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METHODS IN ENVIRONMENTAL EPIDEMIOLOGY (EF SCHISTERMAN AND AZ POLLACK, SECTION EDITORS)

Concepts for Studying Urban Environmental Justice

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Abstract
Purpose of Review This paper offers research frameworks for understanding and acting to address urban environmental justice. Urban neighborhoods tend to concentrate and colocate vulnerable people and toxic environments. Cities are also where the poor and people of color tend to be disproportionately exposed to environmental hazards, such as air pollution, lead in paint and water, and polluting industries.
Recent Findings Researchers and government agencies are increasingly recognizing the need to document cumulative exposures that the urban poor and people of color experience in addition to environmental hazards. These "toxic stressors" can exacerbate the health impacts of pollution exposures and include such social and economic factors as discrimination, racism, linguistic isolation, and political exclusion.
Summary Urban environmental justice research can benefit from a structural racism approach, which requires documenting the historical decisions, institutions, and policies that contribute to today's cumulative exposures. Key research frameworks and methods utilizing this approach for urban environmental justice include community-based participatory research, measuring cumulative stressors, and community-based asset and hazard mapping.

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Introduction

Environmental justice is a framework for understanding and acting to address the disproportionate, unfair, and unequal environmental burdens that the poor and people of color populations experience due to exposures of toxic harms and receiving less legal and other protections than white and well-off communities [1]. The issue of environmental injustice is particularly acute in urban areas, where the poor and people of color are often segregated into neighborhoods where a host of environmental insults are compounded by social and economic deprivation, political disenfranchisement and, what Daniel Patrick Moynihan called in 1969, "benign neglect," or the wholesale government abandonment of predominantly black and brown neighborhoods [2]. Since poverty, race/ethnicity, and immigration status are often highly spatially correlated in metropolitan areas [3••, 4], urban environmental justice research ought to be viewed through a structural racism framework [5]. A structural racism framework identifies the set of historical factors and multiple institutions that constrain the opportunities for people of color today. Structural racism is bias across institutions and society and the cumulative and compounded effects of an array of factors that systematically privilege white people and disadvantage people of color [6]. The Aspen Institute defines structural racism as: "A system in which public policies, institutional practices, cultural representations, and other norms work in various, often reinforcing ways to perpetuate racial group inequity. It identifies dimensions of our history and culture that have allowed privileges associated with 'whiteness' and disadvantages associated with 'color' to endure and adapt over time. Structural racism is not

something that a few people or institutions choose to practice. Instead it has been a feature of the social, economic and political systems in which we all exist" [6].

An urban example of structural racism is racially segregated neighborhoods, which were constructed and are perpetuated through governmental housing policies, institutional practices, and private sector actions such as zoning regulations, discrimination in bank lending, and racially restrictive covenants [7]. Educational inequities are exacerbated by this segregation since public education relies heavily on local property taxes. Environmental burdens tend to locate on or near inexpensive land or operate with impunity since the populations are often politically powerless. Structural racism can act as the entry point for urban environmental justice (EJ) research since it helps reveal the multiple forces that disenfranchise entire communities, not just why a particular polluter or hazardous exposure might be burdening the population or place [8•].

Urban EJ research using a structural racism framework would include at least the following concrete methods: (1) documenting the history of discriminatory policies and practice in places, (2) using community-engaged action research where those living with burdens are part of the inquiry process, and (3) measurement and mapping techniques to capture the multiple and cumulative toxic stressors afflicting low-income populations and communities of color. Using these approaches, urban EJ research can investigate the three core components of environmental justice, namely (a) distributive justice—what are the burdens and where are they located; (b) procedural justice—who is involved in making decisions and what evidence is deemed appropriate; and (c) corrective justice—what set of assets and ameliorative actions, redistributions, and processes can be identified that reverse and eliminate harms [9].

In 2016, the US Environmental Protection Agency recognized the limits of past approaches for building an evidence base to support environmental justice in its report "EJ 2020 Action Agenda" [10]. In the report, the EPA defined environmental justice as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Interestingly, the report was issued during a time when national media were reporting on widespread discrimination in multiple institutions resulting in toxic lead exposures for the largely African-American population of Flint, Michigan [11]. Yet, Flint is only a recent case of a long history of environmental racism in cities, such as lack of garbage removal and segregated hospitals in African-American neighborhoods in the 1960s, to lack of enforcement of illegal dumping of hazardous waste in the 1970s and 1980s, to disproportionate lead paint and air pollution exposures in the 1990s through today [12].

Importantly, the revelation that Flint's water contained high levels of lead and that children were being irreparably damaged came from a concerned mother taking water samples from her home tap and working with researchers from Virginia Tech University, not government scientists [13]. The same report highlighted that years of divestment from Flint and a court-appointed city manager that was not accountable to residents or locally elected officials had pushed-through the cost-saving measure to switch the source of Flint's drinking water which contributed to lead leaching from city's pipes. Impoverished families of color challenged the decision, but it would take over a year for the political processes to acknowledge the extent of the hazard and the urgency of remedial action. The Flint case points to the need for new urban EJ action research frameworks, the important role of community residents in research, and that only studying the hazardous exposure can miss the institutional decisions and structures in place that contribute to inequitable and hazardous burdens for communities of color.

New EJ Research Frameworks

Approaching and understanding environmental injustice as a function of structural racism suggest that researchers must orient their work around a set of normative themes that are anti-reductionist, anti-deterministic, and anti-positivist.

Anti-Reductionist

An anti-reductionist approach to EJ research suggests that urban inequities cannot be reduced to a focus on single behaviors, diseases, or risk factors. Instead, an anti-reductionist approach embraces intersectionality, which recognizes that our identities are not simply single social categories, such as African-American, but rather that we often have multiple overlapping identities that in combination shape experiences with discrimination and inequality. In a similar way, the places where we live, learn, work, and play have multiple characteristics that combine to shape hazardous or ameliorative exposures [14]. As Krieger ([16], p. 353) so clearly articulated:

"a person is not one day African American, another day born low birth weight, another day raised in a home bearing remnants of lead paint, another day subjected to racial discrimination at work (and in a job that does not provide health insurance), and still another day living in a racially segregated neighbourhood without a supermarket but with many fast food restaurants. The body does not neatly partition these experiences—all of which may serve to increase risk of uncontrolled hypertension, and some of which may likewise lead to comorbidity, for example, diabetes, thereby further worsening health status."

The legitimacy of urban environmental justice research will rest on how initial problems are framed. If a problem is framed too narrowly, too broadly, or wrongly, the evidence gathering

and solution generation may suffer from the same defects. For instance, an urban air pollution control strategy focused on a single pollutant cannot produce adequate knowledge about the environmental health consequences of exposure to multiple pollutants—the reality in many EJ communities. The framing of the regulatory issue is more restrictive than the actual distribution of chemical-induced risks and hence is incapable of delivering optimal management strategies.

Anti-Deterministic

An anti-deterministic approach acknowledges that no one institutional practice, toxic agent, or measure of deprivation can characterize urban EJ. In this way, an anti-deterministic approach embraces the relational notion of place, meaning that we must measure the complex mixture of urban place characteristics that contribute to environmental justice, such as the presence or absence of affordable housing, access to healthy food, employment opportunities, safety, quality education, public transportation, opportunities for social connections, and political and cultural expression. This research approach also implies that the qualities of places, such as our neighborhoods, that contribute to justice or injustice relate to one another in complex, often mutually constitutive ways to constrain or promote opportunities to be healthy [16]. In other words, in a relational view of urban EJ research must measure the multiple "environments" that interact to influence well-being, including: (1) the material and physical environment (e.g., housing, streets, parks, air pollution, wealth, etc.), (2) the social and political environment (e.g., social cohesion, networks, political power, etc.), (3) the institutional and policy environments (e.g., the administrative decisions that shape places such as zoning rules, environmental impact thresholds, public participation procedures, etc.), and (4) the cultural environment (e.g., the meanings, interpretations, narratives, perceptions, feelings, and imaginations that get attached to places). These multiple dimensions are critical for EJ research, since documenting all four and how they might be mutually constitutive can help reveal differences in power that explain differences in hazardous exposures.

Anti-Positivist

An anti-positivist approach to urban EJ research extends beyond the neighborhood or even city and suggests that there are mutually reinforcing relationships between the position of places relative to each other and that inequities ought to be understood as a result of endogenous and exogenous processes operating at a variety of spatial scales, not just the neighborhood scale [17]. Similarly, EJ research has tended to be cross-sectional, meaning that it takes a "snap-shot" in time and tests, for example, for correlations between an environmental hazard or polluter and the location of people of color [18•]. An anti-positivist approach would emphasize longitudinal studies and capturing the historical changes in cities that produce segregated and vulnerable communities [19]. The anti-positivist framework suggests that professional scientists and disciplines often create high entry barriers for alternative ideas and kinds of knowledge claims to be considered legitimate science, such as a mothers' intuition about their sick children or experiential knowledge. This intersection of science, lay knowledge, and environmental health decision making remain contested terrain, but local knowledge has proved to be an essential aspect of enhancing science and protecting vulnerable populations and places [20].

The above frameworks lend themselves to specific research practices, a few of which are highlighted in the following section.

Community-Engaged Participatory Action Research

One of the first principles of environmental justice is that communities must "speak for themselves" in characterizing the hazards and opportunities they face and what ought to be done to improve community well-being [1]. Community-based participatory research (CBPR) is an approach to research and set of methods that seeks to transform the scientific enterprise by engaging communities in the research process [21••]. CBPR typically involves academic–community collaborations in which power is shared among partners in all aspects of the research process—the doing, interpreting, and acting on science. The process aims to elevate community knowledge, included the history of places and the biographies of residents, while also challenging traditional power dynamics in the research process [22]. While not explicitly aimed at confronting structural racism, CBPR methods often aim to deconstruct power and democratize knowledge production by lifting up the experiential knowledge of community members alongside other professional ways of capturing data [23]. CBPR is increasingly part of citizen science efforts, where local people experiencing disease and an environmental hazard engage in data collection, interpretation, and using newly gathered evidence for action [17].

CBPR facilitates the translation (i.e., application and interpretation) of research findings to community stakeholders and policymakers and recognizes that technological solutions help little if they are not trusted or accepted by local people. Importantly, CBPR can be as much about what is making a place unhealthy as it can be about the dynamics that are currently working in a place and might be lifted up to improve well-being and environmental health justice [24••]. Community-engaged research is part of CBPR and, as stated by the Agency for Toxic Substances & Disease Registry (ATSDR), "...is a powerful vehicle for bringing about environmental and behavioral changes that will improve the health

of the community and its members. It often involves partnerships and coalitions that help mobilize resources and influence systems, change relationships among partners, and serve as catalysts for changing policies, programs, and practices" ([25], p. 7). Community-engaged environmental justice action research incorporates input and knowledge from members of a community and other stakeholders who are affected by an issue, but involvement can range from one-directional outreach to enhanced local leadership (Fig. 1).

Cumulative Impacts and Toxic Stress

CBPR and community engagement in urban environmental justice research has promoted changes in theories of disease causation and new lines of inquiry that are helping to reshape environmental science [22]. Cumulative impacts research reflects the long-held notion from urban environmental justice advocates that a chemical-by-chemical and source-specific assessment of risk does not reflect the cumulative impacts of multiple physical and social stressors experienced by vulnerable communities [23]. Cumulative impact refers to the total harm to human health and the environment resulting from multiple hazardous or toxic stressors over time. Yet, the prevailing view of risk assessment, such as that articulated by environmental health regulators, has concentrated narrowly on calculating the probability that an individual chemical agent, from a distinct source, through a single exposure pathway, influences a specific health endpoint [26]. If the calculated probability falls below some threshold defined as "acceptable" (say, one cancer in 1,000,000 individuals exposed for a lifetime), then the action itself is deemed acceptable. This approach is based on the tacit (and incorrect) assumption that ecosystems and human populations can tolerate an endless accumulation of innumerable "acceptable" insults [27].

The US EPA's "EJ 2020" draft strategy prioritizes measuring, monitoring, and modifying cumulative impacts on communities and proposes to do this by "developing and using assessment, screening and decision tools that look at communities holistically, and drive action when possible" ([10], p. 5). Cumulative impacts research suggests that methods must recognize that our bodies do not partition experiences with inequality and these experiences act as stressors on the immune and neurologic systems that are now known to contribute to a range of diseases and premature death [14]. While stress can be lifesaving—fight-or-flight mechanism—constant adversity is toxic, meaning that the prolonged activation of the stress response systems can disrupt the development of the brain architecture and other biologic systems [15]. EJ research needs to work with communities to identify and measure toxic stressors in the specific places where we live, learn, work, and play, rather than just assuming certain environmental and social ills are burdening populations the same way.

For example, reports of discrimination by African-Americans and Asian-Americans have been linked with visceral fat accumulation, which increases the risk of metabolic syndrome (and thus the risk of heart disease and diabetes), but this can manifest itself differently in communities with strong or weak social support systems [14]. In a review of 45 different cross-sectional and longitudinal research studies investigating the relationship between neighborhood characteristics and mental health outcomes, Mair et al. [29] conclude that

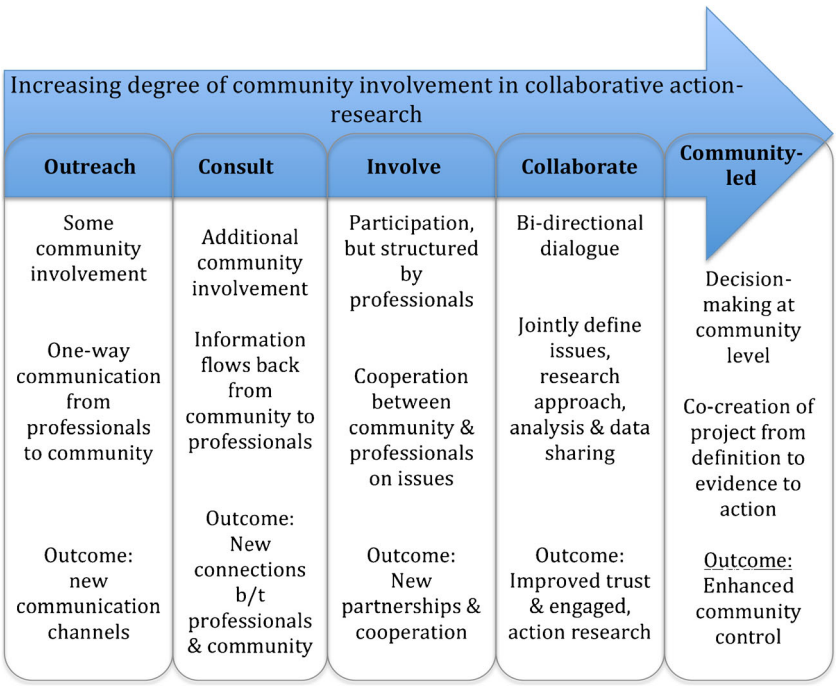

Fig. 1 Continuum of community involvement in collaborative research

"features of neighborhoods such as lack of resources, disorder, violence, inadequate housing, and lack of green spaces may function as stressors" that contribute to depression and poor mental health, but how long the stressor or asset has been present can also matter (p. 940). EJ research must include both direct assessments of experiences with racism/discrimination and measurement that captures the place-based inequitable living conditions that can contribute to chronic toxic stress.

One often understudied place-based stressor is the disproportionate impact communities of color and the urban poor face from climate change. Climate change is making already socially and environmentally vulnerable urban communities more vulnerable to adverse health and other impacts from intense heat events, flooding, and local air pollution [30]. People of color are already disproportionately impacted by air pollutants in cities, such as ground level ozone, which will only increase with rising temperatures. Higher ozone levels result in more asthma attacks, more heart attacks, decreases in lung function, and increased hospital admissions and deaths [31]. In California, the Environmental Health Coalition in San Diego is working with a network of community health workers to understand which populations and communities are most at risk from heat events and air pollution. In Oakland, California, the Resilience and Adaptation Committee of the Oakland Climate Action Coalition (OCAC) is working to address the threats of climate change with locally scaled solutions that build on community knowledge and focus on transportation, heat resilience, and air quality. Research is exploring how local actions, such as improved infrastructure, urban greening/tree planting, reducing truck idling, and housing energy audits and improvements, can reduce vulnerability to climate change-induced events. Measurement with communities of multiple risk and resilience factors will be necessary to understand the most effective strategies at promoting urban climate justice (http://climatehealthconnect.org/solutions/stories-from-the-field/).

Thus, urban EJ must work to identify which place or population-based resources may act to buffer or mitigate existing and future "toxic stressors". The EPA recommends a suite of tools for capturing cumulative impacts including EJSCREEN, Community-Focused Environmental Risk Screening Tool (C-FERST) (http://www.epa.gov/heasd/c-ferst/), Next Generation Compliance4 advanced environmental monitoring tools, and Health Impact Assessment (HIA) [10].

Making the Invisible Visible Through Community Mapping

A third practice for urban EJ research is making visible, to both residents and decision-makers, the environmental burdens, and assets that communities experience. Participatory map making can help communities define the environmental hazards they face and document the cumulative interplay of multiple hazards in places [28]. When map-making processes are defined and conducted by community residents, they can also identify local assets, how things might have changed over time, and the community narratives that can help explain the "why" behind the "what." For instance, EJ research tends to measure physical and social environments using static land use, census, or crime statistics [4]. Community-driven map making might challenge the use of administrative data and the notion that physical proximity is ideal for accessing an environmental good, such as a grocery store. This is the notion behind the concept of "food deserts." However, community mapping where residents are asked to map their activity space—or where they travel during a day or week—might reveal that residents shop for food near where they work, not live, because the store may be more affordable or culturally appropriate. In this way, a food outlet farther away from where one lives might be preferred to a physically proximate food outlet [16]. Community-engaged mapping can highlight this often hidden dynamic in EJ research and reveal the interplay of economic, sociocultural, environmental, and political/administrative scales and distance across and within an urban area [17].

Community-driven mapping as a central aspect of EJ research has moved beyond paper maps or even desktop Geographic Information Systems (GIS). Mapping process are engaging young people, especially as new technologies, web, and social media geared toward youth become commonplace as mapping tools. Partnering with youth can also help ensure that map making is fun, tied to local culture and even to a broader fundraising strategy. Engaging youth can also support mapping as a strategy to build new organizational capacity, leadership, and power, especially when community members drive the research questions, selection of appropriate data, and interpretation and presentation and use of results [32].

Communities can generate their own data and maps, thereby making their expertise visible, using such free and publically accessible web-based mapping tools such as Google Maps, MapServer, OpenStreetMap, and GRASS GIS to only name a few (maps.google.com, Mapserver.org, openstreetmap.org, grass.fbk.eu). These web-based tools have made sophisticated mapping available to community and nonprofit groups with limited resources, in part because they have centralized and made freely available very high-resolution background geographic data including satellite data, street photography, and building outlines. In East Oakland, California, an EJ group called Communities for a Better Environment (CBE) used mapping tools to capture local knowledge about unregulated toxic facilities and combined these data with regulatory maps and databases to generate detailed maps of neighborhood cumulative exposures (www.cbecal.org/wp-content/uploads/2013/01/cumulative_impacts_final.pdf).

New social media, sometimes linked to mapping technologies, are reshaping definitions of community and how people see themselves in relationship with their surroundings, neighbors,

and institutions—by mapping such things as access to public transportation or the responsiveness of government agencies. For example, individuals and community-based organizations have mobilized citizens to send text messages and photos from mobile phones to track a range of community health "field" data that can be located on a map, many with additional geo-referenced data, such as incidents of violence, housing code complaints, dangerous streets and intersections, and pedestrian injuries (cf., crimemapping.com, www.everyblock.com, www.seeclickfix.com, www.infrastructurist.com/f-this/, www.appsfordemocracy.org/stumble-safely, http://www.mybikelane.com, healthycity.org). Software developed by groups such as Ushahidi (ushahidi.org) are allowing community map makers to track identified community hazards and assets through time (i.e., at what time of day a report was sent) and space (i.e., geographic location)—giving rise to sophisticated "time-space health biographies." These, in turn, are enabling collaborative researchers to suggest that movement, and thus exposure, varies from person to person (e.g., elderly vs. adult vs. young person) living in the same place.

Conclusions: Values and Urban EJ Research

As suggested throughout this article, urban EJ research can employ a structural racism lens to identify research participants, expand the range of methods, and expand what is deemed as credible evidence. This approach to urban EJ research demands that problem setting, or understanding why a community of color is vulnerable, requires an engagement with the history of places and the people living there. Researchers must start urban EJ research by asking what institutional decisions over time may have contributed to today's inequitable burdens and how might multiple institutions—from environmental protection, to urban planning and transportation, to housing and economic development, and to criminal justice and social policies—have had overlapping and cumulative impacts on communities of color. These must be identified as part of today's cumulative environmental burdens, and residents experiencing these burdens must be leaders that define research questions, methods, data, analytic techniques, and translating findings into actions.

Urban EJ research must also recognize that places are dynamic and complex, not static, and the interactions among multiple hazards and assets in places must also be captured. CBPR and mapping processes can help ensure that community residents and their knowledge helps co-produce the ever-changing science of cumulative impacts [10]. In these ways, environmental justice research can help forge a new citizen science where participants are more diverse that in most professional science and acceptable data and evidence reflects the lived realities of already vulnerable social groups. Participatory research can open up new forums for environmental health science, moving out of the lab and narrow disciplines and into "the street." These processes can engage community residents, professional scientists, and decision-makers in ongoing discussions about, for instance, the strengths and limits of new technologies for addressing environmental injustices. The idea is that urban EJ research must inject the normative and social into the scientific, since pursuing justice for the poor and communities of color cannot be achieved by scientists working independently. Judgments and values about the kind of society we want to live in, whose lives are valued, and how restorative justice can address the damage already done to communities must be part and parcel of the research enterprise.

Summary

1. Urban EJ research can benefit from a structural racism framework.
2. Community-driven research can ensure research is accountable to place-based hazards, capitalize on local knowledge, and translate findings into locally legitimate interventions.
3. Cumulative exposures that include physical and social hazards act as "toxic stressors" that must be captured to accurately characterize risks in urban environments.
4. Community-driven map making can reveal hidden data and community assets that can ensure research is relevant to specific cultures and places.
5. An explicit aim of urban EJ research should be to democratize the scientific enterprise to new, often marginalized populations that have traditionally been subjects, not participants, in science.

Compliance with Ethical Standards

Conflict of Interest Jason Corburn declares that he has no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

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