Insights that Endure

Investing in Science for Lasting Impact

A Message From the Chair

It is rare for any single new scientific finding to quickly inform public and private decisions on individual and community health. In reality, scientific knowledge builds over time until there is a consensus among experts in a range of relevant disciplines. To that end, HEI has always sought to build *Insights that Endure,* the theme of this report. For decades, HEI's trusted independent research has identified top priority scientific and policy questions in environmental health, built strategic plans to answer those questions, and invested in innovative science for lasting impact.

This past year is no exception. Questions about the lowest levels at which air pollution might affect health arose in HEI's strategic plans, and HEI invested in wide-ranging studies of millions of U.S., Canadian, and European citizens. The findings are now at the center of active public discussions in the United States and the European Union about setting new health-protective air quality standards.

Much the same can be said of HEI's longstanding efforts to understand the effects of and solutions to exposures from vehicle traffic. HEI science informed a series of public and private decisions, along with technology advances, that resulted in every vehicle entering the marketplace today being dramatically cleaner than its counterparts of 10–20 years ago. But challenges remain. In the past year HEI issued its latest systematic review of the world's literature on traffic and health, which noted improvements but identified key continuing questions that HEI will now pursue to ensure lasting progress.

Long-term investment has been essential as well in the efforts of HEI's Global Health program to advance understanding of air pollution and health around the world. Starting some two decades ago in Asia, the Global Health program's dedicated synthesis of existing research, capacity strengthening among local scientists, and effective communication—in particular, through its State of Global Air initiative—have resulted in a growing community of scientists who are advancing understanding in China and India. In 2022 HEI also made new investments in building scientific networks in East Africa as countries there grapple with air pollution.

This progress comes at a time when the world is increasingly turning its attention to an even bigger challenge: promoting an energy transition that will reshape the ways we use energy in transportation, industry, our homes, and every other aspect of our lives. With these changes come opportunities for substantial additional health benefits, but also the challenge of identifying potential unintended consequences for health. Even as it moves forward with new energy research across the United States, HEI Energy is reaching out to sponsors and to the broader community to identify key new directions, such as exploring the health impacts of increased roles for hydrogen and carbon capture and storage. The institute is taking the first steps toward building capability to produce research that will inform the energy transition over the long term.

HEI also recognizes that it must undertake efforts to include scientists from a range of backgrounds and communities that have historically been underrepresented in science and, more specifically, in environmental health fields. HEI's Diversity, Equity, and Inclusion initiative is actively broadening how HEI recruits scientists to its staff, Board, and committees; encourages and receives proposals from underrepresented scientists; and seeks to build a pipeline of young scientists engaged in environmental health.

But HEI's efforts have not stopped there. 2022 brought active engagement with community leaders from marginalized communities, scientists who have been working successfully with those communities, and government agencies. The aim was to identify the best ways that HEI can build programs that have lasting impacts in advancing cleaner air in marginalized communities that have endured disproportionate adverse health effects.

It is sometimes a challenge to convince sponsors of science that, while their investments may not have immediate impact, a well-designed, strategic research program can make a long-term difference. HEI is fortunate to have ongoing support that enables it to make enduring contributions that matter.

Yours,

Richard A. Meserve
Chair, HEI Board of Directors
replies-to-richard-meserve@healtheffects.org

Convening Communities

Everyone has a stake in clean air because everyone benefits from it. To advance science that guides stakeholders, HEI brings communities, industries, policy makers, and scientists together to exchange ideas, voice concerns, and find common ground. Our role as a convener is critical to our ability to ask the right questions—and find the right answers.

Vital Conversations

How can we learn what issues are of greatest concern to people and their communities? How do we know what types of evidence will be most useful for decision makers? To bring out the core questions that are important to stakeholders—and identify where investments in science can make the biggest impact—requires honest, productive conversations among people with diverse experiences and interests. HEI brings together people and organizations from across all sectors of society for meaningful discussions about air pollution, its sources, and its impacts.

The public is both stakeholder and beneficiary when credible science is applied to policy making. HEI is committed to ensuring that the benefits of our work impact all communities, especially those that have been historically marginalized. To inform a growing nationwide effort to better serve communities experiencing disproportionate burdens from pollution, HEI hosted a two-day workshop on "New Science to Inform Environmental Justice" in the fall of 2022. The event forged new connections among a broad array of environmental justice stakeholders from community and nongovernmental organizations, academic institutions, government, and industry. It represented an important first step in identifying priorities, barriers, and possible solutions to address the environmental health challenges many historically marginalized communities face.

HEI also places a high priority on engaging people who live and work in areas that are the focus of our research programs. HEI Energy (see page 17) hosted two open-house events in the spring of 2022 to engage local communities in its research program on exposures related to unconventional oil and natural gas development across the United States. The public events—held in person in Longmont, Colorado, and virtually for communities in the Permian and Eagle Ford regions in Texas—provided residents and other stakeholders with an opportunity to meet research teams, ask questions, and learn about the purpose of the research and how to stay up to date. More community engagement events are planned as the research program continues moving forward.

Sharing Science

For nearly four decades, HEI's Annual Conference has been a hallmark of our role as a convener. In 2022 the conference, held in person again after taking place

U.S. EPA Deputy Administrator Janet McCabe gave the keynote address at HEI's Annual Conference 2022 in Washington, D.C. Photo by Jay Mallin

virtually in 2020 and 2021, featured U.S. Environmental Protection Agency (EPA) Deputy Administrator Janet McCabe as keynote speaker and welcomed attendees from the EPA, industry sponsors, academic institutions, and nongovernmental organizations. Participants shared the latest scientific findings and policy developments on setting ambient air quality standards, emerging trends in mobility, relationships between climate and ozone levels, environmental justice, air pollution's effect on the immune system, and much more.

Prioritizing Diversity, Equity, and Inclusion

Addressing inequities requires consistent, intentional action. HEI recognizes that we have a key role in addressing inequities and a responsibility to promote diversity, equity, and inclusion (DEI), both through our work and our organizational culture.

We have been excited to welcome an increasingly diverse group of people to the HEI network in the past year, including newcomers to our staff as well as Annual Conference speakers who joined us from around the world. In addition, we launched a new DEI Committee consisting of five HEI staff members who volunteered to help develop and move forward HEI's official DEI plan, set annual goals and communications objectives, facilitate dialogues and learning, and evaluate HEI's progress in implementing these measures.

In 2022, HEI also launched a new Summer Fellowship Program, which aims to encourage undergraduate students from backgrounds that are underrepresented in the environmental health sciences to explore research opportunities in this area. The program, a collaboration between HEI and the International Society of Exposure Sciences and the International Society for Environmental Epidemiology, will support its first cohort of summer fellows in 2023.

Insights
on Low
Exposure

Three recent HEI research reports shed new light on the potential health impacts of low levels of air pollution. With their large sample sizes and rigorous scientific methods, these studies offer powerful insights and test long-held assumptions about what pollution levels are safe.

One study, led by Harvard researcher Francesca Dominici, examines mortality trends among more than 68 million older Americans and links pollution exposure with an increased risk of death even at concentrations below the current U.S. National Ambient Air Quality Standards (NAAQS). According to the findings, a slightly lower air quality standard for $PM_{2.5}$—10 micrograms (µg) per cubic meter instead of the current standard of 12 µg/m^3—would have saved more than 143,000 lives over the course of a decade. The researchers used five different analytical approaches to conduct their study over four years, strengthening their confidence in the findings and bolstering the case for a likely causal effect between long-term pollution exposure and mortality.

In another study, University of British Columbia researcher Michael Brauer and colleagues combined satellite data, air monitor data, and atmospheric modeling to assess the relationship between pollution and mortality in over 7 million Canadian adults. Their results link long-term outdoor exposures to fine particle air pollution as low as 2.5 µg/m^3 with an increased risk of death, underscoring the opportunity to yield further health gains from cleaner air even in a country such as Canada, which has some of the lowest pollution exposures in the world.

A third study, led by Bert Brunekreef at Utrecht University in the Netherlands, found that exposures to relatively low levels
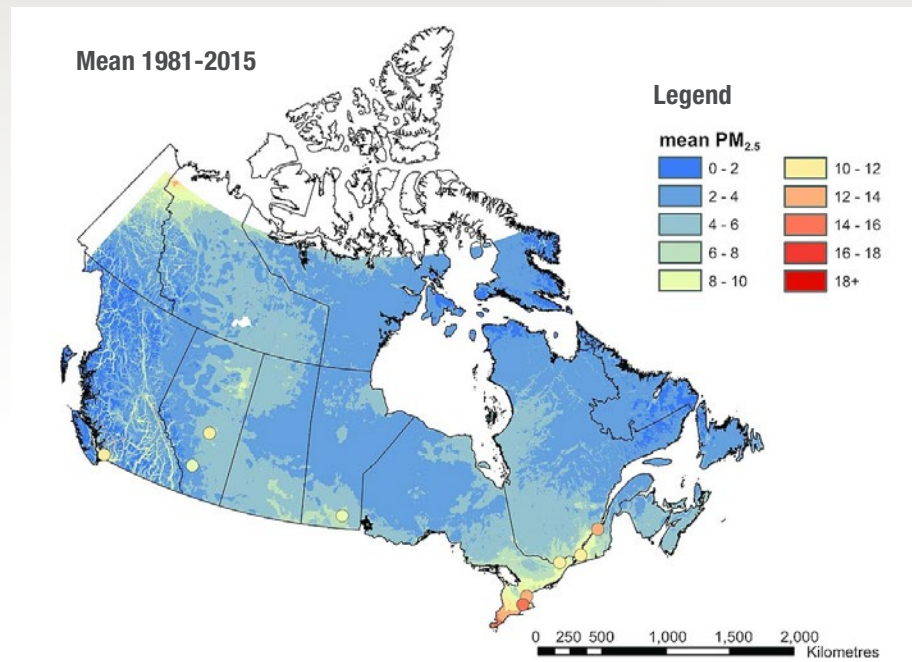

Figure from the HEI study conducted in Canada by Brauer and colleagues shows estimates of fine particulate matter ($PM_{2.5}$) annual means averaged over the entire study period (1981–2015). City-level estimates for the largest cities are shown in the circles.

of three pollutants (fine particulate matter, black carbon, and nitrogen dioxide) were significantly associated with death from all causes, heart disease, respiratory disease, and lung cancer, but that exposure to ozone was not linked to an increased risk of death from these causes. The study analyzed data from over 28 million people across 11 European countries and suggests these three pollutants may adversely affect health at concentrations below current European Union air quality limit values.

Informing New Standards

These studies come at an important moment as governments across several global regions consider tightening pollution regulations. When the study led by Dominici was published, the *New York Times* reported, "Older Americans who regularly breathe even low levels of pollution from

smokestacks, automobile exhaust, wildfires and other sources face a greater chance of dying early, according to a major new study." Based in part on these findings, the EPA subsequently proposed a draft rule to lower the annual NAAQS from 12 µg/m^3 to 9–10 µg/m^3 and is expected to issue a final rule in 2023. In Europe, findings from Bert Brunekreef and colleagues have contributed to a new European Commission proposal to lower its $PM_{2.5}$ Air Quality Limit Value to an annual limit of 10 µg/m^3, a level that is substantially below the current value of 25 µg/m^3.

Based on recent research, such actions could likely be expected to reduce harmful exposures and yield further health benefits for millions of people.
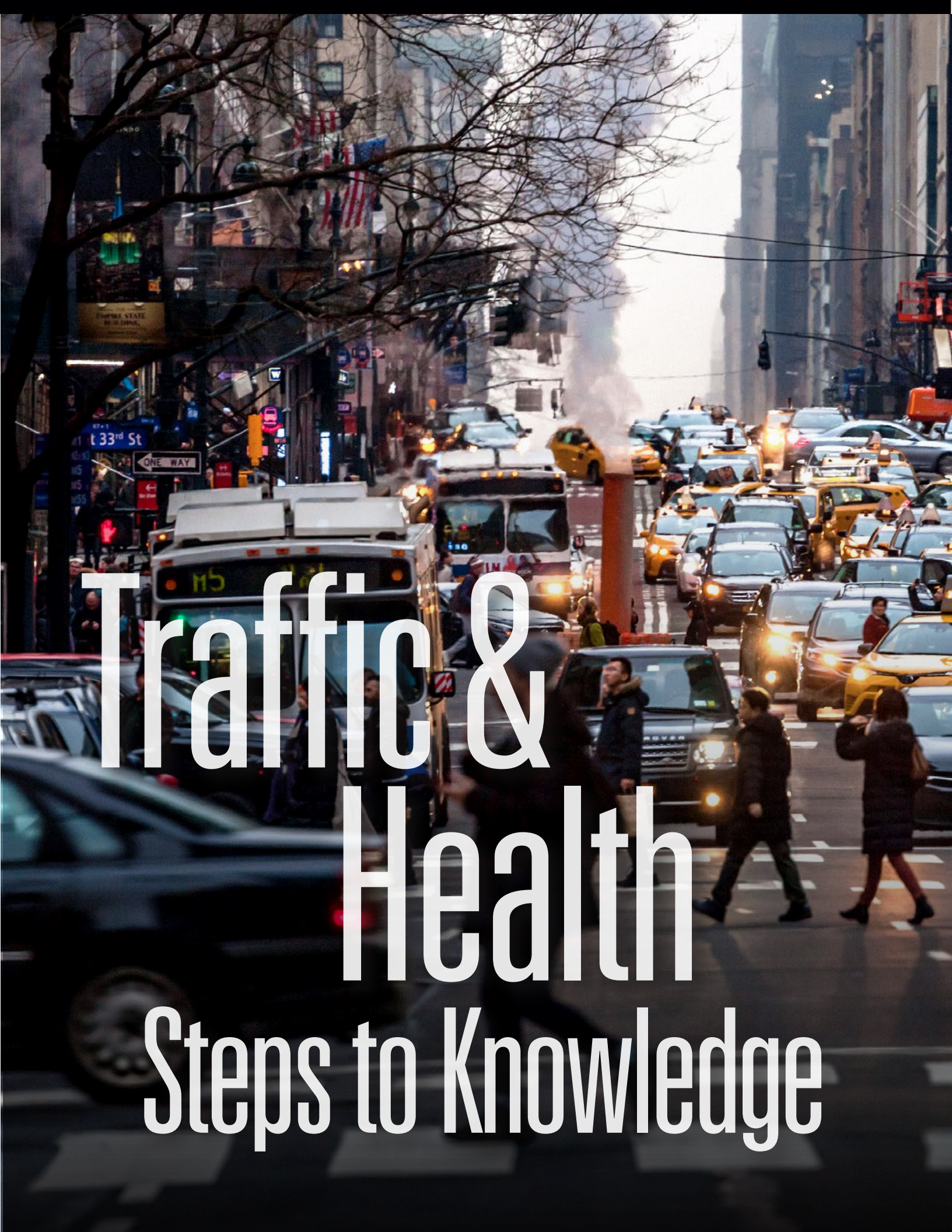
Traffic & Health
Steps to Knowledge

In many higher-income countries, a dramatic reduction in tailpipe emissions over the past several decades has been hailed as one of the great successes in air pollution control. Technological improvements by industry, along with regulations on fuels and vehicle emissions, have contributed to a steady decline in some air pollutants in many places. However, worldwide progress has been uneven. Population growth, urbanization, and economic activity have increased traffic congestion, counterbalancing some of the air quality gains seen in some places while worsening pollution in others.

HEI's Special Report 23, *Systematic Review and Meta-analysis of Selected Health Effects of Long-Term Exposure to Traffic-Related Air Pollution*, presents a new landmark review of scientific literature, offering a detailed look at the health effects of long-term exposure to traffic-related air pollution and insights on global trends.

Why Our Health Is (Still) Tied Up in Traffic

Vehicle emissions continue to drop in many places thanks to increasing vehicle emissions control, a growing adoption of electric vehicles, and other trends, but this is not enough to fully offset the fast-growing number of vehicles on the road globally. Traffic pollution is rising rapidly in many low- and middle-income countries, where increasing rates of car ownership are contributing to congestion and many older, higher pollution-emitting vehicles remain on the roads. As a result, according to the HEI report, both tailpipe and non-tailpipe emissions remain key sources of pollution that influence health and disease worldwide.

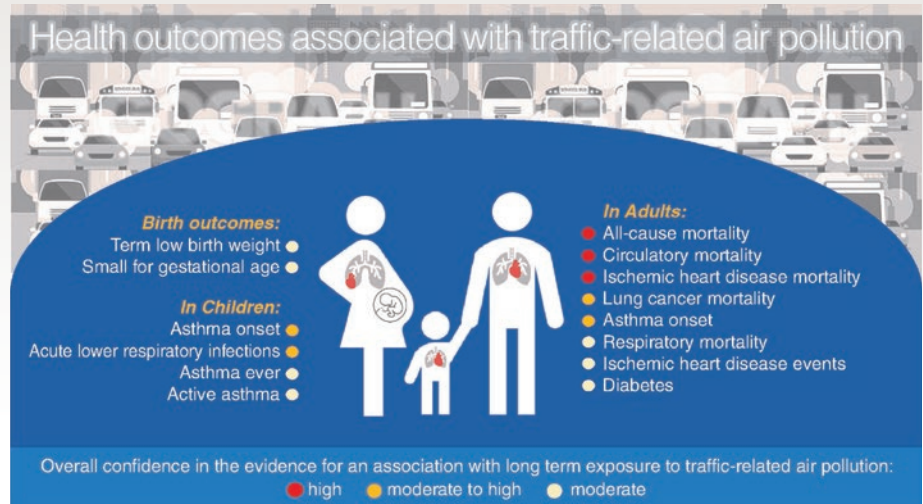Conducted by a panel of 13 renowned

Figure from HEI Special Report 23.

experts who reviewed 353 published studies, the report represents the largest and most comprehensive scientific review on the topic to date. It updates and builds upon HEI's widely cited 2010 report on traffic-related air pollution with an analysis of studies spanning four decades.

The Consequences of Congestion

The report concludes with a high level of confidence that exposure to traffic-related air pollution is strongly linked with early death from any cause, including cardiovascular diseases. It also reports moderate to high confidence in linkages with death from lung cancer and asthma onset in adults, as well as asthma onset and acute lower respiratory infections in children. Associations identified with moderate confidence include low birth weight, diabetes, and early death from respiratory diseases in adults. Exposures at the local level (within one kilometer of a major roadway) provided the greatest potential in determining the health effects of traffic-related air pollution.

To date, almost all traffic pollution regulations target tailpipe emissions. The report highlights continuing questions about

non-tailpipe sources of emissions generated by traffic, including road dust, abrasion of the road surface, and wear from brakes and tires, which can release heavy metals such as iron and copper. In 2022, HEI held a competition for targeted studies of these emissions and funded two new studies in London and Toronto.

The Road Ahead

In the fall of 2022, informed by the findings of Special Report 23, HEI issued a request for applications focused on assessing health effects of traffic-related air pollution in the context of a changing urban transportation landscape. In 2023 the program will allocate $5 million to a small number of studies using novel or improved methods to evaluate pollution exposures and effects as technologies and fuels change, the vehicle fleet turns over, mobility transforms, and electrification makes greater inroads around the world.

Air pollution is a global problem with local consequences. It sweeps across geopolitical borders, mountain ranges, and oceans; it drifts through urban centers and rural landscapes; and it affects people in all walks of life. To help inform policy for cleaner air, HEI communicated widely in 2022—through webinars and in person in Brussels, Bulgaria, Beijing, Delhi, and elsewhere—to draw connections between global air pollution exposures and health impacts for people the world over.

Data Wherever You Live

Three recent special reports of HEI's State of Global Air initiative drew locally relevant insights from global trends in air pollution exposures and health impacts. One report, How Does Your Air Measure Up Against the WHO Air Quality Guidelines?, focused on how fine particulate matter ($PM_{2.5}$) air pollution levels compare to air quality guidelines established by the World Health Organization (WHO). It found that no countries meet the WHO guidelines for healthy air (5 µg/m^3) and that a majority of the world's population is exposed to levels of $PM_{2.5}$ pollution higher than WHO's least stringent interim air quality target, 35 µg/m^3, a level that puts many at risk for serious health impacts.

A second State of Global Air report, Air Quality and Health in Cities, provided a detailed examination of pollution in urban areas, which suffer some of the poorest air quality on the planet. According to the analysis, cities saw 1.7 million deaths linked to fine particle air pollution exposure in 2019, with urban areas in Asia, Africa, and Eastern and Central Europe seeing the

Air Quality and Health in Cities provides a detailed examination of pollution in urban areas, which suffer some of the poorest air quality on the planet.

worst disease burdens. Rapid urbanization around the world puts cities at the forefront for actions to reduce the health effects of air pollution, especially in low- and middle-income countries.

A third report, How Does Air Pollution Affect Life Expectancy Around the World?, quantified air pollution's harsh impact on health in terms of decreased life expectancy. Globally, the analysis estimated that recent air pollution levels reduce the average person's lifespan by about 1.8 years, with reductions of 2 to 3 years in more heavily polluted countries. In 2023, State of Global Air expects to issue a new comprehensive report with updated analyses of air pollution and its health impacts for more than 190 countries.

What's Producing All the Pollution?

To design effective interventions to reduce air pollution, decision makers need to know the major sources of pollution in a particular area. These sources vary considerably from place to place, from pollutant to pollutant, and from source to source. HEI's Research Report 210, Global Burden of Disease from Major Air Pollution Sources (GBD MAPS): A Global Approach, provided the first comprehensive analysis of pollution sources for every country in the world. The report documented the key role fossil fuel combustion plays as a primary source of air pollution—linked with more than 1 million deaths globally in 2017—and in particular the continu-

ing burden of disease from coal combustion. Underscoring the continuing impacts from fuel combustion despite dramatic increases in clean-energy technologies, the findings can help guide approaches to simultaneously improve air quality and mitigate climate change around the world.

Regional Insights for Targeted Action

Two recent HEI reports drilled deeper into air pollution trends in particular regions in order to guide evidence-based action. A special State of Global Air report on Southeast Europe, as well as reports focused specifically on Serbia and Bulgaria, revealed that this region suffers a rate of death due to air pollution nearly four times higher than the rate seen in Western Europe. The report highlighted energy poverty and access to clean energy as key issues to address if the region is to reduce air pollution and its associated disease burden.

A second regional report focused on air pollution trends in Africa and drew attention to the high disease burden of household air pollution, which is generated from burning solid fuels such as coal, wood, and charcoal for cooking. This source of pollution is associated with particular health impacts for newborns and young children, with air pollution accounting for nearly 1 in 6 deaths in children under 5 across Africa. Fine-particle air pollution from energy production, vehicles, and industrial activities also combines with windblown dust (a natural pollution source) in some parts of Africa, contributing to some of the highest pollution levels in the world.

Committees

Current as of January 1, 2023

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
Associate Professor, Occupational & Environmental Health Division, Dalla Lana School of Public Health, University of Toronto, Canada

Christina Fuller
Associate Professor, School of Environmental, Civil, Agricultural and Mechanical Engineering, University of Georgia College of Engineering

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

Heather A. Holmes
Associate Professor, Department of Chemical Engineering, University of Utah

Neil Pearce
Professor of Epidemiology and Biostatistics, London School of Hygiene and Tropical Medicine, United Kingdom

Ana M. Rule
Assistant Professor and Director, Environmental Exposure Assessment Laboratories, Department of Environmental Health and Engineering, Johns Hopkins School of Public Health

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

Evangelia (Evi) Samoli
Associate Professor of Epidemiology and Medical Statistics, Department of Hygiene, Epidemiology and Medical Statistics, School of Medicine, National and Kapodistrian University of Athens, Greece

New Committee Members

In 2022 HEI welcomed four leading experts to its scientific committees. From left, Research Committee members Christina Fuller, Ana Rule, and Neeta Thakur and Review Committee member Ulrike Gehring. (See below for academic affiliations.)

Neeta Thakur
Associate Professor of Medicine, University of California, San Francisco

Gregory Wellenius
Professor, Department of Environmental Health, Boston University School of Public Health

REVIEW COMMITTEE

Melissa Perry, *Chair*
Dean, College of Health and Human Services, George Mason University

Sara D. Adar
Associate Professor and Associate Chair, Department of Epidemiology, University of Michigan School of Public Health

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

Ulrike Gehring
Associate Professor, Institute for Risk Assessment Sciences, Utrecht University, Netherlands

Michael Jerrett
Professor and Chair, Department of Environmental Health Sciences, Fielding School of Public Health, University of California, Los Angeles

Frank Kelly
Henry Battcock Chair of Environment and Health and Director of the Environmental Research Group, Imperial College London School of Public Health, United Kingdom

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

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

Eric J. Tchetgen Tchetgen
Luddy Family President's Distinguished Professor, Professor of Statistics and Data Science, The Wharton School, University of Pennsylvania

Sponsors
Funding HEI Programs During 2022

CORE SPONSORS

U.S. Environmental Protection Agency

Office of Research and Development
Office of Air and Radiation
  Office of Air Quality Planning and Standards
  Office of Transportation and Air Quality
  Office of Atmospheric Programs
  Office of Radiation and Indoor Air
Office of International Affairs

Motor Vehicle Industry

BMW of North America, LLC
Caterpillar, Inc.
Cummins Inc.
Daimler AG
Detroit Diesel Corporation
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
John Deere and Company
KIA Motors America, Inc.
Mazda Motor Corporation
Mitsubishi Motors Corporation
Nissan Motor Company, Ltd.
PACCAR, Inc.
Stellantis
North American Subaru, Inc.
Toyota Motor Corporation
Volkswagen of America, Inc.
Volvo Cars of North America, LLC
Volvo Powertrain North America

OTHER SPONSORS

American Petroleum Institute
Children's Investment Fund Foundation
Clean Air Fund
ConocoPhillips
ExxonMobil

Angie Shatas, U.S. EPA, at HEI's Annual Conference 2022.

From left, Karen Wesson, U.S. EPA; Marusia Popovich, ExxonMobil; and Donna Vorhees, HEI Energy CEO and Vice President, at a meeting in Boston.

In November 2022, HEI President Dan Greenbaum, Vice President Bob O'Keefe, and Director of Science Ellen Mantus toured the Cummins Technical Center in Columbus, Indiana, to learn about progress from the Cummins Technical and Environment Team. From left: Amy Henderson, O'Keefe, Mantus, Cheryl Klepser, Carol Henry, Greenbaum, Brian Mormino (Executive Director), and Gary Parker.

Ongoing Studies and Reports under Review and in Press *Status at end of fiscal year (June 30, 2022)*

ACCOUNTABILITY

Assessing the national health and educational benefits of the EPA's School Bus Retrofit and Replacement Program: A randomized controlled trial design. *Sara Adar, University of Michigan*

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

How do household energy interventions work? *Sam Harper and Jill Baumgartner, McGill University, Canada*

Impacts of vehicle emission regulations and local congestion policies on birth outcomes associated with traffic air pollution. *Perry Hystad, Oregon State University*

Accounting for the health benefits of air pollution regulations in China, 2008–2020. *Patrick Kinney, Boston University*

Environmental and health benefits of mobile source and electricity generating unit policies to reduce particulate pollution. *Stefanie Ebelt, Emory University; David Rich, University of Rochester*

AIR POLLUTION EPIDEMIOLOGY

COUPH: COpenhagen Ultrafine Particles and Health. *Heresh Amini, University of Copenhagen, Denmark*

Urban air and noise pollution in sub-Saharan Africa: A study of prenatal exposures, birth outcomes, and sleep disturbances in infants. *Raphael Arku, University of Massachusetts, Amherst*

Air pollution exposure and prefrontal connectivity in early adolescence. *Megan Herting, University of Southern California*

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

* Report in the HEI review process as of June 30, 2022

**Long-term outdoor air pollution and cause-specific mortality in a pooled analysis of 23 Asian cohorts. *Roel Vermeulen, Utrecht University, Netherlands*

COVID-19, AIR POLLUTION, AND HEALTH

Long-term exposure to air pollution and COVID-19 mortality and morbidity in Denmark: Who is most susceptible? (AIRCODEN). *Zorana Andersen, University of Copenhagen, Denmark*

Effect of air pollution reductions on mortality during the COVID-19 lockdown: A natural experiment study. *Kai Chen, Yale University*

Ambient air pollution and COVID-19 in California. *Michael Kleeman, University of California, Davis*

Race, Ethnicity, and Air pollution in COVID-19 Hospitalization OUTcomes (REACH OUT). *Jeanette Stingone, Columbia University*

Air pollution in relation to COVID-19 morbidity and mortality: A large population-based cohort study in Catalonia, Spain (COVAIR-CAT). *Cathryn Tonne, Barcelona Institute for Global Health (ISGlobal), Spain*

EMISSIONS AND EXPOSURE ASSESSMENT

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

Accounting for mobility in air pollution exposure estimates in studies on long-term health effects. *Kees de Hoogh, Swiss Tropical and Public Health Institute, Switzerland*

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

Spatial statistical learning methods for estimating ambient air pollution. *Gerard Hoek, Utrecht University, Netherlands*

Investigating the consequences of measurement error of gradually more sophisticated long-term personal exposure models in assessing health effects: The London Study (MELONS). *Klea Katsouyanni, Imperial College London, United Kingdom*

Optimizing exposure assessment for inference about air pollution effects with application to the aging brain. *Lianne Sheppard, University of Washington*

Comparing the estimated health impacts of long-term exposure to traffic-related air pollution using fixed-site, mobile, and deep learning models. *Scott Weichenthal, McGill University, Canada*

EPIDEMIOLOGY AT LOW EXPOSURES

**Identifying the shape of the association between long-term exposure to low levels of ambient air pollution and the risk of mortality: An extension of the Canadian Census Health and Environment Cohort using innovative data linkage and exposure methodology. Phase 2. *Michael Brauer, University of British Columbia, Canada*

GLOBAL HEALTH

Integrating satellites, ground monitoring, and modeling to estimate long-term NO_2 exposures and associated pediatric asthma impacts. *Susan Anenberg, George Washington University*

MECHANISMS AND METHODS

Air pollutants and the gut microbiota and metabolome during early life: Implications for childhood obesity. *Tanya Alderete, University of Colorado*

Robust statistical approaches to understanding the causal effect of air pollution mixtures. *Joseph Antonelli, University of Florida*

Publications

July 1, 2021–June 30, 2022

Ongoing Studies
(Continued from previous page)

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

TRAFFIC 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*

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

WILDLAND FIRES AND AGRICULTURAL BURNING

Australian fires and perinatal health risks. *Michelle Bell, Yale University*

Contributions of prescribed fire and agricultural burning to air quality and health. *Talat Odman, Georgia Institute of Technology*

Research Report 206
JULY 2021
Social Susceptibility to Multiple Air Pollutants in Cardiovascular Disease
Jane Clougherty, Drexel University

Research Report 208
SEPTEMBER 2021
Mortality and Morbidity Effects of Long-Term Exposure to Low-Level $PM_{2.5}$, BC, NO_2, and O_3: An Analysis of European Cohorts in the ELAPSE Project
Bert Brunekreef, Utrecht University, the Netherlands

Research Report 209
FEBRUARY 2022
Associations of Air Pollution on the Brain in Children: A Brain Imaging Study
Mònica Guxens, Barcelona Institute for Global Health (ISGlobal), Spain

Research Report 210
DECEMBER 2021
Global Burden of Disease from Major Air Pollution Sources (GBD MAPS): A Global Approach
Erin McDuffie, Washington University in St. Louis

Research Report 211
JANUARY 2022
Assessing Adverse Health Effects of Long-Term Exposure to Low Levels of Ambient Air Pollution: Implementation of Causal Inference Methods
Francesca Dominici, Harvard T.H. Chan School of Public Health

Special Report 23
JUNE 2022
Systematic Review and Meta-analysis of Selected Health Effects of Long-Term Exposure to Traffic-Related Air Pollution

State of Global Air Special Report
MARCH 2022
How Does Air Pollution Affect Life Expectancy Around the World?

Walter A. Rosenblith New Investigator Award winners joined HEI staff for dinner during HEI's Annual Conference in June 2022. From left: Heresh Amini (2020 awardee), Elise Elliott of HEI, Lucas Henneman (2021), Allison Patton of HEI, Marie Pedersen (2017), Megan Herting (2019), Dan Crouse of HEI, Manabu Shiraiwa (2018), and Raphael Arku (2020).

State of Global Air Special Analysis
MARCH 2022
How Does Your Air Measure Up Against the WHO Air Quality Guidelines?

State of Global Air Spotlight Reports
MAY 2022
Trends in Air Quality and Health in Southeast Europe

JUNE 2022
Trends in Air Quality and Health in Bulgaria

Request for Applications 21-1
OCTOBER 2021
Quantifying Real-World Impacts of Non-Tailpipe Particulate Matter Emissions

Request for Applications 21-2
DECEMBER 2021
Walter A. Rosenblith New Investigator Award

Request for Initial Qualifications 21-3
NOVEMBER 2021
Studies of Air Pollution and Health Effects in India

Financial Summary 2021–2022

HEI made significant progress in fiscal year 2022 toward the objectives of the Health Effects of Air Pollution program by completing 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 to produce and communicate 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, | |
	2022	**2021**
Assets		
Cash and cash equivalents	$6,454,725	$6,089,019
Restricted cash	147,962	147,962
Contributions and accounts receivable	3,609,717	1,645,968
Unbilled incurred costs on grants	5,500,00	4,504,834
Prepaid expenses	43,788	84,841
Office equipment, office furniture and fixtures, and leasehold improvements, net	24,815	54,097
Total assets	**$15,781,007**	**$12,526,721**
Liabilities and Net Assets		
Liabilities:		
Contracted research payables	$312,057	$447,471
Accrued contracted research	2,769,329	1,934,203
Deferred rent payable	36,019	51,185
Other accounts payable and accruals	1,675,543	1,070,663
Total liabilities	**$4,792,948**	**3,503,522**
Net Assets:		
Without donor restrictions	722,041	656,243
With donor restrictions	10,266,018	8,366,956
Total net assets	**10,988,059**	**9,023,199**
Total liabilities and net assets	**$15,781,007**	**$12,526,721**

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,	
	2022	**2021**
Revenues and support:		
EPA grants for the Health Effects of Air Pollution Program	$5,744,711	$5,950,844
EPA contracts for Energy Research	3,421,866	651,100
Industry contributions	5,399,530	5,161,046
Other non-federal grant and contract revenue	449,080	678,918
Other revenues	65,798	39,737
Total revenues and support	**15,080,985**	**12,481,645**
Expenses:		
Research programs:		
Research studies	5,940,177	4,687,594
Research planning and study selection	642,306	618,614
Scientific study management	342,818	276,929
Scientific study review	300,276	285,174
Scientific publication and communication	1,153,281	858,358
	8,378,858	**6,726,669**
Special Scientific projects:		
Energy research	1,048,193	655,620
Traffic studies review	329,993	459,428
Global health science	1,042,768	992,904
	2,420,954	**2,107,952**
Total research and scientific expenses	10,799,812	8,834,621
Administration	2,316,313	1,938,294
Total expenses	**13,116,125**	**10,772,915**
Net increase in net assets	**1,964,860**	**1,708,730**
Net assets at beginning of year	**9,023,199**	**7,314,469**
Net assets at end of year	**$10,988,059**	**$9,023,199**

HEI Staff and Board of Directors

Current as of January 1, 2023

OFFICERS AND STAFF

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Vice President

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Donna J. Vorhees
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Deputy Director of Science

Thomas J. Champoux
Director of Science Communications

Jacqueline C. Rutledge
Director of Finance and Administration

Jason Desmond
Deputy Director of Finance and Administration

Emily Alden
Corporate Secretary

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Ayusha Ariana
Research Assistant

Palak Balyan
Consulting Staff Scientist

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Consulting Principal Scientist

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Staff Scientist

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Executive Assistant

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Consulting Research Fellow

Pallavi Pant
Head of Global Health

Allison P. Patton
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Quoc Pham
Science Administrative Assistant

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Senior Scientist

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Operations Manager

Eva Tanner
Staff Scientist

Alexis Vaskas
Digital Communications Manager

Ada Wright
Research Assistant

BOARD OF DIRECTORS

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Senior of Counsel, Covington & Burling LLP; President Emeritus, Carnegie Institution for Science; former Chair, U.S. Nuclear Regulatory Commission

Jo Ivey Boufford
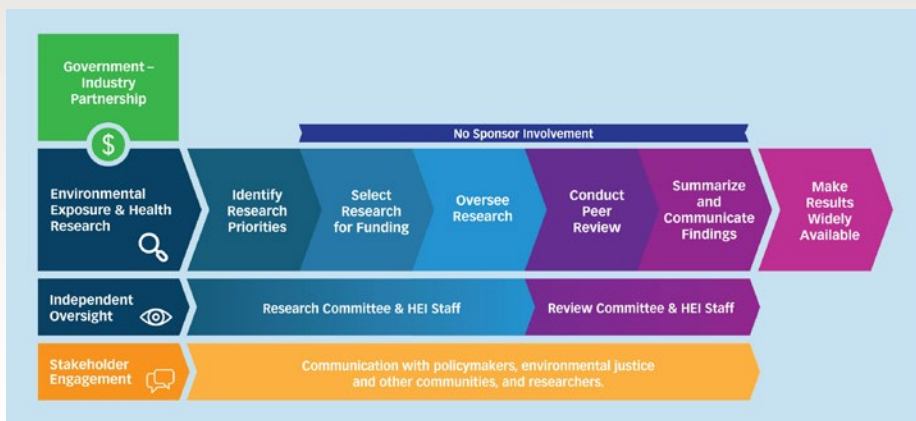*Clinical Professor of Global Health and Pediatrics, New York University*

Homer Boushey
Emeritus Professor of Medicine, University of California–San Francisco

Jared L. Cohon
President Emeritus and Professor, Civil and Environmental Engineering and Engineering and Public Policy, Carnegie Mellon University

Stephen Corman
President, Corman Enterprises

Martha J. Crawford
Operating Partner, Macquarie Asset Management

Ana Diez Roux
Dana and David Dornsife Dean and Distinguished University Professor of Epidemiology, Dornsife School of Public Health, Drexel University; Director, Drexel Urban Health Collaborative

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Alan I. Leshner
CEO Emeritus, American Association for the Advancement of Science

Catherine L. Ross
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Martha Rudolph
Environmental Attorney, Former Director of Environmental Programs, Colorado Department of Public Health and Environment

Karen C. Seto
Frederick Hixon Professor of Geography and Urbanization Science, Yale School of the Environment

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Archibald Cox
Founding Chair, 1980–2001

Donald Kennedy
Vice Chair Emeritus, 1980–2003; Editor-in-Chief Emeritus, Science

New Board Members

The HEI Board of Directors welcomed three new members in 2022, pictured from left: Ana Diez Roux, Catherine Ross, and Martha Rudolph. (Affiliations are below.)

Progress at HEI Energy

How HEI Energy works to provide impartial science for decision making and public understanding.

HEI Energy, an independent affiliate of HEI, invests in research about the potential human exposures and health effects of oil and natural gas development from shale and other unconventional resources in the United States.

At its inception several years ago, HEI Energy embarked on a detailed strategic planning initiative to inform its research agenda. In early 2022, fortified with insight from several stakeholder workshops and a comprehensive review of the current scientific knowledge, it launched its first five funded studies. The studies are using statistical modeling approaches as well as measurements to assess community exposures to noise, chemical emissions to air, and potential chemical releases to water from unconventional oil and gas development activities. This research is complemented by development of a new model that predicts how chemical emissions from specific operations affect local and regional air quality. The studies focus on particular regions of southwestern Pennsylvania, northeastern Colorado, and South and West Texas, with plans to extend the research activities and findings to other shale and sedimentary basin regions across the United States.

Prioritizing Community Engagement

Making affected communities an integral part of the research process helps produce trusted science that benefits decision-making. In the first year of its funded research programs, HEI Energy hosted two public community meetings, bringing local residents together with research teams to begin building relationships and lay the groundwork for continuing engagement. In addition, English and Spanish factsheets provide an accessible overview of the research programs, and each project issues lay-friendly quarterly research updates so communities can stay up-to-date on the latest research findings and activities, as well as ways to engage.

While the funded studies are still in their early stages, the program is already offering useful information for government officials, local residents, researchers, industry personnel, environmental groups, and other stakeholders. To date, HEI Energy has hosted five webinars on topics related to unconventional oil and gas development, including air quality, water quality, noise, abandoned wells, and research fatigue among people living in study locations. Other key activities include tailored briefings, maintenance of a scientific literature database, and presentations of emerging research findings.
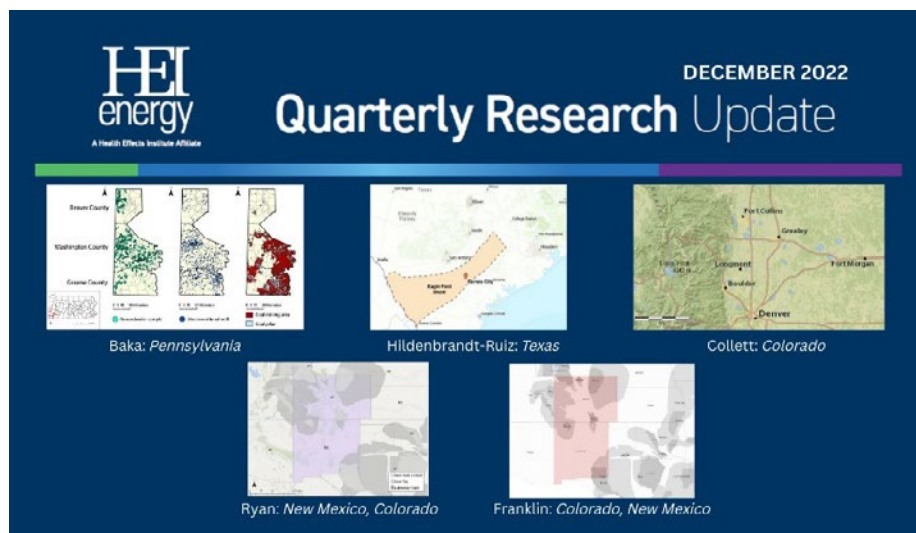
In 2022, HEI Energy launched its first five studies and began publishing quarterly news updates on their progress.

HEI

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