determine the significance of the disproportionality hypothesis, other researchers have published complementary findings. Bouwes et al.[9] found that the vast majority of facilities nationwide generated air pollution health risk scores that fell very close to the standardized mean, whereas a few facilities had risk scores up to thousands of times higher. Abel[10] found that minority and low-income residents in St. Louis, Missouri, lived closer to industrial polluters than nonminority residents and that 20% of the region's air pollution exposure risk in the past decade was spatially concentrated among only 6 facilities. In a study of corporate environmental justice performance, Ash and Boyce[11] found that, of the 100 worst polluters, the top 10 disproportionately affected disadvantaged communities and that minorities living in communities surrounding these 10 polluters were bearing more than half of the health impacts. Although disproportionalities have been noted in the scholarly literature, much environmental policy structures standards on the basis of averages rather than outliers, leading to speculation that the worst offenders are underregulated. As noted by Berry,

> regulations that target highly polluting firms will likely reduce the overall pollution for an industry at a much lower cost than can be achieved by regulations that require incremental reductions from all firms.[2(p262)]

METHODS

I carried this research out in 2009 in conjunction with the EPA Region 5 OECA. Milwaukee, the study area, is one of the EPA's national "showcase communities,"[13] and OECA wanted to prioritize specific environmental justice communities for pollution reduction initiatives. Traditionally, OECA has targeted known polluting sectors (cement, petrochemicals, etc.) for inspection and subsequent enforcement. Moreover, the air, water, and land divisions independently performed their own inspections and related enforcement actions. However, because environmental justice cuts across many sectors, OECA wanted to move to a community or place-based approach that stressed a multimedia perspective. At the time I began this research, regional staff had already conducted several multimedia facility inspections, fostered partnerships with the community and the local government, and participated in mutually beneficial local initiatives within the region.

OECA was using the Environmental Justice Strategic Enforcement Assessment Tool (EJSEAT)[14] as the primary data source for first-tier screening in place-based enforcement. EJSEAT contains 18 variables for all 65 000 census tracts in the United States, grouped into 4 categories: environmental, compliance, demographics, and health. Environmental variables include National Air Toxics Assessment cancer risk, neurologic and respiratory hazard index, and noncancer diesel particulate matter; ozone concentration (8-hour); particulate matter (2.5 mm); and RSEI risk scores. Compliance variables included measures of inspections, violations, formal actions, and facility density. Demographic measures included percentage in poverty; percentage 25 years old or older without a high school diploma; percentage younger than 5 years; percentage older than 64 years; percentage of linguistically isolated households; and percentage of minorities. Finally, health variables included measures of infant mortality and low birth weight. For each census tract, this tool calculates normalized and scaled composite scores by state, which allows census tracts to be ranked according to the degree of environmental justice concern. A key limitation of this tool is that, in some cases, the specific data elements are not available by census tract, so it assigns county-level information to smaller geographic units (census tracts). In addition, the EJSEAT had no relative weighting of variables and explicitly excluded race.

In EPA Region 5, management determined that the top 30% of census tracts in Wisconsin should be considered areas of environmental

Note. EJSEAT = Environmental Justice Strategic Enforcement Assessment Tool.

FIGURE 1—EJSEAT score percentiles in Milwaukee, Wisconsin, before dissimilarity measurements were incorporated.

justice concern. However, this approach lacked sufficient specificity to support local targeting because all 307 of Milwaukee's census tracts fell within the top 30%. Although staff supplemented findings with their working knowledge and information from intra- and interagency contacts, the approach still identified far too many areas than could practically be addressed.

The EPA was also interested in promoting community involvement and corporate accountability through information disclosure based on such tools as the RSEI model.[15] This publicly available database assigns a relative health risk score to every facility reporting toxic emissions. RSEI was developed by the EPA's Office of Pollution Prevention and Toxics to "translate toxic chemical release data into more meaningful risk-related information for use by activists, researchers and policy makers in analyzing disparate impacts by race and income and in properly focusing risk-reduction efforts in communities."[9 (p. 118)] Based initially on each facility's self-reported data derived from the Toxics Release Inventory, scores are weighted for toxicity and population density. The model also accounts for the fate and transport of each specific chemical and for related spatial climatology using a Gaussian dispersion model.

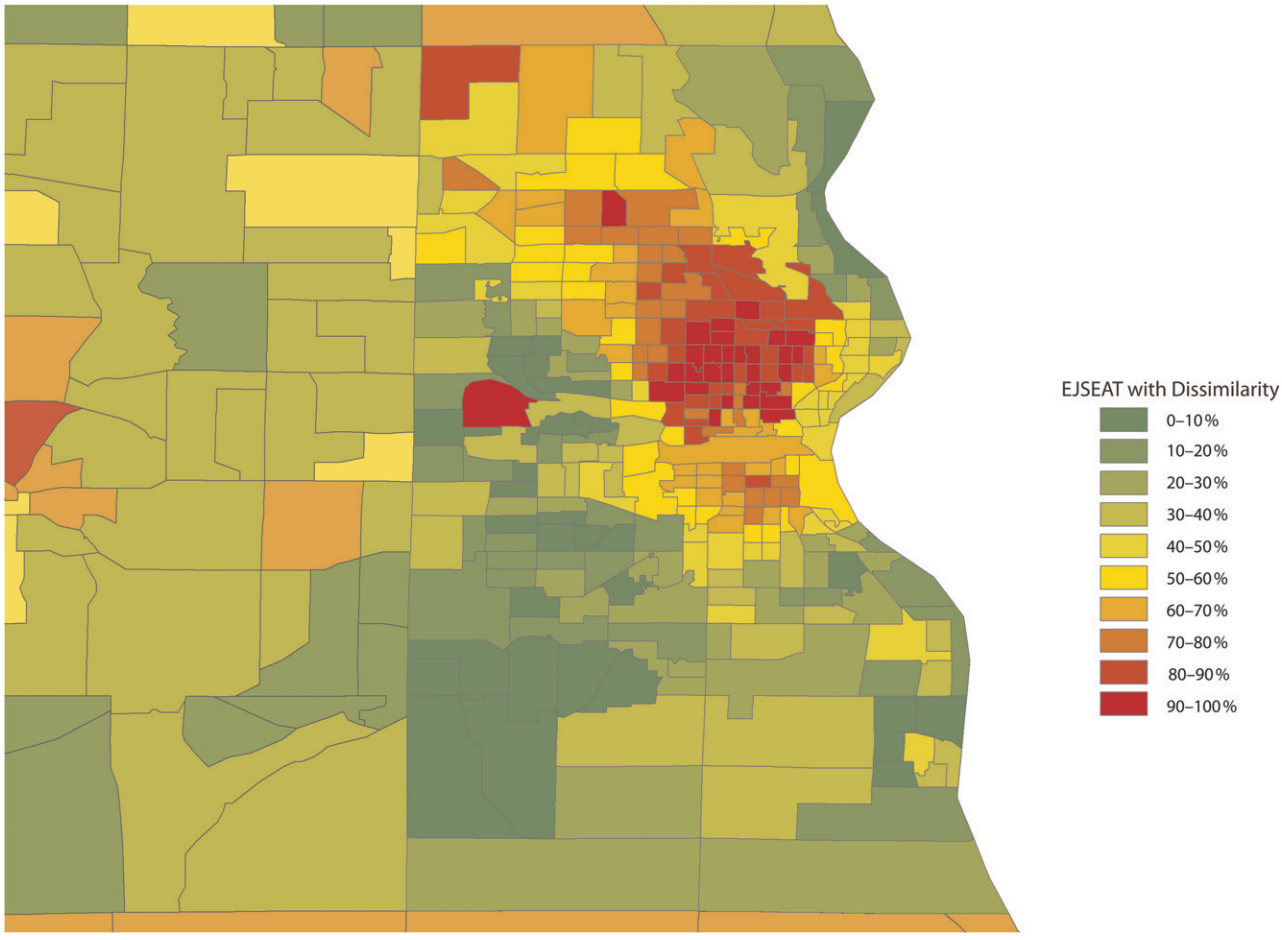
In this research, I addressed several essential questions:

1. What additional data could be added to EJSEAT to increase data granularity and OECA's ability to prioritize communities of environmental justice concern within Milwaukee?
2. Which industrial facilities are contributing the greatest amount of air pollution (RSEI risk adjusted) in environmental justice communities?

2a. Is most air pollution (RSEI risk adjusted) attributable to relatively few heavy polluters; in other words, does a high level of source disproportionality exist?

Question 1: Improving EJSEAT Granularity

To enhance the usefulness of EJSEAT to OECA, I first incorporated a measure of segregation for every census tract in Milwaukee on the basis of both race and class. Morello-Frosch and Lopez[16] found associations between exposure to environmental hazards and segregation; they suggested that future research include segregation as a health risk factor. I assessed segregation using a measure of evenness, called dissimilarity, that addresses how



Note. EJSEAT = Environmental Justice Strategic Enforcement Assessment Tool.

FIGURE 2—EJSEAT percentiles in Milwaukee, Wisconsin, with dissimilarity measurements incorporated.

much a group's population percentage would have to change in a small area (e.g., neighborhood, block) to have the same percentage as that of the same group in a larger area (e.g., city, county, state). Dissimilarity is measured by calculating the difference in variable composition between the larger overall area and the smaller area of interest, and it is the measure of evenness most frequently used in health studies.[17,18] As previously noted, Milwaukee is one of the 5 most racially segregated cities in the United States.[19] Incorporating this segregation measure, based on race and class, into EJSEAT increased the tool's specificity. To do this, I took these steps:

1. I downloaded racial composition data for each of Milwaukee's 307 census tracts from the US Census (2000) Web site.[20]
2. For each census tract, I calculated the proportion of non-White residents.
3. I ascertained the proportion of non-White residents (34.4%) in Milwaukee County at large from American Fact Finder, US Census.[21]
4. To obtain census tract poverty measures, I downloaded poverty data from the Public Health Disparities Geocoding Project for all census tracts.[22] I also used this source to ascertain the proportion of people in poverty in Milwaukee County at large (19.0%).
5. I compared the non-White and impoverished proportions within each census tract in Milwaukee County with the proportion of non-White and impoverished residents in the county overall. This calculation represents the dissimilarity measure.
6. To visualize the locations of clusters of dissimilarity, I mapped these differences.
7. I then incorporated dissimilarity measures into EJSEAT scores. Because EJSEAT scores range from 0 to 100, I had to scale the dissimilarity scores accordingly while preserving the overall distributional integrity. To accomplish this, I applied the following formula to the dissimilarity measures for each census tract:
   a. General scaling formula = $[x / 2(\text{max value})] + 0.5$.
   b. Scaled race dissimilarity = [% non-White / 2 * (0.66)] + 0.5.
   c. Scaled poverty dissimilarity = [% impoverished / 2 * (0.81)] + 0.5.
8. I averaged scaled race and poverty values with the existing EJSEAT scores to yield new EJSEAT scores with dissimilarity incorporated. I mapped these scores to aid in visualization. The census tracts falling into

the top 30% in Milwaukee County were considered to be of environmental justice concern, thereby identifying the 90 highest risk census tracts out of the total 307 tracts.

Questions 2 and 2a: Identifying Health Risk and Source Disproportionalities

I used RSEI data to compare the degree of relative health risk generated by individual facilities. The RSEI model assigns a health risk score to each of Milwaukee's 299 facilities. Although RSEI is a component of the aggregated EJSEAT score, EJSEAT's unit of analysis is census tract as opposed to individual facility. Only after returning to the original RSEI data to identify individual facilities and their risk scores could I compare the contribution to overall risk by facility with areas of environmental justice concern, identified earlier in research question 1.

1. I downloaded the RSEI data (publicly available at: http://www.epa.gov).
2. Although toxicity weighting was preserved in all cases, I considered facility risk scores from both population-weighted and population-unweighted perspectives. I did this because environmental justice focuses on racial and socioeconomic attributes regardless of population density. I performed all analyses twice, once for the weighted dataset and once for the unweighted dataset.
3. I reviewed the data from 1998 to 2005 for each facility in Milwaukee County (n=299).
4. I calculated 1 total risk score for each facility, aggregated first by chemical and second by year.
5. I sorted risk scores from smallest to largest and graphed them to show comparative scores.
6. I calculated total risk score by summing scores for all 299 facilities in the study area.
7. I calculated a share of total risk for each facility.

RESULTS

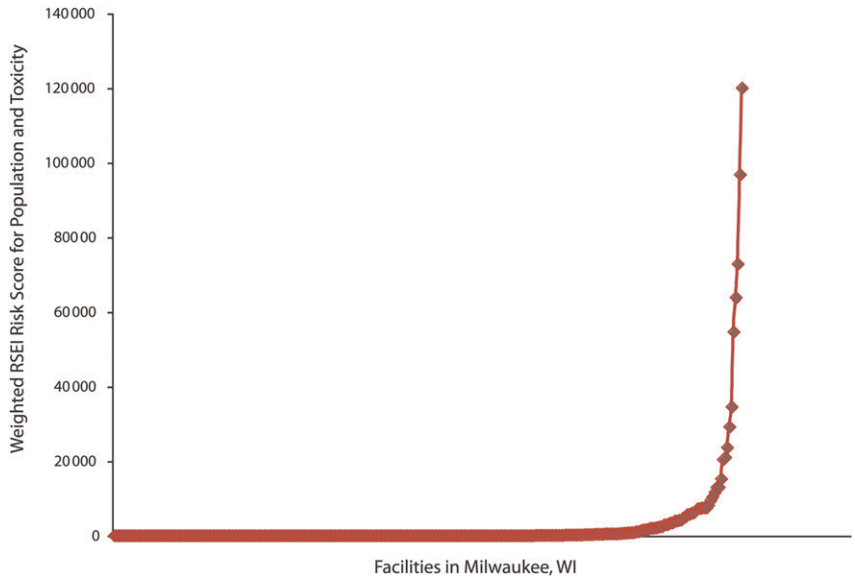
As they relate to the first research question, results showed that EJSEAT can indeed be made more granular to support environmental justice targeting. Calculations of census tract dissimilarity revealed the most highly segregated areas on the basis of race and poverty. Once I integrated these findings into EJSEAT and mapped them, visualization of the most segregated areas was straightforward. A comparison of Figures 1 and 2 shows the greater targeting specificity gained by incorporating degree of segregation. As stated, before dissimilarity measurements were incorporated into EJSEAT (Figure 1), 100% of Milwaukee's 307 census tracts were considered to be areas of environmental justice concern. When I incorporated dissimilarity (Figure 2), only 90 of Milwaukee's 307 census tracts met the criteria to be considered an area of environmental justice concern. These 90 census tracts contained 82 of the region's 299 facilities monitored through RSEI.

Source Disproportionality

With respect to the second set of research questions, the results revealed the presence of substantial variation in risk production by individual facility. Most facilities (269 facilities, or 90%) had very low risk scores, and a small minority (30 facilities, or 10%) produced 90% of all the health risk measured by RSEI (Figure 3). A virtually identical pattern existed regardless of whether weighted or unweighted population density data were considered (with data toxicity weighted in both cases). This pattern constitutes a very high level of source disproportionality, with the top 10% of risk-producing facilities generating an average risk score that is approximately 33 times higher than the average among facilities below the 90th percentile.

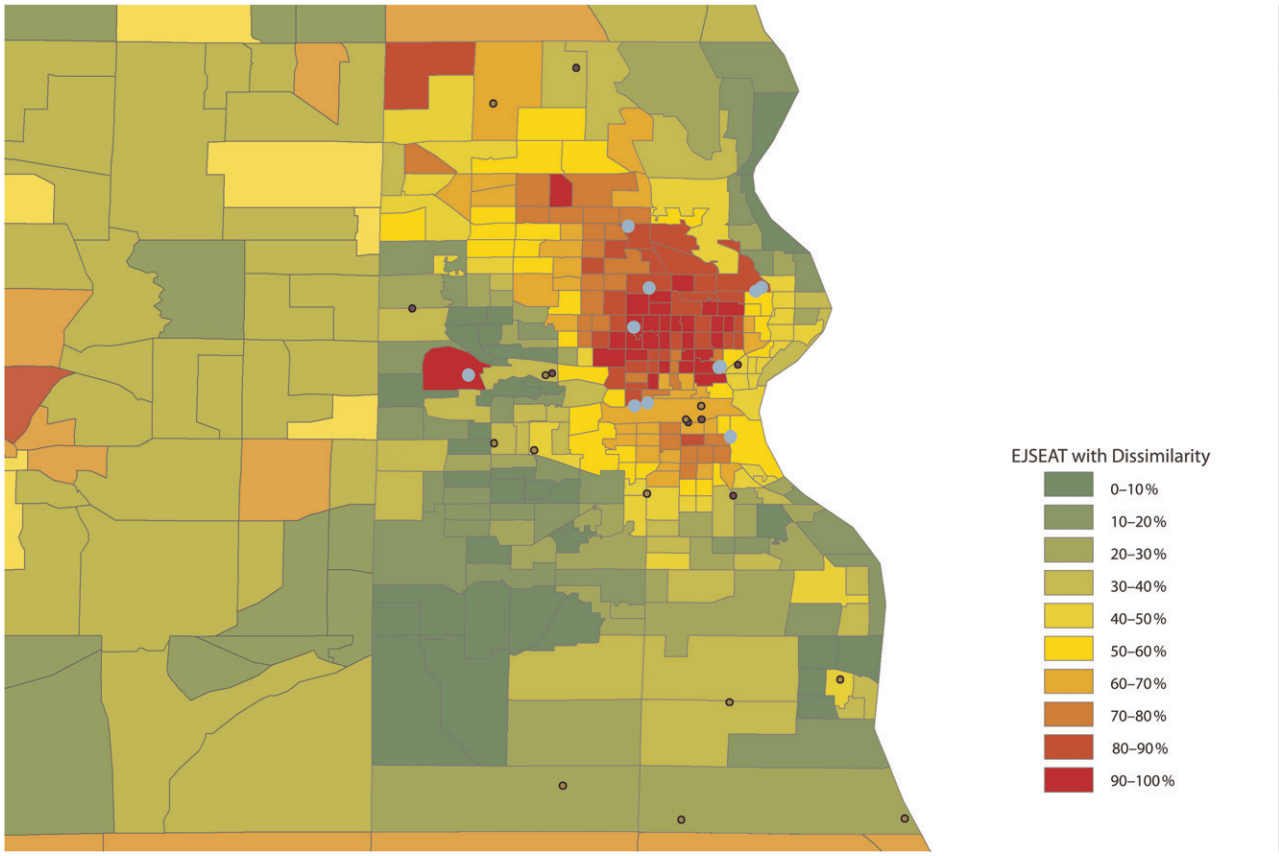
Coupling Source and Impact Disproportionality

Finally, findings revealed the relationship between Milwaukee's top industrial polluters and the areas identified as areas of environmental justice concern. Figure 4 shows the intersection of the 30 major risk producers and areas of environmental justice concern. As it turned out, 11 of the 30 major polluters are located in environmental justice communities of concern. These 11 facilities accounted for 27% of all risk in Milwaukee County. In other words, 3.7%, or 11 of 299 facilities, disproportionately contributed to the health risk in communities of particular concern.



Note. RSEI = Risk Screening Environmental Indicators.

FIGURE 3—Distribution of RSEI-based risk scores by facility in Milwaukee, Wisconsin: 1998–2005.



Note. A dark dot denotes the major health-risk facilities that are not in areas of high concern, and a light dot denotes major health-risk facilities located in environmental justice communities of concern.

FIGURE 4—Map of major polluters in Milwaukee, Wisconsin's, environmental justice communities.

DISCUSSION

Efforts to promote environmental justice clearly benefit from the availability of screening tools that allow regulators to move from a reactive mode focused on responding to complaints to a consistent, areawide proactive approach. Although EJSEAT is one of the most comprehensive tools to date, significant shortcomings still remain, as pointed out by both OECA and the National Environmental Justice Advisory Council.[23] In the short term, the additional data layers added as a result of this study provide greater specificity and a perspective that links environmental justice with corporate responsibility. Environmental justice screening tools will no doubt continue to evolve. As they do, adding geographically specific health indicators such as asthma rates, cancer rates, lead poisoning statistics, and other metrics known to be associated with environmental exposure would be helpful, as would including soil and water contamination and other environmental pollution measures.

Along with improving the specificity and utility of screening tools, one of my goals was to draw attention to another side of disproportionality and environmental inequality, the side that looks at how a relative few societal actors maintain a privileged and largely unquestioned ability to pollute the shared air, land, and water.[8] As Freudenburg[8] has argued, the large differences in pollution loads between industrial sources are seen as legitimate because they are believed to be economically necessary for providing jobs and essential products. In fact, early empirical work in the area of disproportionality theory indicated that this assumed economic benefit may not be present; rather, the heaviest polluters may also tend to be strikingly poor economic performers. It would be interesting to know how the identified heavy polluters (the 10% of Milwaukee's industrial facilities that produce 90% of the area health risk) contribute to the city's economic base or whether they reap profits while overburdened communities bear the human and social costs. At the very least, such questions should be asked explicitly as opposed to blindly accepting source disproportionality as necessary for economic reasons. Future research in this area is important in understanding the relationship between environmental degradation and economic progress and how disproportionality theory can be applied within the regulatory sphere.

Limitations

This study had a number of limitations related to its data sources. Despite validity concerns related to EJSEAT, it remains one of

the most current tools for bringing a consistent and logical approach to environmental justice targeting. Analyses such as this one will help in identifying needed refinements. Regarding the RSEI, it is intended as a screening-level and public disclosure tool and is based on data reported by facilities. Additional assessment, monitoring, and inspection of identified facilities would be needed to determine whether violations exist and whether adverse health effects are truly associated with emissions from the identified facilities. Study conclusions may also benefit from replication with greater geographic specificity using state-of-the-art methods in environmental justice proximity studies. This lack of specificity may not be a serious limitation in Milwaukee because census tracts in the high-minority-population areas are small, averaging approximately 0.5 square mile in area.[19]

Conclusions

I demonstrated how publicly available data can be used in conjunction with mapping software to improve the utility of environmental justice screening tools. Moreover, the results emphasize the practical value of accounting for disproportionality from the standpoints of both impacts and sources. Analyses of this type will be most useful in guiding corrective measures that effectively deal with where or who is most affected and who or what is contributing most substantially to the production of environmental harms. Such analyses encourage a specific linkage between environmental justice and corporate accountability that can be used by regulators and community activists to bring pressure to bear on the worst polluters in overburdened communities. Finally, such analyses provide further evidence to suggest that more attention should be paid to the significance of disproportionalities in the production of environmental harms as manifestations of the broader social and economic inequalities that fundamentally contribute to health disparities in vulnerable communities. ■

About the Author

Mary B. Collins is a PhD student at the Bren School of Environmental Science and Management, University of California, Santa Barbara.

Correspondence should be sent to Mary B. Collins, 2400 Bren Hall, University of California, Santa Barbara, CA 93106-5131 (e-mail: mcollins@bren.ucsb.edu). *Reprints can be ordered at http://www.ajph.org by clicking the "Reprints/Eprints" link.*

This article was accepted January 12, 2011.

Acknowledgments

I thank the editors and anonymous reviewers of the *American Journal of Public Health*, the Environmental Protection Agency's Region 5 Office of Enforcement and Compliance Assurance, the National Network for Environmental Management Studies fellowship program, and Dr. William Freudenburg, who gave me his time and intellectual support with great generosity. All interpretations, omissions, or errors, however, are mine alone.

Human Participant Protection

Institutional review board approval was not needed because all data were publicly available.

References

1. National Center for Health Statistics. *Health, United States, 2007, With Chartbook on Trends in the Health of Americans.* DHHS publication no. 2007-1232. Washington, DC: US Department of Health and Human Services; 2007.

2. Murray CJL, Kulkarni SC, Michaud C, et al. Eight Americas: investigating mortality disparities across races, counties, and race-counties in the United States. *PLoS Med.* 2006;3(9):e260.

3. Mohai P, Pellow D, Roberts JT. Environmental justice. *Annu Rev Environ Resour.* 2009;34:405–430.

4. Maantay J, Chakraborty J, Brender J. *Proximity to Environmental Hazards: Environmental Justice and Adverse Health Outcomes.* US Environmental Protection Agency, trans. Washington, DC: Strengthening Environmental Justice and Decision Making; 2010.

5. Mohai P, Lantz P, Morenoff J. Racial and socioeconomic disparities in residential proximity to polluting industrial facilities: evidence from the Americans' Changing Lives Study. *Am J Public Health.* 2009;99(suppl 3):S649–S656.

6. Faber DR, Krieg EJ. Unequal exposure to ecological hazards: environmental injustices in the Commonwealth of Massachusetts. *Environ Health Perspect.* 2002;110 (suppl 2):277–288.

7. Vila PM, Swain GR, Baumgardner DJ, Halsmer SE, Remington PL, Cisler RA. Health disparities in Milwaukee by socioeconomic status. *Wis Med J.* 2007;106(7):366–372.

8. Freudenburg WR. Privileged access, privileged accounts: toward a socially structured theory of resources and discourses. *Soc Forces.* 2005;84(1):89–114.

9. Bouwes N, Hassur SM, Shapiro MD. Information for empowerment: the EPA's risk-screening environmental indicators project. In: Boyce JK, Shelley BG, eds. *Natural Assets: Democratizing Environmental Ownership.* Washington, DC: Island Press; 2003:117–134.

10. Abel TD. Skewed riskscapes and environmental injustice: a case study of metropolitan St. Louis. *Environ Manage.* 2008;42(2):232–248.

11. Ash M, Boyce JK. *Measuring Corporate Environmental Justice Performance.* Economics Department Working Paper Series. Paper 18. Amherst: University of Massachusetts—Amherst; 2008.

12. Berry L. Inequality in the creation of environmental harm: looking for answers from within. In: Wilkinson RC, Freudenburg WR, eds. *Equity and the Environment. Research in Social Problems and Public Policy,* vol. 15. Bingley, UK: Emerald Publishing Group Limited; 2008; 239–265.

13. US Environmental Protection Agency. *Environmental Justice Showcase Communities.* Available at: http://www.epa.gov/environmentaljustice/grants/ej-showcase.html. Published 2010. Updated March 15, 2011. Accessed September 10, 2010.

14. US Environmental Protection Agency. *Environmental Justice Strategic Enforcement Assessment Tool (EJSEAT).* Washington, DC: Office of Enforcement and Compliance Assurance; 2009. Available at: http://www.epa.gov/compliance/ej/resources/policy/ej-seat.html. Accessed July 1, 2009.

15. US Environmental Protection Agency. *Risk-Screening Environmental Indicators (RSEI).* Washington, DC: Office of Pollution Prevention and Toxics; 2009. Available at: http://www.epa.gov/opptintr/rsei. Accessed July 1, 2009

16. Morello-Frosch R, Lopez R. The riskscape and the color line: examining the role of segregation in environmental health disparities. *Environ Res.* 2006;102(2): 181–196.

17. Acevedo-Garcia D, Lochner K. Future directions in residential segregation and health research: a multilevel approach. *Am J Public Health.* 2003;93(2):215–221.

18. Collins CA, Williams DR. Segregation and mortality: The deadly effects of racism? *Sociol Forum.* 1999; 14(3):495–523.

19. Iceland J, Weinberg D, Steinmetz E. Racial and ethnic residential segregation in the United States, 1980-2000. Paper presented at: Annual Meeting of the Population Association of America; May 9–11, 2002; Atlanta, GA.

20. US Census Bureau. *Summary File 3.* Washington, DC: US Census Bureau; 2000. Available at: http://www.census.gov/census2000/sumfile3.html. Accessed July 1, 2009.

21. US Census Bureau. American Fact Finder. 2000. Available at: http://factfinder.census.gov. Accessed August 10, 2009.

22. Krieger N, Chen J, Waterman P. Painting a truer picture of US socioeconomic and racial/ethnic health inequalities: the Public Health Disparities Geocoding Project. *Am J Public Health.* 2005;95(2):312–323.

23. National Environmental Justice Advisory Council. *Nationally Consistent Environmental Justice Screening Approaches: A Report of Advice and Recommendations of the National Environmental Justice Advisory Council: A Federal Advisory Committee to the US Environmental Protection Agency.* Washington, DC: National Environmental Justice Advisory Council; 2010.