



Cumulative Risk and a Call for Action in Environmental Justice Communities

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Cumulative Risk and a Call for Action in Environmental Justice Communities

Abstract

Health disparities, social inequalities, and environmental injustice cumulatively affect individual and community vulnerability and overall health; yet health researchers, social scientists and environmental scientists generally study them separately. Cumulative risk assessment in poor, racially segregated, economically isolated and medically underserved communities needs to account for their multiple layers of vulnerability, including greater susceptibility, greater exposure, less preparedness to cope, and less ability to recover in the face of exposure. Recommendations for evidence-based action in environmental justice communities include: reducing pollution in communities of highest burden; building on community resources; redressing inequality when doing community-based research; and creating a screening framework to identify communities of greatest risk.

Keywords

Community-based research; Cumulative risk; Environmental health; Environmental justice; Equality; Health disparities; Health surveys; Medically underserved areas; Minorities; Poor; Social inequality; Social status – Health aspects; Vulnerability

Cover Page Footnote

The authors acknowledge the shortcomings of the census and public health data, particularly for Native Americans, immigrant, homeless and very poor people. Local pilot projects and studies, undertaken by trusted community organizations in partnership with the EPA and public health regional offices, may be important resources to supplement this information. The views expressed are solely those of the authors. No official support or endorsement by the EPA or any other agency of the federal government is intended or should be inferred. H. Patricia Hynes was a member of the NEJAC Cumulative Risk Working Group.



Cumulative Risk and a Call for Action in Environmental Justice Communities

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Abstract

Health disparities, social inequalities, and environmental injustice cumulatively affect individual and community vulnerability and overall health; yet health researchers, social scientists and environmental scientists generally study them separately. Cumulative risk assessment in poor, racially segregated, economically isolated and medically underserved communities needs to account for their multiple layers of vulnerability, including greater susceptibility, greater exposure, less preparedness to cope, and less ability to recover in the face of exposure. Recommendations for evidence-based action in environmental justice communities include: reducing pollution in communities of highest burden; building on community resources; redressing inequality when doing community-based research; and creating a screening framework to identify communities of greatest risk.

Key Words: environmental justice, health disparities, social inequality, cumulative risk, vulnerability, community-based research

Introduction

In 2002, the US Environmental Protection Agency (EPA) charged its National Environmental Justice Advisory Council (NEJAC) to study and propose a set of working principles and strategies to guide the agency in addressing cumulative risk and vulnerability, including the social, economic, cultural, and spiritual conditions that affect human health and can worsen the health impacts of environmental pollution. NEJAC created the Cumulative Risk Working Group, inviting members from environmental justice organizations, state health and environmental agencies, universities, and industry. The group was charged to address the following questions: what constitutes cumulative risk, and how should the EPA respond to it. Three prescriptive conclusions from the workgroup's final report (National Environmental Justice Advisory

Council [NEJAC] 2004) emerged as focal points for further discussion in numerous national forums; they are germane to this paper.

- Health disparities, social inequalities and environmental injustice cumulatively affect individual and community vulnerability and risk. Cumulative risk assessment and remedial action need to address all of these sources of vulnerability.
- A partnership model—community with government, community with university, or community with non-profit sector—is the model most likely to generate meaningful research, risk assessment, remedial action, and equitable policy to achieve environmental justice.
- Environmental justice research must embody a bias for action.

This paper further explores these three conclusions. It is written for the purpose of proposing a holistic and evidence-based approach to identify and take action in communities that are most vulnerable to the health effects of pollution. One of the authors was a member of the Cumulative Risk Working Group; however, this paper represents solely the opinions of the authors.

The first conclusion evolved from lengthy discussions among the NEJAC working group on the multiple disparities and disproportionate burdens that add to individual and community stress and ill health and that diminish the capacity to cope and recover in the face of exposures. While generally studied and treated separately, social and health disparities and disproportionate exposure to stressful and toxic environments are not lived separately. The risk, for example, of a child being lead poisoned, developing asthma, having emergency asthma events, or being injured or disabled is heightened if one is low-income, minority, and living in poor housing (Cubbin & Smith 2002; Gottlieb, Beiser & O'Connor 1995; Malveaux & Fletcher-Vincent 1995; Sargent et al. 1999). In the occupational setting, poor and non-white workers are more likely to become injured or ill at work than non-poor and white workers (Robinson 1984). Social inequalities compound occupational, physical, and built environment risks, resulting in greater health disparities among minorities and the poor (Deaton & Labotsky 2003; Diez-Roux 2001).

The second conclusion centers on community collaborative models of environmental health research. Community partners can enhance the reliability and validity of data gathered and the quality of the research design through providing honest, in-depth feedback during pre-testing of instruments; by improving recruitment and attrition rates; by reducing cultural and language barriers; and by providing feedback on the com-

munity response to the research design (Jordan, Lee & Shapiro 2000). Community and local government partners can help assure that research hypotheses and intervention designs are relevant and targeted to the needs of communities. Further, they can increase the likelihood that research results are effectively translated and widely disseminated and that the policy and program implications of research findings—the “so what?” of research—are prioritized and acted upon (National Institutes of Health [NIH] 2004).

The third central conclusion of the working group is one that grows out of communities’ frustration with the “paralysis of analysis” that locks studies into recurring cycles of research and slows corrective action. By research with a bias for action, we mean studies that are framed to address questions the community brings to the research collaboration, that are intentionally oriented to remedies needed, that seek to drive informed action sooner rather than later, that are intended to influence public policy, and that serve the greatest number of people feasible or those most at risk (NEJAC 2004). This final conclusion resonates with the animating spirit of early public health investigations that drove housing code reform and drinking water protection (Rosen 1958), and it also echoes the inclinations of many environmental justice scientists and researchers (Sexton 1997; Schulz & Northridge 2004; Gee & Payne-SturGIS 2004; Hynes & Brugge 2005; Raphael 2000; Martuzzi & Tickner 2004). While it may not be possible to quantify precisely how much cumulative risk poor and minority communities bear, there is a growing consensus that racial and income inequalities are significant determinants of health and that we do not have “the luxury of waiting for conclusive scientific evidence” (Sexton 1997, 264) to take preventive and remedial action to safeguard those who are socially vulnerable.

In this paper, we build toward a call for evidence-based action by exploring multiple and cumulative factors that have been found to increase vulnerability to pollution and risk of ill health. Among these are poverty, income inequality, and economic isolation; racism and racial segregation; and health disparities. We begin first with laying out a framework of vulnerability, employed by the NEJAC working group, within which these multiple risk factors operate. The multi-factorial disease of asthma serves as both a concrete example and a metaphor for how cumulative factors, such as poor housing and inferior health care, initiate and worsen disease, aggravate vulnerability to pollution, and diminish capacity to recover. We conclude this paper with recommendations for researchers, regulators, and practitioners that jointly address social risk factors with environmental and health disparities in order to achieve environmental justice in communities most vulnerable to the health effects of pollution.

Cumulative Risk and the Disease of Asthma

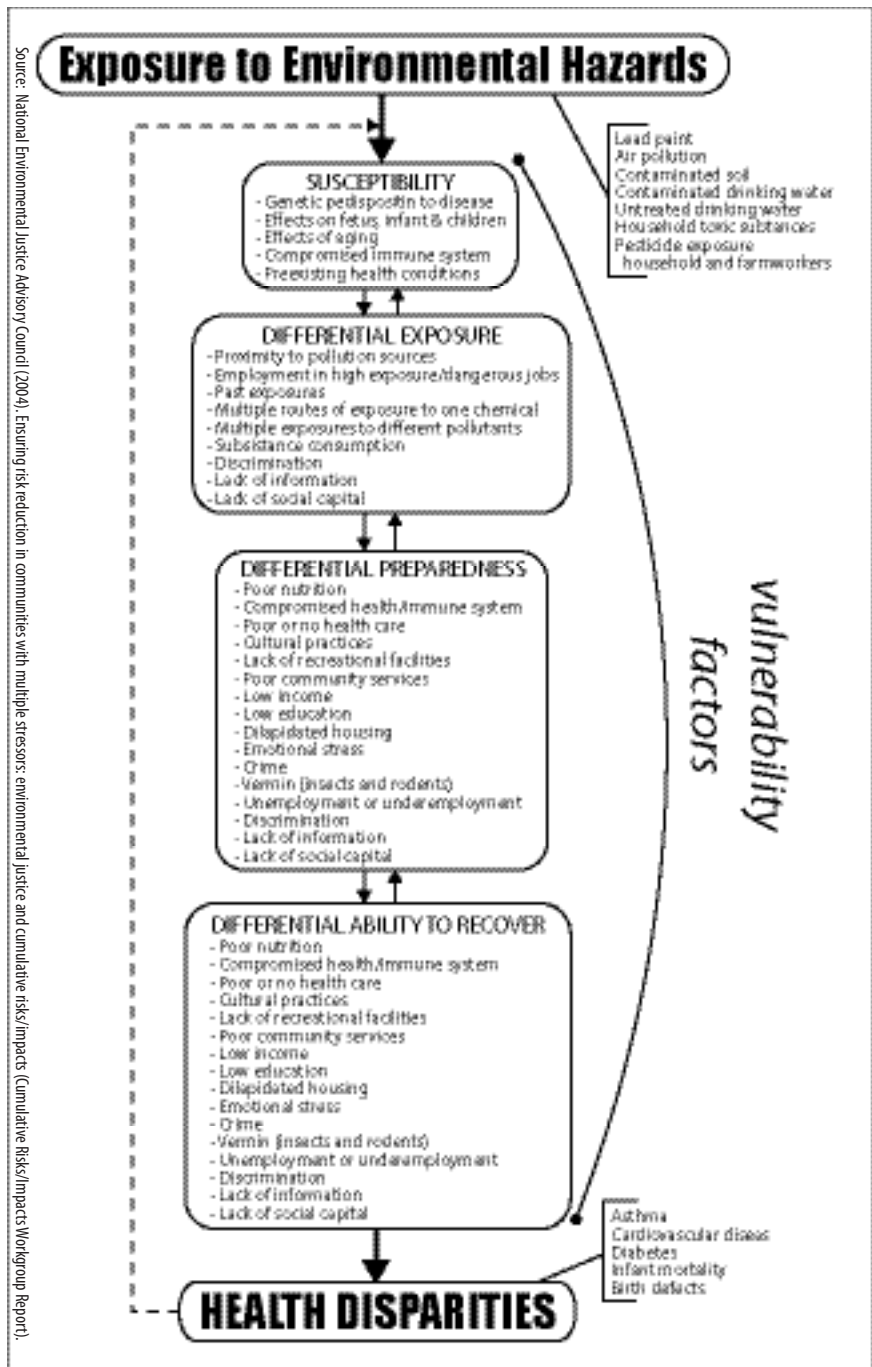
To explore cumulative risk more fully, the NEJAC working group examined aspects and components of vulnerability, as structured by Kasperson (EPA 2003, 39–42), that add to an individual's and community's overall risk. These include: greater susceptibility, greater exposure, less preparedness to cope, and less ability to recover in the face of exposure. These layers of vulnerability account for the fact that some individuals and communities are more susceptible to pollution exposures than others because of historic and disproportionate burdens of pollution, poverty, political powerlessness and unequal health access and quality of care (EPA 2003; see Figure 1). Applying these interrelated components of vulnerability to the disease of asthma helps to illustrate the distinct yet linked contribution of each component of vulnerability to the overall greater burden of this disease for poor and minority individuals and communities.

In the US, the prevalence of asthma has been steadily increasing since 1980 (Mannino et al. 1998), making asthma the most common chronic illness in children and adolescents (Centers for Disease Control and Prevention [CDC] 2000) and the leading cause of school absenteeism for chronic illnesses (Neukirch et al. 1999) and caretaker workdays missed (Ordonez 1997). According to the Centers for Disease Control and Prevention, the self-reported prevalence of asthma increased by 75% from 1980 to 1994, a trend found to be significant ($p < 0.05$) and evident in every region of the country (CDC 1998). This increase has been most marked in children 0–14 years of age and in minority populations; and there is mounting evidence that—as with lead poisoning and child injuries and disability—low-income, inner-city children are most at risk (Weiss, Gergen & Crain 1992; Apter et al. 1999; Aligne et al. 2000). Children living in poverty and children insured by Medicaid are also at higher risk of severe asthma exacerbation, asthma-related use of the emergency room, and hospitalization (Hopkin & Donahue 2004).

How can the multi-level aspects of vulnerability, as delineated by Kasperson, help explain the greater prevalence of asthma morbidity and severity among low-income, urban, minority children; their greater risk of acute episodes and hospitalization; and the greater consequent toll of lost school and workdays and lower quality of life?

Asthma is a complex, multi-factorial respiratory disease influenced by biology; environmental factors in the proximate social, built, and physical environments; and medical access and management. Recent studies on differences in genetic susceptibility to asthma and response to asthma medication among ethnic and racial groups have generated some

Figure 1.



This graphic was developed by the NEJAC Work Group to illustrate the relationship between environmental hazards, vulnerability, and health disparities, and how health disparities are both an outcome of and contributor to vulnerability.

suggestive findings (Federico et al. 2005; Lester et al. 2001). However, population-based analysis of 1997 NHIS survey data for black–white differences in asthma prevalence among children aged less than 18 years old found that significant racial differences existed only at the lowest income level (Smith et al. 2005). These results suggest that it is much more likely that social risks, environmental exposures, health status, and quality of care are the factors of significance that contribute to the disparity in this disease.

More than forty percent of doctor-diagnosed asthma among US children has been attributed to indoor exposures (Sandel et al. 2004). Moisture and mold growth, pest allergens, dust mites, oxides of nitrogen, and exposure to cigarette smoke are among the factors studied for their role in asthma sensitization, asthma onset and asthma exacerbation (Institute of Medicine 2000). Research has documented that low-income people and blacks are 2.2 and 1.7 times, respectively, more likely to live in substandard housing than the overall population and that poor people are more likely to live in overcrowded and under- or over-heated homes (Krieger & Higgins 2002). Damp, moldy and cold housing is associated with chronic respiratory symptoms and asthma, independent of income, smoking, crowding, and unemployment (Krieger & Higgins 2002). Thus, greater exposures to moisture and temperature conditions of poor housing likely explain in part the greater susceptibility to, prevalence, and severity of asthma among low-income, minority children.

Low-income, minority children in cities are also more likely to experience greater exposures to allergens and molds because of poor public school building conditions (Dangman, Bracker & Storey 2005); greater pest infestation at home (Miller & Meek 2004); greater exposure to local air pollutants from heavily trafficked roadways—including ultrafine particulates, nitrogen dioxide, sulphur dioxide, carbon monoxide, and carbon black which remain near the emission sources (O'Neill et al. 2003; Meng et al. 2006); and greater exposure to violence (Massey 2004), the stress from which has been associated with exacerbating asthma (Wright & Steinbach 2001). In sum, inner city children are likely to have greater prevalence of asthma and asthma symptom exacerbation due to greater exposures to indoor and nearby outdoor pollutants and stress from violence, all of which are associated with the disease, worsening symptoms, and greater hospitalization and emergency room visits.

Regarding the third component of vulnerability, preparedness to cope with disease, poor urban children and their families are less prepared to fare well with asthma, a disease that requires careful medical management. Among children followed in an integrated pest manage-

ment (IPM) intervention study in public housing, researchers found that: the majority of children with persistent asthma were not prescribed daily long-term control medication as recommended by national asthma control guidelines and did not have an asthma action plan or peak-flow meter; inner city pharmacies often do not stock long-term medications; families often have no primary care physician; and a majority of children, in the case of one housing development, are restricted from outdoor play because of neighborhood violence (Levy et al. 2004). Researchers made the observation that many residents buy used furniture (a likely reservoir of mites, mold, pests, and allergens) and have minimum storage space (J. Vallarino, Harvard School of Public Health, personal communication, May 15, 2004), which can contribute to clutter, poor sanitation, greater pest infestation and allergen load. Further, the working poor often have little or no sick leave and vacation time and are in danger of losing jobs if they lose too many workdays due to their children's emergencies. Thus, working poverty and economic isolation, disparity in medical services and poor medical management, and inner city neighborhood, housing, and school conditions can undermine parents' and children's ability to optimize their asthma management. Poor asthma management increases risk of acute exacerbation, hospitalization, and death.

Low-income people generally have less control over changing or improving home environments, an important factor in vulnerability, considering that dampness, mold, and pest infestation are generally not amenable to small, low-cost repairs. Especially in substandard housing, these conditions are likely to have structural building problems at their root. Thus, residents' preparedness to recover from the health impact of environmentally-caused ill health is diminished.

Multiple, intense apartment and building interventions are required where there is a high allergen burden, including intensive cleaning, carpet removal, improved ventilation, and integrated pest management. Advice recently provided in a major pediatric journal to parents concerned about asthma triggers—increase ventilation; repair water leaks within 24 hours; remove carpeting (old bedding and used furniture, should also be included); and avoid pressed wood products (Scarborough 2004)—is not generally feasible for most people on very limited incomes and who reside in subsidized multi-family housing. Moreover, recent federal budget cuts to public housing authorities and Section 8 programs undermine capital improvements, operation and maintenance, and the provision of clean, dry, pest-free, and safe housing to those 10%–20% of the population most in need. The Boston Housing Authority capital budget, as an example, was reduced 23% by the US Department

of Housing and Urban Development (HUD) between 2000 and 2004 (Boston Housing Authority, personal communication, April 21, 2004).

Recent asthma intervention studies in low-income communities do, however, indicate that individualized, home-based education and environmental interventions can help reduce symptoms, urgent care visits, and school and work days lost—particularly for more severe asthmatics—and that these comprehensive interventions can be cost-effective, given the reduction in costly urgent care visits (Morgan et al. 2004; Brugge et al. 2004; Nicholas et al. 2005). In other words, vulnerability can be reduced through providing home environment improvements, access to education, and individualized case management that increase adherence to a medication regimen and build skill, motivation, and confidence to manage the disease. Successful interventions, such as these, are beginning to leverage support through Medicaid health insurance coverage for home visits and environmental improvements (Hopkin & Donahue 2004).

Impacts of Economic, Racial, and Other Social Determinants on Health

Most of the vulnerability factors that we cite with the example of asthma derive from social inequalities, less medical access, and poorer medical management. The impacts of poverty and income inequality, racism and racial segregation, and health disparities on health are critical for understanding and undertaking cumulative risk assessment, particularly in communities with historical, multiple, and disproportionate exposure to environmental toxins.

Poverty

Epidemiologic studies have forcefully documented that wealth disparities create health disparities. Being poor and less equal—even when only in childhood or for discrete periods of one's life—puts people at risk of greater illness, injury, and early mortality (Marmot, Kogevinas & Elaston 1987). Poverty has been found to have a larger impact on total mortality rates than lifestyle factors, including smoking, alcohol, body mass index and activity (Lantz et al. 1998). Research on the relationship of income and child injuries at the neighborhood level has determined that for each decrease in neighborhood socio-economic status, there is an average increase of 1.5 million children injured annually in the US (Chen, Matthews & Boyce 2002). Suggested explanatory factors include poor housing conditions, lack of access to material resources, unemployment, and social isolation.

A comprehensive evaluation of the health effects of air pollution found that socio-economic status and race were consistently associated with greater health effects from particulate air pollution. The authors explained this disparity in health consequences using two key vulnerability factors: greater exposure to air pollution from the common siting of highways, power plants, and central vehicle depots in poor communities, and greater susceptibility to air pollution because of less health care access, more chronic medical conditions, poorer nutrition and housing, other pollutant exposures, and witness to violence among poorer people (O'Neill et al. 2003).

Income Inequality

Income inequality, a measure of income distribution and economic disparity in a society, has significant impact on health and may be, in some cases, more significant than absolute poverty. Being poor in a country, state, or city of extremes has been found to be worse for health than being poor in a more equal society, resulting in higher overall mortality and lower overall health status (Raphael 2000; Lopez 2004; Kawachi & Kennedy 1997; Kennedy & Kawachi 1996). The reasons given for this difference are: growing inequality results in increased and deeper poverty, particularly child poverty, with a shift of resources from the less well-off to the more well-off; increases in inequality result in fewer social and health services for the poor; and economically unequal societies and communities have weaker social cohesion, a precursor to increased illness and death (Raphael 2000; Kawachi, Kennedy & Lochner 1997).

Income inequality in the US declined after World War II, rose during the 1980s, and did not decline in the 1990s (Jones & Weinberg 2000). From 2000 to 2003, the number of poor and uninsured increased; and in 2003 income inequality grew, with those who are poorest—single women with children—experiencing the greatest increase in poverty (Leonhardt 2004). In the same period, public investment in education, job training, public housing, child care, basic infrastructure, environment, and energy fell to about one-half its levels in the 1960s and 1970s, when adjusted for the size of the economy (Miller 2004). The US Conference of Mayors reported a dramatic increase in homelessness and hunger among low-income and working families in 2003, worsened by a decrease in the capability of the country's 25 major cities to meet the needs of the growing poor through urban shelter and food assistance programs (Leonard 2003). In 2004, the United Health Foundation published its 15th annual report on the overall health of states in the United States. During 2004, rates of obesity increased; the rate of infant mortality increased, the first increase in 40 years; and in what may be the consequences of growing

income inequality, the percent of children living in poverty increased (United Health Foundation 2004).

Economic Isolation

Associated with growing inequality is the increasing isolation of the poor. Urban and suburban development in the 1950s and 1960s segregated the poor in cities from the middle class in suburbs and rendered poverty invisible (Harrington 1962). Contemporary poverty and rising income inequality have further isolated the poor from the rest of society, rendering them politically powerless and virtually immune to progress (Galbraith 1958). The phenomenon of communities opposing multi-family, subsidized, and affordable housing, along with that of suburban sprawl and the growth of gated communities, are hardening the arterial economic divide (Jargowsky 1996; Quinlan 1999). By 1990, with the growing trend of urbanization of the poor and growing class isolation, more than two-thirds of all central city poor people lived in poor or very poor neighborhoods (Massey 1996). These combined trends and patterns in metropolitan areas in the US are “creating an unprecedented spatial intensification of both privilege and poverty” (Massey 1996, 395).

Neighborhoods with higher percentages of the poor have higher levels of infant mortality, increased risk of avoidable deaths associated with crime and violence, and a greater chance that they will bear a disproportionate burden of the environmental costs of contemporary society (Diez-Roux 2002). Little comparative research exists on the health impacts of reducing concentrated poverty; however, one study of families who moved from living in high poverty census tracts to lower poverty census tracts, through a housing voucher program, found a 50% decreased likelihood of asthma attacks, independent of other risk factors (Katz & Liebman 2001).

Race

Race, independent of poverty, is implicated in higher rates of illness, greater exposure to toxic substances, poorer services, fewer resources, and thus greater vulnerability (Geronimus 1996; Wallace 1988; Wallace & Wallace 1998; Sager 1983). African American children between the ages of one and five have proportionately higher prevalence of elevated blood lead levels (equal to or greater than 10 micrograms of lead per deciliter of blood) than other racial/ethnic groups in all income categories (Brody et al. 1994). Having no explanatory genetic basis, this disparity is a possible health consequence of African Americans' living in more highly segregated neighborhoods with poorer housing quality than any other minority group, itself an outcome of discrimination policies in

housing that include redlining and rental and mortgage discrimination (Denton 1999).

Discrimination in housing, based on race, has deprived African Americans of an estimated \$82 billion from lack of housing appreciation, higher mortgage rates, and denial of mortgages (Denton 1999). Thus, racial discrimination has contributed to the racialization of poverty and economic isolation. Unfortunately, civil rights legislation has not eliminated these social inequities. Recent studies in racial discrimination have found that minorities with comparable education and income continue to receive less favorable treatment than whites in job applications, shopping, and the housing market (Gee & Payne-Sturgis 2004).

Racial Segregation

Racial segregation is the clustering, concentrating, and isolating of groups by reason of race and ethnicity (Taeuber 1985). Rates of racial residential segregation are moderate to high for Asians and Latinos and decline with rising income. However, levels of black segregation are higher than any group in the history of the US and persist more than other racial and ethnic groups at all income levels. The dynamics that have resulted in high and hyper-segregation for blacks are not income or in-group preference, according to numerous researchers. Racial intolerance on the part of whites and historic housing discrimination plausibly explain the extreme segregation rates of African Americans (Massey 2004; Fogelson 2006; Loewen 2006).

Racial segregation reduces upward mobility and the wealth accumulation that American homeowners have enjoyed through rising equity in housing; and it has resulted in a geographical mismatch between where jobs are and where minorities live (Denton 1999; Kain 1968). Thus, segregation contributes to poverty and its correlates: poorer services, poorer schools, greater environmental exposures, and greater health disparities (Massey & Fischer 2000). The health consequences of racial residential segregation include increased morbidity and mortality risks (Acevedo-Garcia 2000; Collins & Williams 1999; LaVeist 2003) and increased odds of self-reported poor health among blacks (Subramanian, Acevedo-Garcia & Osypuk 2005). More highly segregated African Americans tend to live in higher poverty census tracts with lower job growth (Pastor, Sadd & Hipp 2001), greater violence (Massey 2004), lower quality of medical care, more discriminatory medical treatment and prevention care, and greater overall social inequality, all of which are associated with higher stress and higher blood pressure (Polednak 1998).

A study using aggregate analysis of 1990 air toxics exposures found that African Americans are exposed to air with higher total modeled air toxics concentrations than whites in every large metropolitan area in the US; moreover, the more highly segregated the area, the greater the air toxics levels and the greater disparity in levels between blacks and whites (Lopez 2002). In an update using 1996 data, this relationship between segregation and air toxics exposure was found to extend to Hispanics and Asians as well as blacks and to describe a pattern of disproportionate exposure by race and ethnicity in metropolitan areas regardless of size (Lopez 2003).

Health Disparities

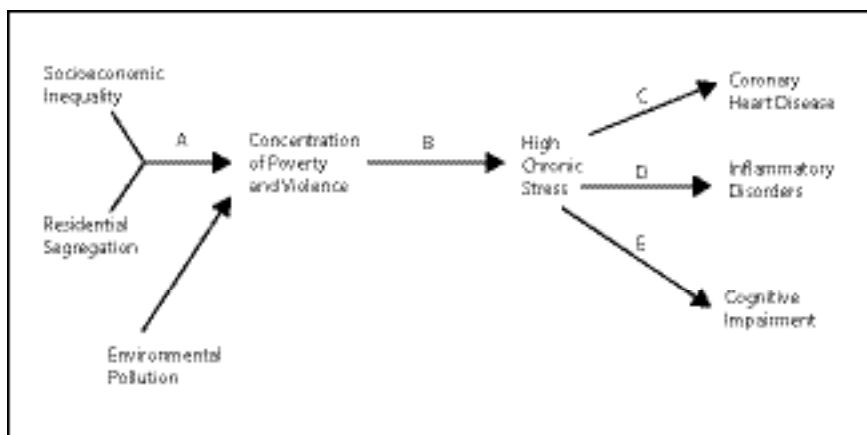
Health status is a consequence of genetics; social, cultural, and physical environments; lifestyle and stage of development; and access to quality care, all interacting together. While the interaction of these variables is not well understood (McGinnis & Foege 1993), it is evident that rates of disease and death vary significantly by race/ethnicity, income and social class. The large societal factors discussed in this paper may, in fact, be the primary factors that determine individual and community health (Sexton 1997).

The 2003 National Healthcare Disparities Report, a baseline of health care disparities issued by the federal Agency for Healthcare Research and Quality (AHRQ), found that, overall, minorities and poorer patients in the US experience discrimination in preventive care and in treatment for medical conditions. Examples of discriminatory care include later screening of minorities for cancer, higher rates of avoidable hospital admissions among blacks and low-income patients, and less likelihood of receiving recommended immunizations for influenza and pneumococcal pneumonia among minorities and poorer patients (AHRQ 2004). Patterns of health disparities vary: African Americans have higher rates of hypertension than Mexican Americans and whites, for example, while Mexican Americans have lower rates of knowledge, medical treatment, and controlled blood pressure than African Americans and whites (Glover et al. 2005). However, the National Healthcare Disparities Report consistently finds communities of color and the poor in inferior health and more likely to die from avoidable conditions such as cardiovascular disease, cancer, asthma, AIDS, diabetes, and other diseases (AHRQ 2004).

There is a growing focus on the role of chronic stress—induced by the material conditions and psychological effects of poverty, racism, and segregation—on health disparities. Stress activates the interactive release

of chemicals from the brain and the endocrine and immune systems that enable the body to handle immediate short-term threats. Prolonged and chronic stress—from poor and overcrowded housing, noise, neighborhood blight, and exposure to violence—can disrupt, inhibit, and compromise the cardiovascular, brain, immune, and nervous systems and may result in increased coronary heart disease, inflammatory and autoimmune diseases, and cognitive impairment (McEwen 2002; McEwen & Lasley 2002; Massey 2004). The model in Figure 2 depicts the hypothesized connection between the stress of poverty and racism, amplified by environmental pollution, and multiple disease outcomes.

Figure 2. Cumulative Risk and Health Disparities



Source: Adapted from Massey 2004

Teasing apart the causal threads in the web of race, racial segregation, poverty, income inequality, burden of pollution, and health disparities to explain their individual and cumulative impact may never be fully possible. At best, we have a body of studies that associates each of these factors singly with poorer health outcomes; shows the interrelationship of some factors, such as race and income and environmental exposures; and is increasingly holistic in identifying the role of macro-social factors, community services and resources, and neighborhood factors on individual and population health (Martuzzi & Tickner 2004; EPA 2003; Mannino et al. 1998; Weiss et al. 1992).

Inequality and Health

Researchers in the field of social inequality have concluded that health disparities within populations are most commonly caused by environmental factors, employing a dimensioned understanding of en-

vironment that includes the social, built and physical environments and not only the notion of environment as the physical media of air, water, and soil. The social environment includes social issues such as gender, income, race, conditions of employment, and status in work and society. The built environment encompasses realities such as housing quality, neighborhood conditions, and proximity to highways and other locally undesirable land uses; and the physical environment includes sources of pollution such as local and regional industry and proximity to hazardous waste sites (Marmot & Wilkinson 1999; Wilkinson & Marmot 2003; Morello-Frosch & Lopez 2006).

Life expectancy is lower for people who are poorer, lower in the workplace hierarchy, and less educated and for those who suffer more stress, have less control over their lives, or experience discrimination. Sustained and cumulative research on the multiple forms of inequality has reached the conclusion that health follows a social gradient and that policy initiatives to improve health and healthful living conditions must strive to reduce the burden of inequality (Marmot & Wilkinson 1999; Wilkinson & Marmot 2003).

Applying these public health and social science findings to the framework of vulnerability, we can only conclude that people and communities which are disproportionately burdened with a host of environmental, social and health inequalities and the chronic biological wear and tear caused by these stressors are excessively exposed (in the past and present), more susceptible to present and future exposures, less prepared to ward off the health consequences, and less able to recover from the debilitating effects. The greater and longer the duration of burdens, the more vulnerable—by every aspect of vulnerability—individuals and communities are to a host of diseases and lower life expectancy. And given the perversely negative feedback loops of inequality, the less healthy people are, the more susceptible they become to future exposures and burdens.

A Call for Action

Environmental justice work—whether in public policy, science, or law or as action on the ground—is marked by a sense of urgency, ethics, and advocacy. So, too, our concluding comments generate from the social goal and responsibility of reducing inequality, health disparities, disproportionate exposure to pollution and vulnerability. We offer these recommendations in the spirit of informed and evidence-based public health practice and advocacy.

1. Health Research and Interventions Must Build on Individual and Community Resources

Health is where all social issues converge (Payne 2004), yet research funding too often reinforces a clinical, individual approach to disease. We are trained in silos, observes epidemiologist S. Leonard Syme, while people's problems "involve schools, parks, roadways, housing, unemployment, crime and politics" [and industrial pollution] (Syme 2004, 6). He estimates that medical researchers understand about forty-five percent of risk factors for coronary heart disease, the major cause of death in the US, and contends that social inequality accounts for much of the remaining risk. Health interventions—if they are to reduce and prevent disease more fully and fairly—must give people "control of their destiny" and hope for their future (Syme 2004). As an example, public investment in capital improvement of low-income housing and provision of affordable housing are social interventions that can reduce indoor environmental exposures, build community resources, reduce the stress of poor housing conditions, and give people a measure of control of their environment—all critical ingredients in health promotion.

2. Reduce Pollution Where People Have the Highest Exposure

In a comprehensive review of studies documenting the differential effects of air pollution on human health by income, Marie O'Neill and colleagues (37) amass evidence that poor communities have disproportionate exposure to gaseous and particulate air pollutants that disperse locally from highway traffic and power plants. The pollutants include nitrogen dioxide, sulfur dioxide, carbon monoxide, carbon black, and ultra-fine particles. Yet air pollution regulations target the reduction of air pollution over regional areas and focus their air pollution permits and mitigation programs on regional air quality, not on local communities that experience the highest exposure.

The authors challenge regulators—those who permit new facilities and review and renew existing permits—to identify and protect communities from disproportionate local exposures. This challenge can be expanded to include identifying and protecting communities with significant health disparities. In the early 1990s, the city of Boston selected an old, idle industrial area of Roxbury to site a state-of-the-art asphalt batching plant for the anticipated construction of the Interstate 93 tunnel through downtown Boston. The proposed facility sailed smoothly through the Massachusetts Environmental Impact Review process, the local zoning board hearing, and the state air permit process. However, local neighborhood communities opposed the facility, based on the dis-

proportionate burden of existing local air polluting facilities and waste sites; the proximity of neighborhood schools, hospitals, and a prison; and the overall poorer health status of the surrounding communities. It was only through their appealing to the public health board of the city, which used the latitude of its statutes to take into consideration existing health and environmental disparities, that the proposed facility was defeated.

3. Race Matters, Gender Matters, Inequality Matters

Epidemiologist Steve Wing, who has worked with communities of color in rural North Carolina conducting studies on the health and environmental impacts of industrial hog farms, has observed that the modern approach in epidemiology is to treat “historical context...as a nuisance to be avoided by design or controlled by analysis” (Wing 1994, 5). Class, race, gender, and occupation are treated as individual attributes, not as social realities with which to contend. Thus, gender can be studied without acknowledging or addressing sexism, as can race without recognizing racism as a structural condition underlying environmental exposures. In writing on poverty in the US, Michael Harrington captured the neutering of social reality differently: “A slum is not merely an area of decrepit buildings. It is a social fact” (Harrington 1962, 140).

Community-based research in environmental health will consistently be confronted with socially caused inequality and its health consequences, no matter what the particular research question. Because of this, community-based research carries with it the challenge to generate meaningful and constructive knowledge and interventions that improve environmental health and that also strive to reduce discrimination and poverty. Beginning with the research process and team, the partners can acknowledge their diversity and the varying levels of privilege, power, and decision-making. This, after all, is the local social ground upon which a multicultural working team will make decisions on research questions and design, data collection, analysis and interpretation, publication and dissemination, and action and advocacy. University partners can provide training and create jobs for community partners within the research process and encourage and seek opportunities for people from low-income communities and communities of color to pursue higher education, so as to build the social resources of communities diminished by structural inequality and ill health. Finally, the research findings can be used to advocate within the public sector for policy change—in environmental standards, building codes, zoning, health programs, and workplace practices. The model of community–university partnership may attract the foundation and public funding sectors to invest in public interest community-based partnerships and intervention programs

proven to be successful in reducing risk and disparities. Based on their experience of engaged community research, academic researchers can promote racial and ethnic diversity in research and teaching within their institutions (Hynes & Brugge 2005; Morello-Frosch et al. 2002; Vasquez, Minkler & Shepard 2006).

4. Design a Screening Framework to Identify Communities of Greatest Cumulative Risk

Environmental justice communities are generally identified by the concentration of racial, ethnic, and low-income populations (N. Wu, Urban Environmental Program, EPA Region 1, personal communication, March 7, 2005) and the number of proximate pollution facilities. The growing understanding that additional factors, such as income inequality, economic isolation, racial segregation and health disparities, contribute to greater vulnerability and poorer health, can be incorporated into this framework to more precisely identify those communities that bear the greatest cumulative risk in order to prioritize health promotion and environmental justice work. Numerous national databases and indices can potentially be utilized to help prioritize federal, state and municipal-level work in the most vulnerable communities. These include national census data; address-based and census tract environmental toxics data; and health surveillance data collected by federal, state and municipal health agencies.

Data Sources

The Census provides data on income, race, gender and ethnicity, housing, education and food security at all geographic areas of interest (from very local to regional and national levels). Federal, state and local public health agencies collect address-based health data on a regular basis in registries, such as the state infectious disease registries and the state cancer registries where they exist; in birth and death vital records; in hospital discharge databases; and through surveillance programs, such as state and city lead poisoning programs. In addition, national standardized health surveys, such as the Behavioral Risk Factor Surveillance System (BRFSS), are administered in every state on a biannual basis, using a probabilistic sampling strategy. Some municipal public health agencies use this survey as an opportunity to ask additional questions that can assist their research departments with further identifying health disparities within neighborhoods of the city.

Environmental databases exist for many environmental releases. Federal and state regulatory agencies maintain databases of regulated and permitted air pollution and water discharge facilities, hazardous

waste sites, overall surface water and drinking water quality, a toxics release inventory, and so on. While the quality and accessibility of these databases vary, they do provide detailed information including addresses of pollution sources. Other data include air quality data, available at the metropolitan level for criteria air pollutants and at the census tract level for modeled air toxics data from the EPA's National Air Toxic Assessment. Smaller, non-regulated businesses can be identified through Standard Industrial Code (SIC) registries and state and federal databases of small waste generators. Environmental data from regulatory programs have been more commonly combined with data on race and income to identify environmental justice communities, but rarely, if ever, with income inequality, racial segregation or health disparities data.

Health disparities, or significant differences in morbidity and mortality rates, health care provision, and access to health care, can be measured at the state, county, and city levels using state disease registries and vital records and the results of the Behavioral Risk Factor Surveillance Survey. Using census data and state and city health data, the state of Connecticut and the city of Boston have issued reports on health disparities by race and ethnicity, and by neighborhood in the case of Boston (Connecticut Department of Public Health 1999; Boston Public Health Commission 2004).

One important potential source of data for identifying disparities is rates of self-reported fair or poor health. The percentage of people reporting their health as fair or poor in one area can be compared to that of other areas. Self-rated health is one of the most accurate predictors of health outcomes such as hospitalization and mortality (Miilunpalo et al. 1997; Kennedy, Kasl & Vaccarino 2001). Its value is not culture-specific and it has been used to assess health status in a wide range of situations and groups (Idler & Benyamini 1997; Finch et al. 2002). The question has been asked in the biannual BRFSS survey and in other survey instruments in a standardized way. Its principal shortcoming is that data are generally available only down to the county level, with occasional surveys at a more detailed geographic level.

Indices

A number of relevant indicator indices have been developed that can identify areas with greater racial/ethnic and income/poverty inequities. Predominately based on Census data, they can be calculated on a variety of geographic scales and even tracked over time. Some indices have been calculated and published. (See, for example, Iceland, Weinberg & Steinmetz 2002; Coulter 1989.) Others can be calculated using available formulas (Coulter 1989).

Income inequality is measured by the GINI Index on a scale of 0 to 100 and is described as the difference between a hypothetical situation where all households earn the same income and the actual distribution of income across households. This measure of economic inequality is available at different geographic levels from country to state, county, and metropolitan areas, using standard databases such as the Census and UN economic data. It is possible to incorporate the GINI Index into a screening tool at the national level to identify states, counties and metropolitan areas most unequal by income and to join this score with others such as racial dissimilarity (discussed in next section) in order to identify metropolitan areas that have high income inequality and high racial segregation, both of which contribute to overall vulnerability of individuals and neighborhoods.

Racial segregation is measured by the Dissimilarity Index on a scale of 0 to 100. The Dissimilarity Index can be described as the proportion of a group that would have to re-locate from their census tract within metropolitan areas in order to achieve complete integration. There is an extensive literature on the Dissimilarity Index and it has been calculated, at least for African Americans, since the 19th century in some large metropolitan areas. Most commonly used to characterize residential segregation, it is also used to describe school segregation.

Economic isolation is measured by the P* Index, which is a function of the average number of people living in poverty around each poor person. Employing census tract level data, this index can assist in identifying metropolitan areas where impoverished people are most likely to be isolated and thus vulnerable to substandard housing, minimal health, and socio-economic resources. The P* Index has also been used to measure racial segregation.

Application of Screening Tools for Cumulative Risk

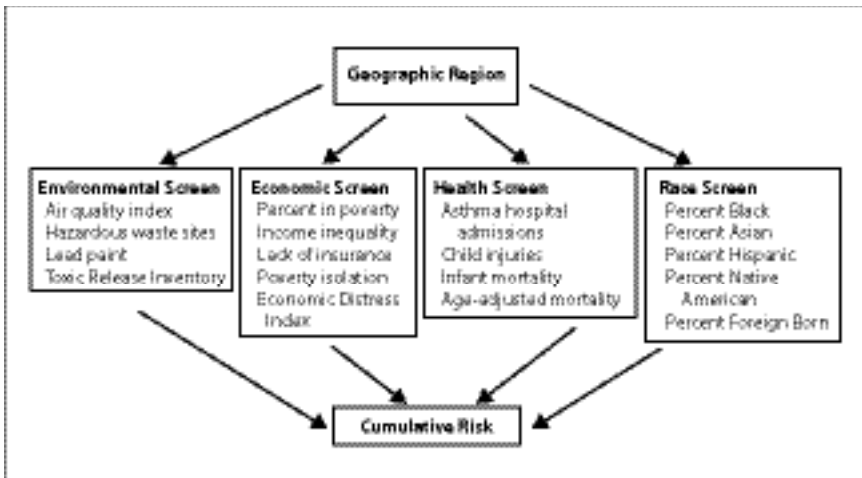
Given the health consequences of the cumulative burden of social and environmental risks, efforts must be made to identify those communities that live with a high cumulative burden of inequality, pollution, and poor health outcomes in order to prioritize the use of public health and environmental resources. The screening could take place on both the national and regional levels by federal agencies whose missions include environmental protection (EPA), public health (DHHS), and provision of housing and economic development for low-income communities (HUD); and at the municipal level by public health departments working with state and city environment and housing departments. The authors are aware of screening tools in development, including one for

the California Air Resources Board that can be integrated into regulatory decision-making and enforcement activities.

National Level Screening

Many studies have documented that certain metropolitan areas have greater levels of inequality and disparate health outcomes. At the national level, screening could utilize the large comprehensive databases developed by the EPA, the US Bureau of the Census, the Centers for Disease Control and Prevention and others. The screening could join data on segregation, income inequality, and economic isolation together with the metropolitan Air Quality Index, modeled air toxics concentrations, the Toxics Release Inventory, CERCLA (Superfund) list, and data on one or more of health endpoints, including self-rated health data, risk behavior rate, black–white age-adjusted or premature mortality, black–white infant mortality, and other available health disparities data. (See Figure 3 for a schematic of how this may be approached).

Figure 3. Schematic for Cumulative Risk



A rank scoring method or z-score methodology (scoring metropolitan areas and counties based on their standard deviations above or below the mean) could help identify those areas with relatively greater cumulative risk. The scores could be grouped into high, medium, and low, given that they are not a literal numeric ranking, but rather an estimate of cumulative risk based on combining numerous social indices and environmental and health databases. This would enable federal agencies, non-profit organizations and philanthropic groups to focus their efforts on addressing metropolitan, county, and urban areas with the most extensive social, environmental, and health inequities.

Local Level Screening

Within metropolitan areas, municipal-level Census data, address-based environmental data, and health data from state health registries and vital records, for example, can be used to compute health disparities within cities by race, ethnicity, and neighborhood. A recent study conducted for EPA Region 1 has proposed joining health disparities data, environmental pollution data, and Census data on race and income variables at the census tract level to identify most vulnerable communities for intervention at the very local level (Badger, Melfi & Silkman 2006). In the example provided in Table 1, we gathered published data on demographic, health, pollution, and crime for two Boston neighborhoods. The data show how two nearby communities can have dramatically different demographic, health, and social statuses and how these differences can be identified for the purpose of prioritizing environmental and public health interventions.

Table 1. Boston Neighborhood Comparison by Cumulative Risk

MEASURE	WEST ROXBURY	ROXBURY
Demographic		
Percent > 65 years old	20%	10%
Percent Black	6%	53%
Percent Asian	5%	5%
Percent Hispanic	4%	22%
Health		
Diabetes rate	12/100,000	38/100,000
Heart disease mortality rate (age-adjusted)	174/100,000	213/100,000
Infant mortality (per live births)	5/1,000	11/1,000
Other		
Non-fatal assaults rate	.2/1,000	.3/1,000
Hazardous waste sites	25/square mile	124/square mile

Sources: Boston Public Health Commission; Green Justice Research Collaborative, Northeastern University

These proposed screening tools can thus help to identify (1) metropolitan areas and counties of estimated highest cumulative risk and (2) neighborhoods within cities and towns that have health disparities and disproportionate environmental burdens in order to prioritize action-oriented environmental and health research and intervention.

Conclusion

We launched this paper from the springboard of questions that a federal agency, the US EPA, posed to its National Environmental Justice Advisory Board: what constitutes cumulative risk; and how should EPA respond to it? These are questions that face all researchers and practitioners engaged in addressing environmental injustice, health disparities, and social inequality. Screening tools that incorporate social, built, and physical factors and health disparities will aid in identifying communities most burdened, most vulnerable, and in greatest need of intervention and action. These tools are a beginning step toward directing resources for action to communities most in need. Done in collaboration with communities, they may also offer a measure of control over their destiny and hope for the future.

Notes

The authors acknowledge the shortcomings of the census and public health data, particularly for Native Americans, immigrant, homeless and very poor people. Local pilot projects and studies, undertaken by trusted community organizations in partnership with the EPA and public health regional offices, may be important resources to supplement this information.

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