Summary of the PERN Cybersminar
Air Pollution and Health Linkages

1-15 December 2003

This Population-Environment Research Network (PERN) Cyberseminar sought to identify the most pressing issues and topics for research and policy in linking air pollution (both indoor and outdoor) and human health. More than 340 researchers were subscribed to the seminar's discussion list, and there were 77 postings, including six panel statements by the following experts:

Dr. Aaron Cohen, Health Effects Institute, Boston, Massachusetts, USA
Dr. Majid Ezzati, Harvard University, Boston, Massachusetts, USA
Dr. Adrian Fernandez, Leonora Rojas-Bracho, and Miriam Zuk, National Institute of Ecology, Mexico
Dr. Bart Ostro, Ph.D., Chief, Air Pollution Epidemiology Unit, California Office of Environmental Health Hazard Assessment, Oakland, California, USA
Dr. Sumeet Saksena, East-West Center, Honolulu, Hawaii, USA
Dr. Kirk Smith, University of California, Berkeley, California, USA

The seminar background paper by Dr. Vinod Mishra (East-West Center) and a complete archive of postings to the seminar discussion list can be found at http://www.populationenvironmentresearch.org/seminars.jsp (click on "View Postings"). This report serves as a summary of the discussion by major thematic area – Air Pollution and the Burden of Disease, Urban Air Pollution, Indoor Air Pollution, and Tools and Methods – and includes a list of resources and citations mentioned by participants. Wherever possible, affiliation information is provided for those who made contributions.

Air Pollution and the Burden of Disease

In his panel statement, Aaron Cohen reported that considerable uncertainties exist in the estimates of that portion of the global burden of disease attributable to air pollution. In a study he led, they estimated that outdoor air pollution, characterized as fine particulate matter (PM2.5, or particulate matter smaller than 2.5 microns) is currently responsible for about 0.80 million (1.2% of world total) premature deaths and 6.4 million (0.5% of world total) Years of Life Lost (YLL) in the populations of the world's large cities (>100,000). He reports that the estimates were subject to considerable uncertainty due largely to the lack of air pollution measurements and information about the shape of concentration-response functions in developing countries. He cited a need for:

- Better estimates not only of ambient concentrations but also of the characteristics of outdoor air pollution, including the contribution of various sources and the size distribution of particulate matter (PM).
- Epidemiologic studies of the effects of long-term exposure to air pollution and mortality from chronic cardio-vascular and respiratory disease. These should be designed to provide age- and disease-specific estimates of air pollution effects.
- Epidemiologic studies of the effect of air pollution on the incidence of acute and chronic cardiovascular and respiratory disease in adults and children (e.g., acute respiratory infections).

Lorena Rojas Bracho reported on a study conducted in Ciudad Juárez, a large Mexican border city, which found that ambient PM10 could increase the risk of mortality due to respiratory causes of poor children between the ages of 1 month and one year old. The authors reported a 62 percent increase in mortality in this age and SES group for a 20μg/m3 PM10 increase.

Duc Hiep (Department of Environment and Conservation, New South Wales, Australia) agreed with Dr. Cohen's assessment about the inadequacy of PM data (PM10 and PM2.5) in health effect studies of air pollution. In the majority of cases, motor vehicles and industry are the main sources of PM. Particle size is important but so is the composition of volatile organic compounds and soot in particles (especially PM2.5).The quality of fuels (including diesel) are different in different countries. So a particular health effect of PM study in a particular city may not give comparative results to another study in a different city or country. Furthermore the different methods, protocols and quality assurances of measuring PM10 and PM2.5 are contributing to the uncertainty in comparative studies.

In his panel statement, Bart Ostro wrote that scores of studies conducted on five continents have documented consistent associations between short-term exposures to ambient particulate matter measured as PM10 and PM2.5 and daily counts of mortality and hospitalization (CARB 2002). These fairly consistent associations suggest that exposure to ambient air pollution is a risk factor for exacerbation of pre-existing cardiac and respiratory illnesses, though pathophysiological mechanisms are not well understood. In contrast, much less is known about: (1) the health impacts of longer-term (i.e., one year or more) exposure, particularly on the development of cardiac or respiratory diseases; and (2) the roles of specific sources, especially traffic-associated emissions, with respect to the pathogenesis of chronic illness.

Ostro's statement sparked some discussion on agricultural land-burning, as well as dust during dry season. Wisa Supanpaiboon wrote to say that in rural areas in Thailand, after rice harvesting farmers burn the stubble and crop residues and a large area is covered by smoke. Ostro responded that he is leading a team to examine the association between daily exposures to particulate matter (PM), including particles from tobacco leaf burning, and mortality in Chiangmai. Puttanna S. Honaganahali (Institute for Social and Economic Change, India) stated that, in India, agricultural burns are seasonal events that last from a fortnight to a month, and depending on water resources, once or twice a year. M.S.R. Murthy (Department of Population Studies, Sri Venkateswara University) added that farmers in India are exposed to coarse particulates from airborne fine soil particles due to farm activity and pulverization by vehicles, and Ramakrishnan Narayana added yet other air pollutant risks to the list: brick kilns, manual mixing of cement and sand in the building construction sector, rice mills, cotton and textiles mills, silk weaving, and mosquito coils.

David Pepper (Asthma Education and Management Unit, UCSF-Fresno) wrote to say that in 2002 Fresno, California had more than 100 days last year of PM and Ozone exceedances. He inquired about comparative figures for Mexico City, Bangkok and Shanghai, and asked participants if there is an established link with asthma. Roger-Mark DeSouza (Population Reference Bureau) provided a partial response by pointing to a PRB publication entitled *Household Transportation Use and Urban Air Pollution* (1999; see bibliography), which includes case studies of Mexico City and Bangkok along with some basic data. Bart Ostro responded that there are many studies indicating that short-term exposure to particulate matter (PM) or ozone will exacerbate asthma, but only a few studies suggest that these common air pollutants will actually initiate asthma. He added that because asthma is a multi-factoral disease, it is not likely that air pollutant levels in these cities would be good predictors of asthma rates. Joseph Schirmer (Wisconsin Department of Health and Family Services) contributed a summary of a *Lancet* article that provides evidence

that ozone exposure may indeed be a contributing cause of asthma (McConnell *et al.* 2002). The authors collected local measures of variation in air pollutants over time and individual questionnaires about participation in sports and time spent outdoors. The results indicate that for children living in communities with high ozone concentrations, participation in sports was associated with a higher probability of developing asthma. A discussion ensued about seasonal asthma rates, and what might account for spikes that occurred in early September. Ostro suggested it might have to do with children returning to school, or the increase could be related to tree pollens.

In a separate posting, Pepper inquired what should be the priorities in terms of greatest health benefit for each dollar spent in control - e.g. should we be focusing on diesel, indoor coal, solid fuels used indoors, all sulfur containing sources, pesticides, fumigants? A partial response was provided by Kirk Smith's panel statement, which addressed the issue of Intake Fractions (IF). IF is that proportion of ambient air pollution that is actually inhaled, and it varies by many orders of magnitude for different sources. In other words, the fraction of released pollutant reaching the breathing zone (or actually inhaled) greatly depends on the location/timing of the source emissions with respect to the places people spend time. Such differences in IF can overwhelm differences in the hazard of a source based purely on toxicity. Thus, in setting control priorities among source categories, there is a clear need to understand their relative IF, i.e., the differential potential for different sources to create exposure. The potential for increased economic efficiency through substituting "exposure trading" for "emissions trading" and more effective regulation in general are significant. The basic approach would be to weight the emissions of a class of sources by their relative IF. In his statement, Sumeet Saksena explored a similar issue, stating that nearly all of the previous epidemiological studies have aimed at quantifying concentration-response relationships. He argued that now there is a need to quantify the more meaningful exposure-response relationships.

In their panel statement, Adrian Fernandez *et al.* pointed out that the lack of research in developing countries leaves them at a disadvantage in terms of developing policy: "Since no cohort mortality study has been conducted in Mexico, we must rely on studies conducted in the United States. Given population and social differences, such as age structure, poverty, SES, nutrition, and health status between the study population and that of Mexico, as well as differences in PM and other pollutants dynamic ranges between Mexico City and cities where cohort studies have been conducted, is it legitimate to apply these concentration-response coefficients to Mexico?" Saksena echoed these concerns in his statement: "I hypothesize that the following factors are a few of the major reasons why exposure levels are likely to be different (in magnitude and distribution) in developing countries: differences in source composition (e.g. higher fraction of two-wheel vehicles, natural dust, etc.); differences in pollutant mixes; lesser use of mechanized ventilation in homes and buildings; differences in activity patterns due to socio-economic, cultural and climatic reasons; and differences in land use and zoning patterns (determining who lives where)." As a result of these differences, some of the emerging state of the art methodologies for studying pollution-health linkages would need to be adapted to developing country situations.

Urban Air Pollution

J. Austin Kerr (Environmental Science Associates, California, USA) is responsible for evaluating impacts to air quality in Environmental Impact Reports (EIR) pursuant to the California Environmental Quality Act (CEQA). Most Air Quality sections of EIRs discuss the location of "sensitive receptors" (e.g., schools, hospitals, and convalescent homes) that could be affected by

adverse changes in air quality resulting from the project being reviewed. He asked how others think "sensitive receptors" should be defined. Honaganahalli responded that in India and China the practice is to divide a city into zones, such as industrial, commercial and residential and, recently, sesitive zones such as hospitals. The regulators specify different ambient air quality standards for each zone within the same city or airshed. He expressed doubt about dividing an airshed based on socioeconomic criterion when fluid flows are only constrained by topographical features, and questioned the actual enforcement of such standards.

Honaganahali added that the US National Ambient Air Quality Standards (NAAQS) are health-based standards for criterial pollutants that apply for an airshed as a whole. These standards have the health risks factored in them, which basically means that if an airshed is compliant with the US-NAAQS then the effects of criteria pollutants may not be in evidence. Addressing every individual "hot spot" may be done but at a cost to society and economic development, as the bar will have to be lowered further (or the standard has to be raised).

B.C. Nagaraja (Centre for Ecological Sciences, Indian Institute of Science) suggested that one means of reducing urban air pollution is planting trees. He stated that increases in urban air pollution in India coincided with decreases in tree cover. Brad Bartholomew forwarded an Associated Press article to the discussion which cites atmospheric scientists who have studied the effects of urban air pollution on precipitation down wind. According to the article, eastward-blowing pollution in California induces a precipitation deficit across the Sierra Nevada mountain range equal to about 1 trillion gallons of water a year. This may create other health risks, independent of direct inhalation of smoke.

Sarath Guttikunda (The World Bank) reported on some research into air pollution and acid rain in China. He reports that emission control efforts in the north will benefit from access to greater quantities of low-sulfur coal, whereas the lack of low-sulfur coal in the South will significantly increase the cost of emissions control. Other findings suggest that gaining a better scientific understanding of the impacts of sulfur emissions, and improving estimates of the relative benefits of different control options, are two important pieces of information for leveraging local implementation efforts.

Indoor Air Pollution

Kai Lee (Williams College, USA) asked if the Global Burden of Disease study estimates for premature mortality from air pollution take into account indoor air pollution. Vinod Mishra (East-West Center, USA) responded, "The calculations of disease burden due to outdoor air pollution do not account for indoor air quality. Disease burden due to indoor smoke from household use of biomass and coal for cooking and space heating is estimated separately. According to the 2002 World Health Report, it is estimated to account for 2.7% of the global disease burden and some 1.6 million premature deaths annually." The numbers come from the The Comparative Risk Assessment Project, organized by WHO.

In his panel statement, Majid Ezatti wrote, "Recent analysis of multiple determinants of exposure including continuous data on pollutant concentrations throughout the day, spatial dispersion of smoke inside the house, and quantitative and qualitative data on time-activity budgets of individual household members have shown a complex environmental-behavioral exposure mechanism. The pollutant concentrations and dispersion themselves largely depend on energy technology (stove-fuel combination), house design (e.g. the size and construction materials of the house, the arrangement of rooms, and the number of windows), and stove-use

behavior (e.g. whether fuel is dried before using). In addition to cooking, whether energy is used for heating is also a crucial determinant of exposure because heating, by definition, involves longer hours of energy use and closer distance of people to the location of combustion." He closed by saying an important question for the research and surveillance community concerns the type of data that would permit design of better interventions according to locally-specific circumstances, and yet be affordable for large scale monitoring.

N. Ramkrishnan (Pondichery University, India) asked whether studies on indoor air pollution took into account the types of fuel used (e.g., firewood, charcoal, cow dung), seasonality (e.g., in the summer cooking is done outdoors), and the effect of mosquito coils, which are increasingly used for malaria control. Kirk Smith responded that the measurements reflect the end-result in terms of air quality, not the specific composition of fuel types. Risk estimates are based on broad indicators of exposure, such as use/non-use of solid fuels and use/non-use of stoves with chimneys. Sumeet Saksena wrote that seasonality affects ventilation in two ways: a) seasonal variations in the difference between indoor and outdoor temperatures create air pressure differences, and b) choice of location of cooking in cases where the stove is portable.

Hassaan Ghazali wrote to say that liquid petroleum gas (LPG) is increasingly being used in rural communities of Pakistan where firewood is scarce. He wondered if there are any health hazards from using LPG for cooking. Puttana Honaganahalli responded that in theory it should be cleaner than other (unspecified) sources, but because of implementation deficiencies, it is probably worse. Kirk Smith suggested that it is far cleaner than the common alternatives, such as kerosene or solid fuels.

Vinod Mishra posed a question concerning the health effects of biomass smoke, which is used in some countries as a means to avoid mosquito bites. Kirk Smith wrote that studies in Africa show that mosquito biting frequency is reduced somewhat by biomass smoke, but malaria prevalence is not. In general, he suggests that use of biomass smoke as vector control is likely to be inefficient, unreliable, and unnecessarily unhealthy. Ankinyemi Akanni (Obafemi Awolowo University, Nigeria) suggested that we need to make a more informed appraisal of these forms of traditional knowledge (i.e., using smoke to control mosquito bites), which constitute adaptations people make to the environment in which they live.

Liz Bates (Intermediate Technology Development Group, UK) reports that ITDG's work in Kenya reveals that smoke hoods and eaves spaces can remove a substantial proportion of indoor smoke. The social acceptability of technologies also needs to be taken into account. For example, A.K. Sharma (HSS Department, IIT Kanpur) wrote that people do not use kitchens in houses provided under different rural development programs. First of all, smokeless *chulhas* are rarely provided or used, and even if they are provided the level of inside pollution is not under tolerant limits because of design faults. So for these populations the only option is to use open space or veranda for cooking.

Tools and Methods

Vinod Mishra suggested that it would be useful to create a website where questionnaires and measurement tools might be shared. Eva Rehfuess (Protection of the Human Environment, World Health Organization) offered to create a repository for questionnaires and measurement tools in relation to indoor air pollution from solid fuel use if such a mechanism does not already exist elsewhere. This would assist in the development of a harmonized methodology to evaluate intervention projects.

Patrick Gubry (Institut de Recherche pour le Développement, France) suggested that population and environment issues can be studied through direct measurement of environmental problems (physical and chemical analyses of air, water, soil), and through household surveys. Household surveys may address the living conditions of population, household equipment, daily environmental problems, living habits related to the environment, and the awareness of environmental problems. He inquired about others using household surveys to address air pollution problems. Brian Tilt (University of Washington, USA) responded that in his work in rural China, the main pollution sources in are small-scale industrial factories that burn coal. The innovative part of their study was that they built a "risk perception index" based on feedback from the community itself. They conducted qualitative interviews within the community for several months, finding out what effects of pollution were particularly acute for local residents. Then they constructed the survey questionnaire based on the content of these interviews.

Haydea Izazola (Unidversidad de Mexico, Xochimilco) wrote that in light of the limited scientific knowledge on the effect of air pollution on health , public perceptions of the issue are in fact an extraordinary way to shed light on this complex phenomenon. She found in research on migration out of Mexico City to other cities in Mexico that environmental perceptions were an important motivating factor. However, Liz Bates pointed to the problems of validity in such research: how do we know that we're testing what we think we're testing, particularly in cultures other than our own, where language and other barriers exist? In China, for instance, the word "pollution" encompasses much more than industrial air pollution. Lori Hunter (University of Colorado) added that, analytically, we shouldn't equate public risk assessment and expert risk assessment. This is not to say that public risk assessment is unimportant, since in many cases it is the publics' perception that defines appropriate programs and/or polices as the public's perception will ultimately define a program/policy's acceptability. Establishing reliable monitoring techniques and estimating health and other effects of pollution is, according to Hunter, the fundamental core of risk analysis. Tilt responded that he has an extensive bibliography on expert versus public risk perception that he is willing to share. Sumeet Saksenas noted that the East-West Center will be developing work related to understanding the differences between public perceptions about air quality levels and inferences based on data from actual monitoring, which will help to design risk communication strategies.

The PERN lists manager forwarded to the list a paper by Anil Nandeo *et al.* (Environment Centre, University of Leads, UK) entitled "A New Approach to Model Air Quality and Health Implications of Transport Scenarios" (see bibliography for citation). The paper describes the development of a modeling package that can be used to support the UK National Air Quality Standards. The package includes a Traffic Emissions Modeling and Mapping Suite, which provides detailed estimates of vehicle emissions on urban road networks, together with a stationary source emissions database and an atmospheric dispersion model that collectively permit a detailed spatial assessment of urban air quality in response to road traffic and meteorology.

Alex de Sherbinin (CIESIN, Columbia University, USA) described some studies by the Columbia Center for Children's Environmental Health (CCCEH) that used new methodologies, such as GIS analysis of Quickbird satellite data (sub-meter spatial resolution) to identify pollutant plumes in neighborhoods affected by a coal-burning power plant, and air monitoring back packs fitted to pregnant mothers to measure the local ambient air quality.

Resources

The Columbia Center for Children's Environmental Health (CCCEH). CCCEH was established to study the effects of various environmental pollutants on children's health. See http://www.healthsciences.columbia.edu/dept/sph/ccceh/index.html

Clean Air Initiative (CAI). CAI advances innovative ways to improve air quality in cities by sharing knowledge and experiences through partnerships in selected regions of the world. See http://www.worldbank.org/cleanair/index.htm

Global Forum for Air Pollution and Public Health. On the website there are links to many studies pertaining to air pollution and public health, as well as a number of links to sites providing real-time data on air quality. The Forum is especially useful because it highlights the differences between approaches to these issues from place to place around the globe. See http://climate.org/topics/air/globalforum.shtml

HEDON Household Energy Network. HEDON is an informal forum dedicated to improving social, economic, and environmental conditions in the South, through promotion of local, national, regional and international initiatives in the household energy sector. Recently a forum for discussion has been added and a 'how to monitor' guide, based on the work we are doing is included. See http://www.hedon.info

Stockholm Environment Institute (SEI), York, Atmospheric Environment Programme. The objective of the Atmospheric Environment Programme is to inform, facilitate and interact with policy processes aiming to reduce atmospheric pollutant emissions to levels that limit their impacts on the environment. It involves research and activities to assess, quantify and model emissions, impacts and emission mitigation options, and link this information to policy processes at different scales. See http://www.sei.se/atmosphere/overview.html

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