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PREFACE

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Over the past 20 years, a vast body of epidemiological literature has provided evidence of strong associations between exposures to ambient levels of particulate matter (PM) found in urban airsheds and a range of serious health effects. Recent research efforts to address uncertainties in results from large-scale cohort mortality studies, to identify population health risk factors, and to characterize the impact of particulate air pollution on life expectancy have important implications for developing policies to protect public health. The Network for Environmental Risk Assessment and Management (NERAM) Colloquium, "Health and Air Quality 2001: Interpreting Science for Decision Makers," was convened to discuss and interpret the results of long-term cohort studies for evidence-based decision making on air quality objectives and to identify research directions that would meaningfully contribute to public health policy development.

The meeting, the first in a 5-year colloquia series, focused on strengthening linkages between the scientific and policy communities in order to improve air quality policy decisions and public health. The colloquium was spearheaded by NERAM in collaboration with an international steering committee comprised of Canadian, U.S., and European regulators, health effects researchers, and representatives of nongovernmental organizations and the business community. Members of the international steering committee included Peter Boyle, Rick Burnett, Tom Dann, Geoff Granville, Dan Greenbaum, Daniel Krewski, Ken Ogilvie, Jonathan Samet, John Shortreed, Arpad Somogyi, Mark Utell, John Vandenberg, Sverre Vedal, and Robert Willes. The meeting was cochaired by Daniel Krewski of the Centre for Population Health, University of Ottawa, and Robert Willes of Cantox Environmental, Inc. Financial support for the meeting was provided by Health Canada, Environment Canada, the Canadian Petroleum Products Institute, and the Canadian Steel Producers Association.

One of the primary objectives of the meeting was to involve stakeholders in framing key scientific questions and defining research priorities that would aid in formulating air quality policies. More than 100 delegates attended the 2-day meeting including representatives from Canadian, U.S., and U.K. health

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and environment regulatory agencies, from environmental and public health groups and from industry and the scientific community. This special issue of the journal includes the presented papers, discussions, and recommendations for policy-relevant research.

Part I of this issue provides an introduction to the discussion of policy issues by presenting an overview of PM regulatory standards in Canada and the United States and a public health perspective on key scientific information requirements for devising cost-effective PM control strategies. Greenbaum presents an overview of the evolution of scientific and regulatory developments in North America and Europe beginning with regulatory action taken in the United Kingdom in the 1950s up to the present time. Maynard discusses the public health implications of the Harvard Six Cities and American Cancer Society studies; he argues that standard setting is a suboptimal risk management approach for PM and calls for fresh approaches based on research to better understand the composition of ambient aerosol mixtures, their sources, health effects, and the costs and benefits of alternative reduction strategies. Raizenne presents an overview of the regulatory approach taken in Canada to manage air quality.

Part II of this issue focuses on the results of the independent audit and the reanalysis of the Harvard Six City prospective cohort study (Dockery et al., 1993) and American Cancer Society Study (ACS) cohort study (Pope et al., 1995) led by Dr. Daniel Krewski of the University of Ottawa (Krewski et al., 2000). Krewski presents an overview of the results of the HEI Reanalysis Project including the data audit, replication of the results of the original investigators, evaluation of the sensitivity of the original findings to alternative analytic methods, investigation of covariate effects, and spatial analyses. The reanalysis study assured the quality of the original data, replicated the original results, and found that alternative risk models and analytic approaches did not substantively alter the original findings of an association between indicators of particulate matter air pollution and mortality. Among the most important findings of the study was the strong influence of educational attainment on risk and the spatial relationships between mortality and air pollution. Hoover et al. discuss the results of the data-quality audit of the Harvard Six Cities Study and the American Cancer Society Study. Willis et al. describe how ecologic-level variables to measure place-specific influences on the association between air pollution and mortality were selected and obtained for the reanalysis of the ACS Study. Siemiatycki et al. discuss the reanalysis team's effort to control for occupational confounding in the Harvard Six Cities Study and the American Cancer Society Study by supplementing the original datasets with two new variables, an indicator of the "dirtiness" of a subject's job and an indicator of exposure to occupational lung carcinogens. In a second article, Willis et al. argue for the importance of considering the effects of geographical scale when obtaining, aggregating, and using ecological data. The article uses the example of the ACS Study and its subsequent reanalysis to examine the effect of changing the scale of analysis from metropolitan areas to counties

on the observed relationship between sulfates and mortality. Abrahamowicz et al. describe the results of flexible analyses of selected subsets of the ACS cohort to assess the shape of the exposure-response curves that describe the effects of long-term average levels of sulfates and $PM_{2.5}$ on mortality. The results reinforce the growing body of evidence against the hypothesis of a putative threshold below which exposure to fine particles does not affect public health. Part II concludes with a series of commentaries presenting various viewpoints on the implications of the findings of the reanalysis study. Krewski provides a response to the commentaries in a rejoinder.

Part III of the issue focuses on the characterization of PM exposures and the examination of the relationship between these exposures and corresponding health effects. Brunekreef gives an overview of recent cohort studies of air pollution and health and discusses design issues related to study hypothesis, exposure assessment, confounder assessment, and effect modification. Tager's commentary discusses the properties of newer cohort and case-control study designs that offer important efficiencies that should be further explored for future policy-relevant epidemiologic studies of health effects related to ambient air pollution. Jerrett et al. assess whether effects attributed to air pollution in the ACS Study remain significant when other ecologic covariates are introduced and when autocorrelation is explicitly controlled in the model; the article discusses the significant impact of spatial autocorrelation on estimates of the sulfate air pollution–mortality relationship. Hayes provides a commentary in support of situating the discussion of the air pollution–health relationship within a broader contextual understanding of influences on health.

In another article, Jerrett et al. discuss the importance of spatial analysis in environmental health research and provide an overview of the methods, applications, and strengths and weaknesses associated with this important approach to understanding disease pathogenesis and guiding environmental health policy.

Cakmak et al. discuss the results of a spatial regression model for examining the association between the prevalence of heart disease and ambient particulate sulfate concentrations using data from the American Cancer Society (ACS) study. Chang et al. discuss the importance of different exposure metrics and time-activity data to predict 24-h personal $PM_{2.5}$ exposure. Coyle et al. combine evidence from long-term exposure studies and the literature on utility-based measures of quality of life to quantify the impacts of reductions in sulfate air pollution on mortality in terms of quality-adjusted life expectancy. Levy discusses the uncertainties related to the Coyle et al. assessment of the health benefits of pollution control and recommends that analysts incorporate detailed and transparent sensitivity analysis in calculating both the magnitude and distribution of benefits. This would assist policymakers in understanding how policy choices can be influenced by assumptions used in the benefits analysis.

Part IV provides a summary of the break-out group and plenary discussions to identify priority research directions for air quality policy development. Samet and Pope provide an overview of epidemiologic research needs for the next decade to determine (1) how the effects of particles vary across locations;

(2) the magnitude of life-shortening associated with particle exposure; (3) the determinants of the toxicity of particles; and (4) the biological mechanisms linking exposure with health effects. Maynard and Cohen identify the need for a broad assessment of the public health impacts of air quality improvements in context with other factors that affect population health. They note the need to understand how the risks of long-term exposure to air pollution vary within and among populations and to further develop methods to assessing the costs and benefits of alternative air quality policies. White and Suh provide an overview of research activities on monitoring exposure to ambient air pollution in two major areas: (1) the development of guidance to the public on minimizing exposure to particles and (2) the incorporation of refined exposure metrics into existing cross-sectional studies. Dominici and Burnett discuss current data limitations and identify research opportunities to improve the estimation of the association between air pollution and health. A concluding article by Maynard et al. defines 10 priority themes for science and policy research and future meetings in the NERAM Colloquia Series to support air quality policy decisions to protect public health.

We thank the colloquium sponsors for their financial support, the speakers for their excellent presentations, and the chairs and rapporteurs for skillfully facilitating and reporting on the break-out group discussions. Special thanks are extended to Bob Willes of Cantox Environmental, Inc., for initiating the colloquium series and collaborating with NERAM in its implementation, to Vic Armstrong for providing technical editing support, to Lorraine Craig, Paula Carty, and Suzanne Therien for their assistance in coordinating the preparation of the proceedings, and to Addy Mitchell for providing assistance with the organization of the meeting.

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