

Environmental Health Disparities: A Framework Integrating Psychosocial and Environmental Concepts

Gilbert C. Gee¹ and Devon C. Payne-Sturges²

¹University of Michigan School of Public Health, Department of Health Behavior and Health Education, Ann Arbor, Michigan, USA;

²Office of Policy, Economics and Innovation, and Office of Children's Health Protection, U.S. Environmental Protection Agency, Washington, DC, USA

Although it is often acknowledged that social and environmental factors interact to produce racial and ethnic environmental health disparities, it is still unclear how this occurs. Despite continued controversy, the environmental justice movement has provided some insight by suggesting that disadvantaged communities face greater likelihood of exposure to ambient hazards. The exposure-disease paradigm has long suggested that differential "vulnerability" may modify the effects of toxicants on biological systems. However, relatively little work has been done to specify whether racial and ethnic minorities may have greater vulnerability than do majority populations and, further, what these vulnerabilities may be. We suggest that psychosocial stress may be the vulnerability factor that links social conditions with environmental hazards. Psychosocial stress can lead to acute and chronic changes in the functioning of body systems (e.g., immune) and also lead directly to illness. In this article we present a multidisciplinary framework integrating these ideas. We also argue that residential segregation leads to differential experiences of community stress, exposure to pollutants, and access to community resources. When not counterbalanced by resources, stressors may lead to heightened vulnerability to environmental hazards. *Key words:* environmental, environmental justice, ethnicity, framework, health disparities, psychosocial, race, review, stress. *Environ Health Perspect* 112:1645–1653 (2004). doi:10.1289/ehp.7074 available via <http://dx.doi.org/> [Online 16 August 2004]

The elimination of disparities in environmental health requires attention to both environmental hazards and social conditions [U.S. Environmental Protection Agency (EPA) 2003a; Institute of Medicine 1999]. However, two major challenges are implicit in this statement: first, to understand how social processes may interrelate with environmental toxicants, and second, to understand why some groups experience greater illness compared with other groups. Our purpose in this article is to provide a multidisciplinary framework that addresses both issues.

We extend the work of Sexton et al. (1993), who documented how the exposure-disease paradigm could explain variation in the health of disadvantaged populations. Implicit in their framework is the idea that disadvantaged populations encounter greater susceptibility to environmental hazards. However, it is unclear what these susceptibility factors might be.

We suggest that psychosocial stress is a key component of differential susceptibility. Stressors, when not ameliorated by resources, may directly lead to health disparities. Additionally, stressors may amplify the effects of toxicants. Residential segregation may be one important reason why communities differ in these exposures (Massey and Denton 1993).

Our framework is built on an ecological perspective, suggesting that health disparities result not only from individual factors but

also from factors operating at multiple levels (Bronfenbrenner 1989; Diez-Roux 1998; Pickett and Pearl 2001; Sallis and Owen 1997). Reinvigoration in ecological approaches has paralleled the development of statistical techniques of multilevel modeling (e.g., hierarchical linear models), an appreciation that ecological factors may not necessarily lead to the ecological fallacy, and a renewed interest in the role of context in health promotion (Diez-Roux 2000; Green and Kreuter 1999).

Health Disparities and the Environment

Disparities exist for many health outcomes, including cancer, cardiovascular disease, diabetes, and mortality [U.S. Department of Health and Human Services (DHHS) 2000]. Although there has been a national decrease in disparities between 1990 and 1998 (Keppel et al. 2002), some regions have reported an increase in disparities during the same period (Margollos et al. 2004).

Environmental conditions are believed to play an important role in producing and maintaining health disparities (Lee 2002; Sexton 2000; Yen and Syme 1999). Minority neighborhoods tend to have higher rates of mortality, morbidity, and health risk factors compared with white neighborhoods, even after accounting for economic and other characteristics (Cubbin et al. 2001; Deaton and Lubotsky 2003; Geronimus et al. 2001).

The Stress-Exposure Disease Framework

The stress-exposure disease framework (Figure 1) provides a conceptual framework from which to understand the relationships among race, environmental conditions, and health. It extends the framework of Sexton et al. (1993) by *a*) explicitly hypothesizing that residential segregation is a major reason why "race" is important; *b*) incorporating an ecological or multilevel perspective; and *c*) arguing that racial variation in stressors may account for differences in vulnerability to health risks.

Reflecting the multilevel approach, Figure 1 emphasizes both community processes (top) and individual mechanisms (bottom). The shading reflects the exposure-disease paradigm. To simplify our presentation, we have separated individual and community processes. However, many processes are interrelated. For example, community wealth is partly a function of individual wealth (e.g., when individuals contribute to the tax base), and individual wealth is also partly determined by community wealth (e.g., when rising property values benefit individual homeowners).

The framework shows that ethnicity is highly correlated with residential location, with minorities and whites often living segregated from one another. Differential residential location comes with differential exposure to health risks. In particular, neighborhood stressors and pollution sources create adverse health conditions, which are counterbalanced by neighborhood resources. Structural factors help determine the boundaries from which health promotion is possible and partially determine the contemporary state of stressors, resources, and pollution in a community.

Address correspondence to G.C. Gee, University of Michigan School of Public Health, Department of Health Behavior and Health Education, 1420 Washington Heights, Room M5224, Ann Arbor, MI 48109-2029 USA. Telephone: (734) 615-7825. Fax: (734) 763-7379. E-mail: gilgee@umich.edu

We thank M. Zimmerman and O. Nweke for their helpful comments with previous drafts of the manuscript.

The views expressed in this document are those of the authors and do not represent official U.S. Environmental Protection Agency policy.

The authors declare they have no competing financial interests.

Received 5 March 2004; accepted 16 August 2004.

When community stressors and pollution sources outweigh neighborhood resources, levels of community stress manifest or increase. Community stress is a state of ecological vulnerability that may translate into individual stressors, which in turn may lead to individual stress. Individual stress may then make individuals more vulnerable to illness when they are exposed to environmental hazards. Further, compromises in individual and community health may further weaken community resources, leading to a vicious cycle. Hence, we include in our framework a return loop from health back to stress.

As an example, zoning policies and tax incentives (structural factors) may encourage the entry of new pollutant industries. The increase in pollutants may lead to economic and social uncertainty (stressors) by driving down local property values, increasing the flight of jobs and fostering a climate of uncertainty and fear. Neighborhood organizations (resources) may not be able to counterbalance these effects, leading to a state of community vulnerability (community stress). Community-level vulnerability, in turn, may translate to individual vulnerability, such as when individuals lose their jobs or become anxious about perceived toxic exposures. When personal coping resources do not adequately counterbalance these external insults, individual stress and illness may result. Individual illness, in turn, may lead to further individual vulnerability, such as by reducing the ability to exercise. Additionally, individuals may affect their communities, such as when disaffected individuals cease participating in neighborhood organizations. Health disparities may arise because minorities are

segregated into neighborhoods with high levels of community stress.

We do not explicitly examine the issue of genetic susceptibility in this framework for three reasons. First, we focus on factors that are amenable to policy change and social action. Second, genetic susceptibility is partly subsumed in the exposure–disease paradigm because it is presumed to partially determine one’s ability to defend against hazards. Third, although genetic factors are important in the etiology of many illnesses, it is likely that genetic factors do not explain racial health disparities (Cooper 1984; Cooper et al. 2003; Garte 2002; LaVeist 1994). It is often acknowledged that race is a social construct. What that means is that racial groups are not inherent biological taxons, but represent socially defined categories during a particular point in history and place. For example, before 1989, the child of a black father and a white mother would be classified as black, but after 1989, the same child would be classified as white (LaVeist 1994). Further, a child born in Brazil, rather than the United States, would be classified as mulatto. Thus, racial designations are the product of social consensus and public policy, rather than biology per se.

Additionally, “genetically identified” groups tend to correlate poorly with socially identified groups because there is more genetic variation within than between groups (Garte 2002; Lewontin 1982; Mountain and Cavalli-Sforza 1997). For example, genetic differences between any two Italians appear to be 5-fold greater than the difference between an Italian and a Japanese, African, or New Guinean (Mountain and Cavalli-Sforza 1997). Observations such as these have led Cooper

et al. (2003) to conclude that race “has not shown to provide a useful categorization of genetic information about the response to drugs, diagnosis, or causes of disease.”

We now review the science that informs this framework, beginning with the exposure–disease paradigm.

The Exposure–Disease Paradigm

The exposure–disease paradigm is a well-known model that shows how environmental toxicants might cause disease (Lioy 1990; Lioy and Pellizzari 1995; National Research Council, 1991a, 1991b; Wagener 1987). It is a continuum that includes the emission of a contaminant from a source through human exposure to the occurrence of a health effect.

Susceptibility/vulnerability intersects the continuum, increasing or decreasing resistance to absorption and/or effect from toxicants. The term “susceptibility/vulnerability” has been used broadly to cover both biological and non-biological factors, including genetic predisposition, pre-existing health conditions, and social conditions. The exact susceptibility/vulnerability factors and their pathways intersecting the exposure–disease paradigm are not well understood. We argue later that community and individual stress is one type of susceptibility factor.

Race and Residential Location

Segregation, the spatial separation of the residences of racial groups from one another, has persisted for many decades (Iceland et al. 2002; Massey 2001; Massey and Denton 1993). Table 1 shows the segregation of blacks, Hispanics, Native Americans, and Asians compared with whites from 1980 to 2000 for metropolitan areas, as measured with the index of dissimilarity (Logan 2003; U.S. Census Bureau 2003). Scored from 0 to 100, a given value of the index indicates the percentage of that group who would have to move to integrate the metropolitan area.

Segregation from whites is highest for African Americans, followed by Hispanics, Asian Americans, and Native Americans. In

Table 1. Segregation of ethnic minorities compared with whites, United States, 1980–2000.

	1980	1990	2000
Native Americans	37.3	36.8	33.3
African Americans	72.7	67.8	64.0
Asian Americans and Pacific Islanders	40.5	41.2	41.1
Hispanics	50.2	50.0	50.9

Segregation was determined using the index of dissimilarity, which measures the evenness of groups over space and can be interpreted as the percentage of a particular group who would have to move in order to integrate the two groups over the region as a whole. For example, in the year 2000, 64% of all African Americans (or whites) would have to move to another census tract in order to integrate all metropolitan areas nationwide. Data are adapted from the U.S. Census Bureau (2003).

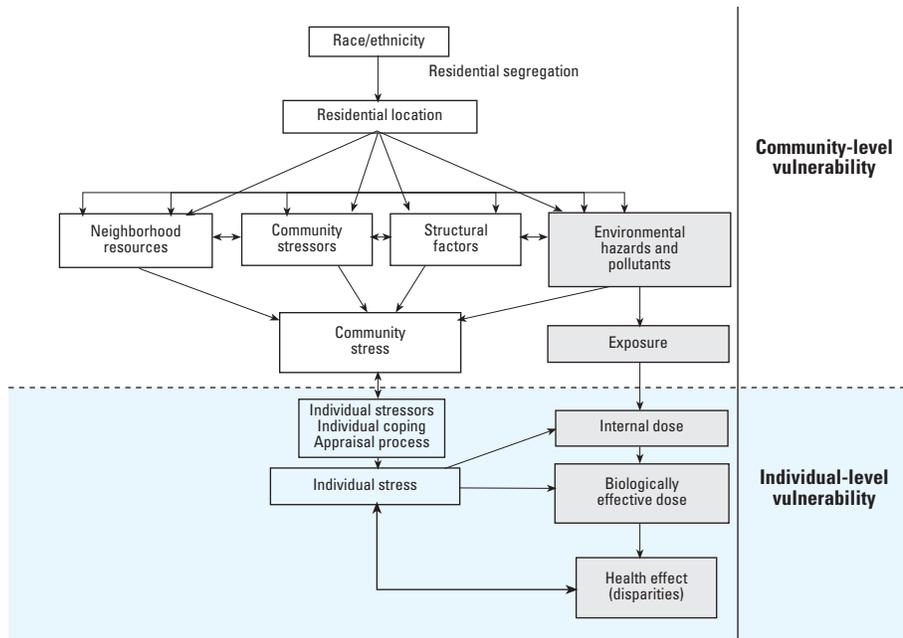


Figure 1. Exposure–disease–stress model for environmental health disparities.

the average U.S. metropolis in the year 2000, about two-thirds of blacks (or whites) would have to move to another neighborhood in order to desegregate that metropolis.

Black–white and Native-American–white segregation has declined since the 1980s, but segregation levels for Hispanics and Asians have remained stable. Further, most of the decline in black–white segregation has occurred in metropolitan areas with the fewest numbers of blacks (Logan 2003).

The causes of segregation are still debated. Some have suggested that segregation is an artifact of broader shifts in the economy—including the decline of manufacturing jobs and suburbanization—that have left behind a cadre of the poor that are disproportionately racial minorities (Wilson 1987, 1996). Others have postulated that segregation results from personal preferences of homebuyers to cluster together (Schelling 1971). Most research has argued that segregation results from institutionalized discriminatory practices in the housing market (e.g., mortgage redlining, racialized “steering”) that persists to the current day (Massey and Denton 1993; Meyer 2000; Munnell et al. 1996; Schwartz 1998; Squires 1994; Squires and Velez 1996).

Some evidence suggests that the mechanisms for segregation vary by ethnic group and region, but most ethnic groups have encountered discriminatory treatment historically and currently (Squires 1994; Feagin and McKinney 2003; Krieger et al. 1993; Williams et al. 1997). For example, a recent audit study suggested that consistent adverse treatment in home buying was similar for Asian-American and African-American homebuyers, with one in five potential homebuyers disfavored compared with whites (Turner and Skidmore 2001). The causes of segregation notwithstanding, it is clear that neighborhoods do cluster on the basis of race and ethnicity.

Studies have reported that segregation is associated with numerous outcomes, including infant mortality [Centers for Disease Control and Prevention (CDC) 2002; LaVeist 1989, 1993], adult mortality (Hart et al. 1998; Jackson et al. 2000; Polednak 1991, 1996), tuberculosis (Acevedo-Garcia 2003), homicide (Peterson and Krivo 1993, 1999), teenage childbearing (Sucoff and Upchurch 1998), exposure to tobacco and alcohol advertising (Alaniz 1998; Luke et al. 2000; U.S. DHHS 1998), and increased exposure to air pollution (Lopez 2002).

Segregation may thus be one critical link between race and environmental health disparities because racial groups, on average, occupy different residential areas. This may lead to differential exposure to health risk factors as well as differential access to resources. Segregation is multifactorial, often conceptualized around five dimensions (Acevedo-Garcia 2000; Massey

and Denton 1988, 1993): *a*) evenness, the inequitable distribution of groups over an area and the dimension receiving the greatest empirical study; *b*) isolation, the degree of potential contact between two groups within a city; *c*) concentration, the extent to which minority groups are confined to a compact area within the city; *d*) centralization, the degree to which minorities are clustered around the center of a city; and *e*) clustering, the extent to which minority neighborhoods are adjacent to one another. Our discussion refers to the general principle of segregation, although it will be an important research endeavor to examine which specific dimensions of segregation are related to environmental health disparities.

Having established a link between race and residence, we now turn to the proximal mechanisms that may account for the relationship between environmental conditions and racial health disparities.

Environmental Hazards and Pollutants

Briefly, environmentally relevant disparities are evident in a variety of outcomes, including asthma, cancer, and chemical poisoning (Institute of Medicine 1999). Although debated, the main hypothesis explaining these disparities is that disadvantaged communities encounter greater exposure to environmental toxicants such as air pollution, pesticides, and lead (Burger et al. 2001; Calderon et al. 1993; Corburn 2002; Fitzgerald et al. 1998; Institute of Medicine 1999; Morello-Frosch 2001; Moses et al. 1993; Northridge et al. 2003; Perera 2003; Pirkle et al. 1998; Woodruff et al. 2003). Mediators of the relationship between toxic exposure and disadvantaged status include the siting of pollution sources (e.g., waste incinerators), illegal dumping, poor enforcement of environmental regulations, and inadequate response to community complaints (Anderton et al. 1994, 1997; Bullard 1983, 1990; Bullard and Wright 1993; Goldman and Fitton 1994; Institute of Medicine 1999; Maantay 2001, 2002; Mohai and Bryant 1992; Perlin et al. 1999, 2001; United Church of Christ 1987; U.S. General Accounting Office 1983).

Structural Factors

Structural factors refer to the historically evolving infrastructure that provides boundaries for health promotion. That is, structural factors are constraints that shape how new conditions emerge as “salutogens” (factors that support health) or pathogens in a community. The local economy, for example, is a structural factor that will help determine a community’s ability to mobilize resources in order to reject undesirable changes (e.g., introduction of a waste facility) or develop desirable ones (e.g., construction of a park). Structural factors that may be especially pertinent to environmental

health disparities include the local and national economy, neighborhood physical conditions, land use patterns, and health infrastructure. This is not an exhaustive list, but rather is meant to be illustrative.

One primary effect of residential segregation may be to concentrate disadvantage (Massey and Denton 1993). Compared with whites, minorities are overrepresented in neighborhoods with diminishing and constrained economic opportunities (Jargowsky 1997; Wilson 1987). For example, in Los Angeles, California, in 1990, only 4.9% of blacks lived in high-job-growth areas, compared with 52.3% of whites (Pastor 2001). Cutler and Glaeser (1997) reported that a decrease in segregation by one standard deviation (13%) would eliminate one-third of the black–white differences in education and employment. Thus, segregation not only may concentrate poverty but also may be partly responsible for the production of poverty among racial minorities (Massey and Denton 1993; Williams and Collins 2001).

There is a clear association between socioeconomic position and health, such that individuals of higher social standing tend to have improved health compared with those of lower standing (Evans and Kantrowitz 2002; Kaplan et al. 2001; Krieger and Fee 1994; Marmot et al. 1987, 1998; O’Neill et al. 2003; Williams and Collins 1995). Further, the relationship between socioeconomic position and health holds not only at the individual level but also at the community level (Haan et al. 1987; Kaplan 1996). That is, persons living in poor neighborhoods, even after accounting for their individual socioeconomic characteristics, tend to have worse health outcomes (Diez-Roux et al. 1997, 2001; Merkin et al. 2002; Waitzman and Smith 1998; Winkleby and Cubbin 2003).

Neighborhood economic deprivation may compromise health-promoting resources (Diez-Roux et al. 2001). For example, poor and minority neighborhoods tend to have fewer grocery stores with healthy foods (Morland et al. 2002) and fewer pharmacies with needed medications (Morrison et al. 2000). Poor nutrition can increase susceptibility to environmental pollutants by compromising immune function (Beck and Weinstock 1988; Rios et al. 1993). Additionally, disadvantaged neighborhoods are also exposed to greater health hazards, including tobacco and alcohol advertisements, toxic waste incinerators, and air pollution (Morello-Frosch et al. 2002). Finally, economic stress within a community may exacerbate tensions between social groups, magnify workplace stressors, and induce “maladaptive” coping behaviors, such as smoking and alcohol use (Brenner 1995). Tobacco and alcohol use can increase susceptibility to environmental toxicants that

are normally metabolized by impairing host defense (Rios et al. 1993).

In general, racial minorities have lower socioeconomic position compared with whites. Although it is intuitive to hypothesize that disparities in health arise because of socioeconomic differences between racial groups, studies often find that racial disparities persist even after accounting for socioeconomic factors (Hayward et al. 2000; Sorlie et al. 1995; Williams 1999).

Although socioeconomic differences do not completely explain racial disparities, it is often argued that social class is an important mediator. That is, it is hypothesized that race determines one's economic resources, which in turn determine health (Williams and Collins 1995). Thus, although socioeconomic conditions do not fully account for health disparities, they are a necessary part of the equation.

Neighborhood physical conditions present another structural factor that may contribute to health disparities (Cohen et al. 2003). Minorities are more likely to live in areas with building code violations and neighborhoods with deteriorated housing (Perera et al. 2002; Rosenbaum et al., unpublished data). In 1999, 3.4% of blacks, 3.8% of Hispanics, and 1.7% of Asian Americans and Pacific Islanders reported living in housing units with severe problems with heating, plumbing, electricity, public areas, or maintenance, compared with 1.5% of whites (U.S. Census Bureau 2000). Substandard housing may contribute to a variety of problems, including exposure to toxicants, increased risk of injuries from falls and fires, and illness due to ineffective waste disposal and presence of disease vectors (Bashir 2002; Jacobs et al. 2002; Krieger and Higgins 2002; Northridge et al. 2003).

Urban minorities tend to fare worse than their counterparts in rural areas (Geronimus et al. 1999; Geronimus et al. 2001). This may be due in part to land use patterns in urban areas. In Detroit, many minority neighborhoods exist next to highways that expose residents to hazards (Schulz et al. 2002). Sugrue (1996) argues that

Detroit's highway planners were careful to ensure that construction of new ... expressways would only minimally disrupt middle-class residential areas, but they had little such concern for black neighborhoods.

Similarly, New York City rezoned its neighborhoods between 1961 to 1998 so as to increase manufacturing zones in areas with higher minority populations and to decrease those zones in areas with fewer minorities (Maantay 2001). Those rezoning efforts led to a higher concentration of industrial burden within manufacturing-designated areas. Further, some policies that appear neutral *prima facie* may result in adverse impacts on already disadvantaged

communities, as in the example of emissions trading systems and their potential to create pollution "hot spots" (Schmidt 2001; Soloman and Lee 2000).

Health infrastructure may also be associated with race. Minorities tend to reside in areas with a lower physician-per-population ratio and lower medication supply (Morrison et al. 2000; Rosenbaum et al., unpublished data; Schulz et al. 2002). Community hospitals are more likely to close in urban minority communities (Whiteis 1992). These findings suggest that segregated communities face structural disadvantages in the provision of health services.

Because so many different structural forces appear to confer disadvantage among minority communities, some scholars have suggested that they continue a history of institutionalized discrimination against minorities (Feagin and McKinney 2003; Gee 2002; Jones, 2000; Krieger et al. 1993; Massey and Denton, 1993; Squires 1994; Williams and Collins 2001). This discrimination may not have a purposeful intent but still may confer adverse impact.

Community Stressors

Community stress theory derives from a century of research on the stress process among individuals (Aneshensel 1992; Lazarus and Folkman 1984; McEwen 1998; Selye 1936; Steptoe and Feldman 2001). "Stress" is a state of activation of physical and psychological readiness to act in order to help an organism survive external threats. "Stressors" are the factors that produce stress and include such phenomena as crime (Morenoff 2003), noise (Babisch et al. 2001; Ouis 2001), traffic (Gee and Takeuchi 2004), and litter, density, and residential crowding (Fleming et al. 1987; Evans and Lepore 1993). Stressors can result directly from environmental hazards, including technological and natural disasters (Baum et al. 1983; Brown 2002).

Health effects of stress. Stressors can trigger the sympathoadrenal system, whose hallmark is rapid release of adrenalin and noradrenalin, which leads to various "fight or flight" responses, including arousal, bronchodilation, tachycardia, and increased blood pressure. The hypothalamic-pituitary-adrenal system is also activated, signified by release of corticotrophin-releasing factor, adrenocorticotrophic hormone, and cortisol. These glucocorticoids have several metabolic and psychological effects, including the mobilization of energy reserves, suppression of the immune system, and heightened vigilance. Chronic activation of the stress system is believed to lead to allostatic load, which is the "wear and tear" on organ systems resulting from stress (McEwen 1998). A full discussion of the biology of stress is beyond the scope of this article but can be found in several publications (Brunner 2000; Hadley 1992; McEwen 1998).

The key point is that stressors can cause illness by weakening the body's ability to defend against external challenges. As an example, Cohen et al. (1991) asked volunteers to self-rate their levels of stress and then randomized them to receive nasal drops containing either placebo or respiratory viruses. Rates of respiratory infection and clinically diagnosed colds followed a positive dose response with level of psychological stress. Findings from this controlled experiment were unaffected by controlling for a variety of factors (e.g., allergic status).

Intriguingly, some evidence suggests that stress may influence the internal dose of a given toxicant. This is because stress may *a*) increase the absorption of toxicants into the body through increased respiration, perspiration, and consumption (Gordon 2003); *b*) compromise host defense systems (McEwen 1998); and *c*) directly cause illness, which in turn may lead to an amplification loop whereby sick individuals are less likely to cope with environmental toxicants (Rios et al. 1993; U.S. EPA 2003b). Stress may induce or unmask a latent effect of a toxicant, possibly altering basal levels of neurofunctioning and shifting the threshold for neurotoxicity [Agency for Toxic Substances and Disease Registry (ATSDR) 1995].

Two factors are purported to determine individual response to stress: how one appraises the situation, and their general state of physical health (Lazarus and Folkman 1984; McEwen 1998). Coping resources, such as social support, help determine the extent to which a stressor is perceived as a threat and subsequent health responses (Israel et al. 2002). For example, workers with high levels of job strain and low levels of co-worker support have higher risk of cardiovascular disease than do those with similar levels of strain and more support (Johnson et al. 1996). Additionally, physical illness will impair an individual's ability to respond to stressors. Individual stress and coping have macro-level analogs, community stressors and neighborhood resources.

Types of community stressors. Community stressors can be categorized into two major types, physical and psychosocial. Physical conditions, including noise, temperature, humidity, barometric/water pressure, visible light, geomagnetism, radiation, and particulate matter, may contribute to stress (Gordon 2003). These stressors can induce a physiological response that makes the body more susceptible to illness. Heat stress, for example, induces sweating and increased skin blood flow, which in turn can facilitate the transcutaneous absorption of pesticides (Chang et al. 1994; Funckes et al. 1963; Wester et al. 1996). Individuals subject to ambient noise have higher levels of noradrenalin, a stress biomarker (Babisch et al. 2001). In a natural experiment, Evans et al. (1998) found that the

chronic exposure to aircraft noise elevated resting blood pressure, norepinephrine, and epinephrine biomarker levels and decreased self-reported quality of life over a 2-year period.

Psychosocial conditions—including crowding, social disorganization, racial discrimination, fear, and economic deprivation—may also be sources of stress (Krieger and Higgins 2002; Macintyre et al. 2002). One stressor that has received extensive attention is fear of crime (Morenoff 2003; Warr and Ellison 2000). Minority neighborhoods tend to have higher crime rates, which may contribute to health disparities. Perceptions of crime and disorder within an individual's community has been associated with numerous outcomes, including anxiety depression, posttraumatic stress disorder, and substance use (Aneshensel and Sucoff 1996; Cutrona et al. 2000; Fick and Thomas 1995; Geis and Ross 1998; Ross et al. 2000; Ross and Jang 2000). Morenoff (2003) found that the neighborhood violent crime rate was one of the “most robust” environmental predictors of infant birth weight, after controlling for both individual (e.g., smoking during pregnancy) and neighborhood (e.g. percentage of poor families) characteristics.

Physical and psychosocial stressors may interact with one another, as seen with natural and technological disasters (Ginexi et al. 2000; Kaniasty and Norris 2000). For example, the trauma of the Love Canal incident in New York resulted from both the chemical hazards and public perceptions (Edelstein and Wandersman 1987; Gibbs 1983; Holden 1980). Further, the relationship between environmental and subjective stressors occurs not only for highly salient events but also for everyday events. Gee and Takeuchi (2004), using multilevel models, reported that persons perceiving stress due to automobile traffic had greater psychological distress and lowered general health status than did those perceiving less stress. However, these outcomes were worst for persons perceiving high stress and living in high traffic areas.

Racial disparities in exposure to stressors. There are racial disparities in the burden of stressors that accumulate over the life course (Geronimus et al. 2001; Holland et al. 2000; Jones 2000; Krieger et al. 1993; Williams et al. 1997). Some have called this racially differential burden of cumulative stress the “weathering hypothesis” (Astone et al. 2002; Geronimus 1996). One of the most prominent stressors may be racial discrimination (Gee 2002; Krieger and Sidney 1996; LaVeist et al. 2000; Williams and Neighbors 2001; Williams et al. 1997). Because racial discrimination has profoundly shaped the experiences of racial groups, discrimination may be among the factors that shape health disparities. Evidence suggests that racial discrimination

still occurs in the present day, especially in structurally important domains such as housing, education, and employment (Essed 1992; Feagin 1991, 2000). Audit studies send a white and a minority prospective tester with identical portfolios (e.g., similar income and job titles) to assess a given housing market. These audits have consistently found that whites are favored over minorities. Hispanics, for example, are more likely to be quoted a higher rent for a given unit than are their white counterparts (Turner and Skidmore 2001). Other studies have shown that minorities are more likely to face discrimination in applying for a job (Kirschenman and Neckerman 1991) or shopping (Lee 2000).

Further, discriminatory treatment within the health care system also might contribute to disparities (Krieger 1999). Minorities appear to have longer waiting times for kidney transplants (Eggers 1995; Klassen et al. 2002) and liver transplants (Kjellstrand 1988; Young and Gaston 2000) and report less satisfaction with their medical visits (Cooper-Patrick et al. 1999; Saha et al. 2003). A review by the Institute of Medicine (2002) concluded:

Racial and ethnic minorities tend to receive a lower quality of healthcare than non-minorities, even when access-related factors, such as patients' insurance status and income are controlled.... [T]he study committee found evidence that stereotyping, biases, and uncertainty on the part of healthcare providers can all contribute to unequal treatment.

Stress from discrimination may lead to illness. Kessler et al. (1999) have suggested that

The conjunction of high prevalence and strong impact would mean that discrimination is among the most important of all the stressful experiences that have been implicated as causes of mental health problems.

Studies have reported that stress due to racial discrimination is associated with high blood pressure (Krieger and Sidney 1996), mental health (Dion et al. 1992; Gee 2002; Kessler et al. 1999; Kuo 1976; Williams et al. 1997), and alcohol consumption (Yen et al. 1999).

Neighborhood Resources

Although a common argument is that segregation is harmful to the health of minorities, there is some indication that segregation may have a counterbalancing effect by concentrating social resources, such as black political power (LaVeist 1993). Others have reported that the clustering of ethnic groups may build a sense of collective identity that helps mitigate trauma (Mazumdar et al. 2000). Thus, supportive social relationships within minority communities may help promote health and well-being and ameliorate the effects of community risks. Our view is that segregation concentrates both risks and resources. It is not

a matter of whether segregation is either “bad” or “good,” but to what degree the negative effects of segregation outweigh positive effects.

Neighborhood resources buffer community stressors (Israel et al. 1998; Kretzman and McKnight 1993). Generally, these resources have been conceptualized in terms of relationships among residents, including social cohesion, social capital, psychological sense of community, informal social control, and community empowerment (Berkman and Clark 2003; Kawachi et al. 1999; Ross and Jang 2000; Sampson et al. 1997). “Social cohesion” is the “extent of connectedness and solidarity among groups in society” (Kawachi and Berkman 2000). Essentially, a community with a high degree of social cohesion has strong social ties between members and minimal conflict. “Social capital” can be considered a type of resource that emerges from socially cohesive groups that facilitates collective action. These resources include norms of reciprocity, aid, and interpersonal trust.

Collective efficacy, defined as “mutual trust and willingness to intervene for the common good” (Sampson et al. 1997), may mediate the adverse effects of concentrated disadvantage and fear (Ross and Jang 2000). Pastor et al. (2001) suggested that social capital was stronger in communities with less “ethnic churning,” referring to the replacement of one minority group with another within a community. They argued that ethnic churning may “weaken the usual social bonds constituted by race and make an area more susceptible to siting of noxious land uses.” Their data indicated that ethnic churning in Los Angeles was associated with the siting of hazardous waste storage and disposal facilities over a two-decade period, after adjusting for economic factors.

Another potential resource is residents' ability to control their environment, which may mitigate community problems in two ways. First, empowered communities may be able to protect themselves from the intrusion of new hazards and eliminate extant ones (Bullard and Wright 1993; Lee 1993; Morello-Frosch et al. 2002; Phoenix 1993; Rich et al. 1995; Zimmerman 2000). These communities may also be able to control the political arena that shapes their health beyond the effect of environmental pollutants. Black political participation, defined by the presence of African-American legislators, has been associated with lower mortality rates in African-American communities (LaVeist 1993). This is possibly due to a higher preponderance among African-American communities to provide a wider range of social services compared with white communities (Schneider and Logan 1982). Second, control per se may be an important factor determining stress and health. Workers with greater control over their work process have lower risk of cardiovascular disease than

do workers with less control (Karasek and Theorell 1990; Kuper and Marmot 2003; Landsbergis et al. 1997). Further, collective control by workers and their unions may also provide health benefits (Johnson 1989; Sorensen et al. 2004).

Community Stress

The cumulation of environmental pollutants, structural process, community stressors, and neighborhood resources is community stress. Community stress is a state of ecological vulnerability. Community resources help buffer community stressors and protect against environmental exposure, but when resources are inadequate, community stress arises. Structural factors constrain the limits of resources and stressors.

Although several factors cross the threshold from “community” to “individual,” we focus on the intersection between community stress and individual stress. In particular, community stress may itself lead to individual stressors. These individual stressors may in turn lead to individual stress and subsequent illness. The terrorist attacks of 11 September 2001 provide an extreme example of how community stress can translate to individuals. The attack was a threat to the American “community.” Although most citizens were not close to the epicenter, many individuals across the United States felt some measure of distress from the attack (Schlenger et al. 2002; Schuster et al. 2001).

Future Directions

Our stress–exposure–disease framework is meant to stimulate dialogue between environmental and social scientists. Several avenues for future work are suggested. First and foremost, although several components within the framework have undergone extensive study, such as between individual stress and health, relatively little work has attempted to integrate the elements as a whole. Studies are just beginning to consider the connections among factors at multiple levels, such as among community stress, individual stress, and health. Future work should continue to test the components of the framework and incorporate multilevel modeling (Raudenbush and Bryk 2002). Longitudinal studies will be necessary to establish the temporal ordering between variables.

Second, public health should more seriously consider the role that residential segregation plays in the production of health disparities. Several lines of inquiry are possible regarding segregation alone. For example, what role might environmental risk perception play in maintaining segregation? Are certain dimensions of segregation more important than others? Are the mechanisms linking segregation to health all negative, or might there be some health-promoting pathways, such as in the clustering of cultural resources? What are the

forms of segregation outside of the United States, and are the mechanisms similar? Does the relationship between segregation and health generalize to all ethnic groups?

Third, we hope that this framework will encourage the environmental justice movement to expand the notion of “environmental hazards” to include community stressors. Are minority communities more likely to receive the siting of workplaces with high job strain (Karasek and Theorell 1990)? Do differences in community stress lead to the “weathering” (Geronimus 1996) of minority communities compared with whites? This means not only examining the main effects of stress and toxicants, but also examining whether psychosocial stress may potentiate (i.e., amplify) the effects of toxicants on the body.

Fourth, research should not only examine the relationship between minority communities and exposures, but also study how the structural conditions of communities may confer additional vulnerability. Disadvantaged communities may be more vulnerable to exposure to environmental hazards because structural conditions, such as substandard housing, may render them more likely to be exposed than are counterparts in more advantaged communities equally distant from these hazards. That is, do minority communities have less protection against a given level of exposure, and do these disparities in protection result from differential social policy?

Conclusions

Our work has implications for environmental justice by suggesting that exposure to physical and chemical hazards is only one route whereby neighborhoods affect the health of racial minorities. Health promotion may require policies and interventions aimed at eliminating environmental toxicants, fostering community resources, and reducing social stressors. Reduction of the gap in health between advantaged and disadvantaged groups, however, may require interventions targeted at eliminating the gap in advantages themselves.

We emphasize racial differences in exposure to stress, rather than racial differences in response to stress. The former conceptualization emphasizes interventions on macro-level social policy (e.g., housing policy), whereas the latter perspective emphasizes interventions at the micro level (e.g., psychological counseling or pharmacological agents). Although micro-level approaches are useful, one disadvantage is that individual interventions require tremendous resources in order to manifest outcomes at the population level (and hence reduce group differences) and, further, are less efficient because interventions must be reapplied to each new birth cohort. However, policy-level changes that target socially produced stressors may prove a promising way to improve the public’s health.

REFERENCES

- Acevedo-Garcia D. 2000. Residential segregation and the epidemiology of infectious diseases. *Soc Sci Med* 51:1143–1161.
- Acevedo-Garcia D. 2003. Future directions in residential segregation and health research: a multilevel approach. *Am J Public Health* 93:215–221.
- Alaniz ML. 1998. Alcohol availability and targeted advertising in racial/ethnic minority communities. *Alcohol Health Res World* 22:286–289.
- Anderton DL, Anderson AB, Oakes JM, Fraser MR. 1994. Environmental equity: the demographics of dumping. *Demography* 31:229–248.
- Anderton DL, Oakes JM, Egan KL. 1997. Environmental equity in Superfund. Demographics of the discovery and prioritization of abandoned toxic sites. *Eval Rev* 21:3–26.
- Aneshensel CS. 1992. Social stress: theory and research. *Annu Rev Soc* 18:15–38.
- Aneshensel CS, Suckoff CA. 1996. The neighborhood context of adolescent mental health. *J Health Soc Behav* 37:293–310.
- Arata K, Picou JS, Johnson GD, McNally TS. 2000. Coping with technological disaster: an application of the conservation of resources model to the *Exxon Valdez* oil spill. *J Traum Stress* 13:28–39.
- Astone NM, Ensminger ME, Juon HS. 2002. Early adult characteristics and mortality among inner-city African American women. *Am J Public Health* 92:640–645.
- ATSDR. 1995. Report of the Expert Panel Workshop on the Psychological Responses to Hazardous Substances. Atlanta, GA:Agency for Toxic Substances and Disease Registry.
- Babisch W, Fromme H, Beyer A, Ising H. 2001. Increased catecholamine levels in urine in subjects exposed to road traffic noise: the role of stress hormones in noise research. *Environ Int* 26:475–481.
- Bashir SA. 2002. Home is where the harm is: inadequate housing as a public health crisis. *Am J Public Health* 92:733–738.
- Baum A, Fleming R, Singer J. 1983. Coping with victimization by technological disaster. *J Soc Issues* 39:117–138.
- Beck BD, Weinstock S. 1988. Age and nutrition. In: *Variations in Susceptibility to Inhaled Pollutants: Identification, Mechanisms, and Policy Implications* (Brian JD, ed). Baltimore, MD:Johns Hopkins University Press, 104–126.
- Berkman LF, Glass T. 2000. Social integration, social networks, social support, and health. In: *Social Epidemiology* (Berkman LF, Kawachi I, eds). New York:Oxford University Press, 137–173.
- Brenner MH. 1995. Political economy and health. In: *Society and Health* (Amick BC, Levine S, Tarlov AR, Chapman Walsh D, eds). New York:Oxford University Press, 211–246.
- Bronfenbrenner U. 1989. Ecological system theories. *Ann Child Dev* 6:187–251.
- Brown JS Jr. 2002. Environmental and chemical toxins and psychiatric illness. Washington, DC:American Psychiatric Publishing.
- Brunner EJ. 2000. Toward a new social biology. In: *Social Epidemiology* (Berkman LF, Kawachi I, eds). New York:Oxford University Press, 306–331.
- Bullard RD. 1983. Solid waste sites and the black Houston community. *Sociol Inq* 53:273–288.
- Bullard RD. 1990. *Dumping in Dixie: Race, Class and Environmental Quality*. Boulder, CO:Westview Press.
- Bullard RD, Wright BH. 1993. Environmental justice for all: community perspectives on health and research needs. *Toxicol Ind Health* 9:821–841.
- Burger J, Gaines KF, Gochfeld M. 2001. Ethnic differences in risk from mercury among Savannah River fishermen. *Risk Anal* 21:533–544.
- Calderon RL, Johnson CC Jr, Craun GF, Dufour AP, Karlin RJ, Sinks T, et al. 1993. Health risks from contaminated water: do class and race matter? *Toxicol Ind Health* 9:879–900.
- CDC (Centers for Disease Control and Prevention). 2002. Racial and ethnic disparities in infant mortality rates—60 largest U.S. cities, 1995–1998. *MMWR Morb Mortal Wkly Rep* 51:329–332, 343.
- Chang SK, Brownie C, Riviere JE. 1994. Percutaneous absorption of topical parathion through porcine skin: in vitro studies on the effect of environmental perturbations. *J Vet Pharmacol Ther* 17:434–439.
- Cohen DA, Mason K, Bedimo A, Scribner R, Basolo V, Farley TA. 2003. Neighborhood physical conditions and health. *Am J Public Health* 93:467–471.
- Cohen S, Tyrrell DA, Smith AP. 1991. Psychological stress and susceptibility to the common cold. *N Engl J Med* 325:606–612.

- Cooper RS. 1984. A note on the biological concept of race and its application in epidemiologic research. *Am Heart J* 108:715–723.
- Cooper RS, Kaufman JS, Ward R. 2003. Race and genomics. *N Engl J Med* 348:1166–1170.
- Cooper-Patrick L, Gallo JJ, Gonzales JJ. 1999. Race, gender, and partnership in the patient-physician relationship. *JAMA* 282:583–589.
- Corburn J. 2002. Combining community-based research and local knowledge to confront asthma and subsistence-fishing hazards in Greenpoint/Williamsburg, Brooklyn, New York. *Environ Health Perspect* 110(suppl 2):241–248.
- Cubbin C, Hadden WC, Winkleby MA. 2001. Neighborhood context and cardiovascular disease risk factors: the contribution of material deprivation. *Ethn Dis* 11:687–700.
- Cubbin C, LeClere FB, Smith GS. 2000. Socioeconomic status and injury mortality: individual and neighbourhood determinants. *J Epidemiol Community Health* 54:517–524.
- Cutler E, Glaeser E. 1997. Are ghettos good or bad? *Q J Econ* 112:827–872.
- Cutrona CE, Russell DW, Hessling RM, Brown PA, Murry V. 2000. Personality processes and individual differences—direct and moderating effects of community context on the psychological well-being of African American women. *J Pers Soc Psychol* 79:1088–1101.
- Deaton A, Lubotsky D. 2003. Mortality, inequality and race in American cities and states. *Soc Sci Med* 56:1139–1153.
- Diez-Roux AV. 1997. Neighborhood environments and coronary heart disease: a multilevel analysis. *Am J Epidemiol* 146:48–63.
- Diez-Roux AV. 1998. Bringing context back into epidemiology: variables and fallacies in multilevel analysis. *Am J Public Health* 88:216–222.
- Diez-Roux AV. 2000. Multilevel analysis in public health research. *Annu Rev Public Health* 21:171–192.
- Diez-Roux AV, Merkin SS, Arnett D, Chambless L, Massing M, Nieto FJ, et al. 2001. Neighborhood of residence and incidence of coronary heart disease. *N Engl J Med* 345:99–106.
- Dion KL, Dion KK, Pappas G. 1992. Personality-based hardiness as a buffer for discrimination-related stress in members of Toronto's Chinese community. *Can J Behav Sci* 24:517–536.
- Edelstein MR, Wandersman A. 1987. Community dynamics in coping with toxic contaminants. In: *Neighborhood and Community Environments* (Altman I, Wandersman A, eds). New York:Plenum, 69–112.
- Eggers PW. 1995. Racial differences in access to kidney transplantation in the Medicare ESRD population. *Health Care Financ Rev* 17:89–103.
- Essed P. 1992. *Understanding Everyday Racism*. Newbury Park, CA:Sage.
- Evans GW, Lepore SJ. 1993. Household crowding and social support: a quasiexperimental analysis. *J Pers Soc Psychol* 65:308–316.
- Evans GW, Bullinger M, Hygge S. 1998. Chronic noise exposure and physiological response: a prospective study of children living under environmental stress. *Psychol Sci* 9:75–77.
- Evans GW, Kantrowitz E. 2002. Socioeconomic status and health: the potential role of environmental risk exposure. *Annu Rev Public Health* 23:303–331.
- Feagin JR. 1991. The continuing significance of race: antiblack discrimination in public places. *Am Sociol Rev* 56:101–116.
- Feagin JR. 2000. *Racist America: Roots, Current Realities, and Future Reparations*. New York:Routledge.
- Feagin JR, McKinney KD. 2003. *The Many Costs of Racism*. Lanham, MD:Rowman and Littlefield.
- Fick AC, Thomas SM. 1995. Growing up in a violent environment: relationship to health-related beliefs and behaviors. *Youth Soc* 27:136–147.
- Fleming I, Baum A, Weiss L. 1987. Social density and perceived control as mediators of crowding stress in high-density residential neighborhoods. *J Pers Social Psychol* 52:899–906.
- Funckes AJ, Hayes GR Jr, Hartwell WV. 1963. Urinary excretion of paranthrophenol by volunteers following dermal exposure to parathion at different ambient temperatures. *J Agric Food Chem* 11:455–457.
- Garte S. 2002. The racial genetic paradox in biomedical research and public health. *Public Health Rep* 117:421–425.
- Gee GC. 2002. A multilevel analysis of the relationship between institutional racial discrimination and health status. *Am J Public Health* 92:615–623.
- Gee GC, Takeuchi DT. 2004. Traffic stress, vehicular burden and well-being: a multilevel analysis. *Soc Sci Med* 59:405–414.
- Geis KJ, Ross CE. 1998. A new look at urban alienation: the effect of neighborhood disorder on perceived powerlessness. *Soc Psychol Q* 61:232–246.
- Geronimus AT. 1996. Black/white differences in the relationship of maternal age to birthweight: a population-based test of the weathering hypothesis. *Soc Sci Med* 42:589–597.
- Geronimus AT, Bound J, Waidmann TA. 1999. Poverty, time, and place: variation in excess mortality across selected U.S. populations, 1980–1990. *J Epidemiol Community Health* 53:325–334.
- Geronimus AT, Bound J, Waidmann TA, Colen CG, Steffick D. 2001. Inequality in life expectancy, functional status, and active life expectancy across selected black and white population in the United States. *Demography* 38:227–251.
- Gibbs LM. 1983. Community response to an emergency situation: psychological destruction and the Love Canal. *Am J Community Psychol* 11:116–125.
- Genexi EM, Weihs K, Simmens SJ, Hoyt DR. 2000. Natural disaster and depression: a prospective investigation of reactions to the 1993 midwest floods. *Am J Community Psychol* 28:495–518.
- Goldman BA, Fitton L. 1994. *Toxic Wastes and Race Revisited: An Update of the 1987 Report on the Racial and Socioeconomic Characteristics of Communities with Hazardous Waste Sites*. Washington, DC:Center for Policy Alternatives.
- Gordon CJ. 2003. Role of environmental stress in the physiological response to chemical toxins. *Environ Res* 92:1–7.
- Green LW, Kreuter MW. 1999. *Health Promotion Planning: An Educational and Ecological Approach*. Mountain View, CA:Mayfield.
- Haan M, Kaplan GA, Camacho T. 1987. Poverty and health: prospective evidence from the Alameda County Study. *Am J Epidemiol* 125:989–998.
- Hadley ME. 1992. *Endocrinology*. Englewood Cliffs, NJ:Prentice Hall.
- Hart KD, Kunitz SJ, Sell RR, Mukamel DB. 1998. Metropolitan governance, residential segregation, and mortality among African Americans. *Am J Public Health* 88:434–438.
- Hayward MD, Crimmins EM, Miles TP, Yang Y. 2000. The significance of socioeconomic status in explaining the race gap in chronic health conditions. *Am Sociol Rev* 65:910–930.
- Holden C. 1980. Love Canal residents under stress. *Science* 208:1242–1244.
- Holland P, Berney L, Blane D, Davey-Smith G, Gunnell DJ, Montgomery SM. 2000. Life course accumulation of disadvantage: childhood health and hazard exposure during adulthood. *Soc Sci Med* 50:1285–1295.
- Iceland J, Weinberg DH, Steinmetz E. 2002. *Racial and Ethnic Residential Segregation in the United States: 1980–2000*. U.S. Census Bureau, Series CENSR-3. Washington, DC:U.S. Government Printing Office.
- Institute of Medicine. 1999. *Toward Environmental Justice: Research, Education, and Health Policy Needs*. Washington, DC:National Academy Press.
- Institute of Medicine. 2002. *Unequal Treatment: Confronting Racial and Ethnic Disparities in Health Care*. Washington, DC:National Academies Press.
- Israel BA, Farquhar S, James SA, Schulz AM, Parker EA. 2002. The relationship between social support, stress, and health among women on Detroit's East Side. *Health Educ Behav* 29:342–360.
- Israel BA, Schulz AJ, Parker EA, Becker AB. 1998. Review of community-based research: assessing partnership approaches to improve public health. *Annu Rev Public Health* 19:173–202.
- Jackson SA, Anderson RT, Johnson NJ, Sorlie PD. 2000. The relation of residential segregation to all-cause mortality: a study in black and white. *Am J Public Health* 90:615–617.
- Jacobs DE, Clickner RP, Zhou JY, Viet SM, Marker DA, Rogers JW, et al. 2002. The prevalence of lead-based paint hazards in U.S. housing. *Environ Health Perspect* 110:599–606.
- Jargowsky P. 1997. *Poverty and Place: Ghettos, Barrios, and the American City*. New York:Russell Sage Foundation.
- Johnson JV. 1989. Collective control: strategies for survival in the workplace. *Int J Health Serv* 19:469–480.
- Johnson JV, Stewart W, Hall EM, Fredlund P, Theorell T. 1996. Long-term psychosocial work environment and cardiovascular mortality among Swedish men. *Am J Public Health* 86:324–331.
- Jones CP. 2000. Levels of racism: a theoretical framework and gardener's tale. *Am J Public Health* 90:1212–1215.
- Kaniasty K, Norris FH. 2000. Help-seeking comfort and receiving social support: the role of ethnicity and context of need. *Am J Community Psychol* 28:545–581.
- Kaplan GA. 1996. People and places: contrasting perspectives on the association between social class and health. *Int J Health Serv* 26:507–519.
- Kaplan GA, Turrell G, Lynch JW, Everson SA, Helkala EL, Salonen JT. 2001. Socioeconomic position and cognitive function in adulthood. *Int J Epidemiol* 30:256–263.
- Karasek R, Theorell T. 1990. *Healthy Work: Stress, Productivity, and the Reconstruction of Working Life*. New York:Basic Books.
- Kawachi I, Berkman LF. 2000. *Social cohesion, social capital, and health*. In: *Social Epidemiology* (Berkman LF, Kawachi I, eds). New York:Oxford University Press, 174–190.
- Kawachi I, Kennedy BP, Glass R. 1999. Social capital and self-rated health: a contextual analysis. *Am J Public Health* 89:1187–1193.
- Keppel KG, Pearcy JN, Wagener D. 2002. Trends in racial and ethnic-specific rates for the United States indicators: United States, 1990–1998. In: *Healthy People Statistical Notes*. No. 23. Hyattsville, MD:National Center for Health Statistics.
- Kessler RC, Michelson KD, Williams DR. 1999. The prevalence, distribution and mental health correlates of perceived discrimination in the United States. *J Health Soc Behav* 40:208–230.
- Kirschenman J, Neckerman KM. 1991. "We'd love to hire them, but ...": The meaning of race for employers. In: *The Urban Underclass* (Jencks C, Peterson P, eds). Washington, DC:Brookings Institution, 203–232.
- Kjellstrand CM. 1988. Age, sex, and race inequality in renal transplantation. *Arch Int Med* 148:1305–1309.
- Klassen AC, Hall AG, Saksvig B, Curbow B, Klassen DK. 2002. Relationship between patients' perceptions of disadvantage and discrimination and listing for kidney transplantation. *Am J Public Health* 92:811–817.
- Kretzman JP, McKnight JL. 1993. *Building Communities from the Inside Out*. Evanston, IL:Northwestern University.
- Krieger J, Higgins DL. 2002. Housing and health: time again for public health action. *Am J Public Health* 92:758–768.
- Krieger N. 1999. Embodying inequality: a review of concepts, measures, and methods for studying health consequences of discrimination. *Int J Health Serv* 29:295–352.
- Krieger N, Fee E. 1994. Social class: the missing link in U.S. health data. *Int J Health Serv* 24:25–44.
- Krieger N, Rowley DL, Herman AA, Avery B, Phillips MT. 1993. Racism, sexism, and social class: implications for studies of health, disease, and well-being. *Am J Prev Med* 9:82–122.
- Krieger N, Sidney S. 1996. Racial discrimination and blood pressure: the CARDIA study of young black and white adults. *Am J Public Health* 86A:1370–1378.
- Kuo W. 1976. Theories of migration and mental health: an empirical testing on Chinese-Americans. *Soc Sci Med* 10:297–306.
- Kuper H, Marmot MG. 2003. Job strain, job demands, decision latitude, and risk of coronary heart disease within the Whitehall II study. *J Epidemiol Community Health* 57:147–153.
- Landsbergis PA, Schnall PL, Dietz DK, Warren K, Pickering TG. 1997. Job strain and health behaviors: results from a prospective study. *Am J Health Promot* 12:237–245.
- LaVeist TA. 1989. Linking residential segregation to the infant-mortality race disparity in U.S. cities. *Soc Sci Res* 73:94.
- LaVeist TA. 1993. Segregation, poverty, and empowerment: health consequences for African Americans. *Milbank Q* 71:41–64.
- LaVeist TA. 1994. Beyond dummy variables and sample selection: what health services researchers ought to know about race as a variable. *Health Serv Res* 29:1–16.
- LaVeist TA, Nickerson KJ, Bowie JV. 2000. Attitudes about racism, medical mistrust, and satisfaction with care among African American and white cardiac patients. *Med Care Res Rev* 27:146–161.
- Lazarus RS, Folkman S. 1984. *Stress, Appraisal and Coping*. New York:Springer.
- Lee C. 1993. Beyond toxic wastes and race. In: *Confronting Environmental Racism: Voices from the Grassroots* (Bullard RD, Chavis B, eds). Boston:South End Press, 41–52.
- Lee C. 2002. Environmental justice: building a unified vision of health and the environment. *Environ Health Perspect* 110(suppl 2):141–144.
- Lee J. 2000. The salience of race in everyday life: black customers' shopping experiences in black and white neighborhoods. *Work Occup* 27:353–376.
- Lewontin RC. 1982. *Human Diversity*. Redding, CT:Scientific American/Freeman.

- Lioy PJ. 1990. Assessing total human exposure to contaminants. *Environ Sci Technol* 24:938–945.
- Logan JR. 2003. Ethnic diversity grows, neighborhood integration lags. In: *Redefining Urban and Suburban America* (Katz B, Lang RE, eds). Washington, DC:Brookings Institution, 235–256.
- Lopez R. 2002. Segregation and black/white differences in exposure to air toxics in 1990. *Environ Health Perspect* 110(suppl 2):289–295.
- Luke D, Esmundo E, Bloom Y. 2000. Smoke signs: patterns of tobacco billboard advertising in a metropolitan region. *Tobacco Control* 9:16–23.
- Maantay J. 2001. Zoning, equity, and public health. *Am J Public Health* 91:1033–1041.
- Maantay J. 2002. Mapping environmental injustices: pitfalls and potential of geographic information systems in assessing environmental health and equity. *Environ Health Perspect* 110(suppl 2):161–171.
- Macintyre S, Ellaway A, Cummins S. 2002. Place effects on health: how can we conceptualise, operationalise, and measure them? *Soc Sci Med* 55:125–139.
- Margellos H, Silva A, Whitman S. 2004. Comparison of health status indicators in Chicago: are black-white disparities worsening? *Am J Public Health* 94:116–121.
- Marmot MG, Fuhrer R, Ettner S, Marks NF, Bumpass LL, Ryff CD. 1998. Contribution of psychosocial factors to socioeconomic differences in health. *Milbank Q* 76:403–440.
- Marmot MG, Kogevinas M, Elston MA. 1987. Social/economic status and disease. *Annu Rev Public Health* 8:111–135.
- Massey D. 2001. Residential segregation and neighborhood conditions in U.S. metropolitan areas. In: *America Becoming: Racial Trends and Their Consequences* (Smelser NJ, Wilson WJ, Mitchell F, eds). Washington, DC:National Academy Press, 391–434.
- Massey D, Denton NA. 1988. The dimensions of residential segregation. *Soc Forces* 67:281–315.
- Massey D, Denton NA. 1993. *American Apartheid: Segregation and the Making of the Underclass*. Cambridge, MA:Harvard University Press.
- Mazumdar S, Mazumdar S, Docuayan F, McLaughlin CM. 2000. Creating a sense of place: the Vietnamese-Americans and Little Saigon. *J Environ Psychol* 20:319–333.
- McEwen BS. 1998. Protective and damaging effects of stress mediators. *New Engl J Med* 338:171–179.
- Merkin SS, Stevenson L, Powe N. 2002. Geographic socioeconomic status, race, and advanced-stage breast cancer in New York City. *Am J Public Health* 92:64–70.
- Meyer SG. 2000. As Long as They Don't Move Next Door: Segregation and Racial Conflict in American Neighborhoods. Oxford:Rowman & Littlefield.
- Mohai P, Bryant B. 1992. Environmental racism: reviewing the evidence. In: *Race and the Incidence of Environmental Hazards: A Time for Discourse* (Bryant B, Mohai P, eds). Boulder, CO:Westview, 163–176.
- Morello-Frosch R, Pastor M Jr, Porras C, Sadd J. 2002. Environmental justice and regional inequality in southern California: implications for future research. *Environ Health Perspect* 110(suppl 2):149–154.
- Morello-Frosch R, Pastor M Jr, Sadd J. 2001. Environmental justice and southern California's "riskycape": the distribution of air toxics exposures and health risks among diverse communities. *Urban Affairs Rev* 36:551–578.
- Morenoff JD. 2003. Neighborhood mechanisms and the spatial dynamics of birth weight. *Am J Sociol* 108:976–1017.
- Morenoff JD, Sampson RJ, Raudenbush S. 2001. Neighborhood inequality, collective efficacy and the spatial dynamics of homicide. *Criminology* 39(3):517–560.
- Morland K, Wing S, Diez-Roux AV, Poole C. 2002. Neighborhood characteristics associated with the location of food stores and food service places. *Am J Prev Med* 22:23–29.
- Morrison RS, Wallenstein S, Natale DK, Senzel RS, Huang LL. 2000. "We don't carry that"—failure of pharmacies in predominantly nonwhite neighborhoods to stock opioid analgesics. *N Engl J Med* 342:1023–1026.
- Moses M, Johnson ES, Anger WK, Burse VW, Horstman SW, Jackson RJ, et al. 1993. Environmental equity and pesticide exposure. *Toxicol Ind Health* 9:913–59.
- Mountain JL, Cavalli-Sforza LL. 1997. Multilocus genotypes, a tree of individuals, and human evolutionary history. *Am J Hum Genet* 61:705–718.
- Munnell AH, Tootell GMB, Browne LE, McEneaney J. 1996. Mortgage lending in Boston: interpreting HMDA data. *Am Econ Rev* 86:25–53.
- National Research Council. 1991a. *Human Exposure Assessment for Airborne Pollutants: Advances and Opportunities*. Washington, DC:National Academy Press.
- National Research Council. 1991b. *Environmental Epidemiology, Vol 1. Public Health and Hazardous Wastes*. Washington, DC:National Academy Press.
- Northridge ME, Shepard PM. 1997. Environmental racism and public health. *Am J Public Health* 87:730–732.
- Northridge ME, Stover GN, Rosenthal JE, Sherard D. 2003. Environmental equity and health: understanding complexity and moving forward. *Am J Public Health* 93:209–214.
- O'Neill MS, Jerrett M, Kawachi I, Levy JI, Cohen AJ, Gouveia N, et al. 2003. Health, wealth, and air pollution: advancing theory and methods. *Environ Health Perspect* 111:1861–1870.
- Ouis D. 2001. Annoyance from road traffic noise: a review. *J Environ Psychol* 21:101–120.
- Pastor M. 2001. Geography and opportunity. In: *America Becoming: Racial Trends and Their Consequences* (Smelser N, Wilson WJ, Mitchell F, eds). Washington, DC:National Academy Press, 435–468.
- Pastor M, Sadd J, Hipp J. 2001. Which came first? Toxic facilities, minority move-in, and environmental justice. *J Urban Affairs* 23:1–21.
- Perera FP, Illman SM, Kinney PL, Whyatt RM, Kelvin EA, Shepard P, et al. 2002. The challenge of preventing environmentally related disease in young children: community-based research in New York City. *Environ Health Perspect* 110:197–204.
- Perera FP, Rauh V, Tsai W-Y, Kinney P, Camann D, Barr D, et al. 2003. Effects of transplacental exposure to environmental pollutants on birth outcomes in a multiethnic population. *Environ Health Perspect* 111:201–205.
- Perlin S, Setzer RW, Creason J, Sexton K. 1995. Distribution of industrial air emissions by income and race in the United States: an approach using the Toxics Release Inventory. *Environ Sci Technol* 29:69–80.
- Perlin SA, Sexton K, Wong DW. 1999. An examination of race and poverty for populations living near industrial sources of air pollution. *J Expo Anal Environ Epidemiol* 9:29–48.
- Peterson RD, Krivo LJ. 1993. Racial segregation and black urban homicide. *Soc Forces* 71:1001–1026.
- Peterson RD, Krivo LJ. 1999. Racial segregation, the concentration of disadvantage, and black and white homicide victimization. *Social Forces* 14:465–493.
- Phoenix J. 1993. Getting the lead out of the community. In: *Confronting Environmental Racism* (Bullard RD, ed). Boston:South End Press, 77–92.
- Pickett KE, Pearl M. 2001. Multilevel analyses of neighbourhood socioeconomic context and health outcomes: a critical review. *J Epidemiol Community Health* 55:111–122.
- Pirkle JL, Kaufmann RB, Brody DJ, Hickman T, Gunter EW, Paschal DC. 1998. Exposure of the U.S. population to lead, 1991–1994. *Environ Health Perspect* 106:745–750.
- Polednak AP. 1991. Black-white differences in infant mortality in 38 standard metropolitan statistical areas. *Am J Public Health* 81:1480–1482.
- Polednak AP. 1996. Segregation, discrimination and mortality in U.S. blacks. *Ethn Dis* 6:99–108.
- Pope CA, Verrier RL, Lovett EG, Larson AC, Raizenne ME, Kanner RE, et al. 1999. Heart rate variability associated with particulate air pollution. *Am Heart J* 138:890–899.
- Raudenbush SW, Bryk AS. 2002. *Hierarchical Linear Models: Applications and Data Analysis Methods*. Thousand Oaks, CA:Sage Publications.
- Rich RC, Edelstein M, Hallman WK, Wandersman AH. 1995. Citizen participation and empowerment: the case of local environmental hazards. *Am J Community Psychol* 23:657–676.
- Rios R, Poje V, Detels R. 1993. Susceptibility to environmental pollutants among minorities. *Toxicol Ind Health* 9:797–820.
- Ross CE, Jang SJ. 2000. Neighborhood disorder, fear, and mistrust: the buffering role of social ties with neighbors. *Am J Community Psychol* 28:401–420.
- Ross CE, Reynolds JL, Geis KJ. 2000. The contingent meaning of neighborhood stability for residents' psychological well-being. *Am Sociol Rev* 65:581–597.
- Saha S, Arbelaez JJ, Cooper LA. 2003. Patient-physician relationships and racial disparities in the quality of health care. *Am J Public Health* 98:1713–1719.
- Sallis JF, Owen N. 1997. Ecological models. In: *Health Behavior and Health Education: Theory, Research, and Practice* (Glanz K, Lewis FM, Rimer BK, eds). San Francisco:Jossey-Bass, 403–424.
- Sampson RJ, Raudenbush SW, Earls F. 1997. Neighborhoods and violent crime: a multilevel study of collective efficacy. *Science* 277:918–924.
- Schelling TC. 1971. Dynamic models of segregation. *J Math Sociol* 1:143–186.
- Schlenger WE, Caddell JM, Ebert L, Jordan BK, Rourke KM, Wilson D, et al. 2002. Psychological reactions to terrorist attacks: findings from the national study of Americans' reactions to September 11. *JAMA* 288:581–588.
- Schmidt CW. 2001. The market for pollution. *Environ Health Perspect* 109:A379–A381.
- Schneider M, Logan JR. 1982. Suburban racial segregation and black access to local public resources. *Social Sci Q* 63:762–770.
- Schulz A, Israel B, Williams D, Parker E, Becker A, James S. 2000. Social inequalities, stressors and self reported health status among African American and white women in the Detroit metropolitan area. *Soc Sci Med* 51:1639–1653.
- Schulz AJ, Williams DR, Israel BA, Lempert LB. 2002. Racial and spatial relations as fundamental determinants of health in Detroit. *Milbank Q* 80:677–707.
- Schuster MA, Stein BD, Jaycox LH, Collins RL, Marshall GN, Elliott MN, et al. 2001. A national survey of stress reactions after the September 11, 2001 terrorist attacks. *N Engl J Med* 345:1507–1512.
- Schwartz A. 1998. Bank lending to minority and low-income households and neighborhoods: do community reinvestment agreements make a difference? *J Urban Affairs* 20:269–301.
- Selye H. 1936. Syndrome produced by diverse nocuous agents [Letter]. *Nature* 138:32.
- Sexton K. 2000. Socioeconomic and racial disparities in environmental health: is risk assessment part of the problem or part of the solution? *Hum Ecol Risk Assess* 6:561–574.
- Sexton K, Olden K, Johnson BL. 1993. "Environmental justice": the central role of research in establishing a credible scientific foundation for informed decision making. *Toxicol Ind Health* 9:685–727.
- Shepard PM, Northridge ME, Prakash S, Stover G. 2002. Preface: advancing environmental justice through community-based participatory research. *Environ Health Perspect* 110(suppl 2):139–140.
- Soloman BD, Lee R. 2000. Emissions trading systems and environmental justice. *Environment* 42:34–46.
- Sorensen G, Barbeau E, Hunt MK, Emmons K. 2004. Reducing disparities in tobacco use: a social-contextual model for reducing tobacco use among blue-collar workers. *Am J Public Health* 94:230–239.
- Sorlie PD, Backlund E, Keller JB. 1995. U.S. mortality by economic, demographic, and social characteristics: the National Longitudinal Mortality Study. *Am J Public Health* 85:949–956.
- Squires GD. 1994. *Capital and Communities in Black and White*. Albany:State University of New York Press.
- Squires GD, Velez W. 1996. Mortgage lending and race: is discrimination still a factor? *Environ Plan* 28:1199–1208.
- Steptoe A, Feldman PA. 2001. Neighborhood problems as sources of chronic stress: development of a measure of neighborhood problems and associations with socioeconomic status and health. *Ann Behav Med* 23:177–185.
- Sucoff CA, Upchurch DA. 1998. Neighborhood context and the risk of childbearing among metropolitan-area black adolescents. *Am Sociol Rev* 63:571–585.
- Sugrue TJ. 1998. *The Origins of the Urban Crisis: Race and Inequality in Postwar Detroit*. Princeton, NJ:Princeton University Press.
- Turner MA, Skidmore F. 2001. *Mortgage Lending Discrimination: A Review of Existing Evidence*. Washington, DC:Urban Institute.
- United Church of Christ. 1987. *Toxic Wastes and Race in the United States: A National Report on the Racial and Socio-Economic Characteristics of Communities Surrounding Hazardous Waste Sites*. New York:United Church of Christ, Commission for Racial Justice.
- U.S. Census Bureau. 2000. *The Population Profile of the United States: 2000* (Internet Release). Washington, DC:U.S. Census Bureau. Available: <http://www.census.gov/population/www/pop-profile/profile2000.html> [accessed 21 October 2004].
- U.S. Census Bureau. 2003. *Housing Patterns - Table 7-1*. Available: <http://www.census.gov/hhes/www/housing/resseg/tab7-1.html> [accessed 14 October 2004].
- U.S. DHHS. 1998. *Tobacco Use among U.S. Racial/Ethnic Minority Groups—African Americans, American Indians and Alaska Natives, Asian Americans and Pacific Islanders, and Hispanics: A Report of the Surgeon General*. Atlanta, Georgia: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health

- Promotion, Office on Smoking and Health. Available: http://www.cdc.gov/tobacco/sgr/sgr_1998/sgr-min-sgr.htm [accessed 7 October 2004].
- U.S. DHHS. 2000. *Healthy People 2010*. 2nd ed. Washington, DC:U.S. Department of Health and Human Services. Available: <http://www.healthypeople.gov/publications/> [accessed 7 October 2004].
- U.S. EPA. 2003a. *Framework for Cumulative Risk Assessment*. EPA/600/P-02/001F. Washington, DC:U.S. Environmental Protection Agency, Office of Research and Development.
- U.S. EPA. 2003b. *Supplemental Guidance for Assessing Cancer Susceptibility from Early-Life Exposure to Carcinogens*. (External Review Draft). EPA/630/R-03/003. 2003. Washington, DC:U.S. Environmental Protection Agency.
- U.S. General Accounting Office. 1983. *Siting of Hazardous Waste Landfills and Their Correlation with Racial and Economic Status of Surrounding Communities*. Washington, DC:General Accounting Office.
- Wagener DK, ed. 1987. *The Role of Biomarkers in Reproductive and Developmental Toxicology*. *Environ Health Perspect* 74:3–199.
- Waitzman NJ, Smith KR. 1998. Separate but lethal: the effects of economic segregation on mortality in metropolitan America. *Milbank Q* 76:341–373.
- Warr M, Ellison CG. 2000. *Rethinking social reactions to crime: personal and altruistic fear in family households*. *Am J Soc* 106:551–578.
- Wester RC, Quan D, Maibach HI. 1996. In vitro percutaneous absorption of model compounds glyphosate and malathion from cotton fabric into and through human skin. *Food Chem Toxicol* 34:731–735.
- Whiteis DG. 1992. Hospital and community characteristics in closures of urban hospitals, 1980–87. *Public Health Rep* 107:409–416.
- Williams DR, Collins CA. 1995. U.S. socioeconomic and racial differences in health: patterns and explanations. *Annu Rev Sociol* 21:349–386.
- Williams DR, Collins C. 2001. Racial residential segregation: a fundamental cause of racial disparities in health. *Public Health Rep* 116:404–416.
- Williams DR, Neighbors H. 2001. Racism, discrimination and hypertension: evidence and needed research. *Ethn Dis* 11:800–816.
- Williams DR, Yu Y, Jackson JS, Anderson NB. 1997. Racial differences in physical and mental health: socioeconomic status, stress, and discrimination. *J Health Psychol* 2:335–351.
- Williams RW. 1999. Environmental injustice in America and its politics of scale. *Political Geography* 18:49–73.
- Wilson WJ. 1987. *The Truly Disadvantaged*. Chicago:University of Chicago Press.
- Wilson WJ. 1996. *When Work Disappears: The World of the New Urban Poor*. New York:Alfred A. Knopf.
- Winkleby MA, Cubbin C. 2003. Influence of individual and neighborhood socioeconomic status on mortality among black, Mexican-American, and white women and men in the United States. *J Epidemiol Community Health* 57:444–452.
- Woodruff T.J., Parker J.D., Kyle A.D., Schoendorf K.C. 2003. Disparities in exposure to air pollution during pregnancy. *Environ Health Perspect* 111:942–946.
- Yen IH, Syme S.L. 1999. The social environment and health: a discussion of the epidemiologic literature. *Annu Rev Public Health* 20:287–308.
- Yen IH, Ragland D.R., Greiner B.A., Fisher J.M. 1999. Workplace discrimination and alcohol consumption: findings from the San Francisco Muni Health and Safety Study. *Ethn Dis* 9:70–80.
- Young C.J., Gaston R.S. 2000. Renal transplantation in black Americans. *New Engl J Med* 343:1545–1552.
- Zimmerman M.A. 2000. Empowerment theory: psychological, organizational and community levels of analysis. In: *Handbook of Community Psychology* (Rappaport J, Seidman E, eds). New York:Kluwer Academic/Plenum Publishers, 43–63.