Examples of Scientific and Policy Impacts of PM Centers Research

PM Center findings have been cited by a variety of organizations, both to inform various audiences about PM and its health effects, and as evidence for establishing standards and creating policy. The Centers' research has been influential in forming public health advice and in stimulating new hypotheses and directions in PM research. In addition to significant contributions in air pollution research, the Centers have helped launch new frontiers in environmental health research, having an impact in the broader science community. The work of the PM Centers has also helped leverage additional funding for research that extends the scientific impact of the Centers' preliminary findings. While it is not possible to catalog or quantify all of the impacts of PM Center research, the examples described below illustrate the Centers' broad relevance and depth of influence.

EPA Air Pollution Policy Decisions and Outreach

PM Center findings have been used by EPA in its evidence review for the PM National Ambient Air Quality Standards (NAAQS). The last PM NAAQS proposal was based on a review of the scientific evidence that ended in 2004. Given the number of new studies that were published too recently to be included, EPA screened and surveyed the recent literature and developed a provisional assessment that placed those studies of potentially greatest relevance in the context of the findings of the 2004 science review. This was completed in 2006, prior to issuing the final PM NAAQS. Of the 215 national and international citations in this PM provisional assessment, 71 (or 33.%) were papers from the PM Centers. The next draft integrated science assessment (ISA) will be publicly available by the end of 2008.

In addition, EPA's Office of Transportation and Air Quality (OTAQ) finds the PM Centers' research to be highly valuable in informing policy development related to mobile sources. PM Center research on the size fractions of PM responsible for adverse health outcomes (ultrafine PM, fine PM, coarse PM) is used by OTAQ to assess the potential need for additional regulatory action. Research currently underway at the PM Centers will help address data gaps that currently limit OTAQ's ability to provide relevant guidance to States and Regions with regard to exposure-effects near major roadways. Results of PM exposure-response relationships that identify toxic components of the near roadway aerosol that are most strongly related to adverse effects will be used to inform mitigation strategies.

Public Health, State, and Local Policy Impacts

One approach to evaluating the PM Centers' impacts on public health, state, and local policy is to review the citations in key documents summarizing the basis for public health and policy recommendations. For example, the American Heart Association issued a scientific statement on air pollution and cardiovascular disease in 2004, reviewing the literature and addressing the public health indications for clinicians and policy implications for regulators. Of the statement's 108 recent citations (since 2000), which include international sources, 18 (or 16.7%) were PM Center papers. Examples of other organizations citing PM Center work include the American Academy of Pediatrics, the American Lung Association, and the Northeast States for Coordinated Air Use

Management. Local and State agencies including the South Coast Air Quality Management District, the California Air Resources Board, and the Virginia State Advisory Board on Air Pollution, and international agencies like the World Health Organization and the United Nations Environmental Programme have also cited the program's research. Examples of organizations citing PM Center research are listed at the end of the Bibliographic Analysis (Tab 1-E).

The PM Centers have also provided information as to how state, local and other organizations use and value this research. A few examples are described below:

- The Southern California Particle Center (SCPC) published findings describing how concentrations of ultrafine particles vary with distance from the freeway. The Center also supported the California Children's Health Study in examining how proximity to roadway affects the respiratory health of children. According to the study findings, living in a residence with more nearby traffic increases the risk of childhood asthma. These studies, together with those supported by the California Air Resources Board and other funders, were influential in the development of a new California state law prohibiting the construction of new schools within 500 feet of freeways.

- Reflecting the value of the Center's research to local concerns and regulatory importance, the South Coast Air Quality Management District dedicated one million dollars to support the SCPC research on asthma.

- The New York University PM Center played a major role in characterizing exposures and health risks resulting from the collapse of the World Trade Center Buildings on September 11, 2001. The capabilities developed for the PM Center enabled its scientists to rapidly and effectively help EPA, New York City, and the nation respond to this emergency.

- Reflecting the value of the Rochester Center's research to State concerns and regulatory importance, the New York Department of Environmental Conservation (DEC) has provided space and support at their local air pollution monitoring site in Rochester allowing continuous measurements of ultrafine particles. The ongoing monitoring provides more than 5 years of continuous UFP number data and may serve as an important resource in understanding environmental exposure to UFP and consideration of regulation.

- The Harvard Center is examining the toxicity of particles emitted from vehicles and coal power plants. Linking particle toxicity to primary and secondary emissions from specific sources is very important for the development of cost-effective emission control strategies for state and federal agencies.

- Immediately following the second PM Centers meeting, HEI, EPA and the PM Centers co-sponsored a meeting that included discussions of changes that EPA was planning in its monitoring network to replace one type of carbon monitor

with another. The new technique has a number of advantages over the old one but also produces very different results. Such a break in the data stream could hamper efforts by health researchers to use these data for time series analysis. Researchers from the San Joaquin Valley Aerosol Health Effects Research Center (SAHERC), the Johns Hopkins PM Center, other PM center investigators, and STAR grantees worked with EPA scientists to increase understanding of the research impacts of this change. As a result, the EPA monitoring program will co-locate monitors in several locations over several seasons to develop solutions for long-term health studies.

New Frontiers in Science

The PM Centers' focus on ultrafine particles has helped to provide a foundation for a new and important field of study on the health effects of exposure to nanoparticles with Center research featured in *Science* (Nel et al. 2006) and in the Environmental Health Perspectives "paper of the year" (Oberdorster et al. 2005). In the recent NAS report, *Toxicity Testing in the 21st Century: A Vision and a Strategy,* SCPC research was prominently cited in the Vision chapter, describing a "revolution taking place in biology" with progress being made in the elucidation of cellular-response networks (Xiao et al. 2003; Nel et al. 2006). Emphasized in this report is the broad concept that toxicology should move from a descriptive *in vivo* science to a predictive mechanism or pathway-based toxicological science that can use *in vitro* approaches to help prioritize and speed up *in vivo* testing.

Extending the Scientific Reach of the PM Centers Research

There are multiple examples illustrating how research supported by the PM Centers can lead to further discoveries and broader impact. The findings of the PM Centers are of great interest and help draw support from multiple funders for additional analyses, data collection, and related studies to extend the scientific reach of the Centers' work. In addition, the technologies developed through Centers help leverage additional grants that broaden the application of these important research tools. As noted by the SAB Panel in its 2002 *Interim Review of the PM Research Centers of the USEPA:*

> *"*The existing and new studies funded by other organizations and by other Agency programs presents and important benefit to EPA, leveraging its limited funds for PM research and gaining access to the additional science generated on this broader scale. By providing a "critical mass" of experience, interest, and expertise, a Center becomes attractive to outside funding agencies as a credible source for generating answers to their questions in a cost-effective way. Specifically, the breadth of PM health effects research at most of the Centers is significant and appears to exceed substantially the $1.5 million/year contributed by the Agency's PM Centers Program." (Tab 4-N)

The examples below are meant to illustrate the impact of Center funding on expanding the depth and breadth of PM research.

- Results of the Rochester PM Center on ultrafine particle translocation and induction of extrapulmonary effects serve as basis for a multi-disciplinary, multi-

university grant on nanotoxicology sponsored by the Air Force Office of Scientific Research.

- Suggestions from results of epidemiological studies that genetic polymorphisms influence the PM-associated effects in susceptible populations led to the expansion of the large European AIRGENE study to include Rochester PM Center-sponsored gene analysis in the study subjects.

- The SCPC conducted research on the adjuvant effect of diesel particles in an animal model of asthma. These findings on the oxidative stress mechanism of injury contributed to the UCLA Asthma and Allergic Disease Clinical Research Center's (AADCRC) successful competition for renewal of an NIAID grant. The UCLA Asthma Center is now investigating the impact of ambient particles in human asthma, including the oxidative stress mechanism in humans and possible interventions using anti-oxidant treatments.

- Based on asthma research findings regarding particle effects acting via an oxidative stress pathway, SCPC researchers successfully competed for NIEHS funding to investigate a similar mechanism for PM in the development of atherosclerosis. Research on the oxidant injury mechanism for atherosclerosis begun under the NIEHS grant is now carried forward in the PM Center. Two recent publications have elucidated the role of ultrafine ambient particles in the development of atherosclerosis in an animal model.

- One of the Harvard PM Center's projects examines the association between PM exposures and intermediate markers of autonomic dysfunction, systemic inflammation, endothelial activation, and oxidative stress in the Normative Aging Study cohort. In particular, this investigation examines the role of genes, medication use, and nutrition. As a result of leveraging, an NIEHS grant will expand the pool of genes and will include measurements of DNA methylation. These additional measurements will be critical to the efforts to elucidate biological mechanisms and to identify susceptible individuals due to their genetic predisposition.

- The extensive PM cardiovascular research undertaken in the original Harvard PM Center served as the basis for a new NIEHS grant that evaluates not only autonomic mechanisms, but also potentially interrelated vascular and inflammatory mechanisms associated with cardiovascular effects. The research will provide data on a spectrum of at-risk subjects including populations with Type 2 diabetes, coronary artery disease and acute cerebrovascular events. The synergy between the two programs has been highly valuable for the exchange of ideas, interpretation of findings and scientific advancement.

- One goal of the EPA PM Centers program is to associate sources and source categories with health effects. Typically, this is done by source apportioning atmospheric samples. SAHERC (UC Davis) has obtained substantial additional

funding from the California Air Resources Board and the Electric Power Research Institute to develop and deploy an instrument that collects source-oriented aerosol particles from the atmosphere. The toxicity of these samples will be assessed by SAHERC PIs. The advantage of this method over collecting from the sources directly is that the particles will have undergone oxidation and other atmospheric processing that may substantially alter their toxicity and better represent the size distribution and composition of particles that people inhale.

- The presence of the Johns Hopkins PM Center helped make the case that Johns Hopkins University is a fertile environment for a mentored research award funded by NIEHS to allow a junior investigator (mentored by a more senior researcher) to investigate the impact of indoor particulate matter exposure on non-allergic asthma.

- The national data sets (e.g. Medicare, Speciation Trends Network) that are assembled in the Johns Hopkins Center's Data Management Core are providing an exceptional resource for obtaining other grants. A member of the Johns Hopkins team was successful in obtaining one of the highly competitive ONES (Outstanding New Environmental Scientist Awards) from NIEHS, based on the potential of the Johns Hopkins Center as a platform for her research. Another Johns Hopkins investigator was successful in obtaining a grant from the EPA STAR program to develop statistical methods and conduct analyses to assess the health impact of the air quality regulations.

References:

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