The Southeastern Center for Air Pollution and Epidemiology (SCAPE)

The Emory/Georgia Tech Collaborative: Multi-Scale Assessment of Health Effects of Air Pollution Mixtures Using Novel Measurements and Models

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Center Overview:

Objectives: A multi-institutional, multi-disciplinary Center is proposed to address critical issues relating to the public health impacts of ambient air pollution. The overarching theme of the Center is a focus on characterizing ambient air pollution mixtures and elucidating their role in human health risks associated with air pollution. Novel measurements and modeling approaches will be applied in the context of a tiered multi-scale assessment of the health risks of mixtures characterized based on: 1) biological considerations (oxidants); 2) environmental management (sources); 3) evidence-based considerations (traffic emissions); 4) empirical assessment (data-based approach).

Approach: Four Research Projects will be supported by three Cores: an Administrative Core, an Air Quality Core and a Biostatistics Core. Project 1 will develop and deploy instrumentation to measure oxidants (including aerosol reactive oxygen species) and other species of interest to better understand their origins and atmospheric transformation and for use in characterizing mixtures for the three health studies. Project 2 will make direct use of these measurements to confirm associations with markers of oxidative stress in commuters. Projects 3 and 4 will use a combination of measurements and modeled air quality estimates in large population studies, with Project 3 investigating questions regarding risks of in utero and early life exposures to air pollutant mixtures in two major new birth cohorts and Project 4 assessing underlying consistencies in morbidity associations across selected cities that have comprehensive daily air pollution characterization. The health projects include assessment of potentially sensitive and vulnerable subpopulations.

Expected Results: The Center brings together a productive group of researchers with depth in the relevant disciplines and access to rich air quality and health outcome databases to conduct an integrated and innovative research program. The proposed research program will contribute important new insights regarding health effects of air pollution mixtures.

Project 1: Development and Deployment of an Instrumentation Suite for Comprehensive Air Quality Characterization including Aerosol ROS

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Project Summary:

Objectives: Through new instrument development and extensive field studies Project 1 will comprehensively measure and characterize gas/particle mixtures of air pollutants for this Center's multiscale air quality model validation, health impact assessments and source/process studies. The data will complement and extend current pollutant observations across multiple scales greatly enhancing existing air quality data sets to include more exotic species for retrospective and prospective health studies in other urban settings. A focus of these new measurements will be on identifying and quantifying agents that have been implicated in causing oxidative stress.

Approach: An online instrument to measure and broadly speciate aerosol Reactive Oxygen Species (ROS) will be developed for stationary and in-vehicle measurements and included in an instrumentation package focused on semi-continuous measurements of trace gas and aerosol species. Measurements will be taken across a variety of locations in different seasons to characterize spatial, temporal and chemical distributions, sources, and physicochemical processes or linkages between components of gas/particle pollutant mixtures implicated in adverse health outcomes. Species to be measured include fine particle ROS, redox-active metals, quinones, PAHs, speciated carbonaceous compounds, and ultrafine, fine and coarse particles, along with gas-phase oxidants, VOCs, NOx , and CO.

Expected Results: For different locations and seasons, this project will generate a unique high quality data set with new components that will extensively characterize the ambient air pollutant mix in different urban environments. The data will inform air quality modeling and health studies by specifically addressing questions on the origins, transport and transformation of constituents of multipollutant atmospheres that are relevant to human health effects. Predictive parameterizations of the more exotic components of the air pollutant mixture measured in this project by air quality parameters routinely recorded by monitoring agencies will be used to extend the project's unique data set to retrospective health studies and to studies in other urban settings. Identification of chemical linkages and physicochemical mechanisms relating to $PM_{2.5}$ ROS concentrations will provide a better understanding of sources, processing and health impacts. Therefore, results from Project 1 will contribute to the ability of Center Projects 2 through 4 to address regional and temporal differences in air pollution risk and health impacts of single pollutants in a multi-pollutant context.

Project 2: Examining In-Vehicle Pollution and Oxidative Stress in a Cohort of Daily Commuters

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EPA Grant Number: R834799-01

Project Summary:

Objectives: Vehicle emissions comprise a complex mixture of particulate and gaseous pollutants that have been linked to numerous adverse health outcomes. Despite this, there is limited knowledge concerning in-vehicle mixtures and corresponding acute health responses among daily automobile commuters. A more complete understanding of the pollutant-related health effects in commuters is becoming increasingly necessary, as commuting durations as well as roadway congestion have steadily increased throughout the U.S. during the last 20 years. To investigate in-vehicle exposures among car commuters, we propose to conduct a panel-based exposure and health assessment study of 30 healthy and 30 asthmatic adults in the metropolitan Atlanta area. The primary objective of this study is to examine the associations between particulate mixtures that occur during typical automobile commuting and corresponding oxidative stress-mediated pathways of cardiorespiratory injury. Our central hypotheses are that: a) commuters are exposed to high levels of in-vehicle particulate pollutant mixtures as compared to other, indoor E's; and that b) these short-term exposures are associated with acute changes in oxidative stress in asthmatic and healthy adults.

Approach: We will use novel methods for measuring highly chemically-resolved PM, focusing on specific particulate components that contribute to PM oxidative potential including polycyclic aromatic hydrocarbons, transition metal species, elemental carbon and ultrafine particles. In addition, this study will be among the first to measure several highly-sensitive, non-invasive biomarkers of oxidative stress (i.e., glutathione in exhaled breath) at numerous time intervals, with the goal of following the progression from oxidative stress to clinical response.

Expected Results: This project is particularly suited towards examining the health effects of air pollutant mixtures. Expected exposure science results will further our understanding of: a) in-vehicle concentrations of size- and chemically-resolved PM mixtures within periods of peak traffic; b) the impact of exposure factors such as cabin ventilation and traffic composition on in-vehicle pollutant levels; and c) how exposures to specific ROS generating PM components vary between in-vehicle and other indoor E's. In addition, this study will elucidate several key health effects questions, including: a) the acute, sub-clinical oxidative stress-mediated responses due to real-world exposures to traffic-related PM, its components and pollutant mixtures using individual-specific metrics of personal exposure; b) the temporality of these exposure-response functions; c) whether daily commuters comprise a potentially vulnerable sub-population to these health effects during commuting; and d) whether baseline health status, and specifically asthma, modifies the risk of traffic PM.

Project 3: Novel Estimates of Pollutant Mixtures and Pediatric Health in Two Birth Cohorts

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EPA Grant Number: R834799-01

Project Summary:

Objectives: In *utero* and early life experiences affect physiological development and can influence sensitivity to environmental factors throughout life. In this project we will explore the interplay between certain early life events, characterizations of air pollutant mixtures developed as part of the Center's Mixtures Characterization Toolkit, and a range of pediatric health outcomes using two large, population-based birth cohorts.

Approach: One cohort consists of roughly 2.3 million Georgia birth records that have been geocoded and linked with pediatric emergency department visits by staff at the Georgia Department of Human Resources. Using this statewide birth cohort, we will investigate acute effects of air pollution mixtures on respiratory health outcomes and ear infections in children, and we will assess whether children who were born premature or low birth weight are more sensitive to ambient air pollutant concentrations than their counterparts. Further, we will use the statewide birth cohort to investigate whether ambient air pollutant mixtures during pregnancy are associated with the risk of preterm delivery or reduced birth weight. The second birth cohort is comprised of children who were members of the Kaiser Permanente Georgia Health Maintenance Organization in metropolitan Atlanta. In this birth cohort, where comprehensive medical and residential histories are available for each study subject, we will examine whether air pollutant mixtures during the first year of life are associated with the incidence of childhood asthma.

Expected Results: This project will advance the science of atmospheric modeling, and it will provide evidence regarding the susceptibility of the developing fetus and children to ambient air pollutant mixtures. Permeating through the project is a strong focus on pollutant mixtures, which includes novel methods for both atmospheric and epidemiologic modeling, and a rigorous approach to data analysis that includes characterization of pollutant lag effects and concentration-response relationships.

Project 4: A Five-City Time-Series Study of Pollutant Mixtures and Acute Morbidity

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EPA Grant Number: R834799-01

Project Summary:

Objectives: Although associations between ambient air pollution and acute cardiorespiratory outcomes have been observed in numerous studies, questions remain about the degree to which these findings are generalizable between locations and whether the observed health effects are due to the individual pollutants measured or to pollutants acting in combination with other pollutants. We propose to conduct a multi-city time-series study to clarify the impacts of air quality on acute cardiorespiratory morbidity in five US cities (Atlanta, GA; St. Louis, MO-IL; Dallas, TX; Birmingham, AL; and Pittsburgh, PA) using novel mixture characterization (MC) metrics. Our overarching hypothesis is that factors related to air pollution mixtures, seasonality and climate, concentration-response functions, exposure measurement error, and population susceptibility and vulnerability can help explain apparent between-city heterogeneity in short-term associations between air quality measures and cardiorespiratory emergency department visits and hospital admissions.

Approach: Individual-level morbidity data for each city will be acquired from existing in-house databases and limited new collection under the current proposal, resulting in 6.5 to 17 years of data for each outcome type across the cities. Rich air quality databases will be acquired through several sources, and will include unusually extensive multi-year daily speciated particle data that will contribute to the development of novel mixtures characterizations. The MC metrics of specific interest for this project include: (1) population-weighted averages and spatially-resolved concentrations; (2) single-species source tracers; (3) multiphase pollutant source apportionment outputs; (4) factor analysis outputs; and (5) modeled reactive oxygen species. These pollutant mixture characterizations will be assessed in relation to acute cardiorespiratory outcomes.

Expected Results: Results from this project will advance our understanding of the specific sources, attributes and constituents of the ambient air pollutant mix that impact cardiorespiratory morbidities at two levels of disease severity. By exploring possible explanations for the heterogeneity in observed health associations across cities, we seek to elucidate common underlying relationships. In the process, we will identify susceptible and vulnerable subpopulations, describe the shape of concentration-response curves, assess the impacts of exposure measurement error, and identify seasonal and meteorological differences in observed associations. By examining the impacts of single pollutants in a multi-pollutant context and applying novel characterizations of pollutant mixtures, results of this project will help inform the development of multi-pollutant management approaches for the protection of human health.