From the cell to the street: Addressing structural determinants to advance the science of environmental justice

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Social Justice Movements (Re)Shape Research & Policy Priorities

Protesting Landfill Siting in Warren County NC
Funding incentives for community-engaged research...

...change how scientists hypothesize and study environmental links to disease
Triple Jeopardy and Environmental “Riskscapes”

**Social Context:** Social inequality, segregation, discrimination

**Demographics:** Race/ethnicity, immigration status, income, wealth, geography

- Exposure Disparities (Extrinsic Factor)
- Social Vulnerabilities (Extrinsic Factor)
- Biological Susceptibility (Intrinsic Factor)

Interaction / Additive Effects

Health Outcomes and Disparities Across the Lifespan

Morello-Frosch et al., 2011
Gee and Payne-Sturges, 2004
O’Neill et al. 2003
IOM, 1999
In utero exposures to multiple toxic chemicals

- We know little about the extent of *in utero* exposures to multiple compounds and the degree to which chemicals are transferred from mother to fetus.

Woodruff et al. 2011
ECHO/Chemicals in Our Bodies 2:
Environmental Chemicals, Chronic Stress & Fetal Growth/Neurodevelopment in Offspring

Prenatal Chemical Exposures

Per- Poly- fluorinated chemicals (PFASs) & PBDEs in maternal serum and phenols in urine

Chronic Stress Exposures

- Maternal perceptions of chronic stressor exposures
- Neighborhood Stressors
- Biomarkers of stress response
  - Maternal Corticotrophin Releasing Hormone (CRH)
  - Telomeres in maternal and fetal cord blood leukocytes

Fetal Growth and Developmental Outcomes

Association of chemical and stress exposures (and their potential interactions) and:
- effect biomarkers (telomeres and CRH)
- perinatal outcomes
- neurodevelopment (7-8 months/2 years/4 years)
Is elevated corticotropin releasing hormone (CRH) a physiologic response to chemical and non-chemical stressors?

- Stress activates HPA axis, increasing cortisol production and CRH
- Excess CRH → preterm birth
- CRH elevated in response to certain endocrine disrupting chemicals (phenols, phthalates, parabens)

Slide courtesy of S. Eick
Prenatal exposure to some PFAS associated with higher CRH

Models adjusted for gestational age at visit, maternal age, race/ethnicity, education, and parity

IQR increase in PFNA associated with increasing CRH

N=497

Stressogens and depression during pregnancy

- Increasing rates of perinatal mood and anxiety disorders
- Long-term health and economic impacts
- Multiple environmental and social factor influences
## Research Findings

<table>
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<tr>
<th>PFAS Mixture</th>
<th>PFUdA</th>
<th>PFDeA</th>
<th>MePFOS</th>
<th>PFOS</th>
<th>PFHxS</th>
<th>PFOA</th>
<th>PFNA</th>
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**Change in CES-D Score**

- **US Born**
- **Immigrant**
- **Overall**

Aung et al. 2023
Research Findings

Aung et al. 2023
Environmental (in)justice

Studies consistently show that people of color are more likely than White people to:

- Live near a hazardous waste treatment and disposal facilities
- Live near coal fired power plants
- Live near concentrated animal feeding operations
- Live in chemical disaster vulnerability zones
- Live in areas out of attainment with the Clean Air Act
- Experience increased cancer risks from air toxics
- Breathe air with elevated rates of traffic-related pollutants
- Lack access to clean drinking water
- Lack green space in their neighborhood
Drivers of Environmental Inequities: Racial Segregation in US Cities and Redlining

Multi-group Dissimilarity (Dm) by Metropolitan Area in the United States
US Census, 2010
Racist criteria used by Home Owner Loan Corporation (HOLC) to grade neighborhoods in the 1930s: Los Angeles

Source: Mapping Inequality: Redlining in New Deal America
The Color Line Reflected in Green

Green space and heat island risks are not distributed evenly across urban areas.
Redlined neighborhoods have less greenspace
Example-- New York City

Nardone A, Rudolph KA, Morello-Frosch R, Casey JA (2021) Redlines and Greenspace: The Relationship between Historical Redlining and 2010 Greenspace across the United States. *Environmental Health Perspectives*. 129(1)
The climate gap: extreme heat & preterm birth

- People of color are more likely to live in “high heat-risk” neighborhoods with less trees and more impervious surfaces, especially in more segregated metropolitan areas.

- Extreme heat is associated with increased risk of preterm birth, particularly in early pregnancy and in neighborhoods with the greatest concentration of racialized poverty.
Heat waves associated with 10-20% increased risk of pre-term birth following unusually hot days defined as Maximum Apparent Temperature $\geq 40^\circ$C (compared to $<20^\circ$C).

Oil and Gas Development: Health Hazards

- Air pollution
- Water pollution
- Excessive light at night
- Other social stressors
Distribution of exposure to wells by HOLC neighborhood grade (N=33 US cities)

Gonzalez et al. 2022 Journal of Exposure Science & Environmental Epidemiology; https://doi.org/10.1038/s41370-022-00434-9
Oil and Gas Development in CA Adversely Affects Birth Outcomes

Approximately 3,080,713 (7.9%) of Californians live within 1 km of an active oil and gas well

- 40% more likely to have a low-birth-weight baby
- 20% more likely to have a small for gestational age birth
- 10% increased risk of preterm birth
- Effects are even stronger for pregnant people living near fracked wells
- Effects shown to be stronger among Latinx pregnant people (preterm birth)

Tran et al. EHP 2020, Tran et al. Environmental Epidemiology 2021, Gonzalez et al. Environmental Epidemiology 2021
Historical redlining and air pollution

Population-weighted mean annual intraurban levels for (a) NO$_2$ and (b) PM$_{2.5}$ by HOLC grade and race/ethnicity


HOLC – Homeowner Loan Corporation
Difference in birth weight (g) associated with full pregnancy particulate pollution exposures, stratified by maternal race/ethnicity (1996-2006)

Morello-Frosch et al.  
*Environmental Health* 2010
AB 32 & SB 32 – California’s Global Warming Solutions Act: Health and Equity Benefits?

California’s historical emissions and targets under AB 32 and SB 32. (Adapted from Greenblatt, 2015)

Co-benefits of addressing climate change: power plants

- In addition to GHGs, power plants emit particulate matter (PM), NOx, SO₂, benzene, mercury, lead, and other pollutants
- >10,000 deaths annually in the U.S. attributable to power plant emissions

Leveraging a “natural experiment” to assess short-term health benefits of power plant closures

California: 8 Oil and Coal Retirements (2001-2011)

Hunters Point, San Francisco Retired: 2006
Pollution Levels Declined in the Wake of Plant Closures

Data at the census tract level
PM$_{2.5}$ estimates from USEPA
Community Multiscale Air Quality

CHANGE IN
MEDIAN PM$_{2.5}$
CONCENTRATIONS
PRE/POST PLANT
RETIREMENT

U.S. EPA annual standard
California power plant closures associated with 2% reduction in preterm birth rates - adjusted results

- Corresponds to a change from 7% in pre-retirement period to 5.1% preterm birth in the post-retirement period
- Benefits stronger for African American and Asian mothers

Hyper-localized Measures of Air Pollution and Preeclampsia in Oakland, CA

Goin et al, ES&T, 2021

Distribution of black carbon (BC), nitrogen dioxide (NO2), and ultrafine particles (UFPs) within Downtown and West Oakland, CA
Preeclampsia risk differences (95% CI) per 100 women associated with hypothetical intervention reducing pollutant levels to the 25th percentile versus observed levels by exposure characterization distance

(Goin et al, ES&T, 2021)

• Estimates shown for each pollutant averaged within 120 m and within 30 m of maternal residence at delivery.
• The 25th percentile was 9.0 ppb for NO2, 0.27 μg/m3 for BC, and 26.6 # × 103/cm3 for UFPs.
• Adjusted for maternal race/ethnicity, insurance type, age at delivery, age squared, smoking history, parity, season of conception, proportion of census block with educational attainment less than high school, and proportion of census block living below the poverty line.
Preeclampsia risk differences (95% CI) per 100 women associated with hypothetical intervention reducing pollutant levels to 25th percentile versus observed levels – stratified by race/ethnicity

(Goin et al, ES&T, 2021)
Implications for addressing cumulative impacts & advancing environmental justice

Underlying science takes awhile...
Communities can’t wait until scientists sort it all out.
Community- and data-driven tools support action-oriented science to:

– Integrate place-level measures of environmental and social “stressogens”
– Highlight communities of regulatory concern
– Target strategies that integrate public health, sustainability, and environmental justice goals
– Target resources (e.g., CA’s Climate Change Investments & Biden Administration's Justice40 Initiative)
Integrating Equity and Sustainability Goals in Climate Policy– California Climate Investments

Revenue from regulation of industrial greenhouse gas emissions targeted for investment in projects that:

- Reduce pollution and greenhouse gas emissions
- Enhance co-benefits of greenhouse gas reductions
- 35% of funds to benefit vulnerable groups
- 20% invested in vulnerable neighborhoods directly
CalEnviroScreen
Mapping Disadvantaged Communities for CA Climate Investment Funds

CEJST – Climate Equity and Economic Justice Screening Tool
Mapping Disadvantaged Communities for Justice

How to use the map:
Zoom in +, search , or locate yourself and select to see information about any census tract.

Things to know:
The tool uses census tracts . Census tracts are a small unit of geography. They generally have populations of between 1,200 - 8,000 people.

Council on Environmental Quality
California Climate Investments
$18.3 billion dollars appropriated to date

http://www.caclimateinvestments.ca.gov/2020-project-profiles
Executive Order on Tackling the Climate Crisis at Home and Abroad

The United States and the world face a profound climate crisis. We have a narrow moment to pursue action at home and abroad in order to avoid the most catastrophic impacts of that crisis and to seize the opportunity that tackling climate change presents. Domestic action must go hand in hand with United States international leadership, aimed at significantly enhancing global action. Together, we must listen to science and meet the moment.

May 21, 2021

Dear Chair Mallory:

The White House Environmental Justice Advisory Council (WHEJAC) enthusiastically submits its final report to you and President Biden. This report is in response to a charge issued in March 2021, from The Council on Environmental Quality to provide recommendations on Justice40, Climate and Economic Justice Screening Tool, and Executive Order 13998 Revisions. Over the next few months, the WHEJAC will also consider and submit recommendations on the Scorecard, the administration and implementation of Justice40, and final recommendations on the Climate and Economic Justice Screening Tool.

The WHEJAC urges President Biden, Vice President Harris and the CEQ to consider the following requests:
Continuum of community engagement in research and policy change

From *Translational* Research... ...to *Transformational* Research

Balazs CL, Morello-Frosch R. *Environmental Justice* 2013
Thank You!
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Children’s Environmental Health Centers
• US EPA (RD83543301)
• NIEHS P01 ES022841
NIH ECHO Program (UG3OD023272 and UH3OD023272)
California Strategic Growth Council (CCRP0022)
US EPA Science to Achieve Results Grant (RD – 84003901)
Centers for Disease Control and Prevention (5U38EH000481)
U.S. EPA Science to Achieve Results Fellowship (91744701-01)
California Air Resources Board
Cal-EPA Office of Environmental Health Hazard Assessment