Association of Groundwater Constituents with Topography and Distance to Unconventional Gas Wells in NE Pennsylvania

**Background and Objective:** Unconventional gas development (UGD) is expanding rapidly worldwide due partly to the increased use of horizontal drilling and hydraulic fracturing (HF) techniques. Many research studies have found links between location of UGD sites and adverse health effects, including asthma, congenital heart defects of newborns, and hospitalization rates. Yet, the effects of UGD on water quality have been widely debated by researchers in recent years. The uncertainty about the effects of UGD on water quality is due to many factors, including groundwater chemistry fluctuations and a lack of data about water quality both pre- and post-drilling/production. This study sought to assess whether UGD has the potential to impact groundwater quality. Dr. Beizhan Yan and his colleagues at Lamont Doherty Earth Observatory hypothesized that levels of constituents in groundwater are associated with the distance to UGD gas wells.

**Methods:** Over the past three years, the researchers collected 58 samples from private wells in NE Pennsylvania. 22 of the samples were collected by Columbia researchers, and 36 of the samples were collected by residents from their own wells. They also analyzed large datasets from other studies conducted in NE Pennsylvania, including private well samples from studies conducted by Duke University (150 samples) and Cabot Oil & Gas (1701 samples). The researchers then grouped the groundwater samples into 4 groups based on their topography (upland or valley) and the distance to the nearest gas well (<1 km and ≥ 1km). Each dataset was analyzed using a Chi-square test to detect differences in the proportion of high levels of chemical constituents among these 4 groups.
Results: The samples collected by Columbia do not have statistically significant differences among the 4 groups, likely due to small sample size. The samples collected by Duke shows statistically significantly higher concentrations of Na and Mn in valley samples far from UGD than in upland samples far from UGD. The samples collected by Cabot showed statistically significantly higher concentrations of methane, Na, and Mn in valley samples far from UGD than in upland samples far from UGD. Valley samples near UGD had concentrations of Ca, Cl, SO₄, and Fe that were statistically significantly higher than the valley samples far from UGD. The figure below shows the ratio of proportions of 10 constituents between groups in the Cabot study, and the error bar of each constituent is the 95% confidence interval of the ratio of proportions.

Conclusions: The results from this study suggest that the concentrations of Ca, SO₄, Cl, and Fe were associated with topography and the distance to the nearest gas well, and that these concentrations are greater in valleys. The increase can be caused by enhanced mixing of shallow and deep groundwater in valley (Figure right), possibly triggered by UGD process. The study therefore contributes to findings that UGD has the potential to impact groundwater. As such, more studies must be conducted on the effects of UGD on quality of groundwater, especially in valley setting and < 1 km to nearest gas wells.

Recent Center Member Research

“B vitamins attenuate the epigenetic effects of ambient fine particles in a pilot human intervention trial”

Ambient fine particle (PM$_{2.5}$) pollution triggers acute cardiovascular events. A new study by Center researchers suggests there may be a way to reduce the impact of air pollution on the epigenome. This is the first study to detail a course of research for developing interventions that prevent or minimize the adverse effects of air pollution on potential cardiac autonomic dysfunction markers. This study, conducted with colleagues at the T.H. Chan School of Public Health at Harvard, and from Sweden, China, Singapore, Mexico, and Canada, illustrates how individual-level prevention may be used to control the potential pathways underlying adverse effects of the PM$_{2.5}$ particles. These findings could have a significant public health benefit in regions worldwide with frequent PM$_{2.5}$ peaks.

Researchers administered either placebo or a B-vitamin supplement (2.5 mg of folic acid, 50 mg of vitamin B6, and 1 mg of vitamin B12) daily to adults recruited for the trial who were or were not exposed to PM$_{2.5}$ (250 μg/m$^3$) for 2 hrs. Volunteers were healthy non-smokers, 18 to 60 years old, who were not taking any medicines or vitamin supplements. Plasma B vitamin measurements taken before and after our weeks of the interventions showed that B-vitamin supplements significantly increased the median plasma concentrations of folic acid, and vitamins B6 and B12 while for those on placebo there was no change. At pre-, post-, 24 h-post-exposure, resting heart rate (HR) and heart rate variability (HRV) with electrocardiogram, and white blood cell (WBC) counts were measured. Compared to sham exposure, PM$_{2.5}$ exposure increased HR, total WBC count, and lymphocyte count. B-vitamin supplementation attenuated PM$_{2.5}$ effect on HR, total WBC count, and lymphocyte count. In healthy adults, two-hour PM$_{2.5}$ exposure substantially increases HR, reduces HRV, and increases WBC. These effects are reduced by B vitamin supplementation.

"While emission control and regulation is the backbone of prevention, high exposures are, unfortunately, the rule still in many megacities throughout the world. As individuals, we have limited options to protect ourselves against air pollution. Future studies, especially in heavily polluted areas, are urgently needed to validate our findings and ultimately develop preventive interventions using B vitamins to contain the health effects of air pollution," said Dr. Baccarelli.


“Organophosphate neurotoxicity to the voluntary motor system on the trail of environment-caused amyotrophic lateral sclerosis: the known, the misknown, and the unknown”

Amyotrophic lateral sclerosis (ALS) is the most common adult-onset paralytic disorder. It is characterized by progressive degeneration of the motor neurons controlling voluntary movement. The underlying causal mechanisms remain unknown, which has precluded development of effective treatments. ALS presents as a sporadic condition 90-95% of the time, without familial history or obvious genetic mutation. This suggests that ALS may have a strong environmental component. Organophosphates (OPs) are prime candidate neurotoxicants in the etiology of ALS, as exposure to OPs was linked to higher ALS incidence among farmers, soccer players, and Gulf War veterans. In addition, polymorphisms in paraoxonase 1, an enzyme that detoxifies OPs, may increase individual vulnerability both to OP poisoning and to the risk of developing ALS. Furthermore, exposure to high doses of OPs can result in OP-induced delayed neuropathy (OPIDN), a debilitating condition similar to ALS characterized by similar motor impairment and paralysis. In this review article, the authors critically present available evidence, discuss current limitations, and posit future research in the search for the environmental origin of ALS. OPIDN offers an exciting trail to follow, which can hopefully lead to the development of novel strategies to prevent and cure ALS.

Sex-Specific Associations between Once-Carbon Metabolism Indices and Posttranslational Histone Modifications in Arsenic-Exposed Bangladeshi Adults

Histones are nuclear proteins that package and order DNA into compact structural units called nucleosomes. As a chief protein component of chromatin, histones act as spools around which DNA winds, and they play important roles in gene regulation. Posttranslational histone modifications (PTHMs) are epigenetic marks that influence the activity of histones. Previous studies have shown that PTHMs are altered by arsenic, an environmental carcinogen. One-carbon metabolism (OCM) is a nutritionally regulated pathway that generates methyl groups used to generate PTHMs. This is the first study to examine the influences of OCM indices on PTHMs in arsenic-exposed Bangladeshi adults. The authors measured global levels of three PTHMs, selected because they were previously identified as being dysregulated in cancers: H3K36me2, H3K36me3, H3K79me2. Levels of these PTHMs were analyzed in peripheral blood mononuclear cells (PBMC) from 324 participants enrolled in a randomized, placebo controlled clinical trial of folic acid supplementation. Sex-specific associations between several blood OCM indices (folate, vitamin B12, choline, betaine, homocysteine) and PTHMs were examined at baseline using regression models, adjusted for multiple tests by controlling for the false discovery rate (P_{FDR}). We also evaluated the effects of folic acid supplementation (400 ug/d for 12 weeks), compared with placebo, on PTHMs.

The results showed associations between choline and H3K36me2 and between vitamin B12 and H3K79me2 differed significantly by sex (P_{diff}<0.01 and <0.05, respectively). Among men, plasma choline was positively associated with H3K36me2 (P_{FDR}<0.05), and among women, plasma vitamin B12 was positively associated with H3K79me2 (P_{FDR}<0.01). Folic acid supplementation did not alter any of the PTHMs examined (P_{FDR}=0.80). The authors concluded that nutritional factors that influence OCM may influence PTHMs in a sex-dependent manner, and folic acid supplementation, at the dose and duration in this study, does not alter PTHMs in PBMCs.


Prenatal lead exposure and fetal growth: Smaller infants have heightened susceptibility

As population lead levels decrease, the toxic effects of lead may be distributed to more sensitive populations, such as infants with poor fetal growth. The objective of this research was to determine the association of prenatal lead exposure and fetal growth and to evaluate whether infants with poor fetal growth are more susceptible to lead toxicity than those with normal fetal growth.

The authors examined the association of second trimester maternal blood lead levels (BLL) with birth-weight-for-gestational age (BWGA) z-score in 944 mother-infant participants of the PROGRESS cohort. The association between maternal BLL and BWGA z-score was determined using both linear and quantile regression. Odds ratios were determined for small-for-gestational age (SGA) infants between maternal BLL quartiles using logistic regression. Maternal age, body mass index, socioeconomic status, parity, household smoking exposure, hemoglobin levels, and infant sex were included as confounders.

While linear regression showed a negative association between maternal BLL and BWGA z-score, quantile regression revealed larger magnitudes of this association in the <30th percentiles of BWGA z-scores. Mothers in the highest BLL quartile had an odds ratio of 1.62 (95% CI: 0.99-2.65) for having a SGA infant compared to the lowest BLL quartile. The authors concluded that while both linear and quantile regression demonstrated a negative association between prenatal lead exposure and birthweight, quantile regression revealed that smaller infants may represent a more susceptible subpopulation.

Welcome Our New Center Members!

Virginia Rauh, ScD, a Professor in the Department of Population and Family Health, has been a member of Columbia's faculty since 1984 and is Deputy Director of the Columbia Center for Children's Environmental Health. Her postdoctoral work in psychiatric epidemiology was supported by NIMH and a career development award from NICHD. Her work focuses on the adverse impact of exposure to air pollutants, including second hand smoke and pesticides on pregnancy and child health, and the susceptibility of individuals and disadvantaged populations to environmental hazards. Dr. Rauh is a perinatal epidemiologist by training, whose expertise is in the area of low birth weight and preterm delivery, particularly with respect to socioeconomically disadvantaged and minority populations. She has been principal investigator on numerous major research projects, including studies of the impact of organophosphorus insecticides and secondhand smoke on child neurodevelopment and brain abnormalities (MRI, fMRI), a randomized intervention trial for low birth weight infants, a multi-site study of lifestyles in pregnancy, a study of developmental outcomes of children born to inner-city adolescent mothers, a multi-level analysis of the impact of Head Start on New York City school children, a study of the effects of ambient air pollutants on pregnant women and their children, and a study of links between race, stressors, and preterm birth. She has worked with other Columbia faculty to study the effects of the World Trade Center disaster on pregnant women and newborns.

Marianthi-Anna Kioumourtzoglou is an Assistant Professor in the Department of Environmental Health Sciences at the Columbia University Mailman School of Public Health, arriving from Harvard last fall. Her research focuses on investigating the relationship between air pollution exposure and adverse health. Specifically, she is interested in statistical issues related to air pollution epidemiology, such as quantifying and correcting exposure measurement error and assessing multi-pollutant exposures. Furthermore, she is interested in exploring how air pollution impacts the nervous system, conducting health analyses to estimate air pollution effects on neurodevelopment and neurodegeneration, as well as mood and psychiatric disorders. Dr. Kioumourtzoglou is also interested in identifying vulnerable subpopulations to air pollution impacts, such as residents of low socio-economic neighborhoods and neighborhoods/ countries more susceptible to climate change impacts.
On November 12th, 2016, the Center for Environmental Health in Northern Manhattan (CEHNM), Columbia Center for Children’s Environmental Health (CCCEH), and WE ACT for Environmental Justice co-hosted the “Urban Communities Organizing for Climate Resilience” Conference. The goal of the conference was to bring together community-based organizations working at the frontlines of climate change to convene and share knowledge/best practices. The conference was well attended by roughly 200 participants, including students, members from community-based organizations across New York City, high school youth, government agency representatives, researchers, and scientists. Dr. Perera gave a keynote address on the health impact of climate change causing air pollution on children. Dr. Perzanowski and Dr. Kinney both gave presentations in the breakout session titled “Impacts of Climate Change on Public Health.” Dr. Diana Hernández and David Chang presented findings from our study of public housing residents’ response to Hurricane Sandy. Adriana Garcia and Tina Wang (Graduate Research Assistants) were both present to help out at the conference.

Jalone White-Newsome from the Kresge Foundation’s Environment Program gave a keynote address about climate change, public health, and resiliency strategies. This was followed by the first panel session of the conference, which framed and uplifted best practices for implementing adaptation and mitigation strategies at the local level. Specifically, participants heard from organizations working at the front lines of climate change and their resiliency strategies, including WE ACT (Aurash Khawarzad), ALIGN (Daisy Chung), South Bronx Unite (Mychal Johnson), The Point CDC (Angela Tovar), Ironbound Community Corp. (Joe Della Fave), and Fifth Avenue Committee (Michelle de la Uz).

Next, there was a roundtable focusing on community and government dialogue. This portion of the program highlighted examples of local policies and initiatives being implemented by citywide agencies. The dialogue served as an opportunity for communities working on the frontlines of climate change to engage policymakers and agency officials on lapses and gaps, models of success, or opportunities for future collaboration.
The individuals featured during this roundtable were from the Mayor’s Office of Recovery and Resilience (Daniel Zarrilli), NYC Panel on Climate Change (Sheila Foster), NYCDENMH (Munerah Ahmed), NYC Housing Authority (Bomee Jung), NYCDEP (Alan Cohn), and NYC Council Environmental Protection Committee (Samara Swanston).

In the afternoon, there were five breakout sessions that conference participants could attend: Impacts of Climate Change on Public Health, Emergency Preparedness, Energy Democracy, Organizing for Climate Resilience in Frontline Communities, and Engaging Youth in Climate Resilience. The breakout session leaders included Dr. Perry Sheffield (Mount Sinai), Dr. Matt Perzanowski (NIEHS CEHNM), Dr. Knowlton (NRDC), Zoe Hamstead (The New School), Adam Glenn (Harlem Heat Project), Elliot Maltby (City as a Living Laboratory), Carol Johnson (East Harlem C.O.A.D.), Raul Enriquez (New America), Greta Byrum (New America), Kathy Ortiz (New America), Gita Nandan (Thread Collective), Noah Ginsburg (Solar One), and Taylor Morton (WE ACT).

“Impacts of Climate Change on Public Health” educated participants about key public health threats due to climate change such as emerging infectious disease, extreme heat, cold and flood, and food insecurity. This breakout session engaged participants to identify important impacts that are likely in New York City. “Emergency Preparedness” taught participants about initiatives, programs, and policy recommendations to assist low-income communities of color in achieving greater climate resiliency during emergencies. “Energy Democracy” highlighted community driven initiatives that are working to achieve energy democracy. This workshop also explored key policy implications for advancing energy democracy. In “Organizing for Climate Resilience in Frontline Communities,” participants heard from organizers and community leaders about grassroots strategies for building power and deepening social cohesion. “Engaging Youth in Climate Resilience” offered students and educators of all ages an in-depth examination of the Northern Manhattan Climate Action Plan. Participants engaged in activities related to energy democracy, social hubs, public participation, and emergency preparedness.

The conference closed with a powerful spoken word poetry performance by Climbing PoeTree.
Elizabeth C. Oelsner, MD, MPH, Assistant Professor, Division of General Medicine; Mentors/Co-Investigators: Andrea Baccarelli, MD, PhD, Professor and Chair of EHS and R. Graham Barr, MD, DrPH, Professor and Chief, Division of General Medicine
Title: “E-cigarettes and circulating microRNAs in extracellular vesicles”; Award: $35K

Abstract: E-cigarettes are increasingly popular, including among youth and young adults. E-cigarettes are also relatively new, so the long-term health effects of e-cigarettes are currently unknowable. E-cigarette vapor is known to contain chemicals that can have potentially toxic effects on the lungs and other organs. So, in order to inform public health and relevant regulation of e-cigarettes, it is important to understand whether e-cigarette use has short-term effects that might allow us to predict long-term risks. In this pilot study, we propose to test for the first time whether e-cigarette use is associated with changes in circulating extracellular vesicles and the microRNAs they contain—often described as “messages in a bottle”—which together serve important roles in cell-to-cell signaling. These can be measured by a simple blood draw, and provide enormous amounts of information on how exposures are affecting cells throughout the body. We propose two related studies to assess the feasibility of our protocol and to obtain preliminary pilot data. First, to assess the chronic effects of e-cigarette use, we will compare the amount and size of extracellular vesicles in the blood, and which microRNAs they tend to contain, in 10 young adults who have never used e-cigarettes, 10 intermittent e-cigarette users, and 10 daily e-cigarette users. Second, to assess the acute effects of e-cigarette use, we will test how quickly and in what ways “vaping” a standardized e-cigarette alters circulating extracellular vesicles and microRNA profiles in 10 intermittent e-cigarette users. If we discover that there are substantial differences in extracellular vesicles and microRNAs between e-cigarette users and non-users, and before and after “vaping,” this will suggest that e-cigarettes may have important health effects, warranting larger-scale studies using these innovative measures.
Anna Navas-Acien, MD, PhD, Professor of EHS and Tiffany R. Sanchez, PhD, Postdoctoral Research Scientist, EHS; Co-Investigators: Miranda Jones, John Hopkins SPH, Maria Grau, EHS, Matt Perzanowski, EHS, Elizabeth Oelsner, General Medicine, R. Graham Barr, General Medicine, Joe Graziano, EHS

Title: “Low-level Arsenic exposure and markers of chronic lung disease among aging US adults: A Pilot Study in the Multi-Ethnic Study of Atherosclerosis-Lung (MESA-Lung)”; Award: $30K

Abstract: Environmental exposures affecting chronic respiratory disease are frequently ascribed to air toxicants and bio-aerosols, meaning research on the environmental sources of respiratory disease tends to focus on inhaled exposures. Interestingly, the ingestion of inorganic arsenic from naturally contaminated groundwater can cause lung cancer and is also associated with non-malignant respiratory disease. Existing research shows that moderate (10-50 ug/L) and high (>50 ug/L) levels of exposure to arsenic through drinking water are associated with poorer lung function in children, adolescents, and adults. Chronic high water arsenic exposure is markedly associated with increased bronchiectasis mortality, a rare lung disease associated with repeated respiratory infections. The existing epidemiologic research comes from Bangladesh, India, Pakistan, Chile, and Mexico. However, few studies have focused on the relation between arsenic and chronic lung disease in the United States, where water arsenic exposure is much lower (<10 ug/L) and populations are exposed to arsenic mostly through food. Computed tomography (CT) markers can further distinguish among different forms of lung disease and detect early changes in structure which are precursors to clinically apparent lung disease. Studying these novel markers in combination with lung function tests will significantly improve the pathophysiologic understanding of arsenic-associated lung disease. The goal of this pilot study is to determine whether chronic low-level arsenic exposure (measured in two urine samples over 10-years of follow-up) is associated with clinically meaningful and mechanistically relevant markers of chronic lung disease in a US-based cohort of older adults. This pilot will draw upon a random sample of 300 participants of the Multi-Ethnic Study of Atherosclerosis-Lung Study (MESA-Lung). Half of the proposed participants already have had Exam 1 (2000-2002) arsenic measured as part of a previous study, in this pilot we will measure arsenic from Exam 1 urine for the other half of the participants (a chest CT scan was first obtained at Exam 1) in addition to measuring arsenic from Exam 5 (2010-2012), when a lung function and a full-lung CT scan were also obtained for all 300 participants.
**Markus Hilpert, PhD,** Associate Professor in EHS; Co-Investigators: **Steve Chillrud,** PhD, LDEO; **David Evans,** PhD, COEC; **Diana Hernandez,** PhD, SMS and COEC Director; **Upmanu Lall,** PhD, Earth & Environmental Engineering; **Mychal Johnson,** Community Partner

**Title:** “Relocation of the ‘Fresh Direct’ Online Food Distribution Facility from Queens to the South Bronx: Impacts on a Community already subjected to Significant Levels of Air Pollution” ; **Award:** $31,000

**Abstract:** Fresh Direct, an online grocery store in NYC, is planning to relocate its distribution center from Queens to the Harlem River Yards in the South Bronx. This area is already heavily impacted by environmental pollution due to waste management facilities, hydrocarbon storage facilities, and vehicle exhaust from major traffic arteries. All school and public playgrounds are in close proximity to these arteries. The elevated levels of air pollution are linked to the exceedingly high prevalence of asthma and cardiovascular disease within the community. The goal of this pilot study is to gather scientific evidence, which will enable the community to advocate for (1) access to high-quality green space and (2) interventions that mitigate the adverse health impacts of the already substantial air pollution, which can be expected to increase due to the relocation. To achieve these goals, we propose to measure, document and analyze current air pollution [Black Carbon (BC) and fine particulate matter (PM2.5)], noise levels, and traffic counts for a 3-month period. We also propose to conduct horizontally and vertically resolved short-term measurements of BC to (1) quantify the exposure of playing children, (2) explore whether exposure would be lower on alternative playground locations on the waterfront, and (3) understand better how emissions from the major traffic arteries cause air pollution in the playgrounds.

**Virginia A. Rauh, ScD,** Professor of Population and Family Health

**Title:** “Prenatal Exposure to Organophosphates and PD-like Symptoms in Adolescence” ; **Award:** $35K

**Abstract:** Findings to date suggest that prenatal exposure to chlorpyrifos (CPF), a widely used organophosphate (OP) insecticide, is associated with persistent brain, behavioral and motor effects in different populations of children, using different biomarkers of exposure (Rauh et al., 2011; Engel et al., 2011; Bouchard et al, 2011). Specifically, in the urban CCCEH cohort, there is recent evidence of persistent motor deficits/movement disorders, including poor finger dexterity and tremor among 11-12 year old children who were highly exposed during the prenatal period (Rauh et al., 2015). In adult populations, there is growing evidence from other studies that OP insecticide exposures may be associated with Parkinson’s Disease (PD), a progressive disorder of the nervous system that affects movement (Pessoli and Cereda, 2013). As part of a new P50 (NIEHS, M-PIs, Peterson and Perera; PI of Neurodevelopmental Study, Rauh), we are now funded to conduct neuropsychological testing and repeated structural MRI at 16-18 years of age on the CCCEH cohort of children (N=350 will receive the full assessment under P50 funding), who have been followed since the prenatal period. In light of the evidence that OP pesticide exposures may be associated with PD in adults, and evidence of measureable motor problems throughout childhood in the CCCEH cohort among those children who were highly exposed during the prenatal period (Rauh et al., 2006; Rauh et al., 2015), we now propose to leverage the existing P50 center grant, in a subset of 75 children, to investigate the novel hypothesis that prenatal CPF exposure in an urban cohort may have long-term motor consequences, as measured by early preclinical and non-motor indicators for PD-like problems.
Spring 2017 NIEHS Center Seminar Schedule

May 18: K. Rashid Rumah, MD, PhD, Postdoctoral Associate at Rockefeller University, New York, NY; “The Origin of Multiple Sclerosis Revisited: The case for a soluble toxin”; EHS Conference Room 1101, 12:00-1:00pm. Host: Joe Graziano

June 1: Maciej Goniewicz, PharmD, PhD, Associate Professor of Oncology, Department of Health Behavior, Roswell Park Cancer Institute, Buffalo, NY; “E-cigarettes: Promise and peril”; EHS Conference Room 1101, 12:00-1:00pm. Host: Ana Navas-Acien

Save the Dates

October 5: NIEHS Center Retreat/External Advisory Meeting, 9am-4pm; Place TBD.

November 11: Johns Hopkins Center for Talented Youth Workshop, “The Environment and Public Health”; Key Note Talk by Joe Graziano; Workshops; Student Panel, 9am-4pm, Mailman SPH.