

Exploration of Health Disparities

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Health disparities have received growing attention in recent years from both the research community (Adler and Ostrove 1999) and the policy community [U.S. Department of Health and Human Services (DHHS) 2000]. Under the leadership of Dr. Kenneth Olden, the National Institute of Environmental Health Sciences (NIEHS) has played a key role in giving prominence to this issue. Some notable milestones in the field of health disparities within the United States include the launch of Healthy People 2010 in January 2000, which signaled the commitment of DHHS to the national goal of eliminating health disparities (DHHS 2000); the creation of the National Center on Minority Health and Health Disparities by Congress in November 2000; and the establishment in 2003 of the Trans-HHS Cancer Health Disparities Progress Review Group, which published its call to action, *Making Cancer Health Disparities History*, in March 2004 (DHHS 2004).

Yet health disparities are not a new problem. They have been documented almost since the beginning of vital records registration in the United States and elsewhere (Krieger and Fee 1996). The leading causes of premature mortality and morbidity have changed over time, as exemplified by the decline in mortality from infectious diseases during the first half of the 20th century, followed by the subsequent rise in chronic diseases such as ischemic heart disease (which initially showed an excess among higher socioeconomic groups). Nonetheless, throughout history, the poor, the less educated, and people of color have always had shorter lifespans compared with the more affluent and advantaged members of society (Link and Phelan 1995).

The reason for the resurgent interest in health disparities—as well as the attendant sense of urgency about solving the problem—is that they have persisted

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despite steady improvements in the standard of living and despite advances in medical knowledge and technology. Indeed, in several instances, health disparities appear to be widening over time. From a global perspective, average life expectancy at birth improved by almost 6 years over the past two decades (Bonita and Mathers 2003). Yet the worldwide gains in average life expectancy at birth hide the massive disparities that persist between rich countries and poor countries, as well as within individual countries. Global life expectancy at birth currently ranges from 81.4 years for women in the established market economies of Western Europe, North America, and Japan, down to 48.1 years for men in sub-Saharan Africa—a staggering 33.3-year disparity (Bonita and Mathers 2003). In sub-Saharan Africa, where the impact of HIV/AIDS has been most devastating, the United Nations Development Program projects that between 2000 and 2005, life expectancy will actually decline by 34 years in Botswana, 26 years in Zimbabwe, 19 years in South Africa, and 17 years in Kenya (United Nations Development Program 2002).

The magnitude and persistence of health disparities within the wealthiest countries are equally striking. In the United States, a black male born in the District of Columbia can expect to live 57.9 years—lower than the life expectancy of the male citizens of Ghana (58.3 years), Bangladesh (58.1 years), or Bolivia (59.8 years). By contrast, an Asian-American woman born in Westchester County, New York, can expect to live on average for 90.3 years (Murray et al. 1998).

These disparities arouse both shock and indignation. But what exactly do we mean by the term “health disparities,” and what causes them? In this commentary we summarize our current understanding of health

disparities and provide guidance for future research and practice in this area within the field of environmental health. In the first section, we define health disparities and provide a description of their extent and nature. In the second, we discuss current theories about the causes of health disparities and provide a case study of health disparities from the field of environmental health (the differential health impacts of air pollution by socioeconomic status). In the final section, we present a blueprint for the future of environmental health research and practice to eliminate health disparities.

What Is a Health Disparity?

There is no single, agreed-upon definition of health disparities. In a comprehensive review of research and policy documents, Carter-Pokras and Baquet (2002) identified no fewer than 11 different definitions of health disparity. Although the definitions varied in crucial respects, they all had in common the key notion of differences in health status across population groups, whether defined by race or ethnicity, gender, social class, geographic location, or sexual orientation. As a matter of scientific practice, the authors noted that the term “disparity” has been used almost exclusively in the United States, whereas other terms such as “health inequality” or “health inequity” are more commonly used outside the United States.

In the absence of a universally agreed-upon definition, health disparities may therefore be thought of as a generic descriptive term to refer to differences or variations in health status between defined population groups. We hasten to add that “differences” (or “variations”) is a loaded term because it leaves open the questions of differences compared with whom and how the differences have been measured (e.g., on the absolute

scale vs. the relative scale). Even more important, the terms health inequality and health inequity, which are often used interchangeably with health disparities, are, in fact, conceptually distinct (Kawachi et al. 2002).

Health inequality is a purely descriptive term referring to any difference in health status between individuals or groups. For example, some people smoke cigarettes their whole life and never succumb to illness, whereas someone else does exactly the same thing (e.g., smokes at the same intensity for the same duration and eats the same quantity of yellow and green vegetables, etc.) but dies of lung cancer. The term health inequality, being purely descriptive, does not imply any moral judgment, as in the preceding example. By contrast, health inequity refers to those inequalities in health that are judged to be unfair or that stem from some form of injustice. Dahlgren and Whitehead (1991) have proposed further distinctions such as whether the inequalities are avoidable or unnecessary. In any case, judgments about fairness or avoidability involve values that science alone cannot adjudicate. Moreover, the distinction between a health inequality and health inequity depends crucially on one's underlying theory about what caused the observed differences. For example, cigarette manufacturers have long maintained that the 2-fold difference in smoking prevalence between poor and middle-class Americans is purely a result of differences in individual choice. However, if a child growing up in a poor community is more likely to become addicted to cigarettes because of outdoor advertising targeted to such communities, few would disagree that the resulting disparity in smoking prevalence between residents of poor and middle-class communities is, in fact, an instance of health inequity.

The important point to note from the preceding discussions is that, notwithstanding the apparent neutrality (and hence political acceptability) of the term health disparity, what we are really interested in eliminating are health inequities. Eliminating a health inequity is both potentially feasible and morally desirable. By contrast, it is unrealistic (and most likely infeasible) to expect that all health disparities could be eliminated because even under conditions of a fair and just distribution of opportunities and social conditions, health status differences would persist because of *a*) chance (including biological variation); *b*) health-promoting or health-damaging behaviors

that are freely chosen; and *c*) life-cycle differences in health status (Kawachi et al. 2002).

What Causes Health Disparities?

The most interesting and challenging aspects of health disparities research to date have focused on efforts to better understand the causal mechanisms underlying the genesis, reproduction, and persistence of disparities. There are four classes of causes of health disparities: *a*) chance, which includes inherited predisposition to health or illness; *b*) personal choices; *c*) access to medical care; and *d*) the environment, including both its physical and social dimensions. Obviously, these are not mutually exclusive categories, and specific causes may interact with one another to produce health disparities (more on this later). We discuss each of these explanations below.

THE ROLE OF LUCK (INCLUDING BIOLOGICAL INHERITANCE)

As alluded to previously, chance or luck (including inherited susceptibility to disease) is usually thought of as a source of health inequality rather than a health inequity. However, just how much of any given health disparity can be explained by inherited biological variation is often highly contested.

For example, a widely held belief (still) is that black/white disparities in health status can be accounted for by biological differences between the "races." The supposedly innate biological inferiority of black Americans relative to white Americans was frequently invoked as a defense of slavery during an earlier era (Krieger 1987). In more recent years, biological explanations of racial disparities have again risen to prominence in the wake of the Human Genome project and the search for race-based genetic markers of susceptibility to diseases such as hypertension and diabetes mellitus.

The prevalence of hypertension and diabetes among black Americans is 2–3 times that of white Americans (National Center for Health Statistics 1998). If faulty genes are responsible for these disparities, the remedies (as well as the moral implications) obviously would be very different than if other causes—for example, exposure to lead in the environment—were the culprit. It remains unproven whether the observed racial disparities in diseases such as hypertension and diabetes are attributable to differences in the average genetic risks of racial groups. Meanwhile, representative surveys of populations in West Africa and African-origin

populations in the Caribbean reveal prevalence rates of hypertension and diabetes 2–5 times lower than among black Americans or black Britons, implicating a strong environmental contribution to their etiology (Cruickshank et al. 2001).

THE ROLE OF PERSONAL CHOICE

The role of personal choice in the genesis of health disparities is similarly contested. The controversy usually revolves around how much of any given health disparity reflects differences in freely chosen health-damaging (or health-protecting) behaviors, as opposed to reflecting social constraints on such behaviors. For example, rational addiction theory in economics posits that fully informed, forward-looking, rational consumers make the decision to use cigarettes after weighing the benefits of smoking (i.e., enjoyment) against the costs (i.e., risk of disease and premature death) (Becker and Murphy 1988). Counterarguments to this approach point out that the overwhelming majority of smokers (85%) become addicted to the habit before the legal purchasing age of 18, when society deems them incapable of making informed choices based on weighing the risks and benefits. Furthermore, children in disadvantaged socioeconomic circumstances face more pressures to start smoking than their middle-class counterparts (e.g., because of advertising targeted to their neighborhoods) and fewer incentives to resist (e.g., other competing risks that threaten their health in their immediate environment) (Ganz 2000).

THE ROLE OF HEALTH CARE

Few would dispute that unequal access to health care is an important determinant of health disparities or that the sheer number of uninsured citizens in this country represents a gross injustice. What is less clear is the size of the contribution that health care, or the lack of access to it, makes to any given health disparity. Health disparities persist in societies in which citizens have universal access to health care. The most likely explanation is because medical care is just one of a number of factors influencing population health status and the extent of health disparities. Hence, although achieving universal health care remains an urgent national priority, expanding medical care coverage alone is unlikely to eliminate health disparities (Kawachi and Kennedy 2002).

THE ROLE OF THE ENVIRONMENT

The fourth and final determinant of health disparities is the environment, broadly construed. As the author of the textbook *Environmental Health* argues, the concept of “the environment” is not simply confined to the ambient physical environment (e.g., air pollution or drinking water quality) (Moeller 1992). Instead, a broader conceptualization of the environment needs to embrace aspects of the social contexts in which people grow up (the family environment), earn a living (the psychosocial work environment), and socially interact with one another (the neighborhood social environment). This view is also reflected in a recent document published by the U.S. Environmental Protection Agency (U.S. EPA), the *Framework for Cumulative Risk Assessment* (U.S. EPA 2003), which includes social stressors along the spectrum of determinants of health important to consider in risk assessment.

Such broadening of the concept of the environment opens up a far richer array of the causal pathways that generate health disparities as well as potential strategies to remedy them. For each domain of the social environment (family, work, neighborhoods), a solid knowledge base exists from which we can explain, and intervene on, health disparities. Thus, in the case of the family environment, Taylor et al. (1997) provide a review of the risk and protective factors (e.g., parenting styles, the presence of child abuse and neglect) that influence human development and that can account for health disparities that emerge in later adult life. Similarly, a vast and growing literature on the psychosocial work environment describes how the labor market sorts workers into healthy or unhealthy job conditions (Marmot et al. 1999). Working environments are important contributors to health disparities not only because of the obvious socioeconomic differentials in physical hazards and exposure to carcinogens but also because of psychosocial exposures such as job strain and social support.

More recently there has been converging interest among social epidemiologists, environmental epidemiologists, sociologists, geographers, and urban planners in understanding the role of residential neighborhood environments as an input to health and health disparities (Kawachi and Berkman 2003). This area of inquiry posits that where people live can affect their health chances independent of their personal choices and characteristics. Combined with the fact that neighborhoods tend to

be segregated (by race and class), this area of research offers a potentially powerful explanation for the genesis and reproduction of health disparities.

The example of the unequal (and inequitable) targeting of tobacco advertising to disadvantaged neighborhoods has already been mentioned. In addition, neighborhoods also vary systematically in other dimensions such as access to services (job markets, police protection, location of fast food outlets), access to physical infrastructure (parks and playgrounds that facilitate recreational physical activity, housing), social interactions (social capital, exposure to crime), as well as the more traditional aspects of physical environment such as exposure to noise, air pollution, and traffic (Kawachi and Berkman 2003).

In many cases, individual domains of the residential environment can interact with one another or with personal characteristics (e.g., individual class position) to give rise to health disparities. A notable example of such interaction was described in a case study of the mortality crisis after the 1995 heat wave in Chicago (Klinenberg 2002). During that heat wave, the chances of survival were not random but displayed a systematic social pattern according to personal characteristics (males, the elderly, and African-American residents were at much higher risk of death) as well as community characteristics. Communities characterized by richer social interactions proved to be more effective at promoting perceptions of safety, thereby pulling isolated seniors out of their homes and into emergency cooling stations. What is clear is that health disparities are often generated both by the unequal burden of exposure to risk and protective factors in the environment and by the unequal effects of any given exposure on vulnerable individuals. We turn now to a case study of an environmental health disparity to further illustrate these points.

Air Pollution as a Source of Health Disparities

A variety of environmental exposures have been linked to health disparities. Extreme heat (Klinenberg 2002) and exposure to lead in homes are well-documented examples (Bailey et al. 1994). Outdoor air pollution exposure has been studied extensively in relation to adverse health outcomes (Brunekreef and Holgate 2002), and a growing body of research has evaluated the contribution of air pollution to health disparities

(e.g., Gwynn and Thurston 2001; Martins et al. 2004; Zanobetti and Schwartz 2000). Several expert workshops have been convened to discuss methodologic and research needs in this area (American Lung Association 2001; O'Neill et al. 2003), reflecting the convergence of interests of researchers to transcend traditional disciplinary boundaries and to combine the insights from fields such as environmental health, epidemiology, and sociology. To illustrate possible future directions and questions raised by this type of research, we summarize recent results indicating that long-term exposure to air pollution has a disproportionate impact on mortality rates among individuals with lower socioeconomic status.

Three studies on chronic exposure to air pollution and mortality conducted in the United States and the Netherlands are considered among the most powerful evidence linking air pollution to health. A recent re-evaluation of two U.S. studies—the American Cancer Society (ACS) cohort that spans 150 cities (Pope et al. 1995) and the Harvard Six Cities Study (Dockery et al. 1993)—collectively representing the experience of > 500,000 people, evaluated the health impact of air pollution exposure by level of educational attainment [Health Effects Institute (HEI) 2000]. Relative risks of mortality were expressed per mean difference in fine particle concentrations, comparing the cleanest with the dirtiest cities in each cohort (24.5 $\mu\text{g}/\text{m}^3$ for the ACS cohort, 18.6 $\mu\text{g}/\text{m}^3$ for the Six Cities Study) across subjects stratified by three levels of educational attainment: less than high school, high school, and greater than high school completion. For both cohorts, a monotonic increase in risk of all-cause mortality was observed with decreasing educational attainment. A subsequent analysis of the ACS cohort revealed a similar pattern across levels of schooling (Pope et al. 2002a). Finally, a Dutch cohort study of 5,000 elderly people who were followed from 1986 to 1994 had rate ratios of all-cause mortality across levels of long-term exposure to black smoke that showed a monotonic increase by decreasing levels of educational attainment (greater than high school, vocational, and primary education) (Hoek et al. 2002).

A separate line of inquiry in social epidemiology has established that higher educational attainment is robustly associated with better health outcomes (Acheson 1998). The likely mechanisms linking schooling to better health outcomes include increased

knowledge about health promotion; improved ability to manage chronic disease and to navigate the health care system (health literacy); skills to manage household budgets and plan for the future; and a host of indirect effects such as access to prestigious jobs, higher incomes, and powerful social connections (social capital). The implication of both the air pollution studies and the studies of the effects of schooling on health is that improved educational opportunities may be an important avenue for mitigating the adverse effects of pollution as well as minimizing health disparities. However, identifying the precise mechanisms responsible for the unequal burden of air pollution among the less educated is an important next step (Finkelstein 2002; Pope et al. 2002b). Are these disparities due to higher exposures among the less educated? Are they due to inequalities in underlying vulnerability related to differential prevalence of co-morbid medical conditions among the less educated? What are the implications of these disparities for overall population estimates of air pollution effects? Do the patterns differ across communities and nations, and how do they relate to other dimensions of social disparities? Finally, these results bring up important policy questions: What are effective interventions to reduce the apparent unequal burden of air pollution exposure among those in lower socioeconomic strata? What are the relative benefits and costs of providing greater access to education versus targeting efforts to reduce air pollution within certain communities identified as being particularly exposed and/or vulnerable?

Clearly, documenting population-level disparities is valuable but additional research is also needed to inform appropriate action and solutions. Recent research has begun to examine the effects of specific environmental interventions on health, not only quantifying the improvements in health that result from a given reduction in exposure but also linking these reductions in exposure to policies that were not specifically designed to improve health. Two salient examples in the air pollution field include a study of the effects of a ban on coal sales in Ireland on air pollution-related mortality and morbidity (Clancy et al. 2002) and a study showing how reducing motor vehicle traffic in Atlanta, Georgia, during the 1996 Olympics reduced ozone pollution and childhood asthma hospitalizations (Friedman et al. 2001).

Combining intervention research with information on social disparities in health outcomes and exposure can thus provide valuable insights into societal action to reduce health disparities.

The Future of Environmental Health Research and Practice to Address Health Disparities

Research on health disparities is an increasingly interdisciplinary endeavor. Within the public health sector, we have highlighted the need for environmental epidemiologists to focus more on the influence of the social environment, that is, the differential effects of physical, chemical, and biological exposures on the health of the disadvantaged. Correspondingly, there is a need for social epidemiologists to focus more on the physical dimensions of the environment through better measures of the built environment, as well as incorporating the collection of biomarkers in study designs, including the assessment of potential gene and environment interactions.

One important legacy of Ken Olden's leadership of the NIEHS is the emphasis on and funding for community-based participatory research. This emphasis has resulted in several successful collaborations and new insights into reducing health disparities within the context of environmental health (O'Fallon and Derry 2002). The process of engaging community organizers and policymakers in designing, conducting, and applying research and establishing trusting relationships among diverse stakeholders is slow; therefore, funding and support for this kind of initiative needs to be sustained and enhanced to allow for continued progress. Recently, Schulz and Northridge (2004) have called for a shift in emphasis from environmental remediation toward environmental health promotion as a means of addressing health disparities. According to Schulz and Northridge (2004), successful environmental health promotion requires addressing social, economic, and political disparities at a societal level, as well as cooperation among diverse actors to address these disparities by ensuring that health and equity issues are addressed by and studied within the context of "urban planning, housing, transportation and social welfare initiatives."

Clearly, the issue of health disparities in environmental health has risen to prominence, as evidenced by the U.S. EPA's integration of these issues into its risk

assessment framework as well as the establishment of the Interagency Working Group for Community-Based Participatory Research, a federal-coordinating body for community-based participatory research (<http://www.niehs.nih.gov/translat/IWG/iwghome.htm>).

In addition to emphasizing the importance of community-based research, Dr. Olden embraced the promise of advances in genetics and molecular science and encouraged the integration of these advances in environmental health research. Sociologist Sara Shostak posits that the ability to identify individual susceptibilities on the basis of genetic variability, as well as to document exposures to environmental contaminants through the use of increasingly sophisticated molecular techniques, has potential revolutionary implications for environmental health (Shostak 2004). Her interviews with environmental justice activists revealed concern that an increased focus on genetic susceptibility has the potential to divert efforts to reduce environmental exposure in vulnerable communities toward a focus on identifying individual susceptibilities, including the potential of overemphasizing genetic susceptibility by race while ignoring the social and political aspects of racism in creating social disparities and environmental inequities. At the same time, many of those working to reduce social disparities in environmental exposure health acknowledge the value of documenting environmental exposures via biomarkers, such as blood lead levels, or molecular “signatures” of genetic damage (Shostak 2004). Such evidence can benefit legal actions and political pressure to remedy situations of inequitable environmental exposures. Clearly, these advances in molecular science have the potential to shift the focus in environmental health protection toward an individualized, “biomedicalized” approach rather than toward the population-level cooperative efforts envisioned by Schulz and Northridge (2004).

Ultimately, the challenge for the future of environmental health research is to use advances in science as a means for understanding exposure and susceptibilities, while retaining an emphasis on prevention of exposure, and working with diverse actors to address fundamental causes of social disparities. The future of research on social disparities and environmental health will depend on implementing the vision set forth by innovators such as Dr. Ken Olden.

SUMMARY

Health disparities have received growing attention in recent years from the environmental health research community. A variety of environmental exposures (e.g., outdoor air pollution, extreme heat, exposure to lead in homes) has been linked to health disparities. For example, the excess mortality risk associated with air pollution has been shown to be greater among lower socioeconomic groups. These disparities simultaneously reflect the unequal burden of exposure to pollution among different socioeconomic groups and the unequal impacts of a given level of exposure on vulnerable individuals. In this essay, we consider a framework for describing the causes of health disparities. Broadly speaking, health disparities stem from four groups of causes: *a*) chance, which includes inherited predisposition to disease; *b*) personal choices; *c*) differential access to medical care; and *d*) differential exposure to risk and protective factors in the physical and social environment. Reducing health disparities calls for interventions that address all these component causes.

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NOTES

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REFERENCES

- Acheson D. 1998. *Independent Inquiry into Inequalities in Health*. London: The Stationery Office.
- Adler NE, Ostrove JM. 1999. Socioeconomic status and health: what we know and what we don't. *Ann NY Acad Sci* 896:3-15.
- American Lung Association 2001. *Urban air pollution and health inequities: a workshop report*. *Environ Health Perspect* 109:357-374.
- Bailey AJ, Sargent JD, Goodman DC, Freeman J, Brown MJ. 1994. Poisoned landscapes: the epidemiology of environmental lead exposure in Massachusetts children 1990-1991. *Soc Sci Med* 39:757-766.
- Becker GS, Murphy KM. 1988. A theory of rational addiction. *J Polit Econ* 96:675-700.
- Bonita R, Mathers CD. 2003. Global health status at the beginning of the twenty-first century. In: *Global Public Health: A New Era* (Beaglehole R, ed). Oxford, UK: Oxford University Press, 24-53.
- Brunekeerf B, Holgate ST. 2002. Air pollution and health. *Lancet* 360: 1233-1242.
- Carter-Pokras O, Baquet C. 2002. What is a "health disparity"? *Public Health Rep* 117:426-434.
- Clancy L, Goodman P, Sinclair H, Dockery DW. 2002. Effect of air-pollution control on death rates in Dublin, Ireland: an intervention study. *Lancet* 360:1210-1214.

- Cruickshank JK, Mbanya JC, Wilks R, Balkau B, McFarlane-Anderson N, Forrester T. 2001. Sick genes, sick individuals or sick populations with chronic disease? The emergence of diabetes and high blood pressure in African-origin populations. *Int J Epidemiol* 30:111–117.
- Dahlgren G, Whitehead M. 1991. *Policies and Strategies to Promote Social Equality in Health*. Stockholm:Institute of Future Studies.
- DHHS. 2000. *Healthy People 2010: Understanding and Improving Health*. Washington, DC:U.S. Department of Health and Human Services.
- DHHS. 2004. *Making Cancer Health Disparities History: Report of the Trans-HHS Cancer Health Disparities Progress Review Group*. Washington, DC:U.S. Department of Health and Human Services.
- Dockery DW, Pope AC, Xu X, Spengler JD, Ware JH, Fay ME, et al. 1993. An association between air pollution and mortality in six U.S. cities. *N Engl J Med* 329:1753–1759.
- Finkelstein MM. 2002. Pollution-related mortality and educational level. [Letter] *JAMA* 288:830.
- Friedman MS, Powell KE, Hutwagner L, Graham LM, Teague WG. 2001. Impact of changes in transportation and commuting behaviors during the 1996 summer olympic games in Atlanta on air quality and childhood asthma. *JAMA* 285:897–905.
- Ganz ML. 2000. The relationship between external threats and smoking in central Harlem. *Am J Public Health* 90:367–371.
- Gwynn RC, Thurston GD. 2001. The burden of air pollution: impacts among racial minorities. *Environ Health Perspect* 109:501–506.
- HEI. 2000. *Reanalysis of the Harvard Six Cities Study and the American Cancer Society Study of Particulate Air Pollution and Mortality (a Special Report of the Institute's Particle Epidemiology Reanalysis Project)*. Cambridge, MA:Health Effects Institute. Available: <http://www.healtheffects.org/pubs-special.htm> [accessed 24 September 2004].
- Hoek G, Brunekreef B, Goldbohm S, Fischer P, van den Brandt PA. 2002. Association between mortality and indicators of traffic-related air pollution in the Netherlands: a cohort study. *Lancet* 360:1203–1209.
- Kawachi I, Berkman L. 2003. *Neighborhoods and Health*. New York:Oxford University Press.
- Kawachi I, Kennedy BP. 2002. *The Health of Nations: Why Inequality Is Harmful to Your Health*. New York:New Press.
- Kawachi I, Subramanian SV, Almeida-Filho N. 2002. A glossary for health inequalities. *J Epidemiol Comm Health* 56:647–652.
- Klinenberg E. 2002. *Heat Wave: A Social Autopsy of Disaster in Chicago*. Chicago:University of Chicago Press.
- Krieger N. 1987. Shades of difference: theoretical underpinnings of the medical controversy on black/white differences in the United States, 1830–1870. *Int J Health Serv* 17:259–278.
- Krieger N, Fee E. 1996. Measuring social inequalities in health in the United States: a historical review, 1900–1950. *Int J Health Serv* 26:391–418.
- Link BG, Phelan J. 1995. Social conditions as fundamental causes of disease. *J Health Soc Behav (Spec iss)*:80–94.
- Marmot M, Siegrist J, Theorell T, Feeney A. 1999. Health and the psychosocial environment at work. In: *Social Determinants of Health* (Marmot M, Wilkinson RG, eds). Oxford, UK:Oxford University Press, 105–131.
- Martins MC, Fatigati FL, Vespoli TC, Martins LC, Pereira LA, Martins MA, et al. 2004. Influence of socioeconomic conditions on air pollution adverse health effects in elderly people: an analysis of six regions in Sao Paulo, Brazil. *J Epidemiol Community Health* 58:41–46.
- Moeller DW. 1992. *Environmental Health*. Cambridge, MA:Harvard University Press.
- Murray CJL, Michaud CM, McKenna MT, Marks JS. 1998. *United States Patterns of Mortality by County and Race, 1965–1994*. Cambridge, MA:Harvard University Burden of Disease Unit, Harvard Center for Population and Development Studies, and the Centers for Disease Control and Prevention.
- National Center for Health Statistics. 1998. *Health, United States, 1998, with Socioeconomic Status and Health Chartbook*. DHHS Publ no. PHS 98-1232. Hyattsville, MD:U.S. Department of Health and Human Services.
- O'Fallon LR, Dearry A. 2002. Community-based participatory research as a tool to advance environmental health sciences. *Environ Health Perspect* 110:155–159.
- 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.
- Pope CA III, Burnett RT, Thun MJ, Calle EE, Krewski D, Ito K, et al. 2002a. Lung cancer, cardiopulmonary mortality, and long-term exposure to fine particulate air pollution. *JAMA* 287:1132–1141.
- Pope CA III, Burnett RT, Thurston GD. 2002b. Pollution-related mortality and educational level [Author Reply]. *JAMA* 288:830.
- Pope CA III, Thun MJ, Namboodiri MM, Dockery DW, Evans JS, Speizer FE, et al. 1995. Particulate air pollution as a predictor of mortality in a prospective study of U.S. adults. *Am J Respir Crit Care Med* 151:669–674.
- Schulz A, Northridge ME. 2004. Social determinants of health: implications for environmental health promotion. *Health Educ Behav* 31:455–471.
- Shostak S. 2004. Environmental justice and genomics: acting on the futures of environmental health. *Sci Cult* 13(4):539–562.
- Taylor SE, Repetti RL, Seeman T. 1997. Health psychology: what is an unhealthy environment and how does it get under the skin? *Annu Rev Psychol* 48:411–447.
- United Nations Development Program. 2002. *Human Development Report 2002*. New York:Oxford University Press.
- U.S. EPA. 2003. *Framework for Cumulative Risk Assessment*. EPA/600/P-02/001F. Washington, DC:U.S. Environmental Protection Agency. Available: <http://cfpub.epa.gov/ncea/raf/recordisplay.cfm?deid=54944> [accessed 24 September 2004].
- Zanobetti A, Schwartz J. 2000. Race, gender, and social status as modifiers of the effects of PM₁₀ on mortality. *J Occup Environ Med* 42:469–474.