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Participatory Research for Environmental Justice: A Critical Interpretive Synthesis

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Background: Environmental health risks are disproportionately colocated with communities in poverty and communities of color. In some cases, participatory research projects have effectively addressed structural causes of health risk in environmental justice (EJ) communities. However, many such projects fail to catalyze change at a structural level.

Objectives: This review employs Critical Interpretive Synthesis (CIS) to theorize specific elements of participatory research for environmental health that effectively prompt structural change in EJ communities.

Methods: Academic database search was used to identify peer-reviewed literature describing participatory research with EJ communities to address environmental health. Synthetic constructs were developed iteratively related to study characteristics, design elements, and outcomes; and data were extracted for included records. Statistical analyses were performed to assess correlations between study design elements and structural change outcomes. Through critical, comparative, and contextual analyses of the "structural change" case study group and "non- structural change" group, informed by relevant theoretical literature, a synthesizing argument was generated.

Results: From 505 total records identified, eligibility screening produced 232 case study articles, representing 154 case studies, and 55 theoretical articles for synthesis. Twenty-six case studies resulted in a structural change outcome. The synthesizing argument states that participatory research with EJ communities may be more likely to result in structural change when *a*) community members hold formal leadership roles; *b*) project design includes decision-makers and policy goals; and *c*) long term partnerships are sustained through multiple funding mechanisms. The assumption of EJ community benefit through research participation is critically examined.

Discussion: Recommended future directions include establishing structural change as a goal of participatory research, employing participatory assessment of community benefit, and increased hiring of faculty of color at research institutions. The power, privilege, and political influence that academic institutions are able to leverage in partnership with EJ communities may be as valuable as the research itself. https://doi.org/10.1289/EHP6274

Introduction

In the 21st century, the greatest threats to human health are intertwined with modern systems of production, distributions of power, capitalist value systems, and modern lifestyle (Filippelli and Taylor 2018; Kishore et al. 2011). Pollution is now the leading global cause of premature death and disease (Landrigan et al. 2018). In 2018, noncommunicable diseases (NCDs), such as asthma, heart disease, diabetes, stroke, and cancers, contributed to more than 80% of illnesses and 71% of deaths worldwide (WHO 2018). NCDs are distributed inequitably; decades of empirical data and lived experiences demonstrate how dominant political and economic structures disproportionately locate environmental pollution and other sources of health risk with communities in poverty and communities of color (Braveman 2014; Bullard 2008; Burwell-Naney et al. 2019; Gee et al. 2019; Gee and Payne-Sturges 2004; Marmot and Allen 2014; NASEM 2017; Schulz et al. 2016).

These "environmental justice (EJ) communities" may possess nuanced knowledge of local sources of environmental health risk but lack regulatory enforcement or formal channels to pursue action (Brown 2017; Corburn and Gottlieb 2005; Konisky 2009). Polluting industries typically possess greater power, in the form of funding and legal strategies, than the EJ communities they put at risk (e.g., Collins et al. 2016; Gunz and Whittaker 2016). Often having formal complaints ignored (e.g., Carruthers 2008; Scott 2016), EJ community members may become discouraged in raising environmental health concerns, even when they are personally affected.

Conventional health intervention and health promotion strategies have largely failed to mitigate the sources of environmental health risk for EJ communities because the strategies often address health at the individual behavior level rather than interacting with relevant social, cultural, and political contexts (Masuda et al. 2010). In recent decades, however, a new generation of academic environmental health researchers have emerged with the commitment to conduct collaborative research in partnership with EJ communities (e.g., Averett 2017; Balazs and Morello-Frosch 2013; Brown 2013; Christopher et al. 2012; English et al. 2018; Farquhar and Wing 2011; Finn and Collman 2016; Matz et al. 2016; Ramirez-Andreotta et al. 2014a; Sampson et al. 2020; Sampson and Roberson 2019). These researchers share an ecological approach to human health (Foget and Lebel 2001; Wilson 2009) and social responsibility ethic (Quigley 2011; Weed and McKeown 2003), though they may employ varied participatory research approaches, such as community-based participatory research (CBPR), participatory action research (PAR), citizen science (CS), or community-engaged research (CEnR). Although different participatory approaches stem from diverse roots (Friere 1970; Lewin 1946), they share the active participation of affected community members to propose research questions, inform study methods, collect and/or interpret data, and communicate findings. Although ample evidence supports the efficacy of participatory research to improve research quality (Balazs and Morello-Frosch 2013; Cargo and Mercer 2008; Farquhar and Wing 2011; O'Fallon and Dearry 2002) and improve community understanding of health risks and behaviors (Loh et al. 2002; Sullivan et al. 2018; Thompson et al. 2018), a much smaller subset of examples demonstrates the ability to address and mitigate the structural causes

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of environmental health risk through informed and organized action (e.g., Cacari-Stone et al. 2014; Lichtveld et al. 2016a; Minkler et al. 2008, 2010; Petersen et al. 2006).

Nevertheless, persistent cultural disconnects, trust barriers, and real structural inequity may prevent academic researchers from establishing equitable research partnerships with EJ communities that result in structural outcomes (Clapp et al. 2016; Wing 2005). A previous review of participatory health studies showed that those led by community-based groups were more likely to result in responsive action than those led by universities (Cook 2008). Academic research partnerships have inadvertently caused harm to EJ communities (Ottinger 2013; Schnarch 2004; Shrader-Frechette 2017) or created barriers to community-driven participatory research (Saxton et al. 2015). Research grant timelines often mandate short-term outcomes without resources for follow-up, degrading community trust (Flicker et al. 2008b; Mah 2017; Stengers 2018). As an Alaskan Native saying goes, "Researchers are like mosquitoes; they suck your blood and leave" (Cochran et al. 2008).

We posit that academic institutions can leverage their positions of power through collaboration with EJ communities in ways that work "upstream" (Butterfield 2002) to structurally address the systems that perpetuate environmental injustice. To examine this hypothesis, we reviewed a diverse body of relevant literature and conducted a critical interpretive synthesis (CIS), aimed at theorizing specific elements of participatory research that prompt action for structural change. "Structural change" is defined here as affecting macro- or meso- level determinants of health (Wilson 2009), such as zoning policy, economic policy, political power, built environment, public service provision, or environmental policy enforcement (Asada et al. 2017; Cole and Farrell 2006; Frohlich and Abel 2014; Rütten and Gelius 2011). This research focus does not intend to dismiss the real value of educational outcomes in environmental health research, such as increasing risk awareness or environmental health literacy, or the importance of protective measures funded and managed by community-based organizations; however, this focus employs an environmental justice approach in placing the responsibility to mitigate pollution on the economic, social, and political structures that produce it.

This research is informed by foundational literature on participatory research for health (Israel et al. 2012; O'Fallon and Dearry 2002; Wallerstein et al. 2017), as well as previously conducted reviews of participatory research for health equity (Brush et al. 2019; Cargo and Mercer 2008; Commodore et al. 2017; Cook 2008; Flicker et al. 2008a; Ortiz et al. 2020; Viswanathan et al. 2004), qualitative environmental health research (Scammell 2010), CBPR case studies in cancer research (Hicks et al. 2012; Simonds et al. 2013), and participatory research concepts in public health (English et al. 2018). English et al. (2018) specifically recommend that "[S]uccessful case studies should be analyzed for common themes to develop a framework for researchers and communities who are especially interested in impacting health and environmental policies" (p. 347). The following synthesis directly responds to this call in its aim to illuminate study design elements that prompt structural change to benefit EJ communities.

Methods

Protocol Development

The body of literature related to participatory research with EJ communities is diverse and complex, represented by empirical work using qualitative and quantitative research, theoretical and commentary work, and diverse disciplines. The goal of this research, rather than to summarize participatory research for EJ, is to generate theory around what catalyzes structural change that benefits EJ communities. This goal requires understanding not only the methods and results of the study, but also the study context. For these reasons, the authors chose to employ critical interpretive synthesis (CIS), a review method developed in the health science field to synthesize a diverse body of evidence for the generation of theory with strong explanatory power (Dixon-Woods et al. 2005, 2006; Flemming 2010; Sutton et al. 2019). The authors' protocol followed the established stages of CIS (see Entwistle et al. 2012, Box 1), as described further below.

Search Strategy

CIS often employs bibliographic search while also allowing sources to emerge organically (Dixon-Woods et al. 2006). In this study, bibliographic search was the primary method to identify relevant literature. Diverse methodological terminology in participatory research (Table 1) importantly distinguishes specific methodological differences (Eitzel et al. 2017; O'Fallon and Finn 2015) but may not be operationalized consistently in the literature (O'Fallon and Finn 2015; Watkins et al. 2009). Furthermore, varying levels of community participation often exists even within specific methodologies, such as citizen science (Haklay 2013; Shirk et al. 2012) or community-engaged research (McCloskey et al. 2011). These realities added complexity in the creation of the search strategy. Working closely with a health sciences librarian trained in information sciences, the authors tested various search term combinations to achieve a high percentage of results relevant to the intersection of participatory research, EJ, and environmental health. The final search was conducted on 12 August 2020 in Scopus, a multidisciplinary database, using the following terms to locate peer-reviewed documents: TITLE-ABS-KEY[("environmental health" OR "environmental justice" OR "environmental injustice" OR "environmental racism") AND ("participatory research" OR "participatory action research" OR "community-engaged research" OR "community-driven research" OR "community-owned and managed research" OR "citizen science")]. No date limitations were set. This search strategy allowed for catching a broad, though not exhaustive, range of literature applying various participatory approaches to address EJ issues and sought to maximize the range of possible cases where participatory research for EJ led to structural change. Consistent with CIS methodology, this strategy relies on principles of sampling and theoretical saturation to develop concepts and theory, rather than aiming for an exhaustive summary of all data (Dixon-Woods et al. 2006). Additional relevant literature was identified through reference chaining, the authors' prior knowledge, Internet searches, and suggestions from colleagues. In some cases, project or partnership websites were reviewed to gain further understanding of case studies described in the literature.

Eligibility Criteria and Study Selection

Consistent with CIS, conceptual relevance was privileged in study selection (Dixon-Woods et al. 2006). Articles were included for review if they described case studies using participatory research methods to address environmental health with an EJ community (as defined in Table 1). Theoretical articles, defined as articles that emphasize theoretical frameworks or propose best practices, rather than report on a specific research study, were also included when they specifically addressed participatory research for EJ or environmental health. Articles were excluded from review if they did not meet the above criteria for inclusion, were not full text articles, or were not available in English or Spanish (the languages of the authors).

Table 1. Key terms and definitions.

Key term	Definition
Environmental justice terms	
Environmental justice (EJ)	Environmental justice frameworks acknowledge and understand that race and class map closely with pollution, unequal protection, and vulnerability. In the face of this understanding, EJ holds the principle that all people and communities have the right to equal protection and equal enforcement of environmental laws and regulations (Bullard 2008, 2001; Mohai et al. 2009; People of Color Environmental Leadership 1991; Schlosberg and Collins 2014; U.S. EPA 2016).
Environmental injustice	Environmental injustice is defined as the disproportionate environmental health risks placed on communities of color and communities in poverty, due to pollution, as well as unequal environmental protection laws, regulations, governmental programs, enforcement, and policies (Clark et al. 2014; Maantay 2002; Taylor 2014).
Environmental racism	Environmental racism describes environmental injustices perpetuated through practice, policy, and/or lack of enforcement, that disproportionately affect Black, Indigenous, or people of color (BIPOC) (Cole and Foster 2000; Taylor 2014). As an example, a 20-year comparative study found that race was more important than socioeconomic status in predicting the location of commercial hazardous waste facilities in the United States. (Bullard et al. 2008).
EJ communities	Environmental justice communities are communities experiencing harm or at risk of harm due to environmental injustice and/or environmental racism. Their layered burdens include both environmental burdens, such as unequal protection from polluting industries, and socioeconomic burdens, such as poverty and lack of access to political power (Wilson 2009).
Health equity, health disparities	Health equity refers to equal opportunities for health, regardless of race, gender, sexual orientation, cultural background, citizenship status, etc. Health disparities are the metric used to measure progress toward achieving health equity. Reduced health disparities, achieved by improving the health of those who are specifically economically/socially disadvantaged, is evidence of increased health equity (Braveman 2014).
Participatory research terms	
Participatory research (PR)	Participatory research is used as an umbrella term for various research methodologies, which all share a philosophy of valuing local people and communities as beneficiaries, contributors, users, and stakeholders of the research. These methodologies may include community-based participatory research, participatory action research, community-engaged research, community-directed research, community-owned and –managed research, citizen science, photovoice, and participatory geographic information systems (Cargo and Mercer 2008; English et al. 2018; Macaulay et al. 2011). Participatory research may be initiated and/or led by an academic research institution with community partners (see community–academic partnership) or initiated and/or led by members of the affected community themselves (see community-driven research, community-owned and -managed research).
Community-based participatory research (CBPR)	Community-based participatory research emphasizes community involvement in determining the issue addressed through the research, the design and process of research, and action to effect change as a part of the research process (Israel et al. 2012; Wallerstein et al. 2017).
Participatory action research (PAR)	Participatory action research involves researchers and participants working together to understand a problematic situation for participants and act to improve the situation. Methods are context-specific and iterative throughout the research process, relying on a cycle of reflection and action. Through this process, participants gain access to power and increased control of their lives. (Baum et al. 2006; Friere 1970).
Community-engaged research (CEnR)	Community-engaged research involves researchers working collaboratively with and through groups of people affiliated by location, interest, or their position to address relevant issues. It is typically initiated by academic researchers and centered on scientific questions, with publication and dissemination of results often being the final desired outcome. However, community partners may identify new questions or inform the research process in a variety of ways. (Michener et al. 2012; O'Fallon and Finn 2015). Community engagement may happen at various levels, from community outreach to shared leadership (See McCloskey et al. 2011, p. 8; Figure 1.1. Community Engagement Continuum).
Community-driven research (CDR)	Community-driven research is defined where community members affected by a suspected or identified problem initiate the research effort to address this problem (Eisinger and Senturia 2001; Wing 2002).
Community-owned and -managed research (COMR)	The community-owned and –managed research approach builds on the principles of CBPR and CDR, but is defined by community ownership and management at each stage of the research process, including community members or staff at a community-based organization acting in the roles of principal investigator(s) and project manager(s) (Heaney et al. 2007, 2011; Wilson et al. 2008).
Citizen science (CS) *Also referred to as* civic science, volunteer monitoring	Citizen science is scientific research conducted with non-professional volunteers, who may contribute to data collection, data analysis, or generation of theory or hypothesis. CS is a term more commonly used in ecological research, although may employed in environmental health research (Bonney et al. 2014; O'Fallon and Finn 2015; Ramirez-Andreotta et al. 2014b). Similar to CEnR, CS projects may involve varying levels of community participation, from "contributory" to "collaborative" (Haklay 2013; Shirk et al. 2012).
Photovoice/videovoice	Photovoice enables community members to document their own reality through providing cameras and uses community photographs or videos to both identify relevant problems and prompt public dialogue. It relies on the immediacy of visual evidence to promote discussion and action (Catalani and Minkler 2009; Wang and Burris 1997).
Participatory geographic information systems (PGIS)	PGIS use geographic information technologies with the aim of creating community-centered spatial information gathering, awareness, and decision making. PGIS attempts to reverse the trend of inequitable access to GIS technologies through using more inexpensive and accessible 3D mapping and modeling tools. (Corbett and Keller 2005; Jiao et al. 2015; Radil and Anderson 2018).
Community–academic partnership; *also referred to as* Community–university partnership, community–academic collaboration	Any partnership between an academic institution and a community-based organization or group may be defined as a community-academic partnership. These partnerships are typically centered on a shared goal, may share a funding source to pursue that goal, and may formalize their working relationship through an interorganizational agreement and/or committee with representatives from all partnering organizations (Brush et al. 2019; Coombe et al. 2020).

Based on established literature on participatory research for health (Farquhar and Wing 2011; Israel et al. 2012; O'Fallon and Dearry 2002; Wallerstein et al. 2017), "participatory research" was defined in this review as community members being engaged in one or more of the following: formulating the research question, developing research methods or tools, or interpreting results. Within these parameters, case studies of varying methodologies and levels of community involvement were included. However, this definition served to exclude projects with limited community involvement, such as community outreach (McCloskey et al. 2011), crowdsourcing (English et al. 2018), 'contributory' citizen science (Shirk et al. 2012), or 'Level 1' citizen science (Haklay 2013). In case studies, this study selection process often mandated full review of the methods section to interpret the type and level of community participation. Articles were excluded if they did not involve EJ community members as defined above or did not provide sufficient detail about participatory methods to inform the research question.

Data Extraction and Analysis

Following the steps of CIS, reviewed studies were translated into each other to produce a summarized account of the content and then compared and contrasted in relation to study contexts to interpret "synthetic constructs," which allowed contrasting aspects of a phenomenon to be unified and explained. From the assembly of synthetic constructs, the evidence and its underlying contexts were used to build "synthesizing arguments" that theorize the phenomenon (Dixon-Woods et al. 2006). Additionally, literature was reviewed critically, in this case by questioning the assumptions, methods, and measures of success of participatory research (Dixon-Woods et al. 2006; Flemming 2010).

After the most recent 100 records were independently reviewed by each author, the authors met to discuss emerging themes and create an initial set of synthetic constructs. A codebook was built around these constructs and was revised inductively throughout the review process as new elements emerged. This final codebook (Table S1) was then used by the first author and a trained research assistant to code all literature, with frequent discussion with the second author throughout the review process. Disagreements were resolved by consensus and by regular comparison of theoretical structures against primary source data. All data was organized in Microsoft Excel (Excel Table S1). When more than one article addressed different aspects of the same research study or partnership, these documents were combined for coding to avoid data duplication. When single articles described multiple case studies, reference chaining and Internet search was used to locate source material for case studies when available.

Mixed methods analysis informed study findings. All included case studies and theoretical articles were reviewed in accordance with established methods for qualitative research (Creswell and Poth 2017; Scammell 2010; Tracy 2010), and unique contextual details, challenges, or novel ideas were recorded as notes. Synthetic construct codes were analyzed for frequency in all case studies and theoretical articles (Table S1; Excel Table S1). Case studies which resulted in structural change to benefit the EJ community were synthesized as a group (Excel Table S2) and compared to the "nonstructural change" case study group. Statistical correlation between study design elements and a structural change outcome was analyzed using the Phi test for correlation in SPSS software (SPSS 25; IBM). Results from these quantitative analyses added understanding to the network of synthetic constructs and relationships between them, and led to the development of a comprehensive theoretical framework, or synthesizing argument, to theorize the mechanisms for participatory research with EJ communities to result in structural change.

Results

Literature Search Results Summary

Figure 1 illustrates the process of identifying and screening literature using a flow diagram modified from Moher et al. (2009). Of 505 total records identified, 232 case study articles representing 154 unique case studies, and 55 theoretical articles were included for data extraction. Publication dates of included literature spanned from 1992 to 2020 (Excel Table S1). However, 60% (172 out of 287) were published since 2014, suggesting a recent increase in the publication of participatory approaches in EJ and environmental health contexts.

Literature was coded within the synthetic constructs developed: *a*) study characteristics; *b*) participatory study design elements; *c*) study outcomes; and *d*) challenges described (Table S1). The frequencies of study design elements observed in case studies without structural change outcomes and case studies with structural change outcomes, as well as correlation of study design elements to structural change, are outlined in Table 2. Table 3 summarizes the most frequently observed best practices for participatory research in environmental health as expressed in theoretical articles, and Table 4 summarizes frequency of challenges expressed in case studies and theoretical articles.

This review illuminated the variety of methodological terms used in participatory research because at least 20 unique methodologies were represented in the literature reviewed. However, 35 studies were excluded from review because their described methods did not meet set criteria for participatory research (community involvement in research question, study design, or interpreting results), despite use of a participatory methodology term in the title, abstract, or keywords. In some cases there appeared to be conflation of participatory methods with methods that collect community input (e.g., Severtson et al. 2002), engage community members in activities (e.g., Hou et al. 2020), or take environmental samples from people's homes (e.g., McCauley et al. 2001).

Funding sources most frequently acknowledged by case studies included for review ($n = 154$) were the National Institute for Environmental Health Sciences (NIEHS) (29%) and the U.S. Environmental Protection Agency (U.S. EPA) (17%) (Excel Table S1). No correlations were observed between funding sources and structural change outcomes. Case studies aimed to address diverse environmental health risks, with industrial facilities being the most frequently cited concern (31%), followed by transportation-related pollution (19%) (Excel Table S1). Notable is that 40% of case studies described social determinants of health as a compounding risk to community members (Excel Table S1). In several projects, social determinants of health such as poverty (Austin 2010) or social stigmatization (Málovics et al. 2019) were cited as the primary health concern.

Because different participatory methodologies may dictate different goals, stated goals of reviewed projects varied widely, from assessing community health concerns, to improving risk communication, to fighting a facility siting decision. Consequently, a wide range of project outcomes were observed (Figure 2). The most frequently described outcomes in case studies included for review ($n = 154$) were participants gaining increased understanding or awareness of environmental health risks (73%) and identifying specific environmental health risks (69%). Twenty-six studies (17%) were coded as resulting in structural change (Excel Table S2).

Participatory Research Design for Structural Change

Table 5 summarizes four of the 26 identified case studies resulting in structural change, to illustrate the range of contexts, activities, and resulting actions represented. Determining evidence of

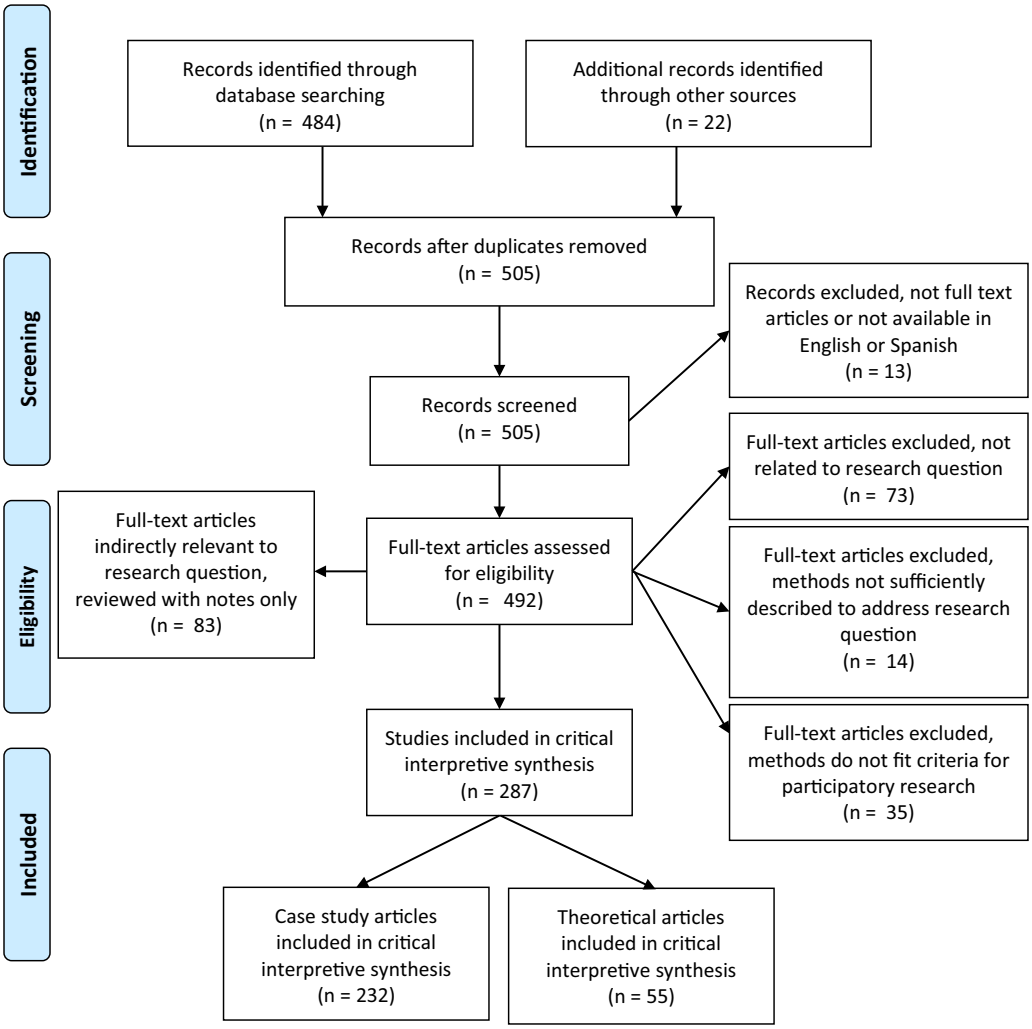

Figure 1. Review flow diagram.

structural change in case studies was sometimes difficult, because the source of environmental health risk may be a culmination of small point sources (Lejano and Smith 2006), legacy pollution (Eggers et al. 2015), or socially constructed (Masuda et al. 2012). Additionally, multiple layers of regulatory and enforcement agencies may be involved. As an example, Dhillon 2017 described a community-driven citizen science and advocacy project to fight the siting of an industrial waste facility. Although the EJ group "lost" when the facility siting was ultimately approved, five of the six demands made by the group were met in the approval process, and all city council members who had supported the siting were defeated in the next election cycle. In a participatory research project with waste pickers in Brazil, Gutberlet and Uddin (2017) described a recycling cooperative to promote and enforce health safety measures emerging concurrently with the study. Though the formation of this group was separate from the activities of the project, it is possible, though difficult to determine, that the project influenced it. Minkler et al. (2010) summarized the ongoing enforcement difficulties experienced after policy wins in two EJ projects: "In both Old Town National City (OTNC) and West Oakland, CA, United States, for example, a policy win (OTNC's amortization ordinance and West Oakland's 2006 truck ordinance) proved difficult to enforce due to either zoning that precluded enforcement or inadequate staff for providing oversight. In New York City, the WE ACT partnership's successful efforts to help close a bus depot in Northern Manhattan (which was home to seven of the City's eight depots) similarly were described as involving a shell game, with the City soon opening another depot in a different part of this community" (p. 809). In case studies, evidence of structural change was assessed to the extent possible, recognizing the dynamic nature of ongoing power and policy shifts.

Of the 26 case studies resulting in structural change, 20 (73%) involved policy changes. In only one case study (Castleden et al. 2017) was the polluting industry responsible for the source of health risk held accountable financially. In several case studies reviewed (Grineski 2006; Spencer-Hwang et al. 2016), the EJ partnership received significant grant funds to instate protective measures (e.g., vegetative barriers, air filters in schools) against polluting facilities, likely because this strategy was more practical, with more immediate harm reduction, than attempting litigation. Although these outcomes undoubtedly result in community benefit, they were not categorized as "structural change" here, because the polluting entity and relevant policy makers were not held accountable. In a parallel example, Brenner et al. (2003) described researchers and partnering health centers successfully lowering pesticide exposure of pregnant women in East Harlem, New York, apartment buildings, in part by sealing cracks where pests could enter. This strategy was successful in reducing risk, but deferred responsibility for basic building maintenance from the landlord to health organizations.

Table 2. Frequency and correlation to structural change of case study design elements.

Study design element	Definition	*n* (%) Case studies with no structural change outcome ($n = 129$)	*n* (%) Case studies resulting in structural change ($n = 26$)	Phi correlation (ϕ) and significance (p) to structural change ($n = 154$)
Study characteristics				
Project/partnership duration >4 y	Project or partnership continued for more than 4 y.	30 (23%)	16 (62%)	$\phi = 0.272$ $p = 0.001$
More than one source of data collected	More than one source of data (e.g. mapping and interviews) were collected.	68 (53%)	20 (77%)	$\phi = 0.081$ $p = 0.313$
Qualitative and quantitative data collected	At least one quantitative and one qualitative source of data (e.g. air quality measurements and focus group data) were collected.	43 (34%)	13 (50%)	$\phi = 0.046$ $p = 0.565$
Project initiation and community engagement				
Community-directed	Community members self-organize to pursue a research question. May recruit a research institution partner or operate independently of a research institution.	18 (14%)	12 (46%)	$\phi = 0.304^{**}$ $p = 0.000$
Research question informed by local knowledge	Research question informed by members of the participant community, and their knowledge or concerns.	76 (59%)	26 (100%)	$\phi = 0.285$ $p = 0.000$
Study design informed by local knowledge	Study design informed by members of the participant community, and their direct input.	83 (65%)	24 (92%)	$\phi = 0.191$ $p = 0.018$
Cultural membership of academic researchers	Staff (or student-staff) at academic institution includes at least one member of the participant community or shares key identity aspects with the participant community.	34 (27%)	10 (38%)	$\phi = 0.099$ $p = 0.221$
Engagement staff	Project staff (often through a CBO) act as recruitment/engagement agents as their primary job role. Includes *promotoras*/community health workers.	43 (34%)	14 (54%)	$\phi = 0.157$ $p = 0.051$
Culturally relevant research tools	Authors describe intentional decisions related to participant research tools to align with local culture, language, values, and technology use within participant community.	73 (57%)	17 (65%)	$\phi = 0.058$ $p = 0.474$
Community members hired	Members of the participant community are hired as paid project staff. May be hired through organizational partner.	29 (23%)	7 (27%)	$\phi = 0.038$ $p = 0.639$
Monetary compensation	Participants are paid (cash or gift cards) for participation. Hiring community members as paid staff or granting stipends for project work not included here.	27 (21%)	5 (19%)	$\phi = -0.017$ $p = 0.831$
Organizational partners				
Formal participant leadership structure	Study includes organizing participant leadership, through a collaborative steering committee, community council, community review board, etc.	39 (30%)	19 (73%)	$\phi = 0.329^{**}$ $p = 0.000$
Partnership with CBO	A partnering CBO is involved in any number of project activities, which may include recruiting participants, informing study design, collecting data, training or education, data dissemination activities, or related policy advocacy.	76 (59%)	21 (78%)	$\phi = 0.161$ $p = 0.046$
School partner	E.g., school(s) collaborate to recruit participants, train students to collect data, provide course credit for study participation, or provide venues for project meetings or events. May include colleges but does not include primary research institution(s).	29 (23%)	7 (27%)	$\phi = 0.038$ $p = 0.639$
Data translation and policy engagement				
Community-centered data report-back	Data report-back is designed and facilitated to maximize accessibility to participants and to provide tools for understanding root causes of problems and possible actions to protect health.	79 (62%)	16 (62%)	$\phi = -0.001$ $p = 0.986$
Data translation for public action	Researchers "translate" data into appropriate forms (maps, statistics, creative visual forms, etc) needed to effectively communicate findings to decision-makers, the public, or media outlets.*	40 (31%)	13 (50%)	$\phi = 0.148$ $p = 0.067$
Decision-makers engaged in research process	Decision-makers (government officials, industry stakeholders) are involved in the research process (e.g. as participants, members of a planning/steering/advisory committee, attendees at presentations).	34 (27%)	19 (73%)	$\phi = 0.367^{**}$ $p = 0.000$

Note: CBO, community-based organization. *Data translation for participants was considered "Community-centered data report-back" and coded in the category above. Indicates moderate correlation ($p < 0.05$, $\phi > 0.2$) between study design element and case study group resulting in structural change, compared to the group of case studies with no structural change outcome, as determined by the Phi test for correlation. **Indicates strong correlation ($p < 0.01$, $\phi > 0.3$) between study design element and case study group resulting in structural change, compared to the group of case studies with no structural change outcome, as determined by the Phi test for correlation.

Table 3. Most frequently observed best practices for participatory research with EJ communities recommended by theoretical articles.

Study design element	Definition	*n* (%) Theoretical articles recommending (*n* = 55)
Project initiation and community engagement		
Community-directed	Community members self-organize to pursue a research question. May recruit a research institution partner or operate independently of a research institution.	21 (38%)
Research question informed by local knowledge	Research question informed by members of the participant community and their knowledge or concerns.	24 (44%)
Study design informed by local knowledge	Study design informed by members of the participant community, and their direct input.	34 (62%)
Cultural membership of academic researchers	Staff (or student-staff) at academic institution include at least one member of the participant community or share key identity aspects with the participant community.	24 (44%)
Monetary compensation	Participants are paid (cash or gift cards) for participation. Hiring community members as paid staff or granting stipends for project work not included here.	30 (55%)
Data translation and policy engagement		
Challenges official knowledge	Data produced suggests different conclusions from those communicated by "official" sources (e.g., regulatory agency or industry).	38 (69%)
Data translation for public action	Researchers "translate" data into appropriate forms (maps, statistics, creative visual forms, etc.) needed to effectively communicate findings to decision makers, the public, or media outlets.	40 (31%)
Decision-makers engaged in research process	Decision-makers (e.g., government officials, industry stakeholders) are involved in the research process, e.g., as participants, members of a planning/steering/advisory committee, attendees at presentations, etc.	19 (35%)

Note: Data translation for participants was considered "Community-centered data report-back" and coded as such. EJ, environmental justice.

The comparisons between case studies that did and did not result in structural change, synthetic constructs and their relationships, and data contextualized within primary source documents led to the creation of a synthesizing argument, described in detail below. This argument posits that participatory research with EJ communities may be more likely to result in structural change when *a*) community members hold formal leadership roles; *b*) project design includes decision-makers and policy goals; and *c*) partnerships are designed to sustain multiple years through multiple funding mechanisms. In addition, the assumption of community benefit via participation is critically examined.

Community Members as Leaders

In the words of community scientist Wilma Subra, "Citizen science only works when the community needs information. . .when a community invites you in, and says, please help us understand what is going on - that community will probably be very open to citizen science *as it applies to their situation*" (Sullivan and Parady 2018). Notably, 100% of studies that described structural change outcomes (*n* = 26) started with local knowledge informing the research question (Table 2). Additionally, EJ community members held leadership roles in all studies resulting in structural change (Table 2), though in diverse ways, including: *a*) project management by a community-based organization or group (e.g., Heaney et al. 2007, 2011); *b*) community members hired as paid project staff (e.g., Cantu et al. 2016; Evans-Agnew et al. 2018; Jelks et al. 2018; Lewis et al. 2016; Lichtveld et al. 2016b; Staudt et al. 2016; Teedon et al. 2015; Warren et al. 2014); *c*) community advisory boards (e.g., Ablah et al. 2016; Acosta et al. 2015; Claudio et al. 2018; Farquhar et al. 2013; Haynes et al. 2011; Schwartz et al. 2015); or *d*) cultural/community membership among the academic researchers (Málovics et al. 2019). Strong statistical correlations were observed between structural change outcomes and the following key characteristics of partnerships and participatory approaches: *a*) projects being community-directed (later referred to as community-directed research); and *b*) formal participant leadership structures (Table 2).

Table 4. Frequency of challenges described.

Challenge	Definition	*n* (%) Case studies describing theme (*n* = 154)	*n* (%) Theoretical articles discussing theme (*n* = 55)
Time intensive	Authors comment on time intensiveness of activities related to participatory method.	64 (42%)	4 (7%)
Recruitment challenges	Authors describe challenges in recruiting participants. May describe modifications made in recruitment methods or goals based on initial challenges encountered.	22 (14%)	5 (9%)
Trust barriers	Authors describe encountering some distrust of scientists, science, regulatory agencies, or researchers within participant community.	26 (17%)	10 (18%)
Receiving data concerns	Members of participant community express concern about receiving results (e.g., low contamination results could undermine a local claim, high contamination results could hurt business/ property values).	7 (5%)	20 (36%)
Data validity questioned	Decision maker(s) question the validity of data produced through participatory or "nonprofessional" methods.	7 (5%)	18 (33%)

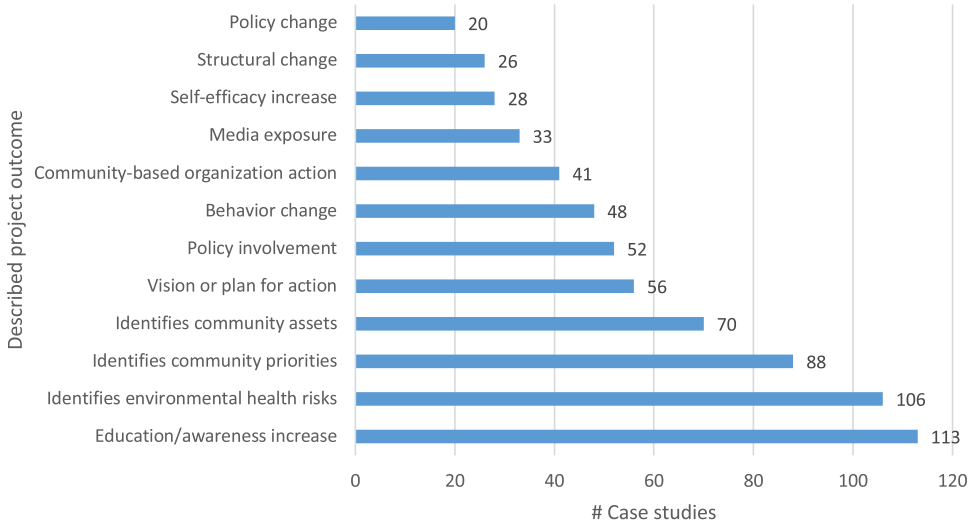

Figure 2. Frequency of case study outcomes described. Project outcome categories are defined in Table S1. Literature review codebook.

Both the critical importance of community-based organizations (CBO) partnerships (Tables 2 and 3) and the challenges of establishing equity in CBO partnerships were frequent themes (Table 4) (e.g., Garzón et al. 2013; Loh et al. 2002; Parker et al. 2010; Quach et al. 2015; Quigley et al. 2000; Robottom and Colquhoun 1992; Wilson et al. 2014, 2017). Cultural differences, social inequities, and the assumption and subsequent resentment that research institutions have "billions and millions of dollars" (Goldberg-Freeman et al. 2007) were cited as potential reasons for trust barriers between researchers and CBO staff (Brush et al. 2019). Even when project funding is distributed fairly, structural inequities may loom in the background (Ortiz et al. 2020; Wilson et al. 2014). As Quandt et al. (2001, p. 437) reflected on a past partnership: "Although the grant that funded this collaboration paid the research expenses (including salary, travel, phones, supplies) for each partner, the differences in infrastructure were striking. The academic partners had secretaries and accountants who managed the paperwork. They had comfortable offices with reliable heating, cooling, and plumbing. They had computer-support personnel to keep their computers running and up-to-date. They had email and sophisticated telephone message systems. They had libraries. The community partners, in contrast, had offices in a rented storefront. The same people who worked on [the project] interviewing and developing interventions also wrote proposals to bring funding to the organization and pay salaries. They were responsible for paying the bills and writing the checks that kept their organization running. In addition, when there was work to do maintaining the equipment and facilities, staff members had to do it."

In effort to address this organizational inequity, Wilson et al. (2017) recommended sharing indirect cost rate (IDC) agreements with CBO partners to support the added administrative burden. Interorganizational memorandums of understanding (MOUs) were also widely cited as an effective strategy for developing mutual understanding of roles and responsibilities upfront, avoiding later misunderstanding and mistrust (e.g., Meyer et al. 2018; Suarez-Balcazar et al. 2005; Williams et al. 2010). De Marco et al. (2014) reflected, "Community partner capacity building should be one of the primary aims and budgeted items in a community–academic research partnership," suggesting the shared benefits of ample compensation for community partners in project budgets. Multiple resources offer further guidance and tools for maintaining authentic, equitable academic-community partnerships (Brush et al. 2019; CCPH 2013; Loh 2016; Suarez-Balcazar et al. 2005; Wilson et al. 2014), with further resources currently in development by the U.S. Citizen Science Association's Environmental Justice Practitioners Working Group (Shirk 2020).

Cases studies that involved hiring community members at the academic institution as project staff reported both the invaluable benefits and challenges due to some unpredictable life stressors affecting the EJ community (e.g., Jordan et al. 2000; Lewis et al. 2016; Lichtveld et al. 2016b; Wilson et al. 2017). Abara et al. (2014) reflected on their choice to recruit staff and volunteers from the partnering community as "instrumental in gaining acceptance, alleviating community concerns, enhancing community empowerment, and improving the likelihood of success of initial and long-term recovery efforts." Downs et al. (2010), reflected after their project that hiring several committed community residents in paid positions would have offered "the best chance of weighing [the project's] benefits and harms" and likely would have improved community engagement. Crowe et al. (2008) described concern that they may be "asking too much of community members," who are already juggling multiple responsibilities, by asking them to take on larger project roles. Pandya (2012) supports this assumption that EJ community members' competing demands on time and resources pose major barriers to participation in research and advocacy. Providing paid project roles, which could replace the need for other paid work, addresses this obvious barrier. As compensation of community members in research may raise ethics and equity questions, Srinivasan and Collman (2005) drew from three case studies that compensated community staff and participants through pay and/or incentives in their recommendation that community members be involved with decisions around their own compensation to further build trust both with academic partners and within the community group.

Community advisory boards (CABs), committees where community representatives and other project stakeholders inform project-related decisions, also emerged as an effective structure for community leadership (e.g., Claudio et al. 2018; Crowe et al. 2008; Haynes et al. 2011; Parker et al. 2003; Wilson et al. 2017). CABs have been criticized in some cases as being performative, allowing project directors to "check the box" of community engagement by granting community members an "advisory" role with limited influence on project decisions (Community-Campus Partnerships for Health 2007; Newman et al. 2011). The presence of expertise, whether from a research institution, government agency, or polluting industry, can easily overpower community representatives and endanger authentic participatory process

Table 5. Summarized examples of case studies resulting in structural change.

Case study summary 1	
Literature cited	Cacari-Stone et al. 2014; Garcia et al. 2013
Participants & location	Residents of Riverside, Long Beach, Wilmington, and Commerce, with other community partners in Los Angeles, CA, and the surrounding region.
Environmental health stressors	Port of Los Angeles and Long Beach Ports receive 40% of goods imported to the US. Related stressors include multiple railyards, marine terminals, highways with high diesel truck traffic, and noise. Port activities were under-regulated, in part because foreign ships fall outside regulatory jurisdiction.
Recruitment methods	Several events occurred prior to the study (a lawsuit, major newspaper article, creation of a city task force) raised public awareness and concern about port-related pollution. Following these events, USC researchers held a town hall meeting to share their research on air pollution's health effects and hold space for open sharing by participants. At this meeting, representatives from community-based organizations, advocacy groups, and researchers were able to meet and formulate plans for collaboration. Subsequent town halls meetings were held every few years, and cited as a strong method for engagement.
Project design elements & research tools	Primary partners University of Southern California, Occidental College, and Center for Community Action and Environmental Justice, had worked together on previous projects and already had a trust relationship. Collaboration later expanded to include four other partner organizations. USC brought previous non-participatory epidemiological data on health effects of air pollution. Staff trained promotoras and other community leaders (Neighborhood Assessment Teams, or "A" Teams) to conduct traffic counts and measure particulate matter. Additional grant funding solidified collaboration among regional partners and formalized THE Impact Project. Staff conducted participatory education workshops with "A" Team members on air quality and goods movement. "A" Team-produced data and "A" Team members' testimonies were presented at government agency hearings.
Challenges described	Challenges cited include the difficulty of working across multiple policy jurisdictions, and time and resources required by all partners to engage with many stakeholders intensively.
Actions resulting from study activities	Authors described "shifting the policy debate" to include health considerations along with economics in goods movement decision-making. Health-related language was added to official ports and transportation documents. Expansion of a major freeway through the area was delayed to assess and plan for mitigation of health effects. Ports' Clean Air Action Plan (CAAP) was adopted, facilitating policy collaboration between city, regional, state, and federal authorities under the commitment to reduce pollution from ports by 45% within 5 y. THE Impact Project representatives were elected and appointed to related advisory boards, and a government task force. When the CAAP was revised and renewed in 2010, representatives were able to stop the potential passage of a "watered-down" version of the plan, because of their positions on decision-making boards.
Case study summary 2	
Literature cited	Cummins et al. 2010; Eggers et al. 2015
Participants & location	150 households on the Apsaalooke (Crow) reservation, Montana (97 wells sampled).
Environmental health stressors	Uranium in drinking water from residential wells
Recruitment methods	Recruitment was conducted via flyers in public locations, ads in the local newspapers, information tables at community events, and word of mouth. The authors cited personal recruiting through friends and family as "by far the most effective strategy." Recruitment was capped at 150 participants due to budget and time limitations and as this was a sufficient sample for analysis. The project steering committee members, primary project coordinator, and students/interns facilitating the project are all Crow tribal members.
Project design elements & research tools	Project design and decisions were guided by the Crow Environmental Health Steering Committee (CEHSC) members, an active local group of tribal members with environmental, health, social and cultural expertise, in partnership with students from a local college and a local university. Study combining well water testing for uranium and other analytes with homeowner surveys and secondary health and economic data. The project coordinator met each participant at their home, explained the project, answered questions, and collected well water samples for microbial and chemical analyses. Participants received a stipend and a follow up visit to discuss test results and treatment options. Spatial distribution of well water contaminants and local surface water samples was mapped using GIS to better assess risk and mitigation. Report back to participants included a spreadsheet comparing their well water contaminant concentrations, with EPA standards and a letter reviewing and explaining their well water test results. Ongoing project results and GIS maps of well water contaminants were reviewed and discussed regularly at CEHSC meetings and were presented to several other local groups and at a larger Crow community forum. A poster displaying maps and explaining the health risks of uranium was prepared and displayed at local health fairs and in the Crow Agency project office. Several two-day professional development workshops on local water quality were held for local K–12 teachers. Presentations were also given in school classrooms and at health fairs.
Challenges described	Homes were as far as 121 km (75 mi) away, and participants were often only available in the evening, making home visits more difficult to arrange. Well water was tested only for total dissolved uranium. The authors note that particle-bound uranium may also be present in well water, which would demonstrate different test results as far as exceeding safe standards. Uranium is likely produced by natural sources, perhaps exacerbated by human activity, thus difficult to mitigate at the source.
Actions resulting from study activities	A university faculty member, also a Crow tribal member, is described as leading an environmental health literacy campaign with fourth graders, focused on surface and groundwater stewardship, and well and septic system care. GIS maps were shared with the Environmental Health Department, which contracts to drill wells for well owners. The CEHSC and project staff continue to work on assessment, communication, and mitigation of health risks from contaminated well water; including access to safe drinking water and promoting environmental health literacy, pursuing additional grants to fund well water testing and health screenings for adults with a history of consuming contaminated well water, and new research regarding how climate change impacts health risks from waterborne contaminants. Project data were provided to the Crow Tribal Council at the request of the Tribal Chairman, to the Crow Tribal Environmental Protection Department and to the local wastewater authority, which subsequently was able to raise funds to install an automated water dispensing system, which allows rural residents to purchase municipal water at very low cost.

Table 5. (*Continued.*)

Case study summary 3	
Literature cited	Allen 2018; Cohen et al. 2018
Participants & Location	816 households of the Étang de Berre industrial region in Marseille, France.
Environmental health stressors	Hundreds of chemical, gas, and steel facilities, including almost 50 Seveso high-hazard threshold facilities. Previous state-sponsored health studies had found absence of elevated health problems in region despite local claims. Residents had attempted to get health data from health agencies, but information was not made available.
Recruitment methods	Researchers knocked on doors based on random sampling of a cross-section of households two towns in the industrial area. If no one was home, a flyer was provided with information to participate online or by phone.
Project design elements & research tools	Prior to the study, researcher conducted 45 semistructured interviews with diverse local stakeholders around policy-relevant science and resident participation or exclusion in science/policy processes. Hired project manager who was native to the industrial region as primary communicator with participants. Conducted door-to-door survey to discuss household health issues, designed specifically to honor local knowledge. Held open data report-back meetings, and 30 smaller (5–10 people) focus groups. Focus groups included local doctors who co-interpreted survey data with residents and collectively brainstormed actionable next steps. Participants discussed cleaner industrial processes and cumulative impacts of siting and permitting decisions.
Challengesdescribed	Previous health studies had used tightly-constructed questions that had not allowed for residents' lived experiences or concerns to be expressed, which is a potential reason for the lack of previous findings.
Actions resulting from study activities	Survey results showed regional asthma rates to be significantly higher than the rest of France, conflicting with findings of previous studies. The mayor of one participating town used study data to insist on greater scrutiny in repermitting a nearby industrial incinerator and attempt to stop the expansion of a commercial incinerator. The final study report prompted news articles, reports, and podcasts highlighting the findings. Media coverage included interviews with local residents who "'owned' the data, understood and were comfortable talking about the science, and the findings aligned with what they knew to be true in their daily lives" (p. 963). For the research team's next project, they plan to conduct a training on community-based environmental health research and strongly participatory health science methods, so that similar studies can be conducted by local residents in collaboration with local scholars, thus more accessible and affordable.
Case study summary 4	
Literature cited	Dhillon 2017
Participants & location	Resident-participants of a grassroots EJ group in Los Angeles, CA.
Environmental health stressors	New waste facility siting decision.
Recruitment methods	Author documented activities of self-organized residents as an EJ group against the approval of a new regional waste transfer station. Group included members of local organizations such as unions, schools, non-profits, and faith-based groups, and individuals; from a variety of racial, ethnic, and socio-economic backgrounds.
Project design elements & research tools	EJ group organized residents and met with city leaders and the waste company. EJ group made presentations and educated the community on potential environmental health issues, concisely summarizing information in English and Spanish. Group members reviewed technical documents EIR and ESAs including researching significant health impacts in the EIR. An environmental health expert cross-checked their conclusions and completed peer reviews of the EIR, which highlighted unresolved concerns. EJ group documented the mishandling of hazardous wastes at nearby existing facilities through photos and community mapping project. Group members coordinated with local and regional agencies to acquire secondary environmental data. The EJ group translated all provided technical information into Spanish and made formal requests for translation at public meetings. In all, group activities resulted in the production of map and spatial analysis of existing waste and toxics-related facilities, secondary research review of health effects of contaminants, photos of current material mishandling, resident-produced estimates of large truck traffic and annual waste production which contradicted expert reports, and personal testimonies.
Challenges described	City council did ultimately approve the new facility siting, amid strong public opposition. However, two city council members who supported the project were not reelected and were replaced with two who did not support the siting. This new city council attempted to retract the siting agreement but could not afford the potential corporate lawsuit. The author described "increased respect, recognition, and credibility" achieved through research activities of the EJ group, however the project approval itself reveals limitations on the level of increased recognition." (p. 1489)
Actions resulting from study activities	Participants learned how to understand, interpret, and question an EIR. One participant describes their transition, through doing research, to feeling like an "expert." The EJ group publicly contested the expert-produced conclusions from the EIR and ESAs using local knowledges through scientific translation, their own experiences and calculations, and community mapping and photos. The data, photos, report summaries, and maps produced by the EJ group provided effective content for public testimonies at hearings and more than 6,000 opposition letters to the city council. Subsequent city council elections favored candidates who sided with the EJ group. The EJ group and community supporters established themselves as a political power. As one participant stated: "The next time we show up, they're going to look and say, 'Do we really want to fight another long campaign like that one?'"

Note: EIR, environmental impact report; EJ, environmental justice; ESA, environmental site assessment.

(Mah 2017; Ottinger 2013; Scott 2016). With careful facilitation and authentic leadership, however, CABs may create a space where EJ community members practice collaborative governance with other stakeholders, including policy makers and industry representatives (González n.d.; Yuan et al. 2020). By performing as peer board members and colearning within the research project context, EJ community members, academic researchers, and policy makers have the opportunity to build relationships across cultural divides that influence long-term outcomes (Cramer et al. 2018; Newman et al. 2011; Yuan et al. 2020).

Unlike contributory citizen science project participants, who are predominantly white and college educated (Evans et al. 2005; Pandya 2012), nearly all participant communities in case studies reviewed here are low-income communities of color. However,

representation from EJ communities is not itself necessarily indicative of justice, because participatory research is "grounded in the conscious recognition that historically, and particularly within ethnic minority communities, research has been done on (in contrast to with) communities of color by predominantly white researchers" (Shiu-Thornton 2003). An important aspect is that 44 case studies (29%) reviewed here describe at least one researcher (faculty, staff, or student) as sharing community membership or key identity traits with the participant community (e.g., deLemos et al. 2007; Schwartz et al. 2015). In these cases, the researcher may play a dual role, representing both the academic institution and the community identity (Dwyer and Buckle 2009; Muhammad et al. 2015). Pushing back against the insider–outsider paradigm, recent research recognizes the complexity and fluidity of researcher identity in community contexts (Merriam et al. 2001; Serrant-Green 2002).

Opening the Policy Window

In case studies resulting in structural change ($n = 26$), 81% collected data from more than one source, 50% collected both quantitative and qualitative data (such as personal stories and air quality measurements), and 50% engaged in data translation for decision makers (Table 2). This finding suggests the importance of data communication and translation to prompt structural action. Participatory research values multiple knowledges, including indigenous and nonwestern forms of knowledge, which are often absent from modern decision-making spaces (Abma et al. 2017; Corburn and Gottlieb 2005; Duntley-Matos et al. 2017; Finn et al. 2017; Houston 2013; Moezzi et al. 2017; Ottinger 2017; Scott 2016). Translation of nonwestern forms of knowledge, or qualitative data, into forms perceived as more legitimate, like statistics, maps, and economic analyses, allows academics with the credentials of the research institution to present community knowledge so that it wields power (Jelks et al. 2018; Krings et al. 2018; Ottinger and Sarantschin 2017; Senier et al. 2008). Additionally, EJ communities face "hermeneutic injustices" (Ottinger 2017), where provided expert data are written in technical language that community members cannot feasibly make meaning from. Decoding relevant policy allows community members to enter policy discussions using their own words and experiences, effectively participate in public debate, and propose informed policy change (Bäckstrand 2004; Burris et al. 2016; Dhillon 2017; Heaney et al. 2011; Tajik and Minkler 2006). To further leverage the power of scientific data for structural change, however, broader data translation or employing "data interoperability" (Gobel et al. 2017) is often necessary to decode data to inform both public action and policy action by decision makers (Corburn 2002; Petersen et al. 2006; Ramirez-Andreotta et al. 2014a).

Comparing environmental monitoring data against regulatory standards has been used to effectively communicate risk and advocate for change (Ottinger 2010; Sandhaus et al. 2018). However, established standards may not exist for many environmental contaminants, increasing the challenge of effectively translating data for action (e.g., Brody et al. 2007, 2014; Emmett and Desai 2010; Ponder-Brookins et al. 2014; Quandt et al. 2004). Researchers with technical literacy, access to secondary data to contextualize information, and understanding of community literacies and narratives, are well positioned to "translate" official data for public audiences (e.g., Dhillon 2017; Minkler et al. 2010). Some case studies demonstrated disseminating translated data through media sources to promote public discussion and political pressure (e.g., Akom et al. 2016; Allen 2018; Cohen et al. 2016; Madrigal et al. 2014, 2016; Tajik and Minkler 2006; Teixeira and Sing 2016). In these examples, public concern raised about an issue placed pressure on decision makers to ultimately influence action.

Moderate correlation was observed between structural outcomes and engaging decision makers in the research process (Table 2). In examples, decision makers may have been involved as project partners (e.g., Jiao et al. 2015; Wier et al. 2009) or through participation in data-sharing events to increase their understanding and trust of the data (e.g., Brickle and Evans-Agnew 2017). Grineski (2006) describes a study culminating in a one-day conference for local residents and stakeholders, including industry officials and policy makers, where residents hosted a "toxic tour" of environmental health stressors in the neighborhood and publicly shared stories about health issues in their household in tandem with researchers' presentation of study results.

Of the 19 case studies that successfully achieved policy wins (Table 2), policy-related activities and goals were included in project planning. Some case studies began by assessing policy feasibility in tandem with environmental health risks (Keune et al. 2010), whereas others began with specific policy objectives (Minkler et al. 2010; Parker et al. 2010; Stokes et al. 2010; Tajik and Minkler 2006; Wier et al. 2009). Evidenced in the both the case studies and theoretical literature (Table 4), policy change through participatory research demands extensive time, energy, and long-term commitment to maintaining policy enforcement (Cacari-Stone et al. 2014; Corburn 2007; Miller et al. 2013; Minkler et al. 2006; Petersen et al. 2007). Coombe et al. (2017) described experience from the Detroit Urban Research Center partnership in informing the recommendation that EJ projects focus on the more attainable "little p" policy, such as administrative rules, local enforcement, and city budgets, rather than "big P" policy, such as state and federal legislation. Of case studies reviewed here that resulted in policy change, the majority affected policy at the city, county, or school district level.

In the examples above, catalyzing policy change is a nonlinear process, because external factors are constantly shifting. Like social movements (Brown et al. 2010; Engler and Engler 2016), EJ partnerships succeed by working on various fronts simultaneously, such as building personal relationships with key stakeholders, educating the public through media campaigns, and producing strategic public demonstrations, to create the environment where policy change and power shifts are possible (Cacari-Stone et al. 2014; Minkler et al. 2010). Felix (2007) discussed how the convergence of multiple "policy streams" (Kingdon 1984), such as leadership change or high visibility events can create a "policy window" for environmental health action. To prepare for policy window opportunities, researchers and partners may conduct power mapping and policy analysis and remaining observant and reflexive as policy streams shift (Minkler et al. 2006; Petersen et al. 2006; Stokes et al. 2010). For example, Garcia et al. (2013) described a high-profile lawsuit and media piece that raised public concern about local air quality and quickly garnered support for local policy. Researchers were able to mobilize quickly due to previously established partnerships with a community organization and a mayor, who were committed to air quality issues, to influence public discussion. Four years later, when a new mayor was elected with an even stronger commitment to addressing local air pollution, their policy goal was able to shift from "no net increase" to the more ambitious "decrease pollution 45% in the next 5 years," which ultimately passed.

Long-Term Commitment

Moderate correlation was observed between structural outcomes and project partnerships lasting more than 4 y (Table 2). In 42%

(64 out of 154) of case studies reviewed, however, time required for true participatory processes was described as a challenge, indicating the time investment may have exceeded what was initially expected (Table 4). Some described iterative changes in project timelines to honor the needs of community partners or participants, which lengthened the planned project timelines (e.g., Brown et al. 2012; Cashman et al. 2008; De Souza et al. 2013; Downs et al. 2010; Johnson et al. 2014; Johnson-Shelton et al. 2015; Spencer-Hwang et al. 2016). Drawing from experience, researchers recommended 6- to 12-months minimum to establish collaborative group norms and culture, though building and maintaining trust and relationship may take even longer (Cargo and Mercer 2008; Cashman et al. 2008; Loh 2016). Abara et al. (2014), for example, described a "community-based participatory service" model, where health professionals spent 3 y providing direct services to a rural community following a catastrophic chemical disaster, only shifting toward a research model when community members expressed interest. Madrigal et al. (2014), reflecting on a 15-y partnership with farmworker families, stated that ". . .the slowness of change, and the commitment of participatory research to action for community or social change, means that planning for continuity of involvement beyond the funded project period is critical."

In case studies resulting in structural change ($n = 26$), 16 represented research–action partnerships spanning more than 4 y, with some still ongoing (Table 2), and acknowledge an average of two funding sources per study (Excel Table S2). Notable examples of community–academic partnerships spanning over a decade include the Detroit Community–Academic Urban Research Center (Coombe et al. 2017; detroiturc.org); Low Country Alliance for Model Communities with the University of Maryland (Wilson et al. 2014, lamcnc.org); West End Revitalization Association and researchers at the University of North Carolina (Heaney et al. 2007, 2011; Wilson et al. 2007); the Akwesasne Mohawk Nation and University at Albany, State University of New York (Hoover 2016, 2017; Ravenscroft et al. 2015; Schell et al. 2005); and the University of Texas Medical Branch and EJ communities in Houston, Texas (Pettibone et al. 2014; Sullivan and Lloyd 2006; Sullivan 2019; Sullivan et al. 2008). Despite the often-cited constraint of research grant funding cycles (e.g., Crowe et al. 2008), these partnerships manage to leverage various means of support through different partners applying for grants. Loh (2016) recommended that community–academic partnerships plan activities in multiyear cycles that connect to form partnerships over decades, adding, "Cultivating partnerships over this generational time scale is not unreasonable, given that many faculty careers are even longer, and many community-based organizations have similar longevity. Finally, this longer time frame is necessary to pursue significant community and structural change as well as institutional transformations in the university."

Notably, some case studies evaluated success using indicators of equitable process (Garzón et al. 2013; Van Olphen et al. 2009), which places emphasis on equity as the primary goal of the study, rather than products that benefit the academic institution. Using process benchmarks in grant reporting may help researchers and funders perceive time-intensive participatory activities as achievements of research objectives rather than as barriers to them (Drew et al. 2012). As Cashman et al. (2008) stated, "There are no shortcuts to including both community and academic partners in data analysis, interpretation, or both. Although equitable involvement lengthens project time considerably, the insights gained from juxtaposing different viewpoints should be viewed as milestone accomplishments along the way to outcomes. Methodologies such as visioning workshops, practice sessions on coding, or mapping often lend themselves to brief intermediate action interventions while, simultaneously, overall research processes continue to be carried out. This duality of research and action can help ensure continued community, academic and funding partner engagement" (p. 1415).

Critique of "Participation as Benefit" in EJ Contexts

Ample research supports the benefit to participants in participatory research for environmental health, citing increased understanding of environmental health risks, as well as self-efficacy to address them (Israel et al. 2012; Wallerstein et al. 2017). However, the benefits of understanding or self-efficacy may not outweigh EJ community members' limited time and energy invested, nor provide a clear path to action (Felner 2020). This review illuminated a lack of clarity among researchers as to defining success in partnerships with EJ communities. Goals such as "empowerment" and "community capacity" are subjective and may be perceived differently by community members and researchers (Coombe et al. 2020; Payne-Sturges et al. 2015; Postma 2008). In some cases included here, a study successfully identified environmental health risks or community priorities but described only hypothetical next steps toward addressing them (e.g., Quach et al. 2015). Although research products such as health impact assessments or policy analyses can offer real value, EJ communities may struggle to use these products toward structural change without political power, funding, or lasting institutional partnerships (Bourcier et al. 2015; Payne-Sturges et al. 2018; Scammell and Howard 2020).

This critique aligns with that of other scholars in calling for clear community benefit as a required goal of participatory research with EJ communities (Barzyk et al. 2018; Cordner et al. 2012; Kraemer Diaz et al. 2013; Schindel et al. 2019) and for community member participation in project evaluation (Brown et al. 2012; Haynes et al. 2016; Watkins et al. 2009).

Discussion

Recommendations for Future Research

Leveraging power and privilege. The strong correlation observed between community-directed research and structural change (Table 2) mirrors previous research findings that community-directed research was more likely than research directed by an academic institution to result in responsive action (Cook 2008). Multiple case studies illustrated the diversity of ways academic institutions can take a supportive, rather than leading, role with EJ community environmental health projects (deLemos et al. 2007; Heaney et al. 2007; Hoover 2016; Watkins et al. 2009; Wilson et al. 2007). The spectrum of potential academic–community relationships raises the question of how academic institutions can best leverage their position to authentically benefit EJ communities.

Though this research focused on case studies that successfully resulted in structural change, it was equally important to examine case studies that described strong community participation, rigorous scientific data, and decision-maker engagement, yet failed to systemically address the source of risk (e.g., Ottinger 2013; Scott 2016; Staudt et al. 2016). For example, in the Aamjiwnaang First Nation community near Sarnia, Ontario, Canada, adjacent to dozens of petrochemical and polymer industrial facilities, community members have collected multiple forms of data for over a decade, from air quality measurements through bucket brigades to "spill calendars" that document the frequency of incidental releases. Despite years of formal complaints supported by empirical evidence, the Canadian Ministry of the Environment continues to

approve permits for local polluting industries (Scott 2016; Wiebe 2016). In a Hungarian city, researchers shifted the project focus toward meeting the basic needs of Romani participants and bridging social classes after realizing how extreme social exclusion of this highly stigmatized group left them critically vulnerable (Málovics et al. 2019). In an adapted Photovoice project around health inequities with residents of three Canadian cities, a frequently reported theme indicated that participants, "perceived stigmatization that they felt was imposed by outsiders that limited the ability of their communities to achieve positive neighbourhood change" (Masuda et al. 2012).

These examples suggest it may not always be a lack of data, commitment, or political strategy that prevents EJ communities from making structural change. Rather, it is a deep prejudice, pervasive in many modern decision-making spaces and power structures, that perpetuates the unspoken belief that certain communities are destined to be the dumping grounds of others (Checker 2016; Taylor 2014). Although participatory research may extend the value and uses of science, a diverse toolbox is needed to address the political, economic, and social structures that create disproportionate environmental health burdens for communities of color and communities in poverty (Brown 2017; Corburn 2002; Cordner et al. 2012). Along with technical and scientific knowledge, proximity to the power and prestige of a university may be an invaluable resource for academic allies to leverage on behalf of EJ communities.

Structural change as a measurable goal. Bibliographic search results highlighted some misuse of terms "community-based participatory research" and "participatory research" in the literature when study methods reflected more limited community engagement. Although correct use of methodological terms is critical, less participatory methods, such as community outreach, may certainly be appropriate in certain contexts (McCloskey et al. 2011). Additionally, where individual or household health behaviors are the primary source of environmental health risk, education and behavior change are appropriate end goals for participatory research (e.g., Alamo-Hernández et al. 2019; Evans-Agnew et al. 2018; Zagozewski et al. 2011). However, when risks are caused by external forces such as city planning or unenforced regulation, researchers may more appropriately place the burden of responsibility on the source of risk by including structural change as a research goal.

Results of this study suggest that prompting structural change requires attention and analysis of power dynamics to effectively work toward systemic power shifts. These results inform the recommendation that the following be included in participatory research with an EJ community: *a*) evaluating root causes of identified environmental health risks; *b*) analyzing power and policy structures surrounding the cause of risk; *c*) identifying feasible structural change goals; and *d*) community-driven evaluation to assess community benefit resulting from the project. These recommendations aim to maximize benefits and minimize harms for EJ communities, as well as enhance scientific rigor in participatory research (Schindel et al. 2019). The further development and testing of existing community-based evaluation tools (Brown et al. 2012; Haynes et al. 2016; Watkins et al. 2009) and tools to evaluate structural change outcomes (Asada et al. 2017) advance this effort.

Supported by this research and other research (Balazs and Morello-Frosch 2013; Cacari-Stone et al. 2014; Corburn 2007; Minkler et al. 2006; O'Fallon and Dearry 2002; Wallerstein et al. 2017), achieving structural change may require long-range planning, with process benchmarks related to policy research, strategic relationship building, and community members in leadership roles. Recent case studies involving these study design elements can serve as meaningful models for developing new research partnerships (Coombe et al. 2020; Heaney et al. 2011; Minkler et al. 2008; Petersen et al. 2006; Wilson et al. 2014).

Considering positionality of academic researchers. Challenges related to trust and equity between academic and community partners were often described (Table 4), stemming from the same socioeconomic and cultural divides that perpetuate EJ. Given these pervasive challenges and the relevance of race/ethnicity and socioeconomic position of all actors in EJ contexts, positionality and identity traits of academic researchers are relevant data in EJ community partnerships (Muhammad et al. 2015; Payne-Sturges et al. 2006). Although it is common to describe socioeconomic characteristics of a partnering community in research, it is not standard practice to describe positionality of academic researchers. Reporting on the researchers' race, cultural background, language proficiency, and any personal ties to local context (e.g., Málovics et al. 2019) in research literature may lend validity and transparency to the research.

Although cultural competency training can support academics to work with EJ communities (Quigley 2016), academic researchers may be more effective by also practicing "cultural humility" (Greene-Moton and Minkler 2020) in recognizing that those with some degree of community membership are often better positioned for community engagement roles (Minkler 2004; Stoeker 1999). As previously described, having EJ community members in leadership roles was observed as a factor related to prompting structural change. To further advance community leadership and move toward bridging the academic-community cultural divide, academic institutions may play a powerful role through hiring members of EJ communities and communities of color in faculty and research positions. Because faculty members may represent the "face" of the institution in EJ partnerships, they themselves serve as human "boundary objects" (Akkerman and Bakker 2011; Singh 2011) when identity traits are shared with the community.

The critical role of the knowledge broker has been widely acknowledged in science and health communication (Meyer 2010; Pennell et al. 2013; Ward et al. 2009). However, the role of the cultural broker (Gentemann and Whitehead 1983; Szasz 2001) may be equally critical for researchers in EJ contexts to translate information between disconnected cultures and connect disempowered community members to the decision makers who dictate conditions of their lives. Multiple studies describe the value that faculty of color bring to the institution and provide recommendations for increasing research faculty of color (Antonio 2002; Bernal and Villalpando 2002; Gasman et al. 2011). Acknowledging the additional career pressures on faculty of color (Gutiérrez y Muhs et al. 2012; Matthew 2016) that may dissuade them from pursuing participatory research approaches, it is critical that research institutions formally value their potential role as "cultural knowledge brokers," with understanding of both the community experience and the science, to enhance the rigor and relevance of participatory research.

Notably, not all case studies resulting in structural change here described a member of the research team sharing identity traits with the community, which suggests authentic allyship is possible even across racial or socioeconomic lines. In any relationship between an academic researcher and an EJ community, many scholars echo the importance of engaging with EJ communities personally and politically (Banks et al. 2013; Brown 2013; Brown et al. 2012; Corburn 2017; Fine et al. 2000; Grineski 2006; Quigley et al. 2019; Weed and McKeown 2003). As Finley-Brook et al. (2018) describe, EJ collaborations "deepen and grow where people directly experience injustices and support each other in shared struggle."

Limitations of this Review

The nonemergence of new themes toward the end of the coding process suggested data saturation to adequately address the research questions (Saunders et al. 2018). However, consistent with CIS, this review did not aim to capture all relevant literature, and it is possible that data from omitted sources could have added new dimensions to the theory generated.

This review predominantly draws knowledge from peer-reviewed academic publications and is written for an academic audience, which inherently privileges academic voice and perspective. Notably, the literature included in-depth interviews with community researchers and EJ activists (Sullivan and Parady 2018; Sullivan and Rosenberg 2018b, 2018a), as well as ethnographic accounts of community-driven EJ efforts (Dhillon 2017; Maida 2011). Especially given the correlation observed between community-driven projects and structural change outcomes, future research would benefit from emphasis on nonacademic perspectives in participatory research for EJ.

Conclusion

Participatory research offers a tool to produce community-informed environmental health data that can contribute to structural change that benefits EJ communities. Because the causes of environmental health risk in EJ communities are typically structural, participatory research partnerships are more likely to result in community benefit when structural change is included as a project goal. The synthesizing argument from this review contends that participatory research with EJ communities may be more likely to result in structural change when *a*) community members hold formal leadership roles; *b*) project design includes decision makers and policy goals; and *c*) partnerships are designed to continue over the long term through multiple funding mechanisms. Academic institutions committed to environmental justice may further leverage their position of prestige and privilege through long-term allyship with EJ communities. Recommended future directions include establishing structural change as a goal of participatory research, further development and testing of community-centered evaluation tools to assess community benefit and structural change, and bridging the academic-community gap through hiring members of EJ communities and communities of color in faculty positions. Because environmental injustices persist worldwide, environmental health researchers have a unique opportunity to join and support EJ communities in shared struggle.

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