December 15, 2023

**Comments from University of California, San Francisco Program on Reproductive Health and the Environment in Response to Request for Information (RFI): Environmental Justice Research Gaps, Opportunities and Capacity Building**

These comments are submitted on behalf of the University of California, San Francisco Program on Reproductive Health and the Environment. We declare collectively that we have no direct or indirect financial or fiduciary interest in any chemical or product that is the subject of these comments. Institutional affiliations are included for identification purposes only and do not imply institutional endorsement or support, unless indicated otherwise.

The literature below seeks to provide additional insight on gaps and opportunities in environmental justice research, per the requested topics.

## I. Scientific Infrastructure to Support Environmental Justice Research

1. Eaves, L. A., Lanier, P., Enggasser, A. E., Chung, G., Turla, T., Rager, J. E., & Fry, R. C. (2023). Generation of the Chemical and Social Stressors Integration Technique (CASS-IT) to identify areas of holistic public health concern: An application to North Carolina. *The Science of the total environment*, *862*, 160409. https://doi.org/10.1016/j.scitotenv.2022.160409

   Historically, research on exposure to environmental chemicals and social stressors have been conducted separately, however increasing evidence has suggested that such exposures have interactive effects. Eaves et al. developed methods to integrate chemical and social stressor datasets to holistically assess population risk. The Chemical and Social Stressors Integration Technique, or CASS-IT, is a framework for identifying geographic areas based on environmental chemical exposure, social vulnerability, and access to health, social, and information resources. The authors applied this approach to the state of North Carolina and found 31 counties with elevated exposures to toxic metals and social stressors, and minimal health resources. The CASS-IT method could be replicated with US datasets to inform health policies and interventions and to reduce environmental disparities.

2. Tehrani, M. W., Fortner, E. C., Robinson, E. S., Chiger, A. A., Sheu, R., Werden, B. S., Gigot, C., Yacovitch, T., Van Bramer, S., Burke, T., Koehler, K., Nachman, K. E., Rule, A. M., & DeCarlo, P. F. (2023). Characterizing metals in particulate pollution in communities at the fenceline of heavy industry: combining mobile monitoring and size-resolved filter measurements. *Environmental science. Processes & impacts*, *25*(9), 1491–1504. https://doi.org/10.1039/d3em00142c

   Residential communities located near industrial operations are exposed to toxic trace metals such as arsenic, lead, and cadmium, posing health risks. Tehrani *et al.* utilized analytical methods to characterize metals in a heavily industrialized community of southeastern Pennsylvania and identify potential emission sources. Integrated particulate matter sampling of 10 discrete size fractions was used to evaluate the size distribution of metals at a fixed site and spatially distributed low-cost sensors and mobile monitoring were employed around the Chester-Trainer-Marcus Hook area. The results revealed levels exceeding previous estimates from the EPA and potential co-exposures to harmful heavy metals. Novel measurement approaches such as those

applied by Tehrani *et al.* could be used to accurately characterize toxic exposures to fenceline communities.

3. EPA, *Science Matters: Next Generation Emission Measurements Help Understand Air Pollutants in Rubbertown Industrial Area of Louisville, Kentucky* (Feb. 9, 2021), https://www.epa.gov/sciencematters/next-generation-emission-measurements-help-understand-air-pollutants-rubbertown

   In 2017-2018, EPA collaborated with the City of Louisville Metro Air Pollution Control District on a study using novel Next Generation Emissions Measurement (NGEM) systems to measure hazardous air pollutants around industrial facilities, including facilities near the city of Rubbertown, a primarily low-income community of color. NGEM technologies improve our understanding of air emissions and their impact on communities and could be applied to other settings to enhance exposure assessment in environmental justice research.

4. Shrader-Frechette K. (2022). Does Hazardous-Waste Testing Follow Technical Guidance, Thus Help Protect Environmental Justice and Health? *International journal of environmental research and public health*, *19*(13), 7679. https://doi.org/10.3390/ijerph19137679

   Inadequate hazardous-waste-site testing may put environmental health and justice at risk. In this article, Shrader-Frechette investigates whether US testing of volatile organic compound (VOC) waste sites tend to follow or violate government technical requirements, and the implications of these results. Of the waste sites investigated in California, almost all violated government technical requirements and systematically underestimated risk. The author notes that this "may help justify less expensive, potentially health-threatening cleanups, mostly in environmental justice communities." Future research should evaluate testing outside of California on other types of waste sites and compare health effects from sites that meet versus fail to meet regulatory testing requirements. However, as Shrader-Frechette notes, in order to conduct these comprehensive analyses, researchers need access to hazardous-site-testing documents in all states, as are available in California's Envirostor online database.

5. Casey, J. A., Daouda, M., Babadi, R. S., Do, V., Flores, N. M., Berzansky, I., González, D. J. X., Van Horne, Y. O., & James-Todd, T. (2023). Methods in Public Health Environmental Justice Research: A Scoping Review from 2018 to 2021. *Current environmental health reports*, *10*(3), 312–336. https://doi.org/10.1007/s40572-023-00406-7

   This recent scoping review by Casey and colleagues sheds light on trends and gaps in environmental justice research methods and provides a range of recommendations for future research. Of the 402 identified articles published between January 2018 and December 2021, 50% described a theoretical EJ framework and 60% evaluated questions relating to socioeconomic status or race/ethnicity. None of the EJ studies that were identified considered gender or sexual minorities. Of the exposure studies, the most common exposure was air pollution (40%), while many personal exposure studies evaluated chemicals (35%). Main effect regression modeling was commonly used for exposure-only EJ analyses (50%) and the most common method in epidemiologic studies was effect modification (58%). Few studies used solution-oriented methods, including intervention-based studies and community-based participatory research. Recommendations proposed by the authors include:

   1. Recognize that EJ, as an evolving field, confronts diverse and intersecting structural problems, which requires the careful contextualized application of the best available theory and methods.

2. Make EJ questions central in environmental health studies and use appropriate methods to answer them.
3. Limit the mischaracterization, misspecification, and/or omission of nuanced social constructs such as race, ethnicity, sex, and gender.
4. Obtain expertise from sociology and other fields in the design and implementation of EJ research.
5. Recognize the importance of community-engaged, community-based participatory, and community-relevant research.
6. Utilize more solution-oriented study design and statistical methods to address environmental justice, given the underlying goal of achieving health equity.
7. Rigorously design and evaluate interventions with a focus on health equity.
8. Expand the scope of EJ research to include Global South populations.

Adoption of these methods will continue to advance EJ research and health equity.

6. Alifa, M., Castruccio, S., Bolster, D., Bravo, M. A., & Crippa, P. (2023). Uncertainty Reduction and Environmental Justice in Air Pollution Epidemiology: The Importance of Minority Representation. *GeoHealth*, *7*(10), e2023GH000854. https://doi.org/10.1029/2023GH000854

   Reduction of uncertainty in health outcome models and exposure disparity studies is critical to develop effective health policy. This article builds upon previous work relating to data scarcity in air pollution epidemiology and environmental justice studies. The authors utilize information entropy to evaluate efficient pathways for uncertainty reduction in an air pollution-mortality model for $PM_{2.5}$ and compare the uncertainty reduction effect of adding new data for Non-Hispanic Black and Non-Hispanic White cases. Alifa *et al.* found that because Non-Hispanic Black populations experience higher levels of exposure to air pollution, the addition of Non-Hispanic Black cases results in higher information value and faster uncertainty reduction. This finding underlines the importance of minority representation in environmental research to calculate more confident estimates of exposure and better assess risk to populations. Future research can use this framework to center minority representation in study designs.

## II. Science, Research, and Data that would support Federal Environmental Justice Actions

***Ways that cumulative impacts, environmental justice, community-led science, population health, and health disparities research can better inform Federal policy actions***

The following five manuscripts were recently authored by an interdisciplinary group of experts convened by the Science Action Network (SAN). They recommend improvements on how science is used in decision-making to strengthen chemical risk assessment at EPA to ultimately offer stronger public health protections, especially for low wealth and communities of color who bear disproportionate chemical burden.

1. Woodruff, T. J., Rayasam, S. D. G., Axelrad, D. A., Koman, P. D., Chartres, N., Bennett, D. H., Birnbaum, L. S., Brown, P., Carignan, C. C., Cooper, C., Cranor, C. F., Diamond, M. L., Franjevic, S., Gartner, E. C., Hattis, D., Hauser, R., Heiger-Bernays, W., Joglekar, R., Lam, J., … Zeise, L. (2023). A science-based agenda for health-protective chemical assessments and decisions: Overview and consensus statement. *Environ Health*, *21*(Suppl 1), 132. Medline. https://doi.org/10.1186/s12940-022-00930-3

a. To better protect people from harmful chemicals, we recommend 5 principles for using science in hazard and risk assessment to improve chemical regulations by reflecting real-world risks.

2. Varshavsky, J. R., Rayasam, S. D. G., Sass, J. B., Axelrad, D. A., Cranor, C. F., Hattis, D., Hauser, R., Koman, P. D., Marquez, E. C., Morello-Frosch, R., Oksas, C., Patton, S., Robinson, J. F., Sathyanarayana, S., Shepard, P. M., & Woodruff, T. J. (2023). Current practice and recommendations for advancing how human variability and susceptibility are considered in chemical risk assessment. *Environmental Health*, *21*, 1–20. https://doi.org/10.1186/s12940-022-00940-1
    a. How to update assessment methods to better account for diversity and vulnerability to chemical risks resulting from exposure to multiple chemicals and non-chemical stressors like poverty and racism.

3. Nielsen, G. H., Heiger-Bernays, W. J., Levy, J. I., White, R. F., Axelrad, D. A., Lam, J., Chartres, N., Abrahamsson, D. P., Rayasam, S. D. G., Shaffer, R. M., Zeise, L., Woodruff, T. J., & Ginsberg, G. L. (2023). Application of probabilistic methods to address variability and uncertainty in estimating risks for non-cancer health effects. *Environmental Health : A Global Access Science Source*, *21*(Suppl 1), 129. https://doi.org/10.1186/s12940-022-00918-z
    a. An updated approach for estimating risk of health outcomes other than cancer that reflects the reality and diversity of the general population.

4. Vandenberg, L. N., Rayasam, S. D. G., Axelrad, D. A., Bennett, D. H., Brown, P., Carignan, C. C., Chartres, N., Diamond, M. L., Joglekar, R., Shamasunder, B., Shrader-Frechette, K., Subra, W. A., Zarker, K., & Woodruff, T. J. (2023). Addressing systemic problems with exposure assessments to protect the public's health. *Environ Health*, *21*(Suppl 1), 121. Medline. https://doi.org/10.1186/s12940-022-00917-0
    a. Four ways EPA can improve exposure assessments to protect public health, such as considering where people live or how they might be more susceptible to toxic chemicals.

5. Maffini, M. V., Rayasam, S. D. G., Axelrad, D. A., Birnbaum, L. S., Cooper, C., Franjevic, S., MacRoy, P. M., Nachman, K. E., Patisaul, H. B., Rodgers, K. M., Rossi, M. S., Schettler, T., Solomon, G. M., & Woodruff, T. J. (2023). Advancing the science on chemical classes. *Environ Health*, *21*(Suppl 1), 120. Medline. https://doi.org/10.1186/s12940-022-00919-y
    a. EPA's approach to regulating hundreds of thousands of chemicals one at a time is not working. We recommend an approach for EPA to regulate toxic chemicals by class or group to better protect people.

6. Chartres, N., Aung, M. T., Norris, S. L., Cooper, C., Bero, L. A., Chou, R., Payne-Sturges, D. C., Wagner, W. E., Reyes, J. W., Askie, L. M., Axelrad, D. A., Flores, D., Johnston, J. E., Lam, J., Lau, P., Martinez, M. E., Nachman, K. E., Rehfuess, E., Rothschild, R., Sutton, P., Zeise, L., & Woodruff, T.J. Development of the Navigation Guide Evidence-to-Decision Framework for Environmental Health. Published online 2023. https://osf.io/fhx27/?view_only=733432d21282414fbb27c1a2cac13026

    This article, which is under peer review and has been posted on Open Science Framework prior to publication, presents the UCSF Navigation Guide Evidence-to-Decision Framework for Environmental Health. This framework provides a transparent and consistent approach for developing recommendations to protect human health from environmental exposures, particularly for historically marginalized communities.

7. Liu, Z., Liu, C., & Mostafavi, A. (2023). Beyond Residence: A Mobility-based Approach for Improved Evaluation of Human Exposure to Environmental Hazards. *Environmental science & technology*, *57*(41), 15511–15522. https://doi.org/10.1021/acs.est.3c04691

   Traditional methods of hazard exposure evaluation use residential data and fail to consider people's mobility and time in alternative locations (work, school, etc.) which can lead to over 10% underestimation of hazard exposures. This recent study by Liu and colleagues proposes a novel mobility-based index for hazard evaluation through the combination of human mobility data and environmental hazard data. The authors found that spatial clustering in high-hazard regions and human movement patterns creates "environmental hazard traps" where residents of high-hazard areas experience an additional 10% exposure to hazards due to their activities and visitation to other areas. A significant portion of the population is also inadvertently exposed to hazards in their daily routine even if they live in areas perceived as safe. These findings offer important insights for public health officials and policy makers around the extent of environmental hazard exposures and environmental injustices in communities. There is opportunity for mobility-based analyses to be conducted on other environmental hazards or in conjunction with health outcome data.

8. McHale, C. M., Osborne, G., Morello-Frosch, R., Salmon, A. G., Sandy, M. S., Solomon, G., Zhang, L., Smith, M. T., & Zeise, L. (2018). Assessing health risks from multiple environmental stressors: Moving from G×E to I×E. *Mutation research. Reviews in mutation research*, *775*, 11–20. https://doi.org/10.1016/j.mrrev.2017.11.003

   In this article, McHale et al. proposes a concept to better understand and characterize the multiple intrinsic (I) and extrinsic (E) susceptibility factors that contribute to adverse health effects in diverse populations. Intrinsic factors include fixed and shifting biological factors (i.e. genetic traits) and extrinsic factors include external stressors across the life course (i.e. psychosocial stress from poverty or racial injustice). The IxE concept integrates the multi-factorial and dynamic nature of health and provides a framework for understanding the variability in human response to chemical and non-chemical stressors.

9. Payne-Sturges, D. C., Taiwo, T. K., Ellickson, K., Mullen, H., Tchangalova, N., Anderko, L., Chen, A., & Swanson, M. (2023). Disparities in Toxic Chemical Exposures and Associated Neurodevelopmental Outcomes: A Scoping Review and Systematic Evidence Map of the Epidemiological Literature. *Environmental Health Perspectives*, *131*(9), 096001. https://doi.org/10.1289/EHP11750

   This recent scoping review identified 218 studies on disparities in neurodevelopmental outcomes in US children exposed to 7 neurotoxicants (combustion-related air pollution, lead, mercury, organophosphate pesticides, phthalates, polybrominated diphenyl ethers, and polychlorinated biphenyls). A third of studies (74/218) reported evaluating interactions or effect modification between the pollutants and sociodemographic or socioeconomic comparators and 69% (51/74) reported finding presence of interactions or effect modification. This review highlights how low-income and racial and ethnic minority children may be disproportionately impacted by exposure to neurotoxicants. The authors also provide recommendations for future research (i.e. the need to improve the rigor and treatment of race in environmental epidemiology studies) and strategies to eliminate exposures and systemic inequities.

10. Morello-Frosch, R., Zuk, M., Jerrett, M., Shamasunder, B., & Kyle, A. D. (2011). Understanding the cumulative impacts of inequalities in environmental health: implications for policy. *Health affairs (Project Hope)*, *30*(5), 879–887. https://doi.org/10.1377/hlthaff.2011.0153

Morello-Frosch and colleagues summarize the evidence on the cumulative health implications of exposure to environmental hazards and discuss how environmental policy can address the cumulative impact of exposure and vulnerabilities of communities of racial or ethnic minorities or people of low socioeconomic status.

11. Payne-Sturges, D. C., Scammell, M. K., Levy, J. I., Cory-Slechta, D. A., Symanski, E., Carr Shmool, J. L., Laumbach, R., Linder, S., & Clougherty, J. E. (2018). Methods for Evaluating the Combined Effects of Chemical and Nonchemical Exposures for Cumulative Environmental Health Risk Assessment. *International Journal of Environmental Research and Public Health*, *15*(12). https://doi.org/10.3390/ijerph15122797

    This article synthesizes seven EPA-funded studies on analytic methods for cumulative risk assessment, highlighting key study findings and opportunities for future research.

12. Pullen Fedinick, K., Yiliqi, I., Lam, Y., Lennett, D., Singla, V., Rotkin-Ellman, M., & Sass, J. (2021). A Cumulative Framework for Identifying Overburdened Populations under the Toxic Substances Control Act: Formaldehyde Case Study. *International journal of environmental research and public health*, *18*(11), 6002. https://doi.org/10.3390/ijerph18116002

    Communities of color, low-income communities, and Indigenous communities experience greater exposure to environmental health hazards and are more likely to lack access to healthcare, education, and healthy food. This paper presents a process that could be utilized by the EPA to conduct cumulative risk assessment under TSCA. Use of these approaches to inform risk estimates and mitigation strategies would help EPA protect communities most burdened by exposure to toxic chemicals.

13. Koman, P. D., Singla, V., Lam, J., & Woodruff, T. J. (2019). Population susceptibility: A vital consideration in chemical risk evaluation under the Lautenberg Toxic Substances Control Act. *PLoS biology*, *17*(8), e3000372. https://doi.org/10.1371/journal.pbio.3000372

    Koman *et al.* recommend "key scientific and risk assessment principles to inform health-protective chemical policy such as consideration of aggregate exposures from all pathways and, when data are lacking, the use of health-protective defaults."

14. National Environmental Justice Advisory Council, *Ensuring Risk Reduction in Communities with Multiple Stressors: Environmental Justice and Cumulative Risks/Impacts*, (Dec. 2004), https://www.epa.gov/sites/default/files/2015-02/documents/nejac-cum-risk-rpt-122104.pdf

    This report from the National Environmental Justice Advisory Council (NEJAC) provides advice and recommendations to EPA on the following question, *"In order to ensure environmental justice for all communities and tribes, what short-term and long-term actions should the Agency take in proactively implementing the concepts contained in its Framework for Cumulative Risk Assessment?"* The NEJAC outlines 12 actions EPA can take to more effectively respond to the cumulative risks experienced by people of color, low-income, and tribal communities.

The following five sources provide information on residential mobility as it relates to toxic chemical exposures. People with lower social and/or economic mobility, such as people of color and low-income people, have historically had higher residential mobility due to lower homeownership and higher likelihood of renting, in part because of discriminatory housing practices. While people of color and low-income people are more likely to move, they're also more likely to move within the same neighborhoods,

meaning their exposure to toxic chemicals would remain consistent, despite their change in residence. This issue is also generational, as a National Academies of Sciences, Engineering and Medicine report found that "about half of Black Americans in the United States have lived in the poorest quarter of U.S. neighborhoods for multiple, consecutive generations." Additionally, a study by Sprung-Keyser *et al.* analyzing census data has found that "80% of young adults migrate less than 100 miles from where they grew up. 90% migrate less than 500 miles. Migration distances are shorter for Black and Hispanic individuals and for those from low-income families." Information from these sources can inform exposure assessments that support federal chemical policy.


15. DeLuca, S., Wood, H., Rosenblatt, P. (2019). Why Poor Families Move (And Where They Go): Reactive Mobility and Residential Decisions. City & Community, 18(2), 556–593. https://doi.org/10.1111/cico.12386

16. Brookings Institute. (2021). Homeownership, racial segregation, and policy solutions to racial wealth equity. Available: https://www.brookings.edu/articles/homeownership-racial-segregation-and-policies-for-racial-wealth-equity/

17. Crowder K, Downey L. Interneighborhood migration, race, and environmental hazards: modeling microlevel processes of environmental inequality. AJS. 2010 Jan;115(4):1110-49. doi: 10.1086/649576. PMID: 20503918; PMCID: PMC2908425.

18. National Academies of Sciences, Engineering, and Medicine. 2022. Research and Data Priorities for Improving Economic and Social Mobility: Proceedings of a Workshop. pp 39-40. Washington, DC: The National Academies Press. https://doi.org/10.17226/26598.

19. Sprung-Keyser B, Hendren N, Porter S. (2022). The Radius of Economic Opportunity: Evidence from Migration and Local Labor Markets. Working Paper CES 22-27. U.S. Census Bureau, Center for Economic Studies. https://www.census.gov/library/workingpapers/2022/adrm/CES-WP-22-27.html


***New or expanded data or knowledge sources that should be considered in Federal decision-making, including community generated data***


20. Env't Just. Health All. for Chem. Pol'y Reform et al., *Life at the Fenceline: Understanding Cumulative Health Hazards in Environmental Justice Communities* (Sept. 2018), https://ej4all.org/assets/media/documents/Life%20at%20the%20Fenceline%20-%20English%20-%20Public.pdf

    This 2018 report from the Environmental Justice Health Alliance for Chemical Policy Reform, Coming Clean, and the Campaign for Healthier Solutions aimed to examine the communities who live in close proximity to hazardous industrial and commercial facilities, the health effects of toxic air pollution exposure for those living within 3 miles of a hazardous facility, and access to healthy foods and critical institutions. The report concluded that the communities who live closest to hazardous industrial and commercial facilities are at risk from multiple threats, including chemical releases and explosions, toxic air pollution, and limited access to healthy foods. These fenceline communities are disproportionately Black, Latino, and living in poverty.

21. Robert D. Bullard et al., United Church of Christ, *Toxic Wastes and Race at Twenty 1987— 2007: A Report Prepared for the United Church of Christ Justice & Witness Ministries,* at 54 (Mar. 2007), https://www.ucc.org/wp-content/uploads/2021/03/toxic-wastes-and-race-at-twenty-1987-2007.pdf.

This seminal report from the United Church of Christ Justice and Witness Ministries contains the first national study using 2000 census data to examine the extent of racial and socioeconomic disparities in the location of commercial hazardous waste facilities in the United States. Analyses revealed that people of color comprise the majority of those living within 3km of hazardous waste facilities. This report aimed to act as a catalyst for grassroots organizing and policy change.

22. Johnston, J. E., Werder, E., & Sebastian, D. (2016). Wastewater Disposal Wells, Fracking, and Environmental Injustice in Southern Texas. *American journal of public health*, *106*(3), 550–556. https://doi.org/10.2105/AJPH.2015.303000

    This 2016 study found that oil and gas wastewater disposal wells are more than two times more common in areas with at least 80% people of color than in predominantly white communities.

23. Brody, J. G., Morello-Frosch, R., Zota, A., Brown, P., Pérez, C., & Rudel, R. A. (2009). Linking exposure assessment science with policy objectives for environmental justice and breast cancer advocacy: the northern California household exposure study. *American journal of public health*, *99 Suppl 3*(Suppl 3), S600–S609. https://doi.org/10.2105/AJPH.2008.149088

    In this community-based participatory research study, Brody *et al.* analyzed indoor and outdoor air pollution levels from 40 homes in an urban fenceline community in Richmond, California, and 10 homes in nonindustrial rural Bolinas, California. Cumulative air pollution burdens were higher indoors than outdoors in the urban fenceline community compared to the rural community. Indoor air quality in nearly half of the fenceline community homes exceeded California ambient air quality standards for respirable particulates. Community-based participatory exposure research is a critical component of EJ research and can contribute to science and inform action on the part of community residents and policymakers.

We appreciate the opportunity to provide public input. Please do not hesitate to contact us with any questions regarding these comments.

Sincerely,

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