HEALTH EFFECTS INSTITUTE ANNUAL REPORT 2019

A Window to Trusted Science
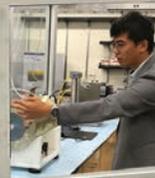
The HEI Way

Above: HEI investigator Lydia Contreras at the University of Texas, with a student.

Facing page, left: HEI investigator Nga L. (Sally) Ng, Georgia Institute of Technology, with Vito Ilacqua of the U.S. Environmental Protection Agency.

Facing page, right: HEI Director of Science Rashid Shaikh.

The integrity of our process has made HEI a respected, go-to source for decision makers in both the public and private sectors for nearly 40 years.
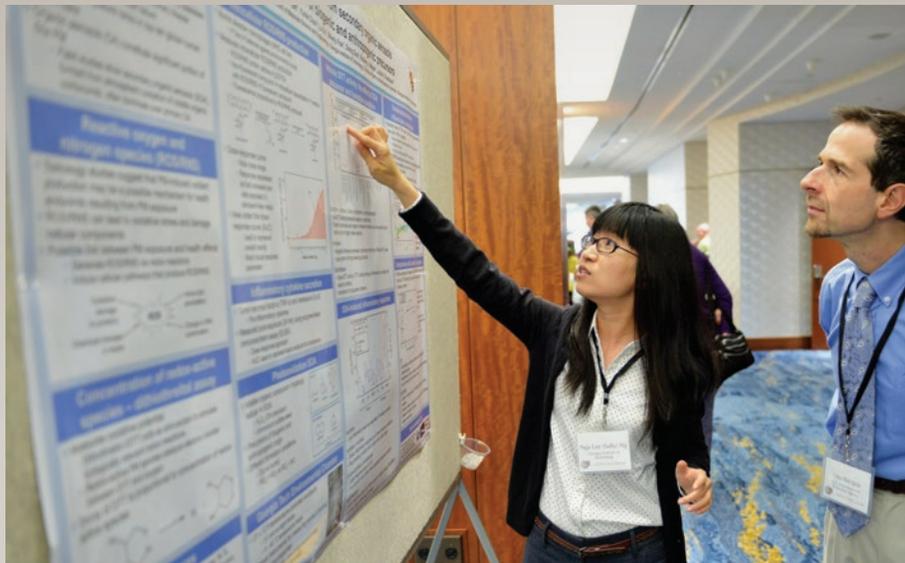
Photos: Jay Mallin

A Mission to Inform

Our mission is to support informed decisions to improve air quality. We do this by funding, overseeing, and critically evaluating research on the health effects of air pollution, and then putting the findings into the context of current science and policy debates.

Independence and Balance

We support independent investigations into air pollution, its health impacts, and its solutions with balanced funding from government and industry. Under our unique model, experts from across the aisle and across sectors come together to guide research priorities and find common ground.

Asking the Right Questions

We consult with sponsors, the scientific community, and environmental, industry, and state-level stakeholders to identify timely science and policy questions to guide our research investments. These priorities are articulated in the *HEI Strategic Plan for Understanding the Health Effects of Air Pollution.*

Getting the Right Answers

HEI's independent Board of Directors appoints widely respected experts across the full range of scientific disciplines to the HEI Research Committee and Review Committee. Along with HEI's scientific staff, the Research Committee creates targeted research programs and oversees rigorous, competitively funded scientific studies. When each study is completed, the Review Committee independently subjects it to a thorough peer-review process to ensure the scientific integrity of the methods and findings. Sponsors help set overall priorities but are not involved in the selection of investigators, oversight of the studies, or review of the results.

Making the Right Call

The Review Committee works with HEI's scientific staff to interpret what the studies mean for science and policy. Along with each study, we publish an objective commentary that puts the findings into context — informing policy decisions without taking a position. Every step in the process is designed to ensure that our work stands up to scrutiny and that our commentaries add value.

Accessing the Data

Access to data is vital for transparency and reproducibility in science. In addition to verifying previous research findings, data can be reused to study other questions and gain further insights, thus helping society get more value out of every dollar invested in research. Since its adoption some 20 years ago, HEI's Data Access Policy has encapsulated HEI's strong commitment to facilitating access to underlying data and methods for the studies it funds.

For the ongoing study of exposure of Medicare recipients to low levels of particulate matter pollution, HEI investigator Francesca Dominici used Medicare data from 61 million Americans over a 13-year period. Through an open data hub, she has made available all of the statistical code and exposure data her team used. Other groups have since accessed the same data set from Medicare to carry out their own studies on air pollution impacts. This includes a study by the Electric Power Research Institute as well as a collaborative effort with the American Petroleum Institute, American Forest & Paper Association, American Wood Council, National Council for Air and Stream Improvement, ExxonMobil Corporation, and other industries.

Scrutinizing the Science

Our nation depends on science to deliver breakthroughs, spark new technological advancements, and engineer solutions for the future. Science informs critical decisions about how to protect and strengthen our communities, our environment, and our economy. That's why it is tremendously important that science be reliable. HEI builds in checks and balances to ensure its funded scientific investigations are sound and the findings are trustworthy — each and every time.

A Process that Works

Our rigorous process starts with the science and policy leaders who make up our independent Board of Directors. A key function of the Board is to select qualified, independent experts to serve on HEI's Research and Review Committees, which operate separately to oversee our research programs and scrutinize the methods and findings of HEI-funded studies.

Committee members are extensively vetted to ensure they bring the appropriate scientific expertise as well as a dedication to objective, impartial research conduct. Our expert committees and scientific staff take the HEI process seriously, meticulously implementing procedures for setting research priorities, identifying qualified investigators, overseeing the use of funds, ensuring proper study design, and interpreting the results.

Before HEI-funded researchers share their full findings, each study undergoes intensive peer review. Independent experts assess the research methods, note strengths and weaknesses, and identify limitations. Finally, the Review Committee produces a commentary — in both detailed and summary form — that interprets the study results in the context of key science and policy questions.

Finding Trust in Transparency

Transparency and reproducibility are key tenets of responsible science. Transparency requires an honest accounting of all data and methods involved in the research. Reproducibility takes it a step further by enabling others to conduct the same study again — and see if the results agree.

In HEI's view, the best way to test the reproducibility and validity of scientific results is not only to repeat the studies but to determine whether the findings hold up when tested in different ways. For example, if the same techniques are applied to a different data set, are the findings roughly consistent? If different statistical analyses are applied to the same data set, do the conclusions remain the same? How sure can we be that the observed patterns are related to the factors being studied, rather than other possible explanations?

HEI has decades of experience overseeing such studies. For example, an HEI Special Report on *Revised Analyses of Time-Series Studies of Air Pollution and Health* assessed nearly 40 studies in light of newly identified issues with the statistical models that were used. Researchers painstakingly reconstructed the original data and conducted new analyses with corrected models. The effort revealed that some of the original studies had overestimated health effects of air pollution but that the revised analyses supported the same overall conclusions.

Another example is HEI's independent *Reanalysis of the Harvard Six Cities Study and the American Cancer Society Study of Particulate Air Pollution and Mortality*, which sought to examine intensively whether the studies' original results were robust to alternative assumptions, models, and potential
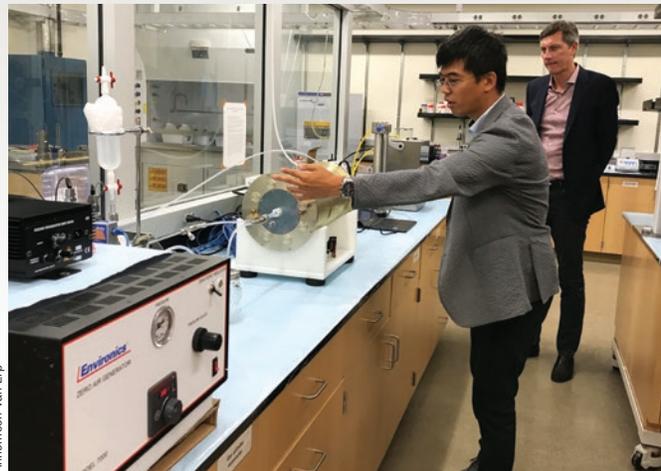
HEI investigator Manabu Shiraiwa (University of California, Irvine) shows HEI Research Committee member Ivan Rusyn (Texas A&M University) the equipment he is using in his study to produce secondary organic aerosols.

Annemoon van Erp

confounders. The analysis confirmed the quality, integrity, and validity of the original results.

HEI demonstrates its commitment to transparency by publishing all research findings, sometimes even reporting on findings throughout the research process when decision timing requires it. For example, HEI recently reviewed and published an initial set of results from two studies on exposure to low concentrations of air pollution, led by Francesca Dominici at the Harvard T.H. Chan School of Public Health and Michael Brauer of The University of British Columbia. The U.S. Environmental Protection Agency is currently reviewing the National Ambient Air Quality Standards for particulate matter, and HEI expects that results from the first two years of these four-year studies can play a constructive role.

Testing Cause and Effect

Air pollution can affect the health of large numbers of Americans and billions of people around the globe. Numerous interventions and regulations have been proposed and enacted. Which ones work? Over the decades, HEI has honed methods for answering that crucial question.

Determining cause and effect is a significant challenge. If a neighborhood sees a drop in traffic-based emissions, is it because cars are getting cleaner, or because road construction has temporarily diverted drivers away from the area? If children experience more asthma attacks in one county, is it because coal-burning power plants are more concentrated there, or because more adults smoke in the home?

Air pollution comes from many sources. At the same time, air pollution-linked health concerns are influenced by myriad factors. Disentangling all these causes and effects is difficult, but vital to informing effective action.

A Way Forward

Fortunately, there are scientifically validated approaches to connecting cause and effect, even for problems as complex as air pollution. The main three are systematic literature reviews, accountability research, and causal inference methods.

For systematic literature reviews, researchers draw on all available lines of evidence, including toxicology studies in cell cultures and laboratory animals, epidemiological studies in human populations, and controlled exposure studies in human volunteers. After identifying all relevant studies, researchers evaluate their quality and weigh the evidence of causation before synthesizing the germane findings into an integrated assessment.

Facing page: Atlanta is one of many places where HEI's accountability program has been evaluating whether environmental regulations achieve their intended goals for better air quality and health.

Accountability research tests the extent to which air quality interventions improve air quality and public health. Researchers must be careful to explore alternative explanations, as well as identify a control group for comparison, in order to have high confidence that changes in emissions and health outcomes are due to the regulatory action.

Causal inference methods are statistical analysis techniques that are rooted in epidemiology but make explicit assumptions about causes and effects. While these methods are vulnerable to confounding variables, they can provide useful insights that contribute to an overall understanding of cause and effect when the analyses are well designed, with proper controls.

Research in Action

HEI has long invested in all three types of causality research, with particular emphasis on accountability studies and, more recently, causal inference methods. One accountability study, described in HEI Research Report 190, examined the effectiveness of pollution controls in Los Angeles from the mid-1990s until around 2010. The researchers found substantial improvements in air quality, though noted the difficulty of isolating specific regulatory actions and their effects. The study also found that children growing up with cleaner air had significantly better lung health.

Another study (Research Report 195), took a different approach. Researchers compared health trends observed in the Atlanta region to what would have been expected in the absence of certain air quality regulations. Based on their models, the researchers estimated that the regulations significantly lowered emergency department visits, primarily by reducing asthma attacks. While there are always uncertainties in the models used in such studies, the study in Atlanta offers useful evidence for projecting potential impacts of air quality interventions.

HEI's accountability research program is now launching its third wave of projects, building on the significant successes and lessons learned from the previously funded studies. These projects, expected to start in early 2020, include a study of the National Clean Diesel Rebate Program, which allocates funding by lottery to school districts around the United States to replace or retrofit old-technology diesel-powered school buses; a study assessing effects of local congestion policies and national motor vehicle emissions regulations on birth outcomes associated with traffic-related air pollution in Texas; and two China-based studies: one assessing impacts of major national air pollution regulations on mortality, and the other evaluating health benefits from a household clean-fuel program in villages around Beijing.

Digging Deep

The average vehicle's emissions have dropped in recent decades thanks to new fuels, engine designs, and emission-control technologies. Have these changes actually reduced emissions along roadways? To find out, Xiaoliang Wang of the Desert Research Institute and colleagues dug into data collected in roadway tunnels (Research Report 199).

With HEI funding, the researchers analyzed more than 300 pollutants in Baltimore's Fort McHenry Tunnel and Hong Kong's Shing Mun Tunnel. They compared current pollution levels with those documented in a 1992 study conducted in Baltimore, a 2004 study conducted in Hong Kong, and studies of tunnels in other locations.

While the total number of vehicles passing through the tunnels each day has not changed much since the previous studies, the researchers found that average vehicle emissions have decreased substantially. They also teased apart the sources of various pollutants and compared the data to emission models used by regulators in the United States and Hong Kong. In its independent review of the study, the HEI Review Committee praised its unique design that allowed researchers to assess emission trends over time, compare measured and modeled emission estimates, and synthesize results from multiple data sources.

Traffic and the New Mobility

Visit any city in the world today, and your options for getting around will be vastly different from the options 20 years ago, or even five years ago. From ride-sharing services to self-driving cars to electric bikes and by-the-minute scooter rentals, people are finding new ways to move — and new business opportunities — around every corner.

What will mobility look like 20 years from now? Leaders in the automotive, energy, and technology industries are racing to prepare for the future — as are the government officials who regulate them. How can we best take advantage of emerging opportunities for convenient, affordable, safe transportation while avoiding potential pitfalls? And, how will the shifting mobility landscape affect the air we breathe?

Going Electric

Electric vehicles are likely to play a big role in our future mobility mix. Sales of electrics and plug-in hybrids are rising steadily, while new battery and fuel cell technologies aim to further increase the appeal and viability of electric vehicles. This trend includes not only cars but buses and trucks, suggesting a significant potential to reduce transportation-related emissions. Electric vehicle sales now top 2 million vehicles a year worldwide, but electrics still represent just a small fraction of vehicles on the road and are only as green as the source of energy they use. They also still produce pollutants from brake and tire wear. Though the future is likely to be decidedly more electric than the past, it will be important to study multiple facets of how this shift affects pollution and human health.

Anticipating Automation

Vehicles are rapidly becoming more intelligent and automated. While the extent to which human drivers will be replaced by self-driving technologies remains unclear, automation will almost certainly become more integral to vehicles and how we use them. In addition to technologies that automate vehicle operation, artificial intelligence systems are enabling new models for ride-hailing, ride-sharing, and shipping.

What will these changes mean for how, when, and where we move; and what might be the effects on air quality and health that HEI should follow?

A Fork in the Road

HEI's 2019 Annual Conference featured a session with lively discussion of the future of mobility and implications for pollution and human health. Speakers considered how electrification, automation, and a broader mix of transit modes could make mobility more efficient, accessible, clean, healthy, and safe — or, on the other hand, how these changes could worsen congestion, increase emissions and exposure, and exacerbate conflict among vehicles, bicycles, and pedestrians.

The participants traded knowledge and posed questions as they eyed potential scenarios: Will automation enable people to zip around town more efficiently than ever before, or will cities become clogged with driverless cars carrying single occupants while public transit systems wither? How can we extend the benefits of the mobility revolution across all segments of society — to the elderly, disabled people, low-income travelers, and to those living in suburban and rural environments? What do these changes mean for air pollution and health?

Melissa Ostrow

HEI's Panel on the Health Effects of Long-Term Exposure to Traffic-Related Air Pollution recently met with HEI staff in Boston.

Responsive Research

As mobility changes, HEI is expanding how we study traffic and transit-related air pollution. We're thinking beyond the tailpipe to examine other vehicular pollution sources and environmental and social factors that either exacerbate or counteract the impacts of traffic. For example, three HEI investigations are assessing how noise, green space, physical activity, and socioeconomic status intersect with traffic-related air pollution: the HERMES study of three large Danish cohorts, the FRONTIER study of pregnant women in Barcelona, Spain, and a study of children in Southern California.

HEI is also undertaking a major review of traffic-related pollution studies in a 10-year follow-up to its seminal literature review (Special Report 17). Whatever the future of mobility looks like, HEI researchers will be at the forefront, employing cutting-edge scientific tools such as low-cost sensors and advanced modeling techniques, to understand how we move and what it means for our health.

State of Global Air

HEI's State of Global Air report, available at *www. stateofglobalair.org*, brings into one place the latest country-by-country information on air quality and health. It is produced annually by HEI and the Institute for Health Metrics and Evaluation's Global Burden of Disease project as an objective, peer-reviewed information source on patterns and trends in air quality and health impacts.

The 2019 State of Global Air report sparked international headlines, many focused on one startling fact: a child born today will die 20 months sooner, on average, than would be expected in the absence of air pollution. This was the first year State of Global Air quantified the impact of air pollution in terms of life expectancy.

The report concludes that more than 90% of people worldwide live in areas exceeding the World Health Organization Guideline for healthy air. It analyzes trends in particular countries and regions, showing that not all areas are getting worse. For example, this year's report noted evidence that China's aggressive pollution controls are yielding results, driving a significant drop in fine particulate matter concentrations since 2011.

Global Health

Air quality in one place can have rippling effects around the world. A global perspective is vital for policy makers and business leaders in the United States as they look to understand air pollution and its environmental, social, and economic impacts.

While funding from HEI's core sponsors focuses on research needs in developed countries (e.g., in North America and Europe), support from philanthropic foundations has enabled HEI to expand its reach internationally. HEI's global program helps address data gaps in some of the most polluted areas of the world by shedding light on the levels and trends in air pollution in every country. It also provides valuable insights to government officials, as well as to businesses evaluating prospects for emerging technologies and markets.

Tracking Effects

It's difficult to evaluate the danger of pollution when that pollution isn't being measured in a systematic or meaningful way. In many countries, air pollution has long been a largely invisible threat — paradoxically, it is precisely in some of the world's most polluted places where air pollution monitoring is most sparse.

With new satellite remote sensing technology and innovative research methods, scientists are working to fill those data gaps and track the true worldwide toll of air pollution. HEI's Global Burden of Disease from Major Air Pollution Sources (GBD MAPS) program builds on the Institute for Health Metrics and Evaluation's Global Burden of Disease project by quantifying pollution from various sources and fuels, including electricity generation, heating, cooking, biomass, coal, and on-road and non-road transportation in all 195 countries included in the GBD. The current effort by HEI is an extension of its previous GBD MAPS projects

Assessing Air Pollution's Effects Across Asia

A forthcoming HEI study is looking at health data from nearly half a million participants in seven countries.
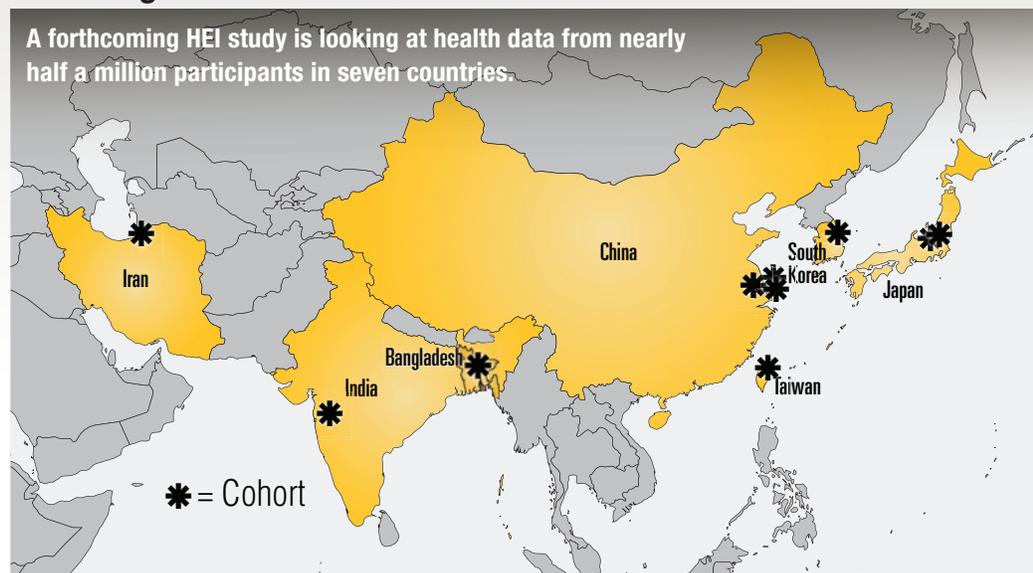
Data for Roel Vermeulen's HEI project with an Asian research consortium derive from three cohorts in Shanghai, China; two Japanese cohorts involving multiple cities; a Korean cohort focused on four urban and rural areas; and cohorts in Iran, India, Bangladesh, and Taiwan.

focused on China and India and is expected to conclude in 2020.

Another study, reported in HEI Communication 19, assessed how household air pollution contributes to ambient air pollution. The project focused on Ghana, where 80% of the population relies on solid fuels for heating and cooking. The study revealed that household air pollution adds substantially to the burden of ambient air pollution and suggested that alternative fuels, such as liquefied petroleum gas, could significantly reduce this burden. The project also surfaced valuable lessons to inform research and air quality actions in other countries in the region.

Two other projects have been focusing on pollution in Asia, where more than half the world's population lives. One study, led by Roel Vermeulen of Utrecht University in the Netherlands, is drawing from several large research cohorts within the Asia Cohort Consortium to understand the longer-term associations between air pollution and death from noncommunicable diseases in Asia (including cardiovascular and respiratory diseases and cancer). Another, led by

Yan Zhang of Fudan University in Shanghai (HEI Special Report 22), looked at air pollution and health impacts generated by shipping-related activity in Shanghai and the Yangtze River Delta, one of China's biggest port regions.

A Global Conversation

HEI staff are frequently invited to speak at international forums on global health challenges. In late 2018, for instance, HEI Principal Scientist Katherine Walker moderated a session at the first World Health Organization Global Conference on Air Pollution and Health in Geneva, Switzerland. In the session, speakers reviewed the acute and chronic effects of air pollution, with emphasis on population subgroups and occupationally exposed workers. They discussed how it can influence the most common diseases — heart attack, stroke, lung cancer, lung disorders, childhood pneumonia, and allergies — and described the evidence on the relative toxicity of Saharan dust, a key regional contributor to particulate air pollution.

Committees 2018—2019

RESEARCH COMMITTEE

David A. Savitz, Chair
Professor of Epidemiology, School of Public Health, and Professor of Obstetrics and Gynecology, Alpert Medical School, Brown University

Jeffrey R. Brook
Assistant Professor, University of Toronto, Canada

Francesca Dominici
Professor of Biostatistics and Senior Associate Dean for Research, Harvard T.H. Chan School of Public Health

David E. Foster
Phil and Jean Myers Professor Emeritus, Department of Mechanical Engineering, Engine Research Center, University of Wisconsin, Madison

Amy H. Herring
Sara & Charles Ayres Professor of Statistical Science and Global Health, Duke University, Durham, North Carolina

Barbara Hoffmann
Professor of Environmental Epidemiology, Institute of Occupational, Social, and Environmental Medicine, University of Düsseldorf, Germany

Allen L. Robinson
Raymond J. Lane Distinguished Professor and Head, Department of Mechanical Engineering, and Professor, Department of Engineering and Public Policy, Carnegie Mellon University

Ivan Rusyn
Professor, Department of Veterinary Integrative Biosciences, Texas A&M University

Research Committee members (from left) Amy Herring, Allen Robinson, David Savitz (chair), Jeffrey Brook, Barbara Hoffmann, and (not pictured) Francesca Dominici, David Foster, and Ivan Rusyn.

REVIEW COMMITTEE

James A. Merchant, Chair
Professor and Founding Dean Emeritus, College of Public Health, University of Iowa

Kiros Berhane
Professor and Chair, Department of Biostatistics, Mailman School of Public Health, Columbia University

Mark W. Frampton
Professor Emeritus of Medicine and Environmental Medicine, University of Rochester Medical Center

Frank Kelly
Professor of Environmental Health and Director of the Environmental Research Group, King's College London, United Kingdom

Jana B. Milford
Professor, Department of Mechanical Engineering and Environmental Engineering Program, University of Colorado, Boulder

Jennifer L. Peel
Professor of Epidemiology, Colorado School of Public Health and Department of Environmental and Radiological Health Sciences, Colorado State University

Roger D. Peng
Professor of Biostatistics, Johns Hopkins Bloomberg School of Public Health

Michael Jerrett of the Fielding School of Public Health, University of California, Los Angeles, recently joined the HEI Review Committee. He is an internationally recognized expert in geographic information science for exposure assessment and spatial epidemiology.

Sponsors 2018—2019

CORE SPONSORS

U.S. Environmental Protection Agency

Office of Research and Development

National Center for Environmental Research

National Health and Environmental Effects Research Laboratory

National Center for Environmental Assessment

Office of Air and Radiation

Office of Air Quality and Planning Standards

Office of Transportation and Air Quality

Office of Atmospheric Programs

Office of Radiation and Indoor Air

Office of International Affairs

Motor Vehicle Industry

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Caterpillar, Inc.

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Daimler AG

Detroit Diesel Corporation

FCA Group

Ford Motor Company

General Motors Corporation

Hino Motors, Ltd.

American Honda Motor Company, Inc.

Hyundai America Technical Center, Inc.

Isuzu Motors, Ltd.

Jaguar Land Rover North America, LLC

KIA Motors America, Inc.

Mazda Motor Corporation

Mitsubishi Motors Corporation

Chona Kasinger

Thomas Luben, U.S. Environmental Protection Agency, at the 2019 HEI Annual Conference.

Nissan Motor Company, Ltd.

North American Subaru, Inc.

PACCAR, Inc.

Renault SAS

Toyota Motor Corporation

Volkswagen of America, Inc.

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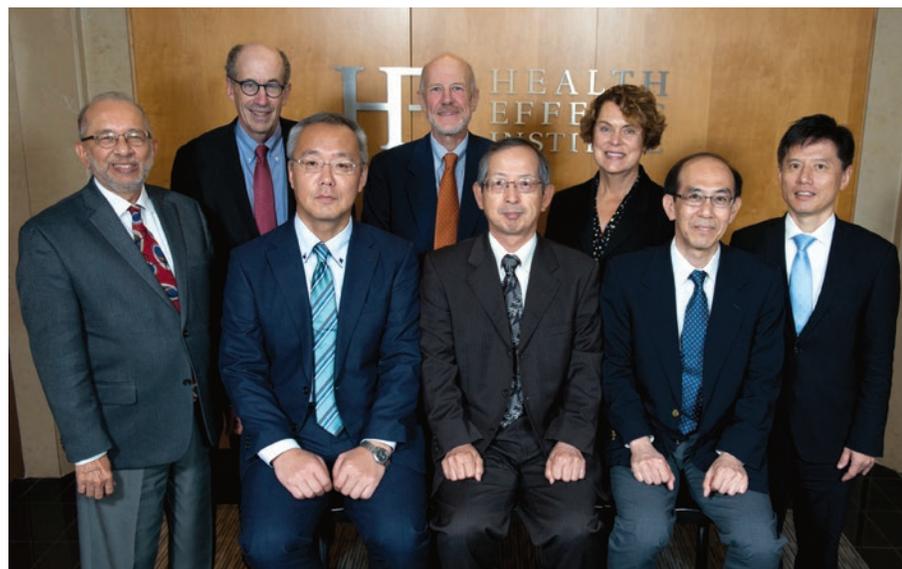Volvo Powertrain North America

OTHER SPONSORS

Bloomberg Philanthropies

CONCAWE (Conservation of Clean Air and Water in Europe)

John Deere and Company

ExxonMobil

William and Flora Hewlett Foundation

Melissa Ostrow

A delegation from the Japan Automobile Manufacturers Association visited HEI for a meeting in October 2018. The representatives included Tsuyoshi Ito (seated, left), Japan Automobile Research Institute; Yoshiaki Shibata (seated, center), Toyota Motor Company; Takuya Ikeda (seated, right), Nissan Motor Company; Tetsuya Yamashita (standing, right), Toyota Motor Company; and Susan Collet of Toyota Motor America. Pictured with them (standing, from left) are Director of Science Rashid Shaikh, President Dan Greenbaum, and Vice President Robert O'Keefe. Also participating were experts from Carnegie Mellon University, Michigan State University, the U.S. Environmental Protection Agency, the American Petroleum Institute, and Ford Motor Company.

Ongoing Studies and Reports under Review and in Press 2018—2019

ACCOUNTABILITY

Quantifying marginal societal health benefits of transportation emission reductions in the United States and Canada. *Amir Hakami, Carleton University, Canada*

Improvements in air quality and health outcomes among California Medicaid enrollees due to goods movement actions, Phase 2. *Ying-Ying Meng, University of California, Los Angeles*

AIR POLLUTION CONSTITUENTS AND MIXTURES

Emissions and Exposure Assessment

Scalable multipollutant exposure assessment using routine mobile monitoring platforms. *Joshua Apte, University of Texas, Austin*

*Enhancing models and measurements of traffic-related air pollutants for health studies using Bayesian melding. *Stuart Batterman, University of Michigan*

*Characterizing the determinants of vehicle traffic emissions exposure: Measurement and modeling of land-use, traffic, transformation, and transport. *Christopher Frey, North Carolina State University*

Chemical and physical characterization of non-tailpipe and tailpipe emissions at 100 locations near major roads in the Greater Boston area. *Petros Koutrakis, Harvard University*

Epidemiology

Susceptibility to multiple air pollutants in cardiovascular disease. *Jane Clougherty, Drexel University*

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*Report in the HEI review process as of June 30, 2019

Air Pollution, Autism spectrum disorders, and brain imaging amongst CHildren in Europe — the APACHE project. *Mònica Guxens, ISGlobal, Barcelona Institute for Global Health, Spain*

Impact of exposure to air pollution on asthma: A multi-exposure assessment. *Marie Pedersen, University of Copenhagen, Denmark*

Long-term outdoor air pollution and cause-specific mortality in a pooled analysis of multiple Asian cohorts. *Roel Vermeulen, Utrecht University, Netherlands*

Epidemiology at Low Exposures

* Mortality–Air Pollution Associations in Low-Exposure Environments (MAPLE). (Phase 1 published November 2019.) *Michael Brauer, University of British Columbia, Canada*

Mortality and morbidity effects of long-term exposure to low-level $PM_{2.5}$, black carbon, NO_2, and O_3: An analysis of European cohorts. *Bert Brunekreef, Utrecht University, Netherlands*

*Assessing adverse health effects of long-term exposure to low levels of ambient air pollution. (Phase 1 published November 2019.) *Francesca Dominici, Harvard University*

Epidemiology of Traffic-Related Air Pollution and Noise

Traffic-related air pollution and birth weight: the roles of noise, placental function, green space, physical activity, and socioeconomic status (FRONTIER). *Payam Dadvand and Jordi Sunyer, Barcelona Institute for Global Health (ISGlobal), Spain*

Intersections as hot spots: Assessing the contribution of localized non-tailpipe emissions and noise on the association between traffic and children's health. *Meredith Franklin, University of Southern California*

Erika Garcia (right), University of Southern California, discusses her study with Danielle Vienneau, Swiss Tropical and Public Health Institute, at HEI's 2019 Annual Conference.

Health effects of air pollution components, noise and socioeconomic status ("HERMES"). *Ole Raaschou-Nielsen, Danish Cancer Society Research Center, Copenhagen, Denmark*

Mechanisms of Health Effects

*Understanding the impact of air quality on the chemistry of ribonucleic acids. *Lydia Contreras, University of Texas, Austin*

Formation of reactive oxygen species by organic aerosols and transition metals in epithelial lining fluid. *Manabu Shiraiwa, University of California, Irvine*

GLOBAL HEALTH

*Impact of shipping sources on air quality and burden of disease in Shanghai, Yangtze River Delta. *Yan Zhang, Fudan University, Shanghai, China*

OZONE

*Multicenter Ozone Study in oldEr Subjects (MOSES) Part 2: Impacts of personal and ambient concentrations of ozone and other pollutants on cardiovascular and pulmonary function. *David Rich and Mark Frampton, University of Rochester*

Scavenger receptor B1 regulates oxidized lipid driven pulmonary and vascular inflammation after ozone exposure. *Kymberly Gowdy, East Carolina University*

Publications 2018–2019

Communication 18
JULY 2018
Household Air Pollution and
Noncommunicable Disease
HEI Household Air Pollution Working Group

Request for Applications 18-1
DECEMBER 2018
Assessing Improved Air Quality and Health
from National, Regional, and Local Air
Quality Actions
Health Effects Institute

Request for Applications 18-2
DECEMBER 2018
Walter A. Rosenblith New Investigator Award
Health Effects Institute

Request for Applications 19-1
MARCH 2019
Applying Novel Approaches to Improve
Long-Term Exposure Assessment of Outdoor
Air Pollution for Health Studies
Health Effects Institute

Research Report 197
MARCH 2019
Cellular and Acellular Assays for Measuring
Oxidative Stress Induced by Ambient and
Laboratory-Generated Aerosols
*Nga L. (Sally) Ng, Georgia Institute of
Technology*

Research Report 198
MARCH 2019
Understanding the Early Biological Health
Effects of Isoprene-Derived Particulate
Matter Enhanced by Anthropogenic
Pollutants
*Jason D. Surratt, University of North
Carolina, Chapel Hill*

Research Report 199
MARCH 2019
Real-World Vehicle Emissions
Characterization for the Shing Mun Tunnel
in Hong Kong and Ft. McHenry Tunnel in the

Chona Kasinger

Walter A. Rosenblith New Investigator Award recipients, from left: Kymberly Gowdy, East Carolina University (2015); Mònica Guxens, Barcelona Institute for Global Health (2016); Manabu Shiraiwa, University of California, Irvine (2018); Joshua Apte, University of Texas–Austin (2017); and Marie Pedersen, University of Copenhagen, Denmark (2017). At right is HEI Managing Scientist Annemoon van Erp.

United States
Xiaoliang Wang, Desert Research Institute

Special Report
MARCH 2019
State of Global Air 2019: A Special Report
on Global Exposure to Air Pollution and Its
Disease Burden
Health Effects Institute

Communication 19
MAY 2019
Contribution of Household Air Pollution
to Ambient Air Pollution in Ghana: Using
Available Evidence to Prioritize Future Action
*HEI Household Air Pollution–Ghana Working
Group*

*Unpublished report
JULY 2018
Evaluation of Alternative Sensor-Based
Exposure Assessment Methods.
Edmund Seto, University of Washington

*Unpublished report
AUGUST 2018
Use of Real-Time Sensors to Assess
Misclassification and to Identify Main
Sources Contributing to Peak and Chronic
Exposures.
*Juana Maria Delgado-Saborit, University of
Birmingham, United Kingdom*

*Unpublished report
OCTOBER 2018
Air Quality-by-Genomics Interactions in a
Cardiovascular Disease Cohort.
*William E. Kraus, Duke University School of
Medicine*

* Not published, but available on request

Financial Summary 2018—2019

HEI made significant progress in fiscal year 2019 toward the objectives of the Health Effects of Air Pollution program with ongoing research on possible health effects from low levels of exposure and examining the potential effects of traffic exposure in its broader context. We have also made progress in expanding our efforts in Global Health Science. These activities were made possible by funding from our core government and industry partners with additional funding from government, industry, and foundation sponsors. Separate funding has also allowed us to move forward with our Energy Research Program. The significant balance in Temporarily Restricted Net Assets ensures we will have funds to continue and expand our current targeted research initiatives in future years.

STATEMENTS OF FINANCIAL POSITION

	June 30	
	2019	**2018**
Assets		
Cash and cash equivalents	$3,883,423	$3,117,536
Restricted cash	147,705	147,535
Contributions receivable and accounts receivable	659,388	326,049
Unbilled incurred costs on grants	5,985,317	3,910,656
Prepaid expenses	62,438	3,739
Office equipment, office furniture and fixtures, and leasehold improvements, net	98,647	130,669
Total assets	**$10,836,918**	**$7,636,184**
Liabilities and Net Assets		
Liabilities:		
Contracted research payables	$565,658	$338,824
Accrued contracted research	1,883,581	1,233,093
Deferred revenue	592,611	802,691
Deferred rent payable	58,768	51,185
Other accounts payable and accruals	640,920	515,064
Total liabilities	**3,741,538**	**2,940,857**
Without donor net assets	616,265	560,151
With donor net assets	6,479,115	4,135,176
	7,095,380	4,695,327
Total net assets	**7,095,380**	**4,695,327**
Total liabilities and net assets	**$10,836,918**	**$7,636,184**

The HEI Financial Statement and the Mayer Hoffman McCann P.C. Auditors' Report may be obtained by contacting Jacqueline C. Rutledge at jrutledge@healtheffects.org.

STATEMENTS OF ACTIVITIES

| | Years Ended June 30 | |
	2019	2018
Changes in unrestricted net assets:		
Revenues and support:		
EPA grants for the Health Effects of Air Pollution Program	$5,812,109	$4,478,732
EPA contracts for Energy Research	462,552	0
Other industry contributions	5,087,321	4,830,262
Other non-federal grant and contract revenue	1,125,080	511,309
Energy Research Program grant	0	875,000
Other revenues	56,114	47,459
Total revenues and support	**12,543,176**	**10,742,762**
Expenses:		
Research programs:		
Research studies	4,522,170	2,606,274
Research planning and study selection	516,682	415,896
Scientific study management	197,249	247,693
Scientific study review	244,278	230,255
Scientific publication and communication	776,581	679,210
	6,256,960	**4,179,328**
Special scientific projects:		
Energy research	1,090,916	527,538
Traffic studies review	113,994	36,878
Global health science	1,254,839	819,652
	2,459,749	**1,384,068**
Total research and scientific expense	8,716,709	5,563,396
Administration	1,426,414	1,924,155
Total expenses	**10,143,123**	**7,487,551**
Net increase (decrease) in net assets	**2,400,053**	**3,255,211**
Net assets at beginning of year	**4,695,327**	**1,440,116**
Net assets at end of year	**$7,095,380**	**$4,695,327**

HEI Staff and Board of Directors 2018–2019

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Two Eminent Leaders Join Board

The HEI Board of Directors recently welcomed new members Martha J. Crawford and Michael J. Klag. Crawford is dean of the Jack Welch College of Business and Technology at Sacred Heart University, and Klag is dean emeritus and Second Century Distinguished Professor at the Johns Hopkins Bloomberg School of Public Health.

Martha J. Crawford   **Michael J. Klag**

Harry Giglio

HEI–Energy Program Reports Progress

Energy is integral to any discussion of air pollution and its health impacts. With oil and gas resource development projected to continue alongside growing efforts to switch to renewables and conserve energy, credible science is needed to support decisions on how best to protect public health.

HEI-Energy, launched in 2019 as a nonprofit affiliate of the Institute and built on the HEI model of independent science, provides high-quality and impartial science about potential human exposure and health effects associated with unconventional oil and gas development (UOGD) in the United States.

Convening Experts

With balanced funding from the U.S. Environmental Protection Agency and the oil and natural gas industry, HEI-Energy offers a framework for experts and stakeholders with different perspectives to find common ground. In a 2018 series of workshops held in Massachusetts, Colorado, Texas, and Louisiana, HEI-Energy convened scientific experts and interested parties to share preliminary findings on what is currently known about potential effects from UOGD. Participants engaged in open discussions with communities, regulators, industry representatives, and other stakeholders to help the HEI-Energy Research Committee formulate plans to review the available evidence and address important knowledge gaps.

Reviewing the Science

Informed by such exchanges of knowledge, as well as extensive reviews of the literature, the HEI-Energy Research Committee recently produced two companion reports, published in September 2019, establishing the research basis for the HEI-Energy program. The first report, a systematic review of the epidemiology literature on health effects associated

HEI-Energy website.

with UOGD, identified strengths and limitations in 25 studies designed to quantify the relationship between human exposures and health outcomes. The second report surveyed existing studies for information about potential UOGD exposures in an effort to better understand who might be exposed across different regions, and how and when those exposures might occur.

Creating New Knowledge

HEI-Energy aims to build on these efforts and provide science that is broadly useful to decision making by regulators, the oil and natural gas industry, environmental organizations, public health experts, communities, and other stakeholders. In the coming year, HEI-Energy expects to begin funding research to better understand potential community exposures associated with UOGD in major oil and natural-gas producing regions of the United States. As this work moves forward, HEI-Energy will share updates on its new website, https://hei-energy.org.

From left, HEI-Energy Research Committee members and HEI-Energy staff: Shari Dunn-Norman, Judy LaKind, Bob O'Keefe (staff), Donna Vorhees (staff), Ted Russell, Howard Hu, George Hornberger, Anna Rosofsky (staff), Peter Thorne, and Stefanie Ebelt.

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