Health Effects Institute

Annual Conference 2024 Abstracts

Listed alphabetically by presenter (underscored)

Key:

HEI *HEI-funded investigator*

HEI energy *HEI Energy-funded investigator*

[R] *Walter A. Rosenblith New Investigator Award recipient*

[W] *Jane Warren Conference Award recipient*

HEI [R]Ambient Air Pollution Exposure is Associated with the Infant Gut Microbiome and Fecal Metabolome

Elizabeth A. Holzhausen[1], Bridget Chalifour[1], Emily Yeo[1], ViLinh Tran[2], Zhenjiang Li[2], Jeremy A. Sarnat[2], Fredrick Lurmann[3], Howard H. Chang[2], Roshonda Jones[1,4], Michael I. Goran[4], Donghai Liang[2], Tanya L. Alderete[1]

[1]*University of Colorado Boulder, Boulder, Colorado, USA*
[2]*Emory University, Atlanta, Georgia, USA*
[3]*Sonoma Technology Inc., Petaluma, California, USA*
[4]*Children's Hospital Los Angeles, Los Angeles, California, USA*

Background and Objectives: Ambient air pollution (AAP) is associated with childhood obesity risk, independent of diet and activity. However, the biological mechanisms underlying these relationships remain uncertain. We hypothesized that AAP alters the developing infant gut microbiome and fecal metabolome, with implications for childhood obesity risk. This study aimed to determine whether prenatal/early life AAP exposure is associated with the gut microbiome in the first 2 years of life.

Methods and Approach: This study examined Latinos from the Southern California Mother's Milk Study. AAP (PM_{10}, $PM_{2.5}$, and NO_2) was modeled using residential address histories. Metagenomics and metabolomics were performed on stool samples at 1-, 6-, 12-, 18-, and 24-months of age. Associations between AAP with the microbiome and metabolome were assessed using negative binomial models and linear mixed effects models, respectively. Metabolomics models adjusted for infant sex, socioeconomic status, season, mother age, infant age, and breast- and formula feeding. Microbiome models additionally adjusted for maternal BMI and delivery mode. Spearman correlations estimated the associations between the microbiome and metabolome. The Benjamini-Hochberg (BH) procedure was used to adjust for multiple testing.

Results and Findings: AAP was associated with 77 gut bacterial species ($P_{BH\_all}<0.05$), with 50% inverse associations. Species from genus *Bifidobacterium* were inversely associated with AAP. *Bifidobacterium* abundance is positively associated with healthy weight. Metabolites linked with AAP included histamine, tryptophan, and carnitine, which have been previously associated with satiety and body weight. Among all microbes and metabolites, 1,835 were correlated (range: -0.61,0.69).

Conclusions and Interpretation: We identified microbes and metabolites associated with AAP, which are linked with childhood obesity. These results suggest that multi-omics approaches can obtain novel mechanistic insights of the adverse effects of early life AAP exposure. Future work in this cohort will include integrated analyses to explore the joint impact of AAP exposure on the gut microbiome and fecal metabolome using LUCIDus.

Acknowledgements: This project is supported by the Health Effects Institute Rosenblith Award, the National Institute of Diabetes and Digestive and Kidney Diseases (R01DK110793), the National Institute on Minority Health and Health Disparities (P50MD017344), the National Institute of Environmental Health Sciences (R01ES035035), the Gerber Foundation (15PN-013), and the National Heart, Lung, and Blood Institute (T32 HL149646). Research described in this article was conducted under contract to the Health Effects Institute (HEI), an organization jointly funded by the United States Environmental Protection Agency (EPA) (Assistance Award No. CR 83,998,101) and certain motor vehicle and engine manufacturers. The contents of this article do not necessarily reflect the views of HEI, or its sponsors, nor do they necessarily reflect the views and policies of the EPA or motor vehicle and engine manufacturers.

Assessing the Impact of Spatially and Temporally Allocated NOx Emissions from Unconventional Oil and Gas Development on Regional Ozone Formation in the Marcellus

Lea Hildebrandt Ruiz[1*], Sewar Almasalha[1], Yosuke Kimura[1], Mrinali Modi[1], Shannon Stokes[1], David Allen[1]

[1]*Center for Energy and Environmental Resources, The University of Texas at Austin, Austin, TX, USA*

**Lead PI for HEI Energy Project*

Background and objectives. Unconventional oil and gas development (UOGD) in the Marcellus is a source of ozone (O_3) precursors such as nitrogen oxides (NOx) and Volatile Organic Compounds (VOCs). Emission rates from these sources can have significant spatiotemporal variability. This poster describes the spatial and temporal allocation of NOx from hydraulic fracturing and its potential impact on ozone formation in the Marcellus as a case study of tools being developed by the group.

Methods and approach. NOx emissions from hydraulic fracturing in Pennsylvania and West Virginia, and completion data for wells fractured in 2023, were obtained using the EPA 2020 Nonpoint Oil and Gas Emission Estimation Tool and S&P Global IHS Dataset, respectively. Two emission scenarios were developed for each state. The first, consistent with the EPA Oil and Gas Tool's approach, distributes annual county-level hydraulic fracturing NOx emissions to all state active wells, assuming continuous year-round emissions. The second allocates hydraulic fracturing NOx emissions to wells fractured that year, assuming a 2-week emission period. Hydraulic fracturing NOx emissions, alongside biogenic isoprene emissions, can lead to significant ozone formation. Biogenic isoprene emissions were obtained from the Texas Commission for Environmental Quality (TCEQ) 2019 Base Case inventory. NOx emissions will be utilized in the Comprehensive Air Quality Model with Extensions (CAMx) to simulate ozone impacts during peak biogenic isoprene months, July-August.

Results and findings. Spatially and temporally allocating NOx emissions returned emission rates orders of magnitude higher than annual average county-level emissions, creating ozone hotspots. Mitigating these hotspots can be part of plans used to attain ozone National Ambient Air Quality Standards (NAAQS).

Conclusions and interpretations. Spatially and temporally allocated emission rates can differ by multiple magnitudes compared to annual average county-level emissions, suggesting that spatial and temporal allocation of NOx emissions may have a significant impact on predicted ozone formation in the Marcellus. We plan to assess ozone impacts to confirm this.

HEI [R]Robust approaches to understanding the causal effect of air pollution mixtures

Joseph Antonelli[1], Suyeon Kang[1], Alexander Franks[2]

[1]*University of Florida, Gainesville, FL, USA; University of California Santa Barbara, Santa Barbara, CA, USA*

Background and objectives: In this study we aim to develop new methodology to assess the potential impact of unmeasured confounders on the associations between air pollution mixtures and multivariate outcomes.

Methods and approach: We derive partial identification regions, which are intervals that contain the effect of air pollution on health outcomes accounting for potential unmeasured confounding bias, under differing assumptions about the nature of unmeasured confounding. We show that we can obtain much more informative intervals in settings with multivariate exposures and multivariate outcomes, and explore how these intervals change when negative control exposure or outcome variables are present.

Results and findings: We show that in certain settings, the observed data can estimate the worst case bias caused by unmeasured confounding when we have multiple exposures and multiple outcomes. This provides intervals that not only account for sampling uncertainty, but also account for potential biases from omitted variables that are common in observational studies. We also show that negative controls can greatly reduce the size of these intervals, and can even point identify the effect of air pollution mixtures on health outcomes.

Conclusions and interpretation: Whenever possible, sensitivity analysis should be incorporated with observational studies to assess the impact of unmeasured confounding on final conclusions. Negative controls are a particularly powerful approach to helping mitigate issues from unmeasured confounding bias.

A conceptual framework towards equity-oriented decision-making in air pollution

Libby H. Koolik[1], Julian D. Marshall[2], Joshua S. Apte[1,3]

1. Department of Civil and Environmental Engineering, University of California, Berkeley, California, USA

2. Department of Civil and Environmental Engineering, University of Washington, Seattle, Washington, USA

3. School of Public Health, University of California, Berkeley, California, USA

Background and Objective: A pressing question in environmental policy is how to prioritize environmental justice alongside climate-change mitigation and advancing public health. Analyses in the literature consistently converge on a similar result: even major emissions reduction scenarios to mitigate climate change or ambient air pollution fail to deliver large reductions in racial/ethnic exposure disparity. Here, we derive an action-oriented conceptual framework that both explains why equity outcomes are often disappointing and suggests key policy features necessary to eliminate air pollution disparities.

Methods and Approach: We propose a conceptual model that identifies features of urban planning, environmental policy, and atmospheric science that cause fine particulate matter (PM_(2.5)) exposure disparity. We then discretize the impacts from each individual component of our framework (e.g., segregation, emissions rate) to evaluate its effects on changes in exposure disparity. Finally, we evaluate several potential policy mechanisms using the conceptual framework to uncover policy features likely to improve environmental equity.

Results and Findings: The framework decomposes air pollution exposure disparity into four discrete multiplicative factors: activity, emissions factor, intake fraction, and a newly defined term referred to as the “disparity factor”. The disparity factor combines societal segregation and source placement to describe the inequality of where emissions are occurring relative to segregated society. Finally, we evaluate an example policy against our conceptual framework and show how it fails to address the disparity factor, therefore failing to reduce the PM_(2.5) exposure disparity.

Conclusions and Interpretations: The proposed conceptual framework explains the recurring and disappointing equity findings by showing how policies that solely reduce aggregate levels of activity and/or emissions factor without altering source placement or segregation will generally be ineffective at addressing exposure disparities. To adequately target PM_(2.5) exposure disparities, policymakers will need to think creatively about how to reduce the disparity factor in addition to emissions.

Drawing the Connections: Energy and Health - an ArcGIS StoryMap on the HEI Energy-funded TRACER Collaboration

Ayusha Ariana, HEI Energy

This ArcGIS story map provides an overview of the Tracking Community Exposures and Releases (TRACER) research collaboration funded by HEI Energy to improve understanding of how communities may be exposed to unconventional oil and gas development (UOGD). The TRACER collaboration includes measurement and modeling of exposures to chemical air emissions and noise in several regions of the United States. The StoryMap is intended to describe the research and underlying method in a visually appealing and accessible manner for a variety of audiences.

Acknowledgements: We would like to thank HEI Staff, the Energy Research Committee, and the TRACER research teams for their valuable input and feedback for this project.

HEI [R]The Accra Birth Cohort (ABC) Profile: A study of prenatal exposures, birth outcomes, and lower-respiratory infections in infants

Raphael E Arku[1], Barbara E Mottey[1], Carissa L Lange[1], Kate A Kyerematen[1], Abosede S Alli[1], Allison F Hughes[2], and ABC Team
[1]*University of Massachusetts, Amherst, MA, USA;* [3]*University of Ghana, Accra, Ghana*

Background and objectives: Urban growth in sub-Saharan Africa (SSA) is the fastest globally. The growth is expected to offer broad improvements in quality of life for urban dwellers, including in healthcare and nutrition. However, environmental pollution, which is increasingly becoming a major public health problem in SSA cities, can negate these urban advantages, especially for vulnerable subpopulations like fetuses and children. Yet, there is little epidemiologic data on the impacts of urban air pollution in the SSA context to support policy and behavioral decisions. Leveraging a comprehensive city-wide exposure data, we have established the Accra Birth Cohort (ABC) to quantify the effects of prenatal and early life exposures to air pollution on adverse birth outcomes in Accra, Ghana, one of the fastest urbanizing metropolises in SSA. The study will also assess the impact of those exposures on respiratory infections in infants.

Materials and approach: Between June 2023-April 2024, the ABC has recruited 3,200 pregnant women at 30 antenatal care clinics of major health facilities across the city. Structured questionnaires are used to gather information on sociodemographic, medical, nutritional, behavioral, along with several other household and community level factors. Pregnancy-specific questions and related outcomes are captured at baseline, follow-up before birth, and at birth. Infant care and respiratory surveys are administered during the after-birth follow-ups. With geocoded information, participants data are linked to recently developed high-resolution space-time empirical models for multiple air pollutants.

Results and findings: Of the 3,200 women (mean age range: 26-30 years), ~1,100 so far have received after-birth follow-up. Overall birthweight ranged 1000-5300g [mean (SD):3600 (520) g], with 10% low birthweight and 0.04% lost pregnancy.

Conclusions and interpretation: We will quantify the effects of long-term maternal and early prenatal exposures to $PM_{2.5}$ and NO_2 pollution on preterm birth, term birthweight, and term low birthweight. The exposure models provide weekly concentrations at 50-meter spatial resolutions, allowing us to examine and identify critical prenatal windows of heightened vulnerability to air pollutants on birth outcomes.

Long-term criteria and toxic pollutants trends in air quality and community exposures over the Marcellus Shale region in the U.S.

Bok-Haeng Baek[1], Regi Oommen[2], and Joseph Wilkins[3]

[1] George Mason University, Fairfax, VA, USA; [2] Easter Research Group Inc., Morrisville, NC, USA; [3] Howard University, Washington, DC, USA

Abstract

The oil and gas industry is a major economic sector in the United States. The need to balance economic sustainability and environmental impacts is indeed a significant concern with broad impacts on local air quality, regional air quality, and the global climate. The impacts of hazardous air pollutants (a.k.a. toxics), and criteria air pollutants (NOx, Ozone, and Particular Matters) are not well-characterized for long-term sources, especially in areas in the country that experience large-scale oil and gas production due to unconventional oil and gas development (UOGD). These pollutants often disproportionately affect sensitive populations (children and elderly) and those historically overburdened due to environmental justice concerns, particularly in the Marcellus Shale areas of West Virginia, Ohio, and Pennsylvania where have experienced UOGD in the last decade.

To comprehensively address the impacts of UOGD emissions on local and regional air quality, it is essential to conduct a long-term trend analysis by employing a multidisciplinary approach that integrates emissions data, atmospheric modeling, and regulatory policy information. These confluences of datasets can provide valuable insights into the contribution of source-level UOGD emissions to air quality and exposure and the effectiveness of evolving policy and industry practices aimed at reducing the exposure to these emissions. Therefore, we propose a comprehensive study on the impacts of UOGD emissions on air quality trends and community exposures using the chemical transport model (CTM) to accurately assess not only the oil and gas industry but also other sources of emissions to gain a precise comprehension of their effects over the Marcellus Shale region. This comprehensive trend analysis will encompass long-term criteria and toxic exposure, focusing on both local and regional exposures, especially to historically disadvantaged communities. We will select the Marcellus Shale areas as our study area.

Unconventional Oil/Gas Development, Water Quality, and Environmental Hazards in the Oldest Hydrocarbon Basin in the US

Jennifer Baka[1], Samuel Shaheen[1], Tao Wen[2], Owen Harrington[1], Lingzhou Xue, Susan L. Brantley[1]

[1]Penn State University, University Park, PA; [2]Syracuse University, Syracuse, NY

Background. Understanding the health effects from potential groundwater contamination related to unconventional oil and gas development (UOGD) requires identifying specific locations of contamination, the nature of the contaminants and possible pathways of contamination. Examining this relationship requires determining whether specific contaminants derive from natural or anthropogenic processes, and, if the latter, determining which process is important. This project, comprised of two HEI-funded studies, evaluates linkages between UOGD and potential water contamination in a tri-county region of Southwestern Pennsylvania (Beaver, Greene and Washington counties) because of the region's long history of energy development in general and UOGD specifically.

Methods. We combine community focus groups and geoscientific analysis in this study. We conducted six focus groups (two per county) in summer 2022 and 2023 to gather community-level observations regarding observed changes to water quality, possible contamination pathways, associated health impacts and broader landscape transformations. Focus groups were coded to identify contaminants, pathways and health risks of community concern. These data informed a statistical analysis of a groundwater sample dataset from the region that contains over 7,000 samples, each with approximately 40 reported chemical analytes. We utilized a machine learning tool (non-negative matrix factorization) to isolate the influences of natural and anthropogenic processes on groundwater chemistry and identify potential linkages between UOGD and water contamination. Preliminary results were reviewed with communities during the summer 2023 focus groups.

Results. Across all three counties, communities documented negative changes to water since the start of UOGD and raised concern about potential water contamination from UOGD chemical inputs (i.e. hydraulic fracturing fluids), chloride and radioactive species. Various health concerns were raised, most prominently cancers, such as Ewing's Sarcoma. We find small, statistically significant correlations in the study region between groundwater contamination from chloride and proximity and density of UOGD. The most likely contamination pathway is brine leaks/spills from wastewater management. Using groundwater chemistry ratio analysis, we estimate that this potential contamination pathway could elevate thallium levels above EPA contamination levels in localized geographic areas of concern (hotspots), which could increase health risks (exposure linked to low birth weights). We observed no evidence for exposure to radioactive elements above EPA limits using the same approach.

Conclusions. The study combined community focus groups and geoscientific analysis to examine potential groundwater contamination from UOGD in a region with historic legacies of fossil fuel extraction. We find a small number of sites with presumable groundwater contamination from brine salt species, which was one concern raised by communities. A follow up study is currently underway to conduct water sampling and household surveys in these sites to better analyze the relationship between UOGD and possible groundwater contamination.

Racial and Economic Disparities in Exposure to and Health Effects Associated with Air Pollution: Recent Research Related to Environmental Justice

Lisa Baxter[1], Thomas J. Luben[1]; Mackenzie J. McCausland[2]; Kristen M Rappazzo[1], Anne Weaver[1]

[1]*Center for Public Health and Environmental Assessment, Office of Research and Development, U.S. EPA, Research Triangle Park, NC*

[2] *University of Washington, School of Public Health, Department of Epidemiology, Seattle, WA, USA*

The cumulative effects of discriminatory policies experienced by marginalized communities likely contribute to disparities in air pollution exposures and its impacts. Here, we summarize recent research related to air pollution and environmental justice that (1) examines the effects of historical redlining on present-day air pollution exposure disparities; (2) assess the cumulative impacts of industrial pollution; and (3) evaluate the effectiveness of state-level environmental justice initiatives.

Evidence suggests that historical redlining in the United States is associated with existing disparities in environmental exposures, including air pollution. We examined associations between traffic density and Home Owners' Loan Corporation (HOLC) neighborhood grade across five cities in North Carolina. On average, less desirable HOLC grades were associated with higher average traffic density suggesting that differences in traffic density by HOLC grade may account for some current-day air pollution disparities.

Industrial pollution often disproportionally affects marginalized communities. Wood pellets are commonly used for electricity generation and home heating in the European Union. The industry has grown ~60% since 2016 with many wood pellet production facilities (WPPFs) located in the southeastern US. We, along with EPA Region 4, are developing an assessment of the cumulative impacts of WPPFs to identify and fill information gaps that could be used for decision making regarding their creation or expansion.

Finally, while various environmental justice initiatives have been undertaken in some of these underserved communities, these mitigation efforts have not always improved conditions. In collaboration with EPA Region 9 and the West Oakland Environmental Indicators Project, we are assessing the impacts of CA Assembly Bill 617 (incentivizing collaboration between communities and the state for pollution reduction initiatives) on air quality and health in West Oakland, CA.

Together, this body of evidence will provide new insights into the impacts of air pollution in environmental justice communities.

HEI Short-term effects of wildfire-specific fine particulate matter and its carbonaceous components on perinatal outcomes: a multicentre cohort study in New South Wales, Australia

Sylvester Dodzi Nyadanu[1,†], Damien Foo[1,2,†], Gavin Pereira,[1] Loretta Mickley,[3] Feng Xu,[3] Michelle L. Bell[2]

[1] *Curtin University, School of Population Health, Perth, Western Australia, Australia*

[2] *Yale University, School of the Environment, Yale University, New Haven, Connecticut, United States*

[3] *Harvard University, John A. Paulson School of Engineering and Applied Sciences, Boston, Massachusetts, United States*

[†] *Contributed equally as first authors*

Background and objectives: Epidemiological evidence on the association between fine particulate matter ($PM_{2.5}$) and its carbonaceous components from wildfires (called bushfires in Australia) with perinatal outcomes is limited. We examined the effects of wildfire-specific $PM_{2.5}$ and its carbonaceous components on perinatal outcomes.

Methods and approach: A multicentre cohort of 9,743 singleton births during wildfire seasons 1 September 2009 to 31 December 2015 across six cities in New South Wales Australia, were linked with daily wildfire-specific $PM_{2.5}$ and carbonaceous components (organic carbon and black carbon). Adjusted distributed lag Cox regression models with spatial clustering were performed to estimate daily and cumulative adjusted hazard ratios (aHRs) during the last four gestational weeks for preterm birth, stillbirth, nonvertex presentation, low 5-min Apgar score, special care nursery/neonatal intensive care unit (SCN/NICU) admission, and caesarean section.

Results and findings: Preliminary daily aHRs per 10 μg/m^3 $PM_{2.5}$ showed nearly inverted 'U'-shaped positive associations and daily cumulative aHRs increased with increasing duration of the exposures. The aHRs for lag 0-6 days were 1.17 (95% CI: 1.04, 1.32) for preterm birth, 1.40 (95% CI: 1.11, 1.78) for stillbirth, 1.20 (95% CI: 1.08, 1.33) for nonvertex presentation, 1.12 (95% CI: 0.93, 1.35) for low 5-min Apgar score, 0.99 (95% CI: 0.83, 1.19) for SNC/NICU admission, and 1.01 (95% CI: 0.94, 1.08) for caesarean section. Organic carbon and black carbon components for lag 0-6 days showed positive associations. The highest component-specific aHRs were 1.09 (95% CI: 1.03, 1.15) and 4.57 (95% CI: 1.96, 10.68) for stillbirth per 1 mg/m^3 organic carbon and black carbon, respectively. The most identified vulnerable subgroups were female births and births to mothers, with low socioeconomic status, and high biothermal exposure.

Conclusions and interpretation: Preliminary results suggest positive associations of short-term wildfire-specific $PM_{2.5}$ exposure and its carbonaceous components with adverse perinatal outcomes.

Highlights from the California Air Resources Board's Health Research Program

May Bhetraratana[1], Hye-Youn Park[1], Bonnie Holmes-Gen[1], Elizabeth Scheehle[1]

[1]*California Air Resources Board, Sacramento, CA, USA*

The California Air Resources Board (CARB) is charged with protecting the public from the harmful effects of air pollution and developing programs and actions to fight climate change. A 2020 CARB Board resolution requires the agency to update health analysis approaches to provide more comprehensive health information, including updates to analysis tools, health outcomes, air pollutants, and evaluation of community impacts. The Health and Exposure Assessment Branch (HEAB) of the Research Division of CARB is responding to this resolution by expanding its analysis of the health benefits of the agency's plans and regulations to reduce air pollution.

Recently, CARB undertook a major update to the agency's health analysis endpoints, in alignment with evidence documented in U.S. EPA's $PM_{2.5}$ integrated science assessments. Through this update, CARB went from evaluating four health endpoints to twelve health endpoints, encompassing mortality, cardiovascular, respiratory, and neurological outcomes, some of which especially impact children and seniors. The updated health endpoints have been incorporated into the agency's latest proposed regulations, providing a more comprehensive understanding of the health benefits of reduced air pollution exposures.

In addition, CARB has been supporting multiple research projects that improve our understanding of the health impacts of pollution in the state. CARB-sponsored researchers are investigating the impacts of $PM_{2.5}$ exposure to update and expand the health endpoints the agency analyzes, such as work loss days, children's neurodevelopment, birth outcomes, neurodegenerative diseases (e.g., Parkinson's and Alzheimer's diseases), and metabolic outcomes (e.g., diabetes).

Moving forward, CARB is incorporating the investigation of health effects in sub-populations and overburdened communities into the health analyses. Throughout all our efforts, CARB staff continue to rely on the best available science to further our health analysis methodology and research.

Further information can be found on CARB's health analysis page (*https://ww2.arb.ca.gov/resources/documents/carbs-methodology-estimating-health-effects-air-pollution*) and research page (*https://ww2.arb.ca.gov/our-work/programs/research-planning/research-division-contracts*).

Increasing ambient temperature disrupts sleep and impairs cognitive function

Godfred O. Boateng[1], Gabriel John Dusing[1], Shaira Shafiquzzaman[2], Stella T. Lartey[3], Eyram Agbe[1], Dozie Okoye[4]

1. York University, Canada

2. University of Western Ontario, Canada

3. University of Memphis, United States

4. Dalhousie University, Canada

Background

The last decade has seen an increase in ambient temperature, with 2023 recording the highest. This increase, which is symptomatic of global warming, has deleterious consequences for socially disadvantaged populations; particularly, those in sub-Saharan Africa. Also, the absence of appropriate data in this region has made it more difficult to examine the compendium of health effects associated with high temperatures. Consequently, this study examined the direct and indirect effects of high temperatures on sleep quality and cognitive impairment among older adults.

Methods and Approach

We created a novel dataset by combining data from the WHO Ghana Study on Global Ageing and Adult Health (2014/2015) with temperature measurements derived from the Climatic Research Unit (University of East Anglia) gridded Time Series (CRU TS v.4.07). Using structural equation models and accounting for data clustering, we examined the direct and indirect relationship between increasing average temperatures in the past year (2014), sleep difficulties, and cognitive impairment.

Results and Findings

After adjusting for covariates, each temperature change saw a corresponding increase in perceived severity of sleep difficulties (β=0.228; 95%CI: 0.088, 0.368) and a decrease in cognitive function (β=-2.086; 95%CI: -3.149, -1.022). Both the direct effects of temperature (β=-3.778; 95%CI: -5.800, -1.757) and sleep difficulties (β=-15.003; 95%CI: -27.780, -2.227), and the interaction term between sleep difficulties and temperature (β=0.467; 95%CI: 0.006, 0.928) were all significant. The effect of temperature significantly increased sleep difficulties for females and older adults (65+) relative to comparative groups.

Conclusions and interpretation

Our study shows that increasing temperature disrupts sleep, which also impairs cognitive function among older adults. Thus, a reduction in temperature will improve sleep quality and enhance cognitive function. Consequently, we recommend the acceleration of climate mitigation and adaptation practices that can reduce the effects of global warming for Low- and Middle-Income Countries.

[W]Oxidative potential of particulate matter and its association to respiratory health endpoints in high-altitude cities in Bolivia

Lucille Borlaza-Lacoste, State University of New York

Jane Warren Conference Award Recipient

Particulate matter (PM) pollution has been demonstrated to pose a threat and risk to human health, prompting a quest for novel air quality metrics that can accurately evaluate the potential harm caused by PM exposure. Oxidative potential (OP), an emerging health-based metric, requires further validation through epidemiological studies in different environments. This study focuses on identifying the most oxidizing PM sources in the lungs in two high-altitude Bolivian cities, with an emphasis on evaluating OP as an indicator of PM impact on human health. Two OP tests, OP_(DTT) and OP_(DCFH), were used to measure OP. The study also investigated associations between three exposures (PM, OP, and equivalent black carbon and the frequency of hospital visits for acute respiratory infections (ARI) and pneumonia. Poisson regression model, adjusted for meteorological factors, was used to analyze these associations with 0- to 2-week lags. Furthermore, we explored the link between these respiratory outcomes and various PM sources, identified using the Positive Matrix Factorization (PMF) model from a previous source apportionment study from the same dataset. Our results indicate that anthropogenic combustion sources, particularly traffic and biomass burning, are the main drivers of OP. Notably, we found strong correlations between ARI and both OP_(DTT) and PM_(2.5) mass concentration. There was also a tendency towards a positive association between pneumonia and OPDTT. The PMF-resolved traffic source was significantly associated with increased hospital visits for both respiratory conditions, underscoring its impact on health. These findings support OP_(DTT) as a promising health-based metric for assessing acute respiratory outcomes due to PM exposure.

Reducing emissions and air pollution from the informal brick sector: Evidence from a randomized controlled trial in Bangladesh

Nina Brooks[1], Debashish Biswas[2], Sameer Maithel[3], Grant Miller[4], M. Rofi Uddin[2], Shoeb Ahmed[5], Aprajit Mahajan[6], Moogdho Mahzab[7], Mahbubur Rahman[2], Stephen P. Luby[8]

1. Boston University School of Public Health, USA

2. Environmental Health and WASH, International Centre for Diarrhoeal Disease Research, Bangladesh (icddr,b), Dhaka, Bangladesh

3. Greentech Knowledge Solutions, New Delhi, India

4. Department of Health Policy, School of Medicine, Stanford University and National Bureau of Economic Research (NBER), Stanford, CA, USA

5. Department of Chemical Engineering, Bangladesh University of Engineering and Technology (BUET), Dhaka, Bangladesh

6. Department of Agricultural and Resource Economics, University of California, Berkeley, Berkeley, CA, USA

7. Graduate School of Business, Stanford University, Stanford, CA, USA

8. Woods Institute for the Environment, Stanford University, Stanford, CA, USA

The industrial sector is a major source of air pollution and greenhouse gas emissions in low- and middle-income countries. In Bangladesh, despite previous efforts to improve the brick manufacturing industry, highly polluting informal kilns continue to dominate the sector. We argue that successful intervention must be incentive-compatible with existing owners, and not depend on action from the state that often has low capacity to enforce regulations. This study presents the results of a randomized controlled trial in Bangladesh aimed at reducing emissions and improving energy efficiency of informal brick manufacturing kilns that tests this hypothesis. We randomized 357 kilns into three arms: 1) provision of technical training and support for improved kiln operation, 2) provision of technical training and support for improved kiln operation along with information and nudges for owners to incentivize their workers to adopt the improved practices, and 3) a control arm. Findings revealed high demand for the intervention, with 65% of intervention kiln owners adopting the improved operating practices. The intervention led to statistically and economically significant reductions in fuel consumption, CO_(2) and PM_(2.5) emissions, along with improved brick quality, higher value of bricks produced, and lower fuel spending. These results demonstrate that substantial reductions in emissions and air pollution from informal industry are achievable.

Effect of Air Pollution Reductions on Mortality During the COVID-19 Lockdown in Early 2020

Kai Chen[1], Yiqun Ma[1], Anne Marb[2], Federica Nobile[3], Robert Dubrow[1], Massimo Stafoggia[3], Susanne Breitner[2], Patrick L. Kinney[4]

[1]Yale School of Public Health, New Haven, CT, USA; [2]Ludwig-Maximilians-Universität München, Munich, Germany; [3]Lazio Region Health Service / ASL Roma 1, Rome, Italy; [4]Boston University School of Public Health, Boston, MA, USA

Background and objectives. COVID-19 lockdowns led to considerable reductions in air pollutant emissions worldwide. This project aimed to quantify the changes in nitrogen dioxide (NO_2) and fine particulate matter ($PM_{2.5}$) due to COVID-19 lockdowns in early 2020, estimate the associations between short-term exposures to $PM_{2.5}$ and NO_2 and mortality rates, and assess the attributable changes in mortality in Jiangsu, China; California, U.S.; Central-southern Italy; and Germany.

Methods and approach. Accounting for meteorological impacts and air pollution time trends, we quantified the changes in NO_2 and $PM_{2.5}$ concentrations due to lockdowns. Using data from 2015 to 2019, we applied interactive fixed effects models to examine the associations of day-to-day changes in $PM_{2.5}$ and NO_2 concentrations with all-cause, natural, and cardiovascular mortality rates in each region. Finally, we assessed the changes in mortality attributable to the air pollution changes caused by the lockdowns.

Results and findings. During the lockdowns, we found meaningful improvements in air quality in Jiangsu, California, and Central-southern Italy, with smaller magnitudes from $PM_{2.5}$ reduction compared to NO_2. In Germany, we observed no significant NO_2 reduction and a small increase in $PM_{2.5}$. We detected significant associations between short-term increases in $PM_{2.5}$ and NO_2 concentrations and increases in daily all-cause, natural, and cardiovascular mortality rates in all four study regions. Consequently, lockdown-induced NO_2 reductions avoided deaths in Jiangsu, California, and Central-southern Italy. Mortality benefits attributable to $PM_{2.5}$ reductions were also significant in these regions, albeit of a smaller magnitude. For Germany, the mortality benefits attributable to NO_2 changes were not significant, and an increase in $PM_{2.5}$ concentrations was associated with an increased mortality.

Conclusions and interpretation. COVID-19 lockdowns in early 2020 overall improved air quality and brought attributable health benefits in areas mildly impacted by the pandemic, especially associated with NO_2 improvements, with notable heterogeneity across regions.

Disparities in associations between long-term exposure to ambient NO_2 pollution and cause-specific mortalities in the U.S.

Lingzhi Chu, Yale School of Public Health

Background and objectives: Evidence is limited on association between long-term exposure to NO_2 and a broad spectrum of causes (e.g., mental disorders, COPD) other than all-cause, total circulatory, and total respiratory mortalities. Furthermore, less is known about disparities in such associations by demographic characteristics. This study aimed to evaluate disparities by sex or race and ethnicity regarding associations between long-term exposure to NO_2 and cause-specific mortalities in the U.S.

Methods and approach: We calculated county-level monthly age-adjusted death counts for 26 categories/subcategories of causes during 2000-2016. We applied fixed-effect models with quasi-Poisson regression adjusted for $PM_{2.5}$, O_3, and temperature using moving averages of NO_2 over months up to three years. Disparities in subpopulations were assessed by stratification.

Results and findings: We included 34,397,706 deaths. Associations were reported at lag 0-29 months (per 5 ppb increase) considering the strongest magnitude with all-cause mortality. We observed significantly increased risk among the entire population for various causes (e.g., all-cause, infectious diseases, neoplasms, dementia, hypertensive heart diseases, myocardial infarction, COPD, digestive diseases, genitourinary diseases, and self-harm). Females had lower mortality risk for digestive diseases (RR=1.01 [95% CI: 1.00, 1.03] versus 1.03 in males) and transport accident injuries (RR=0.98 [0.96, 1.00] versus 1.01). Non-Hispanic Black population had higher mortality risk for all-cause (RR=1.02 [1.01, 1.03] versus 1.01 in either non-Hispanic White or Hispanic White), non-external (RR=1.02 [1.01, 1.03] versus 1.01 and 1.00, respectively), and circulatory diseases (RR=1.02 [1.01, 1.03] versus 1.02 and 0.99, respectively). Non-Hispanic Black and Hispanic White populations were more vulnerable to external causes (1.03 [1.01, 1.06] in both groups versus 0.99 in non-Hispanic White).

Conclusions and interpretation: Our findings reveal disparities in NO_2 -related cause-specific mortalities by sex, race, and ethnicity, underscoring the need for targeted NO_2 reduction strategies to reduce sex and racial-ethnic health disparities associated with long-term NO_2 exposure.

[W]Ozone-related health impacts of hydrogen leakage

Glen Chua, Princeton University

Jane Warren Conference Award Recipient

Hydrogen (H2) is deemed an important fuel for decarbonizing the global economy. Countries, including the U.S., have earmarked billions of dollars for the H2 economy. As adoption accelerates, concerns over the climate impacts of H2 leakage in supply chains have resurfaced, because H2 is a potent indirect greenhouse gas. Less discussed is H2's role as a surface ozone (O3) precursor. An air pollutant, surface O3 harms human health, mostly by exacerbating respiratory illnesses like chronic obstructive pulmonary disease (COPD), causing about 365,000 premature deaths in 2019 according to the most recent 2019 Global Burden of Disease (GBD 2019) estimate. This study aims to quantify surface O3 increases from H2 leakage and the resultant health impacts.

We utilize a global atmospheric chemistry-climate model, the Geophysical Fluid Dynamics Laboratory (GFDL)'s Atmosphere Model version 4.1 (AM4.1), to quantify increases in the health-relevant ozone season daily maximum 8-hour mixing ratio (OSDMA8) associated with increased H2 leakage. We compare a present-day 'Base' scenario with a 'HiH2' scenario that assumes a fivefold increase in anthropogenic H2 emissions (+150 teragrams of H2 per year (Tg(H2)/yr)), consistent with the Bloomberg NEF (2020) 'Theoretical Maximum' estimate of H2 economy size in 2050 and a high H2 leakage rate (10%). We then calculate COPD-related excess mortality following the GBD (2019) study under different population scenarios.

We find that present-day population-weighted surface O3 increases by ~2 parts-per-billion (ppb). This results in present-day COPD-related excess mortality increasing by ~27,000 (~200 deaths per Tg(H2)/yr), mostly in the Northern Hemisphere and especially in developing countries (e.g., China and India). Depending on 2050 population projections, that figure could increase to 100,000-150,000 deaths.,

The quantification of surface O3-related health damages from methane emissions has helped spur methane mitigation policy action. Similarly, we hope to provide lawmakers a fuller understanding of the risks of a more H2-intensive economy.

Designing Research to Inform the National Ambient Air Quality Standards – The U.S. EPA's Integrated Science Assessments

Evan D. Coffman[1], Scott Jenkins[1], Steven J. Dutton[1]

[1]Center for Public Health and Environmental Assessment, Office of Research and Development, US Environmental Protection Agency (US EPA), Research Triangle Park, North Carolina, USA

Background and objectives

Integrated Science Assessments (ISAs) provide the scientific foundation for reviews of the National Ambient Air Quality Standards (NAAQS). ISAs integrate evidence within and across scientific disciplines to draw key scientific conclusions, including causality determinations and conclusions regarding at-risk populations. The process for identifying and evaluating the available science is described in the 2015 Preamble to the ISAs. Since 2015, ISAs have incorporated incremental advances in response to CASAC advice, public input, and improvements in tools/approaches. The National Academies for Sciences, Engineering, and Medicine (NASEM) additionally released a 2022 report detailing recommendations on the ISA causality framework. The ISA development process continues to evolve considering this input.

Methods and approach

ISAs begin with a systematic literature search to identify studies for consideration. Included studies must be peer-reviewed and must present original analyses. Additionally, ISAs use discipline-specific scoping criteria to define the characteristics of studies considered for inclusion. In-scope studies are subject to individual study quality evaluation, with detailed guidelines emphasizing the study characteristics that can increase confidence in study results. Missing information (e.g., pollutant concentration distributions, potential confounders) can complicate the assessment of study quality and may lessen the weight placed on a study. In-scope studies of sufficient quality inform ISA conclusions, including causality determinations. Causal summaries within the ISAs highlight the lines of evidence that contribute the strongest support for causality determinations and describe remaining uncertainties, which can be used to identify areas of research that may be informative for future assessments.

Conclusions

The ISA development process continues to evolve based on input from CASAC, NASEM, and the public. The process emphasizes transparency in identifying relevant literature, characterizing the weight of evidence, and reaching conclusions on the science. The criteria used to identify and evaluate the evidence can be used by researchers to understand how studies are considered and the characteristics of studies that are ultimately included and play a role in reaching key scientific conclusions.

Impact of exposure to air pollution on health studied at the laboratory: the European platform "PolluRisk"

Patrice Coll[1], Ambre Delater[1], Mathieu Cazaunau[2], Sophie Lanone[3] and the Pollurisk team
Pollurisk Team: E. Al Marj[1], Aline Gratien, G. Noyalet[1], J.-C. Macias Rodriguez[1], L. Gerard[1], A. Bergé[1], E. Pangui[2], T. Bertin[2], C. Gaimoz[2], S. Chevaillier[2], B. Picquet-Varrault[2], J.-F. Doussin[2], I. Coll[2], M. Blayac[3], Z. LU[3], C. Buissot[3], C.-H. Yegne[3]

1. Université Paris Cité and Université Paris-Est Créteil, France

2. Université Paris-Est Créteil and Université Paris Cité, France

3. Université Paris-Est Créteil, France

PolluRisk is an experimental platform developed by 2 French Research Units, LISA (lisa.u-pec.fr) and IMRB (imrb.inserm.fr). Its main goal is to expose preclinical models and/or cells to realistic simulated atmospheric pollution (gas and aerosol phases), to investigate its impacts to health. In a nutshell: *in vivo* studies are dedicated to establish the links between exposome components (as air pollution) and health effects, while *in vitro* studies contribute to identify the nature of these links.

The peculiarity of our research lays in the use of the CESAM smog chamber (https://www.cesam.cnrs.fr/) which, by simulating at the laboratory multiphasic realistic atmospheres (i.e., atmospheric mixtures), represents the closest environmentally relevant conditions experimentally achieved so far. Such atmospheres were used to study effects of polluted atmospheric mixtures for example on a Cystic Fibrosis mouse model. This innovative multi-disciplinary approach constitutes an important strength compared to what is done in most studies: it provides a multi-pollutant approach to air pollution that is much more representative of real exposure conditions than standard approaches based on a single pollutant.

PolluRisk confirmed providing new skills and capabilities to investigate health impacts of air quality, both supporting *in vivo* and *in vitro* studies. It has proved particularly interesting for biomedical studies with 4 cornerstone studies, focusing on maternal exposure during pregnancy (Guilloteau et al. 2022; Lu et al. 2022), and adult exposure (Belgacemi et al., 2023; Blayac et al., 2024).

In terms of prospective lines regarding future activities, we will implement studies to investigate at the laboratory the link between air quality mitigations and health effects. Two mitigation examples will be studied: reducing emissions of gas engines and replacing gas engines with biofuel engines.

Measuring and Modelling Air Pollution and Noise Exposure Near Unconventional Oil and Gas Development in Colorado

Jeff Collett[1], Da Pan[1], Weixin Zhang[1], Yong Zhou[1], I-Ting Ku[1], Jerry Duggan[1], Dan Zimmerle[1], Jeff Pierce[1], Mike van Dyke[2], Lisa McKenzie[2], Pamela Rickly[3], Derek Price[3], Zachary Finewax[3]

[1]Colorado State University, Fort Collins, CO, USA; [2]University of Colorado, Denver, CO, USA; [3]Colorado Department of Public Health and Environment, Denver, CO, USA

The United States has become the world's largest producer of both oil and natural gas (O&G) with large increases in production driven by improvements in directional drilling and hydraulic fracturing techniques. In Colorado substantial unconventional oil and gas development (UOGD) occurs in populated areas, raising concerns about potential impacts on nearby residents. These include concerns about noise and emissions of air pollutants, particularly during drilling and completion of large, multi-well pads.

We are utilizing a combination of new and existing measurements of noise and air pollutants around well-pads to characterize impacts during particular UOGD operations in the Denver-Julesburg (DJ) Basin. Our focus is on large pads (~10-30 wells) as they undergo key development steps, including drilling, hydraulic fracturing, and flowback. Monitoring has been coordinated with well development activities by O&G operators who provide operational information needed to interpret field measurements and model activity-based emissions. Air pollution measurements include fast and time-integrated measurements of methane and approximately 50 volatile organic compounds (VOCs), nitrogen oxides, and $PM_{2.5}$. Both mobile and fixed-location monitoring platforms are included.

Monitoring of the complete pre-production lifecycle has been completed at one location while drilling and fracking operations have also been studied at two additional locations. We will present observations of increased air pollution levels during specific operations at these study locations, including a special focus on emissions of C8-C10 alkanes associated with use of synthetic drilling muds often used due to their lower odor impacts. We will also report results of inverse modeling efforts to constrain VOC emission rates during recent UOGD pre-production operations at several well pads in Broomfield, Colorado. These estimates provide an important check on emission rates published in the EPA Nonpoint Oil and Gas Emission Estimation Tool and provide new information about emissions during previously uncharacterized activities including coil tubing/millout operations and closed-loop, tankless flowback operations.

Finally, we will present an overview of progress to date in defining the timing and magnitude of emissions for UOGD operations as part of a collaborative effort with colleagues at UT-Austin to develop the TRAcking Community Exposures and Releases (TRACER) model, focusing here on speciated VOC emissions during specific pre-production activities including drilling, hydraulic fracturing, coil tubing/millout operations, and flowback.

The Joppa Environmental Health Project: Application of a community-based participatory research (CBPR) approach to facilitate action-oriented research on $PM_{2.5}$ pollution and respiratory health in a South Dallas Environmental Justice neighborhood.

Xiara Day, *Texas A&M University School of Public Health*

Due to historical racial segregation, communities of color are disproportionately exposed to particulate matter (PM) air pollution. Accordingly, disparities for PM-related health effects like cardiovascular and lung disease are increased. In South Dallas, citizen concerns about air pollution from local point sources spurred the creation of a community-based participatory research (CBPR) project in Joppa, a predominantly African American and Hispanic community. The Joppa Environmental Health Project (JEHP) was formed to determine community perceptions of air quality and health concerns through a community health survey, and to quantify fine PM (PM_(2.5)) levels through the installation of a local air monitoring network. A community steering committee led numerous engagement events and organized block captains to administer surveys from May to October 2022. Additionally, three low-cost sensors from SharedAirDFW were installed to quantify local PM_(2.5) concentrations. A high survey response rate (51%) showed the majority of participants (62%) rated the air quality in Joppa as poor or very poor. The overwhelming majority (83%) of respondents felt air pollution in Joppa made them or their families sick. Strikingly, 40% of participants reported they avoid exercising outdoors and opening their windows due to concern about air pollution. In terms of respiratory health status, a high percentage of survey respondents were diagnosed with lifetime asthma (18%). Monitor data demonstrated that PM_(2.5) levels were highest along Carbondale Street, which abuts multiple PM sources, compared to Hull Avenue located within the interior of Joppa. Overall, the application of a CBPR approach facilitated robust community engagement and resident-led research to address critical neighborhood concerns. Subsequently, an asphalt batch plant in Joppa voluntarily relocated operations in June of 2023. The steering committee organized a new group known as Justice for Joppa/Justicia para Joppa to sustain momentum created by this work, targeting local zoning, land use policies, and environmental justice.

HEI Accounting for mobility in air pollution exposure estimates in studies on long-term health effects (MOBI-AIR)

Kees de Hoogh[a,b,*], Benjamin Flückiger[a,b], Nicole Probst-Hensch[a,b], Danielle Vienneau[a,b], Ayoung Jeong[a,b], Medea Imboden[a,b], Aletta Karsies[a,b], Sophie Baruth[a,b], Désirée De Ferrars[a,b], Oliver Schmitz[c], Meng Lu[d], Roel Vermeulen[e], Kalliopi Kyriakou[e], Aisha Ndiaye[e], Youchen Shen[e], Derek Karssenberg[c], Gerard Hoek[e],

[a] *Swiss Tropical and Public Health Institute; Allschwil, Switzerland*

[b] *University of Basel; Basel, Switzerland,*

[c] *Department of Physical Geography (Geo), Utrecht University; Utrecht, the Netherlands*

[d] *Department of Geography, University of Bayreuth; Bayreuth, Germany*

[e] *Institute of Risk Assessment Sciences (IRAS), Utrecht University; Utrecht, the Netherlands*

Introduction

Large scale epidemiological studies investigating long-term health effects of air pollution can typically only consider the residential locations of the participants, thereby ignoring the space-time activity patterns that likely influence total exposure. People are mobile and can be exposed to considerably different levels of air pollution or air pollution mixtures when inside vs. outside, commuting, recreating, or working. Neglecting these mechanisms in exposure assessment may lead to incorrect distributions of exposure over the population, which may subsequently lead to incorrect exposure health relations in epidemiological studies. In this study, we investigated whether a more sophisticated mobility enhanced exposure assessment would lead to different exposure predictions and health effects estimates compared to using a residential based exposure.

Methods

Agent-based modeling (ABM) was used to model mobility patterns in Switzerland and the Netherlands based on travel survey information. Hourly air pollution surfaces of NO_2 and $PM_{2.5}$ developed separately fir the Netherlands and Switzerland, for week day and weekend day were overlaid with the ABM data to extract exposures. These air pollution exposures were assigned to two adult cohorts in Switzerland (SAPALDIA and SNC) and the EPIC-NL adult cohort in the Netherlands based on (1) residential address location only, and (2) residential and work address locations plus mobility (mobility-enhanced). In the case of SAPALDIA, known work address location was available and additionally used. Associations with health end points in the three cohorts were investigated. To evaluate the performance of the ABM modeling, we collected GPS readings from 489 participants in Switzerland and 189 participants in the Netherlands in tracking campaigns. The participants recorded GPS readings using both a wearable GPS recording device and a mobile phone App, whilst also recording their time activity in the App diary.

Results

We successfully developed mobility-enhanced exposures for over 3 million subjects, including an assessment of the uncertainty. We found good agreement between exposures estimated with the app and the GPS tracker, supporting scalability of the approach. We evaluated the ABM models with GPS and time activity data independently collected in tracking campaigns that included almost 700 participants from selected areas in the two countries. For these participants, the exposures based on GPS measurements vs. those derived from ABM showed a good agreement (R^2 0.52 – 0.81). Within the

three cohorts, the mobility enhanced exposure compared to exposure based only on the residential location showed very high correlations (R^2 >0.97). Finally, the epidemiological analyses revealed very small differences in the associations across health end points (mortality in SNC; cardiovascular morbidity and mortality in EPIC-NL and lung function and blood pressure in SAPALDIA) within the three cohorts. In SAPALDIA, where the work address was known for a subset of individuals, we were further able to conduct a comparison between ABM modeling with and without known work address indicating little difference in mobility enhanced exposures.

Conclusions

Our results suggest that the assessment of air pollution exposure at the residential address in epidemiological studies generally does not lead to substantial bias in health effects estimates. If time activity patterns in other study areas differ greatly from the patterns analyzed in our study, differences between residential and activity-enhance exposures may be larger. Despite the good agreement between residential and work location, exposure research should continue to strive toward improving exposure assessment in large scale epidemiological studies to minimize exposure misclassification.

Environmental and health benefits of mobile source and electricity generating unit policies to reduce particulate pollution

Stefanie Ebelt, ScD[1], David Q. Rich, ScD[2], Howard Chang, PhD[1], Philip K. Hopke, PhD[2], Armistead G. Russell, PhD[3]

[1]Emory University, Atlanta, Georgia, USA; [2]University of Rochester Medical Center, Rochester, New York, USA; [3]Georgia Institute of Technology, Atlanta, Georgia, USA

Objective. During the past 20 years, air quality policies targeting motor vehicles (MV) and electricity generating units (EGU) were implemented in the US. We assessed whether $PM_{2.5}$ toxicity changed over periods of policy implementation, and quantified health benefits of these policies in three US cities.

Methods. We acquired pollutant data, conducted positive matrix factorization to identify $PM_{2.5}$ sources, and estimated counterfactual daily pollutant concentrations for six monitoring sites in Atlanta, Los Angeles, and New York City for 2005-2019. Using daily counts of cardiovascular (CVD) and respiratory disease (RD) emergency department visits among patients residing within 10 miles of each site and Poisson models, we estimated the rate of CVD and RD visits associated with increased 1-7 day pollutant concentrations, and estimated these associations for four periods (before=2005-2007, during=2008-213, after=2014-2016, later=2017-2019) of policy implementation. Observed and counterfactual daily pollutant concentrations were then applied to the health models to estimate the number of CVD and RD visits prevented by these policies.

Results $PM_{2.5}$ and certain $PM_{2.5}$ source (nitrate, sulfate) concentrations decreased over the study period, while others were stable (diesel, gas, ozone). We observed increased rates of CVD and RD visits associated with increased pollutant concentrations, and increasing RRs over the study period. Reduced $PM_{2.5}$ concentrations attributable to MV and EGU policies ranged from 3.5 to 16.2 $\mu g/m^3$ for $PM_{2.5}$. The average percent of daily ED visits averted at each city-site estimated from tri-pollutant models, ranged from -1.3% to 2.6% for CVD and 1.1% to 8.7% for RD.

Conclusions. Short-term associations between RD and $PM_{2.5}$ and other pollutants changed over time in three US cities, suggesting an increase in $PM_{2.5}$ toxicity that may be related to MV and ECU policy-related changes in air pollution mixtures. However, small percentages of CVD and RD visits in these cities were averted following policy implementation.

Improved Assessment and Characterization of Traffic-Related Particulate Emissions (IMPACT): Preliminary Results from Field Sampling in Year 1.

Greg Evans[1], Matthew Adams[1], Jeffrey Brook[1], Arthur Chan[1], Meredith Franklin[1], Marianne Hatzopoulou[1], Kristin Iorio[1], Cheol-Heon Jeong[1], Maria-Teresa Pay-Perez[1], Sophie Roussy[1], Nicole Trieu[1], Xing Wang[1], Scott Weichenthal[2], Yee-Ka Wong[1]

[1]University of Toronto, Toronto, Canada [2]McGill University, Montreal, Canada

Background. In December 2022, we initiated a three-year HEI-funded project, titled IMPACT, to develop and apply methods to improve the characterization of non-tailpipe (NTP) particulate matter (PM) exposure in the City of Toronto and other major Canadian cities.

Objectives. This project has four complementary objectives: (1) characterize hourly and long-term patterns of NTP PM and emission factors; (2) disentangle spatial patterns of NTP PM using complementary approaches; (3) evaluate and improve lab-based methods to differentiate tailpipe (TP) and NTP PM; and (4) identify, evaluate, and differentiate NTP and TP variations in microenvironments to guide future health studies. To date, our work has encompassed objectives one to three, and in our upcoming poster, we will outline results related to objective two.

Experimental Design. In Year 1, we conducted three field sampling campaigns, the first two of which served as pilot campaigns for method development and evaluation.

1) The Summer Pilot conducted in Ajax, Ontario over three days in May and June 2023 focused on i) measuring resuspended $PM_{2.5}$ using in-vehicle wheel-well level sampling and ii) evaluating the benefits of simultaneous mobile monitoring using three vehicles.
2) The Fall Pilot conducted using 30 fixed sites across the City of Toronto from mid-October to mid-November 2023, focused on testing and troubleshooting methods for data collection and integration. These methods included collecting weekly Ultrasonic Personal Air Sampler (UPAS) filters to analyze PM mass and composition, collecting weekly Ogawa passive sampler filters to measure concentrations of nitrogen oxides (NO_x), mobile sampling, and sensor-based air quality measurements using AirSENCE monitors.
3) The Winter Campaign conducted in the City of Toronto from mid-January to mid-March 2024 used the same methods as the Fall Pilot at 40 fixed sites across the City.

Preliminary Results. Simultaneous mobile sampling using three vehicles during the Summer Pilot yielded consistent maps of resuspended $PM_{2.5}$, with locations closest to highways showing the highest levels. In the Fall Pilot, higher concentrations of marker elements were measured at sites near construction, industry, and traffic congestion. Concentrations of copper (Cu) and barium (Ba) were higher near major roads, while concentrations of crustal elements, such as silicon (Si) and calcium (Ca), were higher near construction and industrial sites. Finally, the sensor-based air quality monitors, AirSENCE, were able to resolve upwind versus downwind differences in vehicle emissions along roads that were reflective of traffic conditions. The execution of these three campaigns generated many logistical challenges. We were able to resolve many but not all of these unanticipated problems.

Conclusions and Interpretation: Preliminary analysis of the data collected in Year 1 has yielded some promising results, although no firm conclusions are yet possible. We are hopeful that this project will yield new and improved methods to characterize and differentiate spatial patterns of NTP and TP PM across cities and improve knowledge of real-world factors that influence near-road concentrations of NTP PM.

Assessing source contributions to air quality and noise in unconventional oil shale plays

Meredith Franklin[1], Gunnar Schade[2], Detlev Helmig[3], Lara Cushing[4], Jill Johnston[5]

[1] University of Toronto, Toronto, Ontario, Canada; [2] Texas A&M University, College Station, Texas; [3] Boulder AIR LLC, Boulder, Colorado; [4] University of California Los Angeles, Los Angeles, California; [5] University of Southern California, Los Angeles, California.

Background. Unconventional oil and gas development (UOGD) has enabled the exploration of previously inaccessible or uneconomic shale plays, resulting in thousands of new extraction sites across relatively small geographic areas. Air emissions related to this shale exploration boom represent significant new sources of pollutants often occurring near where people live and work.

Methods. Our monitoring station located at the northwestern edge of the Permian Basin (PB) in Loving, NM, continuously collects time-resolved data on methane (CH_4), speciated non-methane hydrocarbons (NMHCs), ozone (O_3), nitrogen oxides (NOx), and carbon monoxide (CO) and dioxide (CO_2), black carbon, airborne gas-phase and particle-associated radioactivity, noise and meteorology. The site is downwind of several UOGD point sources, including a gas flare within 100 m. We compare our observations with those collected in the Denver Julesburg Basin (DJB).

With the help of local community volunteers, we are characterizing the spatial distribution of NMHCs through a passive monitoring network near residential areas to better understand population exposures to UOGD activities.

Results. We observed elevated concentrations of all monitored pollutants. During the dry and hot 2023 summer there were 31 days when EPA's 70 ppb National Ambient Air Quality Standard (NAAQS) for O_3 was exceeded. Elevated abundances of petroleum hydrocarbons appear to be the main fuel for photochemical O_3 formation. For instance, the natural gas tracer ethane was observed at concentrations that were 40-60 times higher than in DJB, which also exceeds the O_3 NAAQS. Higher NOx attributed to regional combustion sources may play a role in elevated O_3.

Methane has been particularly high in the winter months with levels frequently exceeding 5 ppm. Preliminary results of our passive monitoring network show elevated NMHC levels at locations nearest to up-stream and mid-stream UOGD facilities.

Conclusions. Our findings point to regional emissions as a driving factor of elevated levels of UOGD related pollutants and photochemical O_3 production. We continue to emphasize the importance of communicating our findings to our local volunteers and broader community through our project website and planned webinars and outreach.

Comparative effect of aircraft emissions from Sustainable Aviation Fuels on pathways of inflammation in a model of human respiratory epithelium

Georgia May Gamble, Imperial College London

Sustainable Aviation Fuel (SAF) is seen as the future of aviation, addressing the growing need to remain connected globally whilst enabling goals to reach Net Zero by 2050. It is important to determine possible health impacts of the emissions of these new fuels. We believe this is the first in vitro study of the putative health impacts of these novel SAFs.

Particulate matter (PM) emissions were collected from an auxiliary power unit (APU) running on three different fuel types: i) commercial aviation fuel (Jet A1), ii) a SAF blend comprising of 88% Hydroprocessed Esters and Fatty Acids (HEFA), and 12% synthesised aromatic kerosene (SAK) SAF and iii) 100% HEFA SAF. Following physicochemical characterisation of the emissions, a human lung respiratory alveolar epithelial type 1 cell model, TT1, was exposed for 4h, 24h and 72h to a uniform particle number concentration of each sample. Cellular viability/activation (MTT assay), oxidative stress (ROS), and changes in protein expression (Flow cytometry) were performed.

Particle number concentrations of SAF fuels were found to be up to 70% lower than that of Jet A1. There was different biological reactivity for the same particle number concentration of emissions produced by the same fuels, depending on the power settings of the APU. Samples collected while the engine was running under “Ready to Load” (RtL) conditions, analogous to an idle setting, were more bioreactive than samples collected when the APU was run at full load, possibly due to more unburnt fuel in RtL emissions. Further results will contrast fuels for the same APU power setting and associations to the physicochemical properties of the emissions.

SAFs may reduce exposure to aviation-derived PM, however, the impact of these emissions on the respiratory health of individuals working and living around airports is complex. Further research to establish the benefits of SAF is required.

Trends in Marcellus-Utica Shale Regional Air Quality due to Unconventional Oil and Gas Development (TriMAQs)

Jeremy M. Gernand[1], Manzhu Yu[1], John Wang[1]

[1]*The Pennsylvania State University, University Park, PA, USA*

Background and Objectives

The Marcellus and Utica shale formations contain recoverable quantities of 214 trillion cubic feet of natural gas, 2.5 billion barrels of natural gas liquids, and 1.8 billion barrels of oil forming an attractive resource for industrial development. Across Ohio, Pennsylvania, and West Virginia, thousands of wells are drilled and completed each year affecting people living in urban and rural areas. At each well that is drilled, fractured, and completed, emissions are released into the air including particulate matter and nitrogen dioxide from generators and trucks, fugitive releases of methane and other volatile organic compounds, and hydrogen sulfide. It is critical to understand the impact and risks this industry poses to local people in order to meet US demands for energy.

Methods and Approach

This project aims to ascertain the contributions of unconventional oil and gas development (UOGD) to local and regional air quality, associated population exposures across the multi-state Marcellus-Utica Shale region from 2004 to 2023, and how changes in industry and government policy have affected those contributions. This project will develop a multi-pollutant ($PM_{2.5}$, NO_2, SO_2, O_3, and VOCs), daily, air quality dataset across the study region from 2004 to 2023 at a resolution of 1 km using a combination of remote sensing, ground measurements, and dispersion modeling; develop a daily dataset of unconventional oil and gas activity and an inventory of expected emissions across the study region that includes drilling, fracturing, transport, and compression; produce spatiotemporal estimates of population exposure to these pollutants and estimate overall risk including an evaluation of exposure to economically disadvantaged areas; and estimate the overall proportion of measured emissions that originate from the UOGD industry together with the impact of specific regulatory policies and technical changes in industry processes on air quality in the region.

Modeling long-term $PM_{2.5}$ exposure and its impact on premature coronary artery disease: A pooled analyses of multiple cohorts in India

[1]Santu Ghosh (PI), [2]Kalpana Balakrishnan (Co-PI),[2]Naveen Puttaswamy (CoI) and [3]Sagnik Dey (CoI)

[1]St John's Research Institute, Bangalore, Karnataka, India
[2]Sri Ramachandra Institute Higher Education and Research, Chennai, Tamil Nadu, India
[3]Indian Institute of Technology, Delhi, India

Background- Coronary artery disease (CAD) is a leading contributor to the adult disease burden in India. Long term air pollution exposure is known to be one of the major risk factors. The density of ambient air quality monitoring stations that can provide continuous $PM_{2.5}$ estimates is low and unavailable in peri-urban/rural areas of India. As a result, most exposure-response (E-R) studies have used primary measurements of short-term exposure that result in considerable exposure misclassification for examining the association with chronic health endpoints.

Objective- The primary objective of the study is to examine the association of PM2.5 exposures with carotid intima-media thickness (CIMT) as a surrogate marker for *premature CAD* as well as other biomarkers of cardiovascular disease. This will be done using three rural urban cohort datasets in Southern India. In addition, a hybrid exposure model will be developed based on satellite derived aerosol optical depth (AOD) based PM2.5, integrated with ambient, micro-environmental and personal level measurements and . The secondary objective of the study is to examine effect modification in the E-R linked to dietary nutrient intake and physical activity.

Methods- Data will be compiled from three existing cohorts namely, CHAI, PURSE-HIS and HAPIN. Together, these provide 1878 ambient; 2948 personal and 3400 micro-environmental measurements of $PM_{2.5}$ along with 13230 measurements of CMIT for adults 18 to 55 years. Ambient PM2.5 estimates corresponding to each household location would be made using the satellite derived $PM_{2.5}$. Both continuous and binary CIMT will be considered for analysis by multivariate linear and logistic regression model with adjustment of potential confounders. Moderation effects will be examined using an interaction model.

Expected outcome- The study is expected to provide considerable refinements for AOD based ambient $PM_{2.5}$ exposure estimates for both rural and urban populations in India. E-R models developed in the study are likely to be a valuable resource for similar applications across other long-term cohort datasets concerning chronic disease health endpoints associated with air pollution exposures in India.

Developing a Transport Modeling Framework for Estimating Community Exposures to Pollutants from Unconventional Oil and Gas Development

Lea Hildebrandt Ruiz*[1], Joel Graves[1], Mrinali Modi[1], Yosuke Kimura[1], Shannon Stokes[1], Munshi Md Rasel[2], Lucas Henneman[2], David Allen[1]

[1]*Center for Energy and Environmental Resources, The University of Texas at Austin, Austin, TX, USA*
[2]*Dept of Civil, Environmental, and Infrastructure Engineering, George Mason University, Fairfax, VA, USA*
**Lead PI for HEI Energy Project*

Background and Objectives

Proliferating unconventional oil and gas development (UOGD) has prompted concerns about the extent of community exposures to UOGD-associated health hazards such as air and noise pollution.[1] Methods for estimating community exposures to air pollutants range from straightforward inverse distance approaches to more complicated and computationally-intensive transport formulations such as gaussian puff models.[2,3,4] *Here, we compare exposure predictions from various models to measurements of CH_4, BTEX, and other UOGD pollutants in Karnes City, TX and provide a broadly applicable framework for exposure estimation.*

Methods and Approach

An area of influence analysis for emission sources in the Eagle Ford Shale (EFS) oil and gas production region in south-central Texas was conducted using a gaussian plume model (AERMOD). Two dispersion model formulations (CALPUFF and AERMOD), a chemical transport model (CAMx) without kinetics, and an inverse distance approach that considers meteorological effects were then compared to observations from a stationary measurement in Karnes City.

Results and Findings

The radial area of influence of a single source in the EFS was determined to be approximately 50-100 km. Discretely modeling the dispersion of the thousands of UOGD sources within this area is computationally-intensive. A space-weighted source aggregation approach, implemented beyond a threshold distance from the measurement site, can reduce computational expense tenfold without compromising fidelity in exposure predictions. In topographically simple regions, like the EFS, dispersion models can reasonably characterize transport over these distances. This is unlikely to be the case in regions of topographical complexity such as the Marcellus production region in Pennsylvania and West Virginia. We are exploring a hybrid approach that treats regional exposures using larger-scale chemical transport models and local exposures with dispersion models in this region.

Conclusions and Interpretations

Strategies for estimating exposures to UOGD pollutants are not universally applicable. An approach for estimating exposures will necessarily need to consider the features of the region, the end-use and the end-user.

1. References

2. U.S. Energy Information Administration (EIA) – 2021.
https://www.eia.gov/dnav/ng/NG_ENR_SHALEGAS_A_EPG0_R5302_BCF_A.htm

3. Deziel, Nicole C., Cassandra J. Clark, Joan A. Casey, Michelle L. Bell, Desiree L. Plata, and James E. Saiers. "Assessing Exposure to Unconventional Oil and Gas Development: Strengths, Challenges, and Implications for Epidemiologic Research." Current Environmental Health Reports 9, no. 3 (May 6, 2022): 436–50.

4. Jerrett, Michael, Altaf Arain, Pavlos Kanaroglou, Bernardo Beckerman, Dimitri Potoglou, Talar Sahsuvaroglu, Jason Morrison, and Chris Giovis. "A Review and Evaluation of Intraurban Air Pollution Exposure Models." Journal of Exposure Science & Environmental Epidemiology 15, no. 2 (March 1, 2005): 185–204.

5. Levy, Jonathan I, John D Spengler, Dennis Hlinka, David Sullivan, and Dennis Moon. "Using CALPUFF to Evaluate the Impacts of Power Plant Emissions in Illinois: Model Sensitivity and Implications." Atmospheric Environment 36, no. 6 (February 2002): 1063–75.

IONA: Impact of non-tailpipe pollution on the asthmatic airway

C Griffiths[1,2], J Scales[1,2], H Hajmohammadi[1,2], K Katsouyanni[3,4], I Mudway[3], D Green[3]

[1] Queen Mary, University of London (London, UK), [2] Asthma UK Centre for Applied Research (UK), [3] Imperial College London (London, UK),[4] University of Athens (Athens, GR)

Background. Particles arising from tire and brake wear, as well as resuspension of road dust, now represent a greater proportion of roadside particulate matter (PM) by mass than direct tailpipe emissions. These non-tailpipe emissions remain unregulated, and their health impacts under explored, particularly in vulnerable groups.

Epidemiological work has associated road dust resuspension to between 4% and 10% increases in all-cause mortality, greater than vehicle exhaust emissions. *In vitro* toxicological studies have observed oxidative stress and inflammatory responses when lung cells are incubated with brake dust in both human and animal models. There are no *in vivo* experimental studies evaluating the impact of non-exhaust pollution on human health.

Research Question. *Does short-term exposure to non-tailpipe particulates impair lung function, as measured by FEV1, in asthmatic adults?*

Methods. A randomised cross-over study of short-term respiratory impacts on 48 non-smoking adults with moderate asthma during and after exposure to two contrasting, and one comparison, exposure environments in central London, UK:

1. Busy road with stop-go traffic to enhance brake wear emissions
2. High speed continuous traffic, to enhance tire and road wear emissions
3. An urban background site away from clear traffic sources.

Adults with mild to moderate asthma will be exposed at each site for two hours using a static bicycle exercise protocol, with enhanced air pollution monitoring employing high-volume PM sampling to collect PM samples for compositional analysis to assist in source appointment into tailpipe and non-tailpipe fractions. Acute response endpoints (lung function: FEV_1 primary outcome, FeNO) will be examined pre-, during & post-exposures and then related to source appointed PM. Airway inflammatory markers associated with worsening of asthma symptoms will be examined using nasal lavage, which will be used to establish the biological dose of source specific PM. Plasma samples and PM filter samples will be banked for secondary analysis.

Progress to date. The study is progressing in line with initial timelines. Notable milestones include

- Established study sites and study documentation
- Established study
- Received institutional ethics approval
- Seeking NHS ethics approval
- Set up Independent Scientific Committee
- Setting up a pilot study evaluating protocol in healthy participants (Results presented in May)
- Received small grants (£5k) for sub-study

Future challenges and opportunities

- Uncertainties regarding recruiting participants for time intensive study
- Seeking opportunities for analysis of bio-banked plasma samples, and banked filter samples.

OpenAQ: Making the World's Air Quality Data Accessible, Interpretable and Actionable for Air Quality, Climate and Health Stakeholders

Christine Hagerbaumer[1], Colleen Rosales[1,2], Russell Biggs[1], Gabriel Fosse[1]
1. OpenAQ, USA
2. University of California-Davis, USA

Background and objectives:

OpenAQ is the world's first and largest open-source, open-access database of ambient air quality data. OpenAQ makes these data easily accessible, interpretable and actionable so that anyone concerned about the health and climate impacts of air pollution has unfettered access to the data they need to analyze, communicate, and advocate for measures to improve human health and reduce inequities.

Methods and approach:

OpenAQ's methodology for collecting and sharing data makes the platform uniquely suited for research to action. OpenAQ harmonizes disparate data into a single, uniform format so that they are easily comparable; shares data in physical units rather than as an air quality index; hosts near real-time and historical air quality data; provides metadata; makes the data available programmatically via a computer-to-computer interface; and keeps the underlying data-fetching software fully open.

OpenAQ works to fully maximize the uses–and ultimate impact–of the data by providing tools and training to users. OpenAQ's Community Ambassador Program provides interdisciplinary skill building for emerging air quality leaders in low- and middle-income countries, including public health professionals.

Results and findings:

OpenAQ publishes the only global assessment of whether and how national governments are producing and sharing air quality data with the public. The most recent assessment found that 61% of countries are conducting or sponsoring some level of air quality monitoring at the national level, but at least one billion people are living where their national government doesn't monitor the most serious environmental risk factor for their health.

Conclusions and interpretations:

By describing the OpenAQ platform, use cases, how to access and make use of the data in OpenAQ, and ways OpenAQ has supported air quality initiatives where people are most vulnerable, this poster is intended to introduce HEI attendees to a useful resource.

How do household energy interventions work?

Sam Harper[1], Jill Baumgartner[1], Ellison Carter[2], Xiaoying Li[1], Zhongjie Fan[3], Shu Tao[4], Yuanxun Zhang[5]

[1]McGill University, Montreal, Quebec, Canada; [2]Colorado State University, Fort Collins, Colorado, USA; [3]Peking Union Medical College Hospital, Beijing, China; [4]Peking University, Beijing, China; [5]University of Chinese Academy of Sciences, Beijing, China

Background. Improving air quality is a policy priority in China. Starting in 2016, the Beijing municipal government designated coal-restricted areas and simultaneously offered subsidies for the purchase and installation of mostly electric-powered heat pumps to replace coal-heating stoves. This study aims to: a) estimate the contribution of changes in $PM_{2.5}$, to the overall effect of the policy on health; b) quantify the contribution of changes in the chemical composition of $PM_{2.5}$ from different sources to the overall effect on health outcomes, and c) quantify the impact of the policy on outdoor air quality and personal air pollution exposures.

Methods. In winter 2017, we enrolled households in 50 Beijing villages not currently in the coal ban (i.e., untreated) into a four-year longitudinal study. By winter 2022, 20 of 50 study villages were participating in the coal ban. We measured indoor and outdoor $PM_{2.5}$ and personal PM exposure, indoor and outdoor household temperature, blood pressure, respiratory and sleep measures, anthropometrics, and blood biomarkers of oxidation stress and inflammation. To understand the impact of the policy, we use a difference-in-difference design, comparing outcomes before and after the policy in treated villages relative to the same outcomes measured in untreated villages.

Results. We completed four winter data collection campaigns with all study measurements (2018, 2019, 2021, and 2022) in 50 villages and a reduced third campaign (due to the coronavirus pandemic) in 2020 limited to air pollution and stove use assessment in 30 villages. A total of 1,234 households were included in the study, 941 of which participated in at least two full campaigns. At baseline, mean participant age was 60 y (SD = 9.2), 60% were female, and most (63%) were agricultural workers. The geometric mean of village-averaged personal exposures to $PM_{2.5}$ and black carbon at baseline ranged from 23 to 387 $\mu g/m^3$ and from 0.8 to 11 $\mu g/m^3$, respectively. Indoor temperatures ranged from 0.0 to 28.0˚C and average systolic/diastolic blood pressure was 130/82 mmHg, respectively, and 61% of participants had hypertension. Preliminary (unadjusted) results indicate that treated households had greater increases in average indoor temperatures and greater reductions in mean indoor $PM_{2.5}$ than untreated households between baseline and follow-up seasons, and that individuals in treated households had greater reductions in mean systolic and diastolic blood pressure than those in untreated households. Preliminary difference-in-differences models estimate that wintertime indoor $PM_{2.5}$ (± SD) decreased by 37.5 (± 13.0) µg/m3 in treated households compared with untreated households, which represents a 44% (14.0% to 73.5%) reduction in mean indoor $PM_{2.5}$ between seasons 2 and 4.

Conclusions. Next steps include finalizing laboratory analysis of filter-based samples for mass and chemical composition and of blood samples collected in the first two seasons, preparation of analyses for submission to peer-reviewed journals, and implementation of statistical models for estimating the total effect of the intervention and mediation analysis to provide insights on the mechanisms linking the intervention and health effects.

HEI ^{R}Air pollution source impacts at fine scales for long-term regulatory accountability and environmental justice

Lucas RF Henneman, Sumaiya Hussain, Ting Zhang

George Mason University, Fairfax, VA, USA

Background. A growing body of evidence elaborates on differing adverse health impacts of and inequities associated with source-specific ambient air pollutants. The study is designed to 1) create fine-scale daily $PM_{2.5}$ source impacts from major source and fuel categories from 2011-2020, and 2) use the source impacts fields to quantify exposure by population groups, with a particular focus on historically disadvantaged populations.

Methods. We are estimating the daily $PM_{2.5}$ source impacts at monitors across the US. We utilized the observation datasets from two networks, the Interagency Monitoring of Protected Visual Environments (IMPROVE) and the Chemical Speciation Network (CSN). We replaced observed species concentrations with unacceptable flags with a random forest (RF)-based method, and clustered monitoring sites separately in the two networks. Extremely high concentration days were removed and/or replaced based on different threshold detection methods and based on their association with special emission events. Each species' uncertainty was assigned in PMF considering its signal-to-noise ratio, fraction of observations below the detection limit, and missing rate. We conducted both multi-site and single-site dispersion-normalized positive matrix factorization (DN-PMF) for daily estimates of $PM_{2.5}$ source impacts from a unified source list. We are modeling source attribution in the Contiguous United States on a 12 km grid using the Integrated Source Apportionment Method (ISAM) within the Community Multiscale Air Quality Modeling (CMAQ) system.

Results. We established a uniform framework to process and prepare observation records over 10 years at over 300 sites for PMF analyses and quantify daily $PM_{2.5}$ source impacts across the contiguous United States. Our initial findings highlight a nationwide decline in sulfate-originated $PM_{2.5}$ consistent with modeled decreases in $PM_{2.5}$ from coal power plants. In addition, we have identified annual variability and overall small increases in contributions from vehicular and industrial sources in many locations.

Predictive, source-oriented modeling and measurements to evaluate community exposures to air pollutants and noise from unconventional oil and gas development

Lea Hildebrandt Ruiz[1], Katarina Konon[1], Pearl Abue[1], Mrinali Modi[1], Evelyn Deveraux[1], Sam Lin[1], Daniel Blomdahl[1], Munshi Md Rasel[2], Lea El Khoury[1], Shihao Zhai[1], Albert Kyi[1], Joel Graves[1], Sewar Almasalha[1], Leif Jahn[1], Yosuke Kimura[1], Shannon Stokes[1], David Sullivan[1], Elizabeth Matsui[3], Roger Peng[4], Lucas Henneman[2], Pawel Misztal[1], David Allen[1]

[1]Center for Energy and Environmental Resources, The University of Texas at Austin, Austin, TX, USA

[2]Dept of Civil, Environmental, and Infrastructure Engineering, George Mason University, Fairfax, VA

[3]Dell Medical School, The University of Texas at Austin, Austin, TX, USA

[4]Department of Statistics and Data Science, The University of Texas at Austin, Austin, TX, USA

Background and objectives. The scale and rate of unconventional oil and gas development (UOGD) in the United States has grown dramatically, raising concerns about impacts on communities. *The main goal of this project is to generate a broadly applicable community model which can assess exposures to air pollutants from UOGD and inform future health studies*. The final model will be named the named TRAcking Community Exposures and Releases or TRACER model. We also conduct targeted field measurements to characterize emissions and to evaluate the model.

Methods and approach. Our work builds upon a coupled emissions and dispersion model originally developed for methane. We are expanding the model by adding emission sources and by including a broader suite of pollutants including air toxics. We are evaluating the ability of multiple exposure models, including dispersion modeling, inverse-distance weighting with and without considering with direction, and CAMx modeling to estimate exposures to pollutants from UOGD emissions on a regional scale. We are using the updated TRACER model to assess community exposures on a local scale. Our study's primary focus is on the Eagle Ford Shale. We are also conducting TRACER modeling in the Marcellus Shale.

Results and findings. Detailed results are presented in separate abstracts and posters at this conference and only highlighted here. In measurements we observe the clear influence of UGOD activity on air quality in the region. Flare plume compositions vary greatly between sources, and at times pollutant concentrations correlate with sound levels. Modeling results suggest that all sources within 50-100km of a receptor site need to be considered to appropriately estimate exposures, and that the spatial and temporal allocations of emissions greatly impact predicted exposures.

Conclusions and interpretations. UOGD emissions influence air quality. The modeling tools we are developing can predict humane exposures to emitted pollutants.

Strengths and Weaknesses of Environmental Justice Regulations from a Technical Perspective

Noah Hirshorn[1], Courtney Taylor[1]

1. Ramboll, USA

Environmental Justice (EJ) regulations are becoming increasingly common on a state and local level to ensure the fair treatment and meaningful involvement with respect to the development, implementation and enforcement of environmental laws, regulations, and policies. With EJ becoming a rapidly evolving topic, there is uncertainty on the types of regulations that may be proposed and how this will affect different stakeholders. Current regulations that address EJ do so by focusing on ways to increase community involvement and by requiring technical analyses of disadvantaged communities (DACs); however, the methods to regulate EJ differ across the nation. In this talk, current EJ laws in Colorado, New Jersey, New York, Illinois, and California are analyzed to explore the strengths and weaknesses of how states define DACs, the technical analyses required by these rules, and the use of EJ screening tools in regulations. Additional insight into the rulemaking process for EJ rules in Colorado and New Mexico is provided to highlight the most common ways that rules change during the rulemaking process. This presentation aims to provide the audience with insight on what to expect from proposed EJ laws, understanding proposed regulatory actions from a scientific perspective, and how to effectively take part in future rulemaking processes.

Comparison of air pollution mortality effect estimates using different long-term exposure assessment methods

Femke Bouma[1], Nicole Janssen[2], Joost Wesseling[2], Sjoerd van Ratingen[2], Jules Kerckhoffs[1], Ulrike Gehring[1], Wouter Hendricx[2], Kees de Hoogh[4,5], Kees Meliefste[1], Matthijs Dijks[1], Roel Vermeulen[1,3,*], Gerard Hoek[1*]

[1] *Institute for Risk Assessment Sciences, Utrecht University, Utrecht, the Netherlands*

[2] *National Institute for Public Health and the Environment (RIVM), Bilthoven, the Netherlands*

[3] *Julius Center for Health Sciences and Primary Care, University Medical Center Utrecht, Utrecht, the Netherlands*

[4] *Swiss Tropical and Public Health Institute, Basel, Switzerland*

[5] *University of Basel, Basel, Switzerland*

Background

Epidemiological studies have used different approaches to assess long-term exposure to ambient air pollution. Little is known about how different exposure models affect health effect estimates in these studies. The aim of this study was to compare air pollution mortality effect estimates in an administrative cohort in the Netherlands based on different exposure assessment methods.

Methods

Annual average air pollution exposure estimates using eight different methods, differing in modelling (dispersion, empirical with different algorithms) and monitoring strategy (fixed site, mobile), were applied to a Dutch national cohort of 10.8 million adults aged ≥30 years. Hazard ratios (HR) for natural and cause-specific mortality were estimated using Cox proportional hazards models with adjustment for individual and area-level confounders. Heterogeneity in effect estimates was assessed using meta-analysis.

Results

Exposure estimates from different exposure models were highly correlated and generally resulted in similar conclusions on the presence of associations with natural, respiratory and lung cancer mortality. However, the effect estimates differed substantially, e.g. the HR (95% CI) for black carbon (BC) with natural mortality ranged from 1.01 (0.99; 1.02) to 1.09 (1.07; 1.10) per increment of 1 $\mu g/m^3$. I^2 values of the meta-analysis across models were above 0.85 for all pollutants with natural mortality.

Discussion

Different exposure models generally resulted in similar conclusions on the presence of associations with natural and cause-specific mortality, but effect estimates differed substantially. Differences in exposure assessment may therefore contribute substantially to the observed heterogeneity of effect estimates in systematic reviews of epidemiological studies.

Designing Research to Inform the National Ambient Air Quality Standards – The Policy Assessment

Mary Hutson, Lars Perlmutt, Karen Wesson and Erika Sasser

U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, USA

Background: The Clean Air Act (CAA) directs the Administrator to set "primary" NAAQS that "in the judgment of the Administrator" are requisite to protect the public health with an adequate margin of safety. In setting standards that are requisite, EPA's task is to establish standards that are neither more nor less stringent than necessary. In addressing the requirement for an adequate margin of safety, EPA considers such factors as the nature and severity of the health effects involved, the size of the sensitive population(s), and the kind and degree of uncertainties. The NAAQS reviews are to be completed regularly and reflect advances in the scientific knowledge on the effects of the pollutant on public health.

Approach: The policy assessment (PA) is a key document in the NAAQS review process and is intended to "bridge the gap" between the Agency's scientific assessments and quantitative technical analyses, and the judgments required of the Administrator in determining whether it is appropriate to retain or revise the NAAQS. The PA evaluates the potential policy implications of the available scientific evidence and the available air quality, exposure or risk analyses. The PA focuses on scientific studies with the greatest potential to inform the evaluation of potential policy options, including studies that provide insight into adverse health effects at ambient concentrations near or below those allowed by standards or studies of adverse effects in populations of particular concern.

Conclusions: Gaps are sometimes encountered in specific study characteristics and data when the PA evaluates potential policy implications of the scientific information. This poster discusses the characteristics of studies that play a key role in informing policy conclusions and provides recommendations on research methodologies, as well as data and information, that could be included in studies to further assist EPA in completing NAAQS reviews.

Replacing diesel school buses with electric buses in Rwanda improves air quality and reduces greenhouse gas emissions

Egide Kalisa[1], Andrew Sudmant[2]

1. University of Western Ontario, Canada

2. Edinburgh Climate Change Institute at The University of Edinburgh, Scotland

About 100% of school buses in Rwanda are powered by diesel and gasoline fuel, and pollution levels on those buses often exceed surrounding areas. Using state-of-the-art air quality monitoring equipment, this study investigates the air quality faced by commuters using different modes of transport. The study also quantified the impact of replacing electric diesel school buses with electric buses on Air Quality and Greenhouse gas (GHG) Emissions. Vehicle emission data were collected from the Kigali vehicle testing centre. Key variables describing vehicle characteristics of the bus fleet composition were collected from Kigali bus fleet operators. Bus emissions with on-road testing were collected using a portable exhaust emission gas analyzer. The results show that the highest air pollution exposure is experienced by children travelling on foot and bicycle. The lowest total air pollution exposure was found for those travelling by bus, emphasizing that a well-functioning bus transport system can reduce congestion, energy expenditure, GHG emissions and air pollution. Replacing all 422 diesel school buses in Kigali by 2028 would save 12.8kt CO2e annually, the equivalent of removing more than 6,000 cars from Kigali's streets. Scenario analysis suggests that modest annual 10 % reductions in air pollution in Kigali could yield more than 200 million US dollars of economic. Implementing policies that support the adoption of electric school buses will generate substantial social, health and economic benefits.

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[1], Dimitris Evangelopoulos[1], Dylan Wood1, Benjamin Barratt[1], Hanbin Zhang[1], Barbara Butland[2,], Evangelia Samoli[3], , Sean Beevers[1], Heather Walton[1], Audrey de Nazelle[1], Evangelos Evangelou[1], Joel Schwartz[4]

[1]Imperial College London, London, UK; [2]St George's University of London, London, UK; [3]National and Kapodistrian University of Athens; Athens, Greece; [4]Harvard School of Public Health, Boston, Massachusetts, USA

Objectives: To evaluate whether increasingly detailed estimates of long-term individual exposure to pollutants, for large-scale studies, are useful and effective in yielding better health effects estimates.

Methods and approach: Data from 344 participants (12,901 person-days) in four personal measurement campaigns were used. The personal exposure measurements were separated into exposures from outdoor and indoor sources and extrapolated to annual exposures (the "true" exposures). Surrogate measures of exposure were assigned based on fixed-site monitors and modelling, with additional adjustment for time-activity patterns. Measurement errors (ME), were calculated and used as input in a simulation study to investigate the resulting bias in health effect estimates. The effectiveness of two correction methods, SIMEX and regression calibration, was tested. The surrogate exposure methods were applied in the UKBiobank London cohort (62,000 subjects) to assess associations with health outcomes and evaluate correction methods.

Results: Exposure to outdoor generated pollution accounted for ≥50% of total personal exposure even in subjects spending almost all of their time indoors. We found large MEs possibly due not only to the nature and uncertainty of using surrogate measures but also to several uncertainties incorporated in assessing the "true" exposure. The resulting bias in health effect estimates from ME was large and mostly towards the null, i.e. health effects were underestimated, sometimes by as much as 100%. SIMEX and regression calibration were effective methods for bias correction. The application to the UKBiobank cohort data showed hazard ratios above one for few surrogate exposures, which were corrected, leading to larger estimated effects.

Conclusions and interpretation: The importance of exposure ME in estimating health effects and the difficulty to obtain an accurate estimate of the true personal exposure to outdoor generated pollutants are underlined. The common use of surrogate measures of exposure introduces possibly substantial ME, leading to large underestimation of effects.

[W]Estimating global trends of air pollution, air pollution-attributable disease burdens, and CO2 emissions in 13,000 cities using large geospatial datasets

Soo-Yeon Kim, George Washington University

Jane Warren Conference Award Recipient

Background/objectives: Urban areas face increasing public health challenges attributable to environmental and climate hazards. Various urban initiatives have been implemented to address the health threats from air pollution and climate change. Nonetheless, there is still substantial uncertainty regarding the effectiveness and benefits of these actions. This study aims to identify temporal trends of PM2.5, NO2, and O3 concentrations, air pollution-attributable disease burdens, and CO2 emissions across 13,000 cities worldwide.

Methods/approach: We aggregated gridded estimates of the air pollutants and CO2 emissions to urban areas with newly available datasets based on satellite data and geophysical modeling. We calculated population-weighted annual averaged air pollutant concentrations, disease burdens attributable to the air pollutants (PM2.5: premature deaths from six major diseases; NO2: pediatric asthma incidence; O3: premature deaths from chronic respiratory disease), and fossil fuel CO2 (FFCO2) per capita.

Results: Globally, O3 and FFCO2 per capita showed increases of 9% and 13% during 2005-2019, while PM2.5 and NO2 showed little change (+2% and +0%, respectively). We found substantial variations in pollutant trends across cities and world regions. For example, while cities in South Asia and Sub-Saharan Africa showed overall increases in both air pollution and CO2, cities in high-income countries showed all decreasing trends. We showed how air pollution-related disease burdens have changed over this period, depending on the pollutant and region, driven by trends in pollution, population, and baseline disease rates.

Conclusions/interpretation: We created a database of air pollution, air pollution-attributable disease burdens, and CO2 emissions for 13,000 cities worldwide. Our use of large geospatial datasets enables tracking of urban progress towards clean air, improved health, and lower greenhouse gas emissions, aligned with Sustainable Development Goals and other targets. We also provide the first city-scale systematic comparison of temporal trends in three health-damaging air pollutants and CO2 emissions, encompassing all urban areas globally.

Accounting for the Health Benefits of Air Pollution Regulations in China

Patrick L Kinney[1], Beizhan Yan[2], Xiaoming Shi[3], Maigeng Zhou[4], Shuxiao Wang[5], Lucas Henneman[6], Jia Xing[5], Phil Hopke[7], Tiantian Li[3], Peng Yin[4], Limin Wang[4], Zhenping Zhao[4], Haotian Zheng[5], Runmie Ma[3], Qinghua Sun[3], Wenrong Zhang[4], Howard Chang[8], Corwin Zigler[9], Haidong Kan[10].

[1] Boston University School of Public Health, Boston, MA USA; [2] Columbia Lamont Doherty Earth Observatory, Palisades, NY; [3] National Institute of Environmental Health, Chinese Center for Disease Control and Prevention, Beijing, China; [4] National Center for Chronic and Non-communicable Disease Control and Prevention, Chinese Center for Disease Control and Prevention, Beijing, China; [5]Tsinghua University School of the Environment, Beijing, China; [6] George Mason University, Fairfax, VA; [7] University of Rochester, Rochester, NY; [8] Emory University, Atlanta, GA; [9] University of Texas, Austin, TX; [10] Fudan University, Shanghai, China

Background and Objectives. China launched ambitious air pollution regulations in 2013 that have resulted in substantial reductions in $PM_{2.5}$ concentrations. The main objective of this project is to analyze whether regulations to control $PM_{2.5}$ have been associated with declining mortality rates.

Methods and Approach. We used both in situ observations and model outputs to characterize observed and counterfactual spatiotemporal trends in air quality from 2008-2019 across China. The community multiscale air quality (CMAQ) model was used to simulate ambient $PM_{2.5}$ and ozone at 27 km^2 for all of China. CMAQ was run using actual estimated emissions as well as counterfactual emission scenarios that quantified the impact of source-specific emission control policies on ambient concentrations. We analyzed the extent to which changes in regulatory policies and related air quality were associated with reduced mortality in two large nationwide cohorts that have data spanning the periods before and after the implementation of major regulations.

Results and Findings. CMAQ evaluation against observations showed good agreement. From 2008-2019, we estimate there was an overall ~40% reduction in $PM_{2.5}$ as compared to a no-control scenario, but with regional heterogeneity. Both source apportionment and CMAQ results showed that both coal burning and steel industry emission reductions played important roles in observed downward $PM_{2.5}$ trends. Associations were observed between $PM_{2.5}$ and mortality rates in both cohorts, though results were somewhat sensitive to model specification. Novel causal models indicated that improvements in $PM_{2.5}$ since 2013 were associated with increased survival probability in both cohorts.

Conclusions and Interpretation. The scope of air pollution regulations and resulting PM improvements in China provided a unique opportunity for accountability research. Our study provides evidence supporting the health benefits of those policies.

Air Pollution and Post-Acute Sequalae of COVID-19 in Southern California

Michael Kleeman[1], Michael Jerrett[2], Claudia L. Nau[3], Deborah R. Young[3], Rebecca K. Butler[3], Chistina M. Batteate[2], Ariadna Padilla[3], Sata Y. Tartof[3], Jason Su[4], Richard T. Burnett[5]
[1]University of California, Davis, California, USA; [2]University of California, Los Angeles, California, USA; [3]Kaiser Permanente Southern California, Los Angeles, California, USA; [4]University of California, Berkeley, California, USA; [5]Health Canada, Ottawa, Ontario, Canada

Background
Some 17.8 million people in the U.S. currently experience post-acute sequalae of COVID-19 (PASC), with some suffering onset of serious health conditions. Two earlier studies suggest an association between PASC and air pollution, but these were based on small samples and unusually high or low exposure profiles. Here we hypothesized that exposure to air pollution would be associated with higher risk of PASC in Southern California.

Methods
Our cohort included 12,634 adult patients who had been hospitalized for COVID-19 between June 1st 2020 and January 31st 2021 and were discharged alive. We defined PASC based previous literature, consultation with attending physicians, and prior evidence of association with air pollution exposure. We estimated exposure to several air pollutants with chemical transport models at 1 km resolution. We used logistic regression to estimate associations. Our analyses focused on exposures 30 days before hospitalization and presentation of PASC within 3 months or 12 months of hospital discharge.

Results
We found associations between ultrafine particle mass ($PM_{0.1}$) and several PASC outcomes, including: cardiac, OR of 1.115 (95% CI: 1.006-1.235); endocrine, OR of 1.130 (95% CI: 1.038, 1.230); and pulmonary, OR of 1.062 (95% CI: 1.009,1.118) using the interquartile range exposure increment. O_3 was associated with the pulmonary outcomes: OR of 1.097 (95% CI: 1.019,1.180) and $PM_{2.5}$ nitrate with cardiometabolic outcomes, OR of 1.181 (95% CI: 1.013, 1.377).

Interpretation
Our results suggest that exposures to air pollution could increase the risk for patients hospitalized with COVID-19 to experience PASC conditions.

Chemical Characterization of Emissions from Unconventional Oil and Gas Development Using Stationary Measurements in the Eagle Ford Shale

Lea Hildebrandt Ruiz*, Katarina Konon, Pearl Abue, Leif Jahn, Lea El Khoury, Austin Turner, Daniel Blomdahl, Evelyn Deveraux, Chou-Hsien Lin, Mrinali Modi, Kristi McPherson, David T Allen, Pawel Misztal

Center for Energy and Environmental Resources, The University of Texas at Austin, Austin, TX

*Lead PI for HEI Energy Project

Background and Objectives

Unconventional oil and gas development (UOGD) continues to grow in the United States, yet its effects on air quality, climate, and human health are not fully characterized. We aim to measure UOGD emissions and use these measurements to aid in the development of a broadly applicable community model which can assess exposures to air pollutants from UOGD and inform future health studies.

Methods and Approach

We sampled ambient air in Karnes City, Texas. This rural town is located within the Eagle Ford Shale, a large oil and gas production region in south-central Texas. The measurement site was collocated with a Texas Commission on Environmental Quality measurement facility. We took gas-phase and particle-phase measurements in the spring and fall of 2023.

Results and Findings

Gas-phase measurements revealed multiple plumes with elevated concentrations of light alkanes, consistent with the hypothesis that emissions from oil and gas production in the Eagle Ford Shale substantially influence air quality at this stationary background location. We also observed periods with elevated concentrations of aromatic hydrocarbons and other air toxics. Additionally, diurnal trends in chlorine concentrations reveal late afternoon peaks, indicating the presence of a photoactive chlorine source. Chlorine, hydroxyl, and other radicals can oxidize primary emitted compounds to form secondary pollutants, which also impact health. Particulate matter measurements included plumes up to 12 micrograms per cubic meter during the fall campaign. This particulate matter was composed mostly of organics and sulfates.

Conclusions and Interpretation

Emissions from UOGD influence air quality in Karnes City. These measurements will contribute to the development of a model that can be used to predict community exposures to air pollutants from UOGD.

HEI energy Chemical Characterization of Emissions from Unconventional Oil and Gas Development Using Mobile Measurements in the Eagle Ford Shale

Lea Hildebrandt Ruiz*, Pawel K. Misztal#, Chou-Hsien Lin, Evelyn Deveraux, Daniel C. Blomdahl, Leif Jahn, Pearl A. Abue, Katarina Konon, Mrinali Modi, Austin Turner, Sulaiman Al Suhaibani, Joel Graves, Albert Kyi, and Shihao Zhai

Center for Energy and Environmental Resources, The University of Texas at Austin, Austin, TX, USA

*Lead PI for HEI Energy Project #Co-PI, Lead for HEI Energy Mobile Measurements

Background and Objectives. The global demand for petrochemical products has fueled the growth of unconventional oil and gas developments (UOGD) in recent decades. UOGD operations are often dispersed and heterogeneous, and require novel approaches to embrace complexities in the assessment of community exposure to air and sound pollution they cause. *Our objective was to conduct mobile measurements around UOGD sites in the Eagle Ford Shale (EFS) to characterize emission plumes associated with different UOGD activities.* The diverse hydrocarbon production of the EFS facilitated the characterization of pollutant emission from a variety of UOGD sites in the EFS, as well as the comparison among them based on production type.

Method and Approach. We conducted mobile measurements using an electric vehicle fitted with instrumentation to assess air and environmental quality, including: Vocus 2R Proton Transfer Reaction Time of Flight Mass Spectrometer (Vocus-PTR-ToF-MS) to monitor the real-time composition of volatile organic compounds (VOCs) via H_3O^+ ionization; Picarro formaldehyde and methane analyzer; Thermo-Fisher ozone monitor and SO_2/H_2S analyzer; Magee Scientific Aethalometer for black carbon measurements; LI-COR monitor for CO_2 and H_2O; and RM Young Ultrasonic Anemometer for meteorological measurements. We collected measurements using repetitive routes around flaring and well sites to capture emission plumes. These data will be used to characterize combustion efficiencies and emission factors from the flaring sites.

Results and Findings. Across the two field campaigns, detected compounds included C6- (e.g., benzene) to >C15-aromatics, reduced aromatics (e.g., styrene), oxygenated and sulfur-containing compounds (e.g., dimethyl sulfide). The chemical composition of flare emissions differed geographically, likely as a function of the combustion conditions and/or gas compositions at the UOGD sites where we measured.

Conclusions and interpretations. UOGD emissions are diverse and chemically complex. Mobile measurements provide a method to characterize these emission sources at high spatiotemporal resolution.

Applying regional and race/ethnicity-specific health cost data to better estimate the economic burden of air pollution in the United States

Nicholas Mailloux, University of Wisconsin–Madison

Background: Ambient air pollution exposure causes adverse health outcomes and associated economic burdens. The Environmental Benefits Mapping and Analysis Program–Community Edition (BenMAP-CE) is widely used for estimating the health effects and economic value of air quality changes. However, BenMAP-CE cost data represent national averages, do not differentiate costs by race/ethnicity, and typically exclude ambulatory care and other health-related costs. We aim to understand how costs differ when using more finely resolved cost inputs.

Methods: We apply regional and race/ethnicity-specific cost data from the Healthcare Cost and Utilization Project (HCUP) for 2019 to hospitalizations and emergency department visits included in BenMAP-CE. Additionally, we compile health-related costs associated with outpatient care, home health care, and prescribed medicines from HCUP and the Medical Expenditure Panel Survey. Finally, we apply this set of valuation functions to the health benefits estimated to occur if the recent update to the primary National Ambient Air Quality Standards for fine particulate matter were met.

Results: Regional hospitalization costs differ from the national average by –16% to 34% for cardiovascular outcomes and –16% to 48% for respiratory outcomes. Race/ethnicity-specific hospitalization costs for cardiovascular outcomes differ from the national average by –1% for Whites, –11% for Blacks, 6% for Hispanics, 32% for Asians, 7% for Native Americans, and 18% for Other. Findings are similar for respiratory outcomes: White (–3%), Black (–2%), Hispanic (7%), Asian (34%), Native American (7%), and Other (17%). Cost variations are wider when stratifying by region and race/ethnicity simultaneously. Accounting for additional costs not included in BenMAP-CE increases health-related costs substantially for some but not all health outcomes.

Conclusions: Our findings demonstrate the importance of using stratified health cost data when estimating the health-related economic burden of air pollution in the United States, particularly in work considering equity implications of air quality changes.

Refining Urban Exposure Estimates: A Modeling Approach Melding Mobile and Fixed-Site Observations

Chirag Manchanda, UC Berkeley

BACKGROUND: Urban air pollution can vary sharply in space and time. However, most strategies for "hyperlocal" monitoring, such as low-cost sensors and mobile monitoring, cannot provide a complete spatiotemporal representation of how air pollution varies across a city. This hampers our ability to assess air pollution exposures, disparities, and health effects. We introduce here a new data-only modeling approach that integrates observations from mobile monitoring and fixed-site sensor networks to make high-resolution predictions to aid in exposure studies.

METHODS: This study develops, validates, and applies our model using data from an intensive 100-day field study focused on black carbon (BC) in West Oakland, CA, a disparately impacted community with major environmental justice concerns. Leveraging both mobile and fixed-site measurements, our approach is distinct from conventional spatiotemporal modeling methods: it relies exclusively on observations as inputs, without additional predictor variables. The model extracts coherent spatial patterns embedded in multi-pollutant mobile measurements to effectively bridge gaps between fixed-site BC measurements.

RESULTS: The model performs very well in reconstructing patterns at fine spatial and temporal resolution (30 m, 15 minutes), demonstrating strong out-of-sample correlations for both mobile ($R \sim 0.77$) and fixed-site measurements ($R \sim 0.95$). The model reveals features that are inadequately captured by the stationary and mobile observation approaches alone, thereby enabling quantification of the impact and extent of dynamic industrial and traffic sources.

CONCLUSION: This data-driven method bridges spatiotemporal gaps, generating fine-scale concentration timeseries at locations lacking direct measurements. The model's reliance on spatiotemporal patterns embedded in measurements ensures the representativeness of these estimates. Moreover, our method's ability to discern the temporal dynamics associated with fine-scale spatial gradients enhances our understanding of air quality, facilitating targeted interventions. This new approach may aid hyperlocal measurements in informing accountability studies of how emissions, exposures, and disparities evolve in response to policy actions.

HEI [R]Designing optimal policies for reducing air pollution-related health inequities

Rachel C. Nethery[1], Patrick Kinney[2], Francesca Dominici[1]

[1]Department of Biostatistics, Harvard TH Chan School of Public Health, Boston, MA, USA; [2]Department of Environmental Health, Boston University School of Public Health, Boston, MA, USA

Background and objectives

While the EPA has committed to tailoring future regulatory policies to mitigate air pollution-related health inequities, existing statistical methods offer a limited toolkit for informing the design of national environmental justice-centered policies. Certain marginalized groups experience heightened exposure to $PM_{2.5}$ and are more susceptible to its adverse health impacts as a result of social structural forces. Moreover, due to differing $PM_{2.5}$ sources and climate patterns across the US, the health effects of $PM_{2.5}$ may also vary over space. All of these factors must be simultaneously taken into account, alongside realistic policy constraints, to design optimal policies for mitigating pollution-related health inequities. Current methods are ill-equipped to characterize this complex effect heterogeneity and to leverage it to inform environmental justice-centered policies. In the proposed work, we address these gaps by developing and implementing statistical methods to characterize spatial and racial/ethnic variation in $PM_{2.5}$ health effects across the US and to design optimal policies for reducing $PM_{2.5}$-attributable health inequities under resource constraints.

Methods and approach

First, we will develop Bayesian causal inference methods to estimate area- and racial/ethnic group-specific causal exposure-response curves (ERC), building on spatially-varying coefficient and Gaussian process modeling techniques. We will apply them to 2009-2018 nationwide Medicare claims data to estimate $PM_{2.5}$ ERCs for each of the three largest racial/ethnic groups in the US (non-Hispanic white, Black, and Hispanic) for several different health outcomes.

Second, leveraging the estimated area- and racial/ethnic group-specific ERCs, we will design and implement two approaches to identify hypothetical $PM_{2.5}$ reduction "policies", i.e., geographic distributions of $PM_{2.5}$ reductions, that minimize racial/ethnic group-specific $PM_{2.5}$-attributable health risks under realistic budget constraints. The first— a Monte Carlo simulation approach—emphasizes transparency and interpretability. The second—a constrained optimization approach—emphasizes statistical rigor and computational efficiency.

Results and findings

N/A

Conclusions and interpretation

N/A

Impact of Prescribed Fires on Air Quality in Southeastern US during 2013–2021

Kamal J. Maji[1], Zongrun Li[1], Jennifer D. Stowell[2], Chad Milando[2], Yongtao Hu[1], Gregory A. Wellenius[2], Patrick L. Kinney[2], Armistead G. Russell[1], Ambarish Vaidyanathan[1,3], and M. Talat Odman[1]

[1]Georgia Institute of Technology, Atlanta, Georgia, USA; [2]Boston University School of Public Health, Boston, Massachusetts, USA; [3]Centers for Disease Control and Prevention, Atlanta, Georgia, USA

Background. Prescribed fires are planned and controlled fires commonly used for reducing the risk of wildfires and managing wildland ecosystems. Unlike wildfires, prescribed fires are conducted under specific weather conditions, leading to the production of smoke with distinct pollution constituents, concentrations, and proportions. To safeguard public health, it is essential to fully understand the impacts of prescribed fires on air quality.

Methods. We employ a clustering algorithm to identify daily prescribed fire information from Fire INventory from NCAR (FINN) and integrate a chemical transport model with a data fusion system to estimate 24-hour average $PM_{2.5}$ and maximum daily 8-hour average O_3 concentration (MDA8-O_3) attributable to prescribed burns.

Results. Across the southeastern US, prescribed fires had substantial impacts on spatiotemporal variations of total $PM_{2.5}$ and MDA8-O_3. Specifically, the average $PM_{2.5}$ concentration attributable to prescribed fires was 0.50±0.87 μg/m^3 (mean± standard deviation), (5th and 95th percentiles range: 0–2.04 μg/m^3), accounting for 8% of ambient $PM_{2.5}$. Notably, higher prescribed fire $PM_{2.5}$ were seen in 2017 (0.63±1.02 μg/m^3, range: 0 to 2.64 μg/m^3) and in 2021 (0.57±1.13 μg/m^3, range: 0 to 2.34 μg/m^3). The average contribution of prescribed fire $PM_{2.5}$ was 0.85±0.17 μg/m^3 (12% of ambient $PM_{2.5}$) in Georgia and 0.83 ± 0.16 μg/m^3 (11% of ambient $PM_{2.5}$) in Alabama. During the burning season (January–April), the average prescribed fire $PM_{2.5}$ concentration was higher, with 1.11±0.27 μg/m^3 in Alabama, 1.38±0.31 μg/m^3 in Georgia, and 1.0±0.14 μg/m^3 in South Carolina. During the study period, the mean prescribed fire MDA8-O_3 level was 0.35±0.65 ppb (range: 0-1.14), amounting to 0.9% of ambient levels.

Conclusions. Prescribed fires have a significant impact on daily $PM_{2.5}$ and O_3 concentrations in the southeastern US. Consequently, exposure to air pollution resulting from these prescribed burns may be linked to an increased risk of emergency department visits for respiratory and cardiovascular diseases.

Long term associations between air pollution from industrial, transportation, and residential sources with respiratory, cardiovascular, neurological, and autoimmune disease-related mortality in Canada

Toyib Olaniyan[1], Tanya Christidis[1], Ivana Popadic[2], Chris Hebbern[3], Mathieu Rouleau[3], Markey Johnson[3], Angelos Anastassopoulos[3], Guillaume Marcotte[2], Naizhuo Zhao[4], Michael Tjepkema[1], Sabit Cakmak[3]

1. Statistics Canada, Canada

2. Environment and Climate Change Canada, Canada

3. Health Canada, Canada

4. McGill Health Center, Canada

Background and Objectives: Transitioning to cleaner energy sources across all sectors of the economy has significant health benefits. Total ambient pollutants are the target of current mitigation policies. However, quantifying the health effects from major air pollution sources in Canada is imperative to identify sources that may disproportionately impact the health of people living in Canada. This study investigated long-term associations between various sources of air pollution, with all-cause and various cause-specific mortality.

Methods: The Canadian Census, Health, and Environment Cohort (CanCHEC) consists of approximately 3-million individuals aged 15 or older, enumerated by the 2006 long-form census, linked to vital statistics and followed to December 31, 2019. Fine particulate matter [PM_(2.5)], sulfur dioxide [SO_(2)], and nitrogen dioxide [NO_(2)] concentrations associated with 20 different source sectors were estimated using GEM-MACH, a chemical transport model incorporating detailed characterization of atmospheric chemistry and meteorological processes. Individuals were assigned annual exposure values based on postal codes obtained from their annual tax fillings. Cox proportional hazard models were used to estimate the risk of cause-specific and all-cause mortality associated with each pollutant and source sector.

Results: Current findings suggest increased risk of mortality from some pollutants and sources. Specifically, an increase in PM_(2.5) from 'off-road vehicles and equipment' was associated with cause-specific mortality increases of: 5.9% (95%CI: 3.3-8.6%) in dementia, 4.5% (95%CI: 0.8-8.3%) in diabetes, and 2% (95%CI: 1.0-4.1%) in respiratory diseases. Similarly, an increase in NO_(2) from 'residential fuel combustion' was associated with increases in cause-specific mortality including 11.4% (95CI%: 4.7-18.5%) in Parkinson's, and 15.1% (95CI%: 12.1-18.2%) in dementia.

Conclusion: The findings suggest an increased risk of mortality from specific pollutants and source sectors. Subsequent analyses aim to explore the joint association of these pollutants and sources on mortality, including the assessment of these complex interactions with traffic pollutants, and across different socioeconomic groups.

HEI [R]**What's in the air? Engaging Native American youth in the Northern plains to reduce air pollution.**

Yoshira Ornelas Van Horne[1], Ana Navas-Acien[1], Raeann Mettler[2], Rima Habre[3,4], Marianthi-Anna Kioumourtzoglou[1], Markus Hilpert[1]

[1] *Department of Environmental Health Sciences, Columbia University Mailman School of Public Health, New York City, NY, USA*

[2] *Missouri Breaks Industries Research Inc, Eagle Butte, SD, USA*

[3] *Department of Population and Public Health Sciences, University of Southern California, Los Angeles, CA, USA;* [4]*Spatial Sciences Institute, University of Southern California, Los Angeles, CA, USA*

Background and Objectives

Nationally, marginalized groups in the USA are disproportionally exposed to air pollution. While the general US population has benefited from a decrease in air pollution levels, these benefits have not been equitably distributed. Such is the case among Native American communities, suggesting environmental disparities in air pollution mitigation. Through US federal laws, the EPA can approve an Indigenous community to receive treatment as a state designation, allowing them to implement and manage certain environmental programs (e.g., air pollution monitoring). Currently less than 15% (86/576) of all federally recognized Indigenous communities operate their own approved air monitoring sites. Not only is there a lack of air monitors but there is also a lack of technical support and investment in programs aimed at building capacity and monitoring infrastructure to accurately assess air quality in Indigenous communities.

Our project seeks to advance a community-academic partnership with Missouri Breaks Industries Research (an American Indian-owned research center serving Indigenous communities in the Northern Plains) and Columbia University to characterize sources of air pollution and identify community-driven solutions through an emissions reduction plan. Specifically, our aims are to 1) engage Native American youth in the formation of a community-based air monitoring network, 2) determine local sources of PM2.5 exposures through ambient measurements and source-apportionment methods, and 3) leverage findings to develop an emissions reduction plan.

Methods and Approach

We are partnering with two high schools in two Indigenous communities in South Dakota. At each high school we will engage 2-3 students and a teacher to install QuantAQ Modulair units to measure PM1, $PM_{2.5}$, PM10, CO, NO, NO2, and O3, along with filter-based monitors. In addition to the quantitative data measurements, the students will also be asked to document any air quality anomalies they observe through photographs, videos, and a written journal, to embrace the concept of 'ground truthing.'

Assessing Changes in Air Quality in India

Pallavi Pant, Health Effects Institute

Outdoor air pollution in India continues to be high in India, and in recent years, there have been significant efforts to address air pollution, including the National Clean Air Programme (NCAP). Launched in 2019, this effort is led by the Ministry of Environment, Forests and Climate Change with the goal of setting up policies and mitigation measures aimed towards reduction of levels of particulate matter. In 2023, HEI launched a project to develop a robust framework for assessment of the changes in air quality in Indian cities, especially since long-term data are not yet available for many cities. The project will benefit from expert input from a five-member expert pane. This project is in line with HEI's longstanding work on accountability, i.e., research to evaluate the effectiveness of air quality interventions.

Mortality Attributable to Ambient Fine Particulate Matter Concentrations in Canada from 2001 to 2021 in a Changing Landscape

Amanda J. Pappin[1], Elysia G. Fuller-Thomson[1], Mathieu Rouleau[1]

1. Water and Air Quality Bureau, Healthy Environments and Consumer Products Safety Branch, Health Canada, Canada

Background and objectives. Air quality management strategies have led to improvements in ambient air quality in Canada over recent decades, including for fine particulate matter (PM2.5). We seek to understand how Canadian population exposure to PM2.5 and associated premature mortality have changed since 2001, and drivers of these trends.

Methods and approach. We run Health Canada's health impact assessment tool every five years from 2001 to 2021. We estimate premature mortality attributable to PM2.5 using dynamic inputs of population, baseline mortality rates, and satellite-based PM2.5 concentrations. We apply linear and non-linear concentration response functions for long-term PM2.5 exposure and non-accidental mortality developed from the 2006 Canadian Census Health and Environment Cohort. We conduct decomposition analysis to examine the influence of changing population growth, baseline health status, and exposure over time.

Results and findings. PM2.5 concentrations in most Canadian urban areas have improved over the past two decades, largely between 2006 and 2016. We estimate 4,000 avoided PM2.5-related premature deaths in 2021 (95% CI: 3,500 – 4,600) due to reductions in ambient PM2.5 since 2001 and a 14% decline in Canada's population attributable fraction (PAF; % of all non-accidental deaths attributable to PM2.5 exposure). While central and eastern Canada have largely experienced improvements in PM2.5 concentrations and PAFs, deteriorations are evident in western Canada. A growing Canadian population and increasing baseline mortality rates have counteracted improvements in concentrations, with a net increase in premature mortality since 2001 even as PAF has largely decreased.

Conclusions and interpretation. Canadian population health has broadly benefitted from reduced exposure to PM2.5. Our results underline the importance of considering how population exposure and baseline health status interact when prioritizing air quality actions for the future.

HEI Impact of Air Pollution on Pregnancy and Newborns – Data Analysis of Cohort Study in Central India

Archana Patel[1], Roshan Wathore[2], Nitin Labhasetwar[2]

[1]Lata Medical Research Foundation, Nagpur, Maharashtra, India; [2]CSIR-National Environmental Engineering Research Institute, Nagpur, Maharashtra, India

Background: Maternal exposure to fine particulate matter ($PM_{2.5}$) has been postulated to be associated with adverse pregnancy and neonatal outcomes such as miscarriages, stillbirths, low birth weight and preterm births. South Asia has the highest burden of pregnancy loss globally and is among the regions with the highest exposures to $PM_{2.5}$ in the world. However, knowledge of the relevant exposure–response function for mothers is insufficient, primarily due to the lack of available air quality data, especially in rural areas. More recently, the availability of long-term, high-resolution satellite-based estimates of ground-based ambient $PM_{2.5}$ and their validations with actual ground-based measurements are being used for analyzing long-term trends in $PM_{2.5}$ and associated mortality, estimation of health impacts and enabling air quality management at local, national and regional scales.

Objective: This study aims to determine a robust epidemiological link between maternal $PM_{2.5}$ exposure and outcomes including adverse pregnancy outcomes (i.e., early or late fetal losses, pregnancy-induced hypertension and infections) as well as neonatal health outcomes (i.e., still births, preterm birth, birth weight) and all-cause mortality in mothers and babies. The study will also quantify the relevant disease burden in a representative population from Central India, which has rapidly urbanized, with a sizable number of industries and coal-based thermal power stations.

Methods: This cohort study will include data of ~ 100,000 pregnant women prospectively enrolled from 2012 to 2023 as part of the Global Network's Maternal Newborn Health Registry (MNHR). This prospectively collected dataset includes demographic and socio-economic indicators as well as pregnancy and neonatal outcomes from rural clusters of Nagpur, Bhandara, Wardha and Chandrapur districts in Central India. Historical satellite-derived $PM_{2.5}$ exposure and meteorological data (T and RH) would be provided by IIT Delhi at a spatial resolution of 1 x 1 km^2 and temporal resolution of 24-hours. The health and exposure datasets would be treated and merged, followed by statistical and machine learning analysis.

Outcome: To our knowledge, this is the first prospective epidemiological and health-risk-assessment study that analyzes the effect of $PM_{2.5}$ on pregnant women and their neonates in Central India. The results will help to understand the impact of air pollution on pregnancy, fetal and newborn health outcomes and mortality using primary air pollution and health data collected in Indian districts.

[W]Maternal and Placental Metabolomic and Epigenetic Alterations Associated with Gestational Exposure to Polycyclic Aromatic Hydrocarbons

Jagadeesh Puvvula, University of Pennsylvania, Philadelphia, PA

Jane Warren Conference Award Recipient

Background: Polycyclic aromatic hydrocarbons (PAHs) are endocrine-disrupting compounds found in motor vehicle exhaust, cigarette smoke, wood smoke, and smoked/grilled foods. They can cross the placental barrier, potentially affecting fetal metabolism and development through pathways like endocrine disruption, DNA damage, and oxidative stress. This study explores the associations between maternal PAH exposure and newborn outcomes using metabolome and epigenome analyses.

Methods: Seventy-five pregnant individuals from the Cincinnati, Ohio, metropolitan area were included in the study. Eight monohydroxylated PAH metabolites from maternal urine, serum metabolome profiles (maternal and cord blood), and epigenome profiles from cord blood mononuclear cells and placenta (maternal and fetal sides) were measured. We identified metabolome features and differentially methylated CpG positions associated with maternal urinary PAH metabolite concentrations using multiple linear regression. Subsequently, metabolic pathway and methylation set enrichment analysis was performed using the metabolome features and CpG sites associated with maternal urinary PAH metabolite concentrations, respectively. Enrichment analysis using the metabolome and epigenome profiles was conducted using the Kyoto Encyclopedia of Genes and Genomes pathways.

Findings: At least 88% of the study participants had urinary PAH metabolites above the detection limits. Up to 2% of metabolome features and 0.01% of CpG sites were associated with maternal urinary PAH metabolite concentrations. Most of these associations were observed in either the placenta/cord-blood metabolome or epigenome. The enrichment analysis indicated that gestational exposure to PAHs may influence the fetal metabolism of amino acids, vitamins, carbohydrates, lipids, and fatty acids.

Conclusion: Gestational exposure to PAHs may influence fetal metabolism and lead to adverse developmental outcomes.

Insights into the Spatial-Temporal Dynamics of $PM_{2.5}$ Pollution in Kampala City: A Local Moran's I Autocorrelation Approach

Wabinyai Fidel Raja[1], Gideon Lubisia[1], Deo Okure[1]

[1]AirQo, Makerere University, Kampala

The rapid urbanization and industrialization observed in many developing cities have led to an increased concentration of air pollutants, including fine particulate matter ($PM_{2.5}$), posing significant threats to public health. This study investigates the spatial-temporal patterns of $PM_{2.5}$ pollutant levels in Kampala City, Uganda. The research makes use of data acquired from 31 AirQo, air pollution monitoring stations throughout the year 2023.

The research methodology involves the calculation of Local Moran's I, a spatial autocorrelation statistic. The objective is to identify concentration clusters of High-High (HH), Low-Low (LL), High-Low (HL), and Low-High (LH).

The Moran's I Index registered a value of 0.198, indicating a moderate positive spatial autocorrelation. This suggests that areas with similar $PM_{2.5}$ levels tend to cluster together spatially within Kampala. Furthermore, the P-value, standing at 0.021, falls below the common significance level of 0.05, affirming the statistical significance of observed spatial clustering in $PM_{2.5}$ levels in Kampala. This emphasizes how unlikely it is for the clustering to have happened by accident. The Z-Value, of 2.254, confirms that there is statistically substantial regional autocorrelation of $PM_{2.5}$ levels in Kampala.

Specifically, the HH cluster was identified near sensors located close to busy road roundabouts such as the Northern Bypass at Kalerwe. HL clusters were observed in areas with significant activity but low $PM_{2.5}$ background levels, notably along Salama Road in Kibuli. LH clusters were prevalent in residential and educational institutions like Makerere University, situated in high-density areas. LL clusters were predominantly found in low-density residential areas like Muyenga, situated at a distance from major highways.

In conclusion, the analysis revealed significant spatial clustering patterns and localized interventions.

Overview of HEI Initiatives to Reduce Environmental Inequities

Anna Rosofsky[1], Samantha Miller[1]

[1]*Health Effects Institute, Boston, MA, USA*

HEI's Program to Reduce Environmental Inequities. In 2023, HEI launched a program that supports scientific research, conducts special projects, and convenes multiple sectors to better understand and meet the needs of historically marginalized communities while addressing environmental inequities. The program is governed by two group: 1) an Advisory Council, comprised of representatives from academia, community groups, non-governmental organizations, and policymaking, that provides strategic advice on program activities, and 2) an Oversight Panel that functions similarly to the HEI Research Committee.

Research Funding Opportunities. In Fall 2022, HEI hosted a workshop with participants from academia, community organizations, industry, government, and nongovernmental organizations to identify knowledge gaps and barriers to conducting effective environmental justice research and explore components of successful community-academic partnerships. The key takeaways from that workshop informed the format and research focus of the two funding opportunities released under this program. The first request for applications (RFA) supports studies that examine effectiveness of policies, interventions, or other actions at improving air quality, health or both for historically marginalized populations; studies will commence in Summer 2024. The second RFA supports building and strengthening of community-academic partnerships and research co-led by those partnerships to examine cumulative impacts of chemical and nonchemical stressors applied to a specific program, policy, or intervention. This set of studies will commence in early 2025.

Path Forward. The research funded under this program will take place over a three-year period and will provide valuable knowledge about effective policies that reduce or exacerbate inequities and solutions for addressing cumulative chemical and nonchemical stressor exposures. The Council and Panel have begun discussing the long-term vision for the program, including how HEI could continue to contribute to reducing environmental inequities in the United States and Globally.

[W]Skyrocketing Pollution: Assessing the Environmental Fate of July 4th Fireworks in New York City

Antonio F. Saporito, NYU Grossman School of Medicine

Jane Warren Conference Award Recipient

Background: American Independence Day is synonymous with fireworks. This study examined the environmental fate of pollutants from the largest fireworks event in the U.S.: Macy's Fourth of July Fireworks show in New York City (NYC).

Methods: Real-time PM_(2.5) and gravimetric PM_(2.5) and PM_(10) were collected at locations along the East River of NYC. Airborne particles were assayed for trace elements (x-ray fluorescence) and organic and elemental carbon (OC/EC). River water samples were evaluated by ICP-MS for heavy-metal water contamination. In addition, spatial-temporal analyses were created using hourly PM_(2.5) concentrations reported by both EPA and PurpleAir monitoring networks for NYC and 5 other major metropolitan areas.

Results: The fireworks event resulted in large increases in PM_(2.5) and PM_(10) mass concentrations at the river-adjacent sampling locations. While background control PM_(2.5) was 10-15 µg/m^3, peak real-time PM2.5 levels exceeded 3,000 µg/m^3 at one site and 1,000 µg/m^3 at 2 other locations. The integrated gravimetric PM_(2.5) and PM_(10) concentrations ranged from 162 to 240 µg/m^3 and 252 to 589 µg/m^3, respectively. Zn, Pb, Sb, and Cu more than doubled in river water samples taken after the event, while S, K, Ba, Cu, Mg, Fe, Sr, Ti, and Zn increased in airborne PM_(2.5) from the fireworks. Data from hyperlocal monitoring networks for NYC and other metropolitan areas yielded similar, but generally smaller, increases in PM_(2.5) levels.

Conclusion: Pyrotechnic displays, such as Macy's Fourth of July Fireworks show, impart considerable negative air and water quality, with widespread dispersal of illicit environmental contaminants. Although exposures to fireworks emissions are acute in nature, repeated exposures and their potential adverse health effects warrant further study.

Air quality trends in Texas and Colorado as associated with Unconventional Oil and Gas Development

Gunnar W. Schade[1] and Detlev Helmig[2]

[1] *Texas A&M University, Department of Atmospheric Sciences*

[2] *Boulder Atmosphere Innovation Research (Boulder A.I.R.)*

Background and objectives: US oil and gas production has increased since the late 2000s due to the introduction of horizontal drilling and hydraulic fracturing using slickwater formulations. The "shale boom's" air pollutant emissions consist largely of vented or leaked petroleum hydrocarbons, but also of nitrogen oxides from combustion. Past studies have investigated regional impacts of emissions from the industry, but few have focused on time series to identify trends in emissions, or how emissions may have changed due to new regulations.

Our objectives are to analyze various data products for trends in the last two decades, using

1. ambient air monitoring data collected in proximity and downwind of Texas' shale oil and gas production basins, such as the Eagle Ford;
2. ambient air monitoring data collected in the Northern Colorado Front Range, downwind of the Denver-Julesburg basin;
3. satellite based formaldehyde measurements above the Permian basin as a proxy for hydrocarbon emissions.

Methods and approach: Our focus will be on tracers such as ethane and propane, but also on benzene as the most relevant hydrocarbon with respect to health impacts. Emphasis will be placed on hourly data where available. Non-negative matrix factorization will be used to extract oil and gas exploration signals in ambient data, and trend analyses will be conducted to elucidate how local air quality has changed over time. Auxiliary data on oil and gas production, as well as regulatory changes will be considered.

Results and findings: The project began in April 2024 and only limited, preliminary data analyses will be presented, including hourly to monthly ethane trend analyses for one site in Colorado and one site in Texas.

Conclusions and interpretation: Ambient hydrocarbon abundances display seasonal and diurnal variations on top of long-term trends. While ethane in Colorado may have been down trending in the last several years, longer term data in Texas show variations correlated with oil and gas production levels.

[W]Spatial variability in the acute effects of outdoor air pollution and temperature on pediatric seizures and epilepsy across New York

Rachit Sharma, Dornsife School of Public Health, Drexel University, Philadelphia, PA, USA

Jane Warren Conference Award Recipient

Background and objectives: Social stressors like being racially minoritized and climate-linked exposures like poor air quality and non-optimal outdoor temperatures are linked to neurological disorders, but research on seizures and epilepsy is scarce. We quantified the effects of daily outdoor fine particulate matter (PM_2.5) and minimum temperature (T_min) on pediatric seizures and epilepsy across New York State (NYS), assessing for spatial variability potentially explainable by social stressors.

Methods and approach: Administrative data on seizures- and epilepsy-related emergency department (ED) visits among children aged 0-4 years across NYS from 2005 to 2019 (n = 300,870) were obtained. Ensemble-modeled block-group level, daily PM_2.5 and T_min estimates were assigned to each presenting case, along with 56 census-tract-level material deprivation indicators from the American Community Survey. Additionally, nine tract-level, annual crime risk indices representing psychosocial stress were assigned to the 2015-2019 subset. Using conditional logistic regression in a case-crossover design, we quantified season-specific effects of PM_2.5 and T_min on daily ED visits at state-, county-, and tract-levels. Employing Bayesian hierarchical spatial models, we then examined for spatial variability in the effects, followed by determining the role of social stressors in explaining the variability using random effects meta-regression.

Results and findings: Warm-season PM_2.5 and cold-season T_min were positively associated with ED visit risk, particularly in New York, Bronx, Albany, and Erie counties. Statewide, spatial variability in ED visit rate differences was observed across tracts and was associated with social stressors. For instance, in New York City, tracts with higher violent crime rates, percent poverty, percent population Hispanic, and unemployment rates showed stronger PM_2.5 effects, after adjusting for T_min and specific humidity.

Conclusions and interpretation: Daily PM_2.5 and T_min exposures may increase pediatric seizures and epilepsy risk in NYS, with spatial variations across counties and census-tracts potentially attributable to differences in social stressors increasing community vulnerability.

US EPA's Air, Climate, and Energy research addressing climate change and environmental injustice along the source-to-impacts continuum

Bryan Hubbell[1], Angie Shatas[1], Sherri Hunt[1], Rebecca Dodder[1]

[1]US EPA, Air Climate, and Energy National Research Program, Durham, NC

Background and objectives

This poster will showcase the Air, Climate, and Energy (ACE) National Research Program work to address climate change and environmental injustice. We will employ the source-to-impacts continuum as a framework.

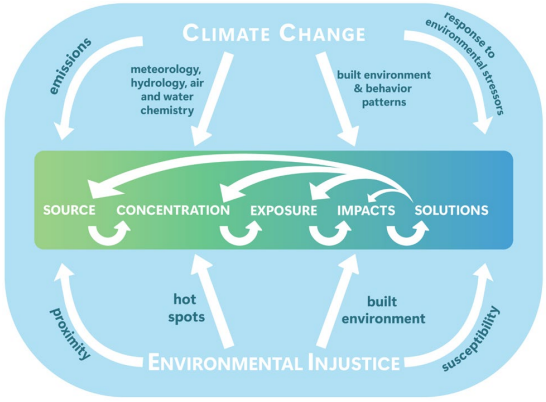
Methods and approach

ACE research responds to the needs of our stakeholders and promotes a systems approach to solution-driven research. The ACE research portfolio is organized around two topics: 1) understanding climate change and air pollution impacts and 2) responding to those impacts and preparing for the future.

Results and findings

ACE research focuses on six interrelated public health and environmental challenges: criteria and toxic air pollution, climate change, environmental and climate injustice, transformation of energy and transportation systems, wildland fires, and indoor air quality. These challenges are interrelated and create a complex landscape upon which to develop effective solutions for reducing air pollution and climate impacts, with climate change amplifying all these challenges.

To advance our understanding of these complex, interrelated environmental, we use the source-to-impacts continuum as a framework and illustrate ACE research that addresses multiple elements of the continuum. The source-to-impacts continuum includes the following components: source, concentration, exposure, impacts.



Conclusions and interpretation

Recognizing that climate change will impact all aspects of the continuum, we focus on climate change to show, for example, that climate change has direct impacts on human and ecosystem health, affects emissions and ambient concentrations of air pollution, and influences how humans and ecosystems respond to air pollution. We also focus on environmental injustice, which results from, for example, proximity to sources, higher air pollution concentrations in vulnerable communities, different exposure pathways, and potentially greater susceptibility to health and ecological impacts for some people and groups.

Optimizing Exposure Assessment for Inference about Air Pollution Effects – Lessons Learned from Cognitive Function in the Adult Changes in Thought Air Pollution Study

Lianne Sheppard, Magali N. Blanco

University of Washington, Seattle, WA, USA

Background

While exposure assessment is fundamental to environmental epidemiology, little is known about the optimal exposure assessment study designs for inference about health. The objective of this project was to advance our understanding of exposure assessment study design for inference about the effect of long-term air pollution exposure on cognitive function.

Methods

We leveraged data from the Adult Changes in Thought (ACT) Air Pollution study to characterize exposures for over 5,000 participants. Using various approaches to sample data from two existing sets of exposure monitoring campaigns – a low-cost monitoring (LCM) campaign that supplemented existing regulatory monitoring data and a year-long mobile monitoring campaign – we determined the impact on exposure prediction and health effect inference, focusing on a cross-sectional analysis of cognitive function. We evaluated the performance and cost of these campaigns.

Results

Stationary mobile monitoring campaigns with at least 12 visits per location optimize inferences about health while limiting costs. Mobile monitoring sampling should cover all days of week, most times of day, and at least two seasons. The popular business hours sampling design has the poorest performance. These results were confirmed using on-road data. For the alternative exposure campaign of supplementing regulatory monitoring data with LCM data, exposure predictions improved considerably with inclusion of the LCM, but costs were steep. However, given the inherently unbalanced exposure data, it was more challenging to develop deep insights from this exposure assessment approach.

Conclusions

There should be greater attention to the design of the exposure assessment data used in epidemiologic inference. Better exposure assessment design leads to better exposure model performance and health inference. Improvements in exposure model performance metrics generally translated into less biased inference, although typically less strikingly. It is possible to design air pollution exposure assessment studies that achieve good exposure prediction model performance while reducing costs.

A Groundwater Modeling Framework for Elucidating Community Exposures Across the Marcellus Region to Contamination Associated with Oil and Gas Development

James Saiers[1], Mario Soriano, Jr[2]., Reed Maxwell[2], Joshua Warren[1]

[1]Yale University, New Haven, CT, USA; [2]Princeton University, Princeton, NJ, USA

Nearly 20,000 unconventional oil and gas wells have been drilled and hydraulically fractured in the Marcellus and Utica/Point Pleasant shale region since 2004. While unconventional oil and gas development (UOGD) has made natural gas plentiful, created jobs, and increased economic activity, it has been accompanied by persistent concerns over its role in contamination of drinking water. Spills of hydraulic fracturing fluids, drilling fluids, and wastewaters have been implicated as sources of well-water impairment in households proximal to UOGD extraction. Our overarching goal is to develop and apply a modeling framework for quantifying the risks posed by UOGD spills on the chemical quality of domestic well waters of the Marcellus region. Our work is guided by three objectives, each leading to the development of an interrelated component of our modeling framework:

(1) advance a hydrologic-based model for well-water vulnerability to UOGD contamination that is suitable for application across the entire Marcellus;

(2) advance a risk-triage platform by combining vulnerability calculations (Objective 1) with data on the occurrence of UOGD spills and other releases; and

(3) advance and test a model for UOGD-related groundwater quality impairments that leverages our vulnerability framework (Objective 1) and risk-triage platform (Objective 2) and accounts for spill characteristics.

Application of this modeling framework will enable novel inferences – that are grounded in physics and tested against data – on the ways that hydrologic conditions and spill characteristics interact to shape contamination risks. This framework will enable fine-scale resolution of risk with approaches that are tailored to accommodate incomplete knowledge of spill characteristics and uncertainty in groundwater flow patterns that govern contaminant dispersal. This information should be valuable in supporting exposure assessment for health studies, planning interventions, designing water-quality monitoring programs, and illuminating relationships between sociodemographic factors and areas at high risk from UOGD-sourced contamination.

HEI Impact of Prescribed Fire Smoke Exposures on Multiple Health Outcomes in the Southeastern US (2016-2020)

Jennifer D. Stowell[1], Ambarish Vaidyanathan[2,3], Kamal J. Maji[3], Zongrun Li[3], Chad Milando[1], Yongtao Hu[3], Armistead G. Russell[3], M. Talat Odman[3], Patrick L. Kinney[1], Gregory A. Wellenius[1]

[1]Center for Climate and Health, Boston University School of Public Health, Boston, Massachusetts, USA; [2]Centers for Disease Control and Prevention, Atlanta, Georgia, USA; [3]Georgia Institute of Technology, Atlanta, Georgia, USA

Background: Prescribed fires are commonly used in the southeastern US to manage wildland fuels and reduce wildfire risk. Prescribed fires take place by permit under controlled conditions aimed at reducing smoke plume dispersion and associated exposures. Despite the regulations surrounding their use, prescribed fires may still lead to excess air pollution exposure and associated health risks in downwind communities. Yet, little is known regarding the health impacts of exposures to smoke from prescribed burning.

Methods: To better understand these impacts, we are analyzing the association between exposure to prescribed fire smoke and respiratory and cardiovascular emergency department (ED) visits 2013-2021 identified in a large health insurance claims dataset across twelve southeastern states: Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia. Smoke exposures were estimated using a combination of fire inventories, permit records, and the Community Multiscale Air Quality model. Utilizing a case-crossover framework we estimate the lagged effects (up to 7 days) of exposure to fire-specific fine particulate matter ($PM_{2.5}$) and ozone (O_3) using conditional logistic regression, controlling for meteorology and seasonality.

Results: Health data linkages and preliminary analyses are ongoing. Fire-specific $PM_{2.5}$ accounted for ~8% of ambient $PM_{2.5}$ and fire-specific O_3 accounted for ~0.9% of ambient levels. We expect that our results will shed light on the health impacts from exposure to prescribed fire smoke for both cardiovascular and respiratory health. Preliminary results suggest these impacts may be smaller than those related to similar levels of air pollution derived from wildfire smoke. We will provide meaningful estimates of the risk of ED visits to increase our understanding of the effect of exposure on populations in the southeastern US.

Conclusions: Results from this study may help shape our understanding and to inform policies regarding the use of prescribed burning in the future.

Exploring the use of machine learning to improve prediction of highly heterogeneous ambient air pollutants

Julien Vachon[1,2], Stéphane Buteau[1,2], Jules Kerckhoffs[3], Ying Liu[1], Keith Van Ryswyk[4], Audrey Smargiassi[1,2]

1. Department of Environmental and Occupational Health, School of Public Health, University of Montreal, Montreal, Canada. 2. Center for Public Health Research (CReSP), University of Montreal and CIUSSS du Centre-Sud-de-l'Isle-de-Montréal, Montreal, Canada. 3. Institute for Risk Assessment Sciences, Utrecht University, Utrecht, the Netherlands. 4. Air Pollution Exposure Science Section, Water and Air Quality Bureau, Healthy Environment and Consumer Safety, Health Canada, Ottawa, Canada

Background and objectives: Machine learning (ML) methods are increasingly popular but whether they outperform statistical approaches in estimating the spatiotemporal variation of outdoor air pollutants is unclear. We compared the predictions of outdoor nitrogen dioxide (NO_(2)), ultrafine particles (UFPs) and black carbon (BC) models based on both ML and statistical methods.

Methods and approach: We searched Web of Science and Scopus up to December 15, 2022, to systematically review studies that compared ML and statistical models of ambient NO_(2), UFPs and BC. Differences in R^2 and RMSE between statistical and ML methods of included studies were calculated and compared. We also compared the R^2 and RMSE of daily and annual UFP models, developed using statistical and ML methods with data from a 2019-20 mobile monitoring campaign in Quebec City, Canada. Methods included linear, nonlinear and regularized regressions, and ML algorithms such as Random Forest (RF), XGBoost, Neural Networks, and Support Vector Regression.

Results and findings: A total of 37 model comparisons (23 for NO_(2), 8 for UFPs and 6 for BC) were included in the systematic review. Linear non-regularized methods and RF were most frequently used. Mean R^2 and RMSE differences (95% confidence intervals) between best ML and statistical models were 0.10 (0.06, 0.14) and 18% (9%, 27%) respectively. Nonlinear or regularization methods were scarcely used but provided similar performance to ML methods. In Quebec City, ML methods outperformed statistical ones for both daily (R^2 = 0.43-0.47 vs. R^2 = 0.07-0.17) and annual UFP models (R^2 = 0.77-0.87 vs. R^2 = 0.58-0.71). Tree-based methods performed best amongst ML methods in both the review and in UFPs modelling.

Conclusion and interpretation: ML methods were superior to linear non-regularized methods for predicting ambient concentrations of NO_(2), UFPs and BC, but not always to nonlinear or regularized methods.

Environmental justice implications of energy infrastructure clustering across the United States: A nationwide equity analysis using the [EI]3 Database

Breanna van Loenen, Boston University

Introduction: Fossil fuel infrastructure emits air pollutants that contribute to poor ambient air quality and pose significant public health threats. Although some work has examined individual pieces of the energy sector, little work has considered the cumulative impact of co-located infrastructure components. Leveraging the [EI]3 Database, a comprehensive nationwide repository of all publicly available energy infrastructure in the United States, we conducted an environmental justice analysis to examine associations between infrastructure clusters and disadvantaged communities.

Methods: Population data for the contiguous United States was collected from the Justice40 Initiative on demographics (i.e., race and ethnicity) and socioeconomics (i.e., below the Federal poverty line), including an indicator for census tracts with high populations both below the Federal poverty line and considered a disadvantaged race or ethnicity. For each census tract, we calculated per capita infrastructure by sociodemographic group. Using comparison groups of White non-Hispanic and above the Federal poverty line (i.e., the most advantaged groups), we calculated the mean difference of per capita infrastructure by sociodemographic characteristics.

Results: Out of 73,302 census tracts nationwide, 92% (n=67,545) contained ≥1 piece of emitting infrastructure. Census tracts with the highest percentage of non-white populations (≥75%) had nearly 5 times more emitting infrastructure per square kilometer compared to those with the lowest percentage of non-white populations (≤25%). In further stratified models, this difference was starker – census tracts with majority Hispanic populations and below 100% of the poverty line contained nearly 22 times more emitting infrastructure per capita on average than the most advantaged groups.

Discussion: We find evidence that emitting energy infrastructure in the United States is disproportionately located in disadvantaged communities of color, especially when considering cumulative disadvantages (e.g., high percentage Hispanic or Latino populations and below the federal poverty line). Future work will examine how co-located energy infrastructure impacts population health, including examination of proposed infrastructure projects.

The Application of Mobile Air Monitoring to Evaluate Local Air Quality in Dallas' Environmental Justice Neighborhoods

Eva Vitucci, Texas A&M University

Due to historical redlining practices the residents of the Joppa neighborhood located in Dallas County, TX are forced to live near some of the top contributors of particulate matter and volatile organic compound (VOC) air pollution in Dallas County. As a result, Joppa residents have concerns regarding accurate exposure assessments and their health. To improve resident exposure assessments, we conducted mobile air monitoring at sites within and outside of the Joppa neighborhood to identify levels of VOCs present over a 3-day sampling period in June 2023. Estimated maximum, 95% percentile, and average concentrations of the VOCs, benzene and toluene, were elevated within the Joppa neighborhood and near the local industrial point sources relative to local background levels measured outside of the Joppa neighborhood. Of these measurements, the most extreme differences were observed when comparing the estimated local background maximum and 95% percentile concentrations to the estimated levels detected within Joppa and near the local industrial points. Estimated maximum concentrations ranged from 15- to 108-fold and 14.5- to 117.24-fold higher at 9 out of 10 different sampling sites within the Joppa neighborhood for benzene and toluene, respectively. Similarly, estimated 95% percentile concentrations of benzene ranged from 1.5- to 5.0-fold and 1.5- to 5.5-fold higher at 4 out of 10 different sampling sites within the Joppa neighborhood for benzene and toluene, respectively. Importantly, estimated average benzene and toluene concentrations at all sampling sites were within safe exposure limits. Together, these data highlight the elevated VOC concentrations in the Joppa neighborhood. Ongoing analysis of this study using non-targeted analysis of the mobile air monitoring data will identify additional emitted VOCs and integrate this data into an online platform to help develop a predictive model of VOC emissions. With this publicly available model, residents of Joppa can better assess their VOC exposure and can use this information to help reach their goal of the removal of these emission sources from their community.

Cleaner Air, Healthier Children (State of Global Air Video Short)

Ada Wright, Health Effects Institute

Around the world, children under 5 experience disproportionate health impacts from air pollution. Join HEI's State of Global Air Team on the launch of their short video, "Cleaner Air, Healthier Children", to explore the multitude of ways air pollution harms children and the unique reasons why children are at greater risk.

Scoping Review on Health Effects of Air Pollution in East Africa

Ada Wright and Victor Nthusi, Health Effects Institute

In East Africa, as public and governmental interest in air pollution is growing, there is increasing demand for data and evidence on air pollution levels and trends and associated health effects. However, locally generated evidence on the health effects of air pollution in the region is limited. The Health Effects Institute is working with an expert Panel to conduct a scoping review on the short- and long-term health effects of exposure to ambient and household air pollution in East Africa. By mapping and synthesizing the available evidence, and highlighting gaps in evidence, this review aims to inform decisions aimed at improvement of public health in a region acutely in need of information on the health impacts of air pollution.

Air Pollutant Emissions from Electric Vehicle Fast Charging Stations

Yuan Yao, UCLA

Background and objectives: To combat climate change, policymakers across the globe have committed to accelerating the transition to electric vehicles (EVs). This unprecedented large-scale transportation electrification will necessitate the establishment of a vast network of EV fast chargers globally, which may inadvertently expose large populations to pollutants emitted from Direct Current Fast Charging (DCFC) stations.

Methods and approach: We selected 35 representative DCFC locations across 32 cities in Los Angeles County and monitored air pollutants concentrations at the alternating current to direct current (AC/DC) converter at each station.

Results and findings: Here we reported that the AC/DC converters at DCFC stations are emitters of particulate matter with diameters less than 2.5 μm (PM_ (2.5)), which is associated with increased morbidity through the life course and premature death worldwide.

Conclusions and interpretation: Our work has uncovered a previously overlooked issue that could compromise air quality and public health for billions globally during the transition to EVs. Currently, no emission standards exist for DCFC, and these poorly understood particles remain unregulated under existing air pollution law. Without regulation or interventions, emissions from DCFC stations could expose nearby communities, EV users, and the workforce operating these facilities to high levels of PM_ (2.5), potentially leading to widespread health consequences.

Short term air pollution exposure during pregnancy and acute changes in markers of immune function measured in maternal blood

Catherine Yount, University of Rochester

Background and Objectives: Air pollution exposure during pregnancy has been associated with numerous adverse pregnancy and birth outcomes. One proposed mechanism underlying these associations is maternal immune activation and dysregulation. Therefore, we examined whether air pollution exposure during pregnancy was associated with changes in immune markers within immune function groups (TH1, TH2, TH17, Innate/Early Activation, Regulatory, Homeostatic, and Proinflammatory), and whether those associations changed across pregnancy.

Methods and Approach: Within a pregnancy cohort study in Rochester, New York, we measured immune markers in maternal plasma at up to 3 times during pregnancy. We estimated ambient PM_(2.5) and NO_(2) concentrations at participants' home addresses using a spatial-temporal model, and immune markers measured using Luminex. Using mixed effects models, we estimated changes in immune marker concentrations associated with each interquartile range increase in PM_(2.5) (2.88 micrograms/m^3) and NO2 (7.83ppb) 1 to 7 days before blood collection, and assessed whether associations were different in early, mid, and late pregnancy.

Results and Findings: Increases in ambient NO_(2) were associated with higher maternal immune markers, with associations observed across TH1, TH2, TH17, Regulatory, and Homeostatic groups of immune markers. Furthermore, the largest increases in immune markers associated with per unit increase in NO_(2) concentration were in late pregnancy (e.g., IL-23 slope= 0.23, 95% CI 0.06, 0.41) compared to early-pregnancy (IL-23 slope = 0.10, 95% CI -0.06, 0.26).

Conclusions and Interpretation: Overall, results were suggestive of NO_(2)-related immune activation during pregnancy. Increases in effect sizes from early to mid to late pregnancy may be due to changes in immune function over the course of pregnancy. These findings provide a basis for immune activation as a mechanism for previously observed associations between air pollution exposure during pregnancy and reduced birthweight, fetal growth restriction, and pregnancy complications.