Poverty, Environment, and Health

The Role of Environmental Epidemiology and Environmental Epidemiologists

Marie S. O'Neill,† Anthony J. McMichael,‡ Joel Schwartz,§ and Daniel Wartenberg¶*

Abstract: International attention is focusing increasingly on environmental concerns, from global warming and extreme weather to persistent chemical pollutants that affect our food supplies, health and well-being. These environmental exposures disproportionately affect the poor and those residing in developing countries, and may partly explain the persistent social gradients in health that exist within and between nations. We support recent calls for environmental epidemiologists to play a more active role in furthering the global agenda for sustainability, environmental health and equity. We further suggest that the discipline of environmental epidemiology, as well as relevant funding agencies, broaden their focus to include rigorous research on the upstream, larger-scale societal factors that contribute to inequitable patterns of exposure and health outcomes. By widening the scope of our vision and increasing the strength and breadth of the evidence base about how poverty and environment together affect health, we can better participate in efforts to promote social justice and responsible use and protection of the environment, and thus reduce health inequities. That is both a primary mode and rationale for achieving sustainability.

(*Epidemiology* 2007;18: 664–668)

Poverty and its impact on human development have been the focus of concern, study, and interventions for centuries. More recently, issues of poverty have become entwined with environmental issues. The changing environment affects the human condition, often in the interaction with poverty and social injustice. Such problems have become increasingly prominent concerns in research and public health practice. Environmental concerns include the growth of the world's population, technological development, and the increase of environmental contamination and pollution worldwide—disrupting various physical, chemical and biologic processes, and even entire ecosystems. Today, the prospect of major environmental changes and potential disasters, such as global warming, water shortages, and inadequate local food supplies in some regions, have led to a reconsideration and reevaluation of where the world is heading, and what policy and technical responses are needed to sustain our very being.

This month, in light of these concerns, more then 220 scientific journals throughout the world will simultaneously "publish papers . . . to raise awareness, stimulate interest, and stimulate research into poverty and human development."[1] The International Society for Environmental Epidemiology (ISEE) is proud to have been invited to participate even though the society is not typically thought of as addressing issues of poverty and human development. For many years, we have been the primary professional society associated with the journal EPIDEMIOLOGY, and have proffered commentaries from leading environmental epidemiologists on pressing environmental health problems of our time, including the potential role of environmental exposures in the association of poverty and health, and suggestions of specific research directions for improving public health globally.[2,3]

Foremost among these efforts has been an examination of the United Nations' Millennium Development Goals (MDGs),[4] including discussions at a plenary session of our 2005 Annual Conference held in Johannesburg, South Africa. Based in part on that session, in which several of us participated, Soskolne and colleagues,[5] in these pages, called for focusing increased concern and action on sustainability. Specifically, they stressed the importance of linking concerns about equity, both within and between nations, to the environmental exposures that likely contribute to persistent social gradients in health.[5,6] This proposal addressed the links between environment, health and sustainability and called for a broadening of the traditional vision of environmental epidemiology to integrate "sustainability," with a more global and international focus, particularly addressing North-South equity concerns.

Building on this seminal proposal, we suggest several emerging directions for environmental epidemiology that

Submitted 13 July 2007; accepted 31 July 2007.

From the Departments of *Epidemiology and †Environmental Health Sciences, School of Public Health, University of Michigan, Ann Arbor, Michigan; ‡National Centre for Epidemiology and Population Health, The Australian National University, Canberra, Australia; §Department of Environmental Health, Harvard School of Public Health, and Channing Laboratory, Harvard Medical School, Boston, Massachusetts; and ¶Division of Environmental Epidemiology, Department of Environmental and Occupational Medicine, UMDNJ Robert Wood Johnson Medical School, New Jersey.

Correspondence: Marie S. O'Neill, University of Michigan School of Public Health, 6631 SPH Tower, 109 South Observatory, Ann Arbor, Michigan 48109-2029. E-mail: marieo@umich.edu.

ISSN: 1044-3983/07/1806-0664
DOI: 10.1097/EDE.0b013e3181570ab9

address the interactions of environmental exposures and poverty that may affect public health, the role of environmental epidemiology in research and action in response to these impacts, prospects for funding, and future directions for research and policy in the context of increasing interest in global health.

PHYSICAL ENVIRONMENTAL EXPOSURES AND POVERTY

Exposure to chemical, biologic, and radioactive substances that impair health continue to be important subjects of research and action,[2,3] with increasing and compelling evidence of irrevocable global environmental change due to human activities.[7] These activities bring to the fore the need to understand and adapt to the consequences of these changes for human health.[8] Priorities for study and subsequent intervention include respiratory infections and cardiovascular impairment associated with indoor exposures to air pollution from biomass fuel combustion[9]; similar effects of outdoor air pollutants[10,11]; diarrheal disease related to lack of adequate water for drinking and sanitation[12]; exposure to heatwaves such as the one occurring in Europe in 2003[13]; and increasing evidence of the role that persistent organic pesticides may play in reproductive and cancer outcomes.[14] Further, the populations most vulnerable to environmental insults are those with fewer resources, older technology, and more compromised health, and yet research and interventions are not always focused on these populations. It is imperative that, in conducting the research and recommending increased prevention, remediation, and interventions, we, as scientists, consider the interactive effects of these vulnerabilities (such as poverty, malnutrition and other medical impacts of deprivation) with environmental triggers in assessing effects and impacts. For example, in addressing the unusual frequency and severity of heat waves seen over the past few years in the United States and Europe, it is not sufficient to recommend that people spend more time in cool or climate-controlled locations, or that they get air conditioners or use other technological fixes, unless they have the access and resources to do so. It is also important to explore the role that environmental exposures, not simply social factors and deprivation, play in the association of poverty with health.

Poverty can mean different things in different contexts, depending on how it is measured and conceptualized, but the discussion about poverty is fundamentally linked with understanding the causes and implications of inequality in access to material and psychosocial goods and resources.[15] In recent years, environmental epidemiologists and others concerned with environmental health have been asking how the physical and social environments (conceptualized in terms of poverty, deprivation, and other metrics) together may contribute to worsening health and quality of life,[16,17] in part because of moral concerns about equity in the distribution of poor health and the circumstances that produce it,[18] but also out of concern about efficiency of interventions. Simultaneously, researchers focusing on social determinants of health are offering explanations that include physical environmental exposures patterned by social circumstances for observed differences in health outcomes across social groups or geographic areas.[19,20]

Young women carry buckets of laundry through trash piles in Kibera, Africa's largest slum, in Nairobi, Kenya.

One example of this growing interest is a recent review of the emerging literature examining how socioeconomic circumstances can modify the effects of air pollution on mortality.[21] This review highlights the challenges of making inference and generalizations when socioeconomic indicators are often available at only coarse geographic resolution or when variation in study designs prevents valid comparison of results. The authors comment on the importance of considering the ranges of typical exposures within different communities in evaluating how socioeconomic circumstances modify air pollution effects. Very large differences, indeed of varying orders of magnitude, in air pollution exposures are seen between cities in Asia and Africa and cities in many parts of the industrialized world, as substantiated by directly monitored and estimated levels of particulate pollution in hundreds of global cities.[22] Accounting for how these exposure differences may relate to or be modified by social context is an important research challenge.

The agendas of reducing such unfairly distributed environmental exposures (environmental justice) and the inequitable burden of poverty are converging, as reflected in recent suggestions to integrate efforts to make equitable environmental health policies with action on social, economic, and political disparities[23]; to address environmental health concerns along with the social determinants of health in governmental policies and programs[24,25]; and the inclusion of the concept of environmental equity in a separate chapter

of the 2006 global update of the World Health Organization (WHO) air quality guidelines.[26]

But how does integrated research that incorporates both poverty and environmental exposure provide evidence that can lead to preventive interventions?[27]

PREVENTIVE INTERVENTIONS

The definition of "preventive interventions" and the level at which they are implemented (from individually-based interventions, such as vitamin supplementation or genetic counseling to population-based changes in energy policy, tax structure and other "nonhealth" policies that have important health consequences) can influence the scope of the disciplinary lens of environmental epidemiology. Indeed, the debate over the purview of epidemiology and appropriate level of focus has been continuing for some time, addressing issues such as individual versus population health, upstream versus downstream causes, and what type of research will lead to the greatest good for population health.[28–31]

The global agenda that Soskolne and colleagues[5] propose may lead to beneficial changes as research questions are framed in a way that brings environmental health into discussions of such issues as energy use where the health implications often take a back seat to economic and other considerations. An excellent example of an energy-related preventive intervention is the coal use ban in Ireland, which resulted in substantial reductions in air pollution and declines in cardiovascular and respiratory mortality.[32]

One important feature of the MDGs, upon which the Soskolne global agenda is based, is that only the seventh explicitly addresses the environment (Table 1). In fact, sustainability and environmental quality are essentially prerequisites to attaining the other development goals, and it is therefore very important that the framers and government implementers of these goals consider them in this light.

A more integrated vision of health, human development, poverty reduction, and environmental improvements in global policy agenda is also called for by David Victor,[33] who suggests that the sustainable development agenda has actually been driven too much by environmental concerns in isolation from broader social and health considerations. Sustainable development's original purpose was to help "the poor live better, healthier, and fairer lives on their own terms," but this only can be achieved through "economic development, in particular poverty alleviation" as well as "the other 2 prongs of sustainability: environmental protection and social justice."[33] Victor recommends that the sustainability agenda "be revived by following 4 courses of action: making a priority of alleviating poverty, dropping the environmental bias that has hijacked the entire movement, favoring local decisions over global ambitions, and tapping into new technologies to spur sustainable growth."

For those of us who define ourselves by our interest in environmental health and quality, Victor's[33] perception that environmentalists have "hijacked" a movement with a narrow perspective that does not leave room for other concerns affecting health and development is food for thought. This call to broaden thinking to clarify linkages between environment and these other important goals might also be applied to the World Bank. The Bank is funding many water projects in the developing world in the interest in fostering improved health, but other environmental health concerns emerge from Bank-funded energy projects and roads. The poor tend to live closer to roads and polluting facilities, so these projects may be both increasing pollution and contributing to inequitable exposures. Recent studies on intake fraction (the likelihood of a particle or molecule penetrating into the lung) show that traffic exhaust can have an order of magnitude higher exposure probability, particularly near roads.[34] What is needed is a more holistic, or systems, approach to such situations, to make sure that the solution to one problem is not the cause of another.

Concerns about "unfair gaps" in health and well-being among "vulnerable and socially disadvantaged people" led to the formation of the WHO Commission on the Social Determinants of Health in 2005.[35] This WHO initiative, which has similarities to the global agenda for environmental epidemiology, explicitly calls for commitment to the value of equity, and advocates an "evidence-based approach" intended to encourage more effective translation of research results into policy action.[36] It also discusses the importance of studying the patterns of distribution of health determinants, thus requiring an approach that incorporates multiple causes—proximal, intermediate, and distal—of ill health.[35(p. 16)]

THE FUNDING CLIMATE

We strongly believe that research addressing complex systems and incorporating interdisciplinary approaches is needed to generate knowledge to inform prevention, foster sustainable development, and improve the human condition. These goals explicitly include examination of more upstream forces that affect the distribution of health-promoting or harming conditions, be they social or "environmental," as part of more traditional mechanistic research on health.

To facilitate and refocus research in this direction, funding sources, too, must prioritize research designed to

TABLE 1. The Eight Millennium Development Goals

1. Eradicate extreme poverty and hunger
2. Achieve universal primary education
3. Promote gender equality and empower women
4. Reduce child mortality
5. Improve maternal health
6. Combat HIV and AIDS, malaria, and other diseases
7. Ensure environmental sustainability
8. Develop a global partnership for development

integrate social conditions with environmental conditions, economic solutions with scientific solutions, short-term impacts with long-term impacts, and a focus on equity of care and health status for all. For example, we would like to see the strategic plan of the U.S. National Institute for Environmental Health Sciences (NIEHS), which has placed an emphasis on disease outcomes, clinical medicine and mechanistic research, broaden to call for research that addresses more upstream risks and exposures, and embrace more explicitly the broad concerns of equity and global sustainability. This same suggestion would apply to funding bodies in other parts of the world. We believe that mechanistic research (eg, effects of particular metals on cardiovascular function) and research that focuses on more broadly defined exposures and health outcomes (eg, effects of urban sprawl or green space on obesity rates) can both contribute to the evidence base for preventive interventions and lead to the improvement of the human condition. Although the use of modern molecular and genetic tools for promoting environmental justice has been met with mixed reviews by environmental justice activists, several acknowledge the importance of these sophisticated tools in providing strong evidence for exposures leading to adverse health outcomes in affected communities,[37] as do we. We note that global health is emerging as a priority for NIEHS,[38,39] and research areas under this rubric include health issues that disproportionately impact developing countries (including indoor biomass fuel burning), echoing the global agenda's call for more North-South collaboration. We hope that funding entities will follow up on and prioritize these types of issues and approaches.

More generally, we need to link the efforts of those who study the larger social forces that affect distributions of environmental exposures leading to ill health to those who focus on more proximate causes. The better-off in society often benefit before the poor when new preventive interventions are introduced, reinforcing inequalities in health over time.[40] This pattern suggests that a focus on understanding mechanisms by which environmental exposures contribute to disease without considering the context in which these exposures occur, will not lead to the most effective preventive interventions, and that a more broad-based, equity-focused approach would better improve health overall.

A further important concept in considering how environmental exposures may contribute to health inequities is the costs and benefits that accrue from technology use, and to whom. If those building coal-burning power plants in China, or using the electricity from them, had to internalize the currently external costs of the imposed health burden, they would make different choices about installing scrubbers or other control technologies. However, most current political and economic systems and market forces are ineffective at fostering the incorporation of externalities into environmental policy, and thus legislation and other proactive policies are needed to change the incentives, thereby benefiting the poor and vulnerable.[41] Countries such as China, which is accumulating wealth through successful trade policies and relatively low consumption, could invest some of this wealth in environmentally sustainable technologies, such as importing scrubbers for power plants.

FUTURE DIRECTIONS

ISEE activities pertaining to examination of the intersection of poverty and health include sessions at the annual meetings and specific outreach activities to foster more "North-South" collaborations and application of research results to action. Opportunities for further collaborations with those who research and encourage action on social inequalities in health should be sought. If environmental epidemiologists and environmental epidemiology are to contribute to local and global efforts to improve health, foster sustainable development, and achieve social justice, a broader vision of the scope of our research and action is necessary. As part of the ISEE leadership team, we plan to encourage and continue the dialogue on these issues so that we play a central and cooperative role with those outside our discipline who are working toward the same goals.

ABOUT THE AUTHORS

MARIE S. O'NEILL is an ISEE Councilor for the 2007–2009 term. Her research interests include environmental equity; health effects of exposure to air pollution and temperature extremes, and climate change and health. ANTHONY J. MCMICHAEL is the incoming President of ISEE. His primary research interest is in environmental epidemiology, with particular reference to climate change and to the broad influences of social and economic changes on patterns of health and disease. JOEL SCHWARTZ is an ISEE Councilor for the 2006–2008 term. His research includes outdoor and indoor air pollution, temperature extremes, disinfection byproducts, lead toxicity, cost-benefit analysis, and gene-environment interactions. DANIEL WARTENBERG has been a member of ISEE since its inception,and now serves as President (2006–2008). His primary research interests are environmental epidemiology and surveillance, with particular emphasis on disease prevention, disease clustering,and the application of geographic information systems (GIS).

ACKNOWLEDGMENTS

We thank Irina Mordukhovich for formatting assistance.

REFERENCES

1. Council of Science Editors. Global Theme Issue on Poverty and Human Development. Available at: http://www.councilscienceeditors.org/globalthemeissue.cfm. Accessed July 9, 2007.
2. McMichael AJ, Smith KR. Seeking a global perspective on air pollution and health. *Epidemiology*. 1999;10:1–4.

3. Hertz-Picciotto I, Brunekreef B. Environmental epidemiology: where we've been and where we're going. *Epidemiology*. 2001;12:479–481.
4. United Nations. UN Millenium Development Goals. Available at: http://www.un.org/millenniumgoals/. Accessed July 9, 2007.
5. Soskolne CL, Butler CD, Ijsselmuiden C, et al. Toward a global agenda for research in environmental epidemiology. *Epidemiology*. 2007;18:162–166.
6. Berkman LF, Kawachi I, eds. *Social Epidemiology.* 1st ed. New York, NY: Oxford Unviersity Press; 2000.
7. IPCC. Intergovernmental Panel on Climate Change. Climate change 2007: The Physical Science Basis. Summary for Policymakers. Available at: http://www.ipcc.ch/SPM2feb07.pdf. Accessed July 9, 2007.
8. Miller KA, Siscovick DS, Sheppard L, et al. Long-term exposure to air pollution and incidence of cardiovascular events in women. *N Engl J Med*. 2007;356:447–458.
9. McCracken J, Díaz A, Smith K, et al. Chimney stove intervention to reduce long-term woodsmoke exposure lowers blood pressure among Guatemalan women. *Environ Health Perspect*. 2007;155:996–1001.
10. Schwartz J. Long-term effects of exposure to particulate air pollution. *Clin Occup Environ Med*. 2006;5:837–848.
11. Katsouyanni K, Touloumi G, Samoli E, et al. Confounding and effect modification in the short-term effects of ambient particles on total mortality: results from 29 European cities within the APHEA2 project. *Epidemiology*. 2001;12:521–531.
12. Pruss-Ustun A, Corvalan C. How much disease burden can be prevented by environmental interventions? *Epidemiology*. 2007;18:167–178.
13. Le Tertre A, Lefranc A, Eilstein D, et al. Impact of the 2003 heatwave on all-cause mortality in 9 French cities. *Epidemiology*. 2006;17:75–79.
14. Kortenkamp A. Ten years of mixing cocktails—a review of combination effects of endocrine disrupting chemicals. *Environ Health Perspect.* [online]. July 2007.
15. Kim J, Millen J, Irwin A, Gershman J, eds. *Dying for Growth: Global Inequality and the Health of the Poor.* Monroe, Maine: Common Courage Press; 2000.
16. Evans GW, Kantrowitz E. Socioeconomic status and health: the potential role of environmental risk exposure. *Annu Rev Public Health*. 2002;23:303–331.
17. O'Neill MS, Jerrett M, Kawachi I, et al. Health, wealth, and air pollution: advancing theory and methods. *Environ Health Perspect*. 2003;111:1861–1870.
18. Braveman P, Gruskin S. Defining equity in health. *J Epidemiol Community Health*. 2003;57:254–258.
19. Diez Roux A, Green Franklin T, Alazraqui M, et al. Intraurban variations in adult mortality in a large Latin American city. *J Urban Health*. 2007;84:319–333.
20. Klinenberg E. *Heat Wave: A Social Autopsy of Disaster in Chicago.* Chicago, IL: The University of Chicago Press; 2002.
21. Laurent O, Bard D, Filleul L, Segala C. Effect of socioeconomic status on the relation between atmospheric pollution and mortality: a review. *J Epidemiol Community Health*. 2007;61:665–675.
22. Cohen AJ, Ross Anderson H, Ostro B, et al. The global burden of disease due to outdoor air pollution. *J Toxicol Environ Health A*. 2005;68:1301–1307.
23. Schulz A, Northridge ME. Social determinants of health: implications for environmental health promotion. *Health Educ Behav*. 2004;31:455–471.
24. Payne-Sturges D. Workshop summary: connecting social and environmental factors to measure and track environmental health disparities. *Environ Res*. 2006;102:146–153.
25. EPA US. Framework for Cumulative Risk Assessment. Available at: http://cfpub.epa.gov/ncea/raf/recordisplay.cfm?deid=54944. Accessed July 9, 2007.
26. World Health Organization. Air Quality Guidelines: Global Update 2005: Available at http://www.euro.who.int/document/E90038.pdf. Accessed July 9, 2007.
27. Samet JM. Environmental sustainability: a target for environmental epidemiology? *Epidemiology*. 2007;18:179–180.
28. Rockhill B. Theorizing about causes at the individual level while estimating effects at the population level: implications for prevention. *Epidemiology*. 2005;16:124–129.
29. Rothman KJ, Adami HO, Trichopoulos D. Should the mission of epidemiology include the eradication of poverty? *Lancet*. 1998;352:810–813.
30. Kaplan GA. The role of epidemiologists in eradicability of poverty. *Lancet*. 1998;352:1627–1628.
31. McMichael AJ. The role of epidemiologists in eradicability of poverty. *Lancet*. 1998;352:1627.
32. Clancy L, Goodman P, Sinclair H, Dockery DW. Effect of air-pollution control on death rates in Dublin, Ireland: an intervention study. *Lancet*. 2002;360:1210–1214.
33. Victor D. Recovering sustainable development. *Foreign Aff*. 2006;85:91–103.
34. Greco S, Wilson AM, Spengler JD, Levy JI. Spatial patterns of mobile source emissions to exposure relationships across the US. *Atmos Environ*. 2007;41:1011–1025.
35. WHO. Commission on the Social Determinants of Health. Available at: http://www.who.int/social_determinants/strategy/QandAs/en/index.html. Accessed July 9, 2007.
36. Kelly MP, Bonnefoy J, Morgan A, Florenzano F. The development of the evidence base about the social determinants of health. In: Mekn, ed. *World Health Organization Commission on Social Determinants of Health.* Available at: http://www.who.int/social_determinants/resources/mekn_paper.pdf. Accessed July 9, 2007.
37. Shostak S. Environmental justice and genomics: acting on the futures of environmental health. *Sci Cult*. 2004;13:539–562.
38. National Institute of Environmental Health Sciences. NIEHS strategic plan: new frontiers in environmental sciences and human health. *Environ Health Perspect.* 2006;114:A280–A283.
39. National Institute for Environmental Health Sciences. Global Environmental Health: Conference Summary. Available at: http://www.niehs.nih.gov/external/geh/summary.htm. Accessed July 9, 2007.
40. Victora CG, Vaughan JP, Barros FC, Silva AC, Tomasi E. Explaining trends in inequities: evidence from Brazilian child health studies. *Lancet*. 2000;356:1093–1098.
41. Butler C, McMichael A. Environmental justice: the role of epidemiology in protecting unempowered communities from environmental hazards. In: Sidel V, Levy B, eds. *Social Injustice and Public Health*. Oxford, UK: Oxford University Press; 2006:318–336.