Understanding the Relationships between Air Pollution Levels and Human Health Outcomes

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The U.S. Congress passed the Clean Air Act (CAA) to mitigate the adverse impacts of air pollution on human health and the environment. As mandated by the CAA, the U.S. Environmental Protection Agency (EPA) established National Ambient Air Quality Standards (NAAQS) for criteria pollutants and conducts periodic review of the NAAQS to assess if they need to be revised. The CAA then provides for implementation of the NAAQS based on a combination of local controls determined by the states, and national-scale programs determined by EPA to address regional pollution sources. In this regard, EPA uses the risk paradigm in determining if there is a problem (risk assessment) followed by the development of a mitigation strategy (risk management), if needed. Accountability, whereby the Agency evaluates whether regulatory programs have produced intended benefits to human health and the environment, closes the air quality management loop. For example, EPA has examined the impact of its NOx SIP Call on the emissions, ambient ozone concentrations, and health outcomes (Godowitch et al., 2008 and 2010; EPA, 2009; Garcia et al., 2011). A recent article reported that life expectancy at birth in the United States has increased by at least six months because of the improvement in ambient air quality stemming from the implementation of the CAA (Pope et al., 2009).

This special issue of EM is meant to foster better communication between the health and atmospheric sciences communities by improving our understanding of the relationship between air pollution and human health. During the past four decades, EPA has made substantial progress in improving the Nation's air quality even in the presence of economic and population growth (EPA, 2010). In spite of positive outcomes from EPA's regulatory actions, however, air pollution continues to be a major issue for vulnerable populations. An assessment of the public health burden in the U.S. of recent levels of ozone and fine particles reported that at least 130,000 premature deaths in 2005 were attributable to air pollution (Fann et al., 2011). EPA and state agencies are continuing studies that address air pollution and associated health issues, and the health community perseveres in its search for better methods to discern pollutant-health relationships. Other new research efforts are underway to better understand the nature of the urban air pollution mixtures typically found in metropolitan areas around the U.S., and how differences in those mixtures contribute to heterogeneity in health responses to air pollution (Dominici et al., 2011).

In this special issue, we discuss current achievements and challenges in reducing health impacts from ambient pollution, and suggest approaches to refine risk assessments, mitigate risk and assess the efficacy of control actions. Specifically, Laden and Neas review how air quality monitoring data are used in different types of epidemiologic studies and recommend expanded use of continuous air quality monitoring. They note that acute effect studies typically utilize daily health data and air quality observations. Wyzga and Mauderly identify and examine gaps in information, including mixtures of pollutants, accurate exposure information, linkage of health effects with specific pollutants, synergies and antagonisms. They also recommend more air quality monitoring, including the use of continuous monitors.

Garcia and Beevers provide examples of how models can inform exposure and the importance of understanding regional versus local sources of pollution in metropolitan areas. In addition, they demonstrate the importance of characterizing the variability of exposure within metropolitan areas and suggest such studies are critical in addition to examining across-city exposure variation. Özkaynak et al. examine how different exposure metrics affect the outcome of epidemiological studies, and discuss the strengths and limitations of various data sets in delineating health risks. They point out limitations with the use of central site monitors and the inability of the current monitoring network to capture gradients due to local sources. They also examine various exposure metrics for multiple pollutants and suggest that more refined exposure estimates will provide greater power in detecting a health signal. Wesson et al. present the need for better understanding exposure in characterizing risks. Finally, Rao et al. discuss the various dynamical forcings, controlled by the physical and chemical processes occurring in the atmosphere, that are imbedded in ozone and $PM_{2.5}$ concentration time series. They suggest that seasonal or longer-term concentrations should be used as the basis for managing ambient air quality and protecting human health.

In total, these articles investigate current achievements and limitations of using existing data to detect associations between air pollution and health, and suggest approaches to improve the characterization of exposure for ongoing and future studies. In addition, new concepts to address air pollution and its impact on human health are presented. Such approaches not only will help us to detect associations between air pollution and health endpoints, but also assist us in optimizing control actions to address the spatial and temporal aspects of multiple pollutants, and to understand the impact that these control actions actually have on ambient air quality.

Although the articles in this issue have been reviewed and approved for publication by the U.S. Environmental Protection Agency, they do not reflect the views and policies of the Agency.

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