6

Research Methods and Methodologies

Ryan Petteway, Sarah Commodore, Chad Raphael, and Martha Matsuoka

Community-engaged research (CER) for environmental justice (EJ) employs many methods to measure exposures to hazards, document inequities, represent injustices, and tell the stories of EJ communities. This chapter provides a critical review of characteristic methods and methodologies of CER in EJ research, which are detailed more fully in methods textbooks and the technical literature than we can do in a single chapter.[1] We use *method* and *methodology* interchangeably here because the line between discrete methods (e.g., beta attenuation monitoring) and broader methodological approaches (e.g., environmental monitoring) is often blurry in practice. We focus more on methods for data collection than those for analysis, discussing the strengths and weaknesses of each method, potential uses, and how they are employed in example studies. We include citations to relevant sources that offer greater technical and procedural detail on how to use these methods.

Our discussion is grounded in some commonly held insights of antiracist, decolonial, and feminist approaches to methods and knowledge production. These traditions recognize that to choose a set of research methods is also to choose a set of power and property relations—between research teams and participants, and among credentialed researchers and their community partners—in

1 Especially valuable textbooks and handbooks on how to apply community-engaged research methodologies include sources on action research (Bradbury 2015), participatory action research (Chevalier and Buckles 2019; Kindon, Paine, and Kesby 2007), community-based participatory research (Blumenthal et al. 2013; Israel et al. 2013; Minkler and Wakimoto 2022; Wallerstein et al. 2017), and citizen and community science (Lepczyk, Boyle, and Vargo 2020). For more detail on how to apply Indigenous and decolonizing research methods, see Atalay 2012; Denzin, Lincoln, and Smith 2008; McGregor, Restoule, and Johnston 2018; Smith 2021; Wilson 2008; and Windchief and San Pedro 2019.

TABLE 6.1. CER for EJ Methods

Dimension of Justice	In CER Methods for EJ
Distribution *Who ought to get what?*	Choosing research methods that share resources and access to data, and that develop communities' capacities to conduct their own research
	Prioritizing methods that allow for community members to materially and professionally benefit from their contributions
Procedure *Who ought to decide?*	Centering community voice and influence in the selection of research methods and in data collection, analysis, and dissemination processes
	Prioritizing data sovereignty
Recognition *Who ought to be respected and valued?*	Practicing epistemic and cognitive justice, and decolonizing knowledge, by choosing methods that recognize the validity of and differences among local, experiential, and Indigenous knowledges
	Respecting communities' rights to consent and to control data about themselves
Transformation *What ought to change, and how?*	Transformation of relations between research institutions and communities by choosing methods that co-create knowledge rather than extracting data from the community, and that allow communities to speak effectively to power holders

the production of knowledge. This choice is shaped by the social and institutional conditions in which epistemologies and research methodologies developed. Contemporary methodologies continue to bear the influences of capitalism, settler colonialism, white supremacy, and patriarchy. Many methodologies are designed to extract data from communities—from biological specimens to opinions and beliefs—and profit by converting them into research funding, publications, patents, and professorships. Data analysis typically proceeds without communities' participation or consent, according to dominant epistemologies (such as Western science) that exclude, erase, and disrespect community knowledges, cultures, and values. The knowledges produced—and the production process itself—often function to further subjugate oppressed and colonized peoples, and to build researchers' and research institutions' prestige rather than creating equitable and reciprocal relations with and within researched communities (Petteway 2022). In contrast, the CER paradigm strives to center community knowledges by pursuing new methodologies, and by questioning and remixing mainstream methodologies to transform traditional knowledge, power, and property relations within research collaborations to better align with principles of epistemic, procedural, distributive, and, ultimately, research and data justice. Thus, throughout this chapter, we consider how the choice and application of research methods can advance the dimensions of justice common to CER and EJ (summarized in table 6.1). Of course, research justice is not guaranteed simply by choosing the "right" methodology, but also depends on, for example, how it is applied. Moreover, as many of our examples show, CER often combines two or more methods to address multiple research questions and strengthen the relevance, reach, and impact of the research. Thus, considerations of research justice are a matter of continuous, layered, and iterative reflection and researcher reflexivity.

SURVEYS

Surveying poses questions to gather information from people. The resulting data may be quantitative (collected by asking respondents to rate or rank items on numerical scales), qualitative (gathered in respondents' own words as they answer open-ended questions), or a mix of both kinds of data.

Survey research offers many advantages for CER. Community participants can learn to conduct their own surveys with minimal training and gather their own data relatively inexpensively, rather than depending on complex or proprietary research equipment and data sets. Many community members and advisors can participate in co-creating and reviewing survey questions and procedures, ensuring they reflect local needs and values, and building collective consent for the research. Surveys can help a community to compile and validate many kinds of knowledge about itself—beliefs, attitudes, practices, experiences, identity characteristics, environmental and social risks—and explore the relationships among them. Open-ended questions can allow respondents to share multiple cultural perspectives and kinds of knowledge, not only those anticipated by researchers. Survey methods can respect research ethics that matter to EJ communities: conferring anonymity offers respondents some control over their privacy, and surveying can explore the interactions of multiple risk factors without conducting randomized control trials that might expose community members to hazardous substances or withhold remedies from some participants (Korn and Graubard 1991). Survey data can contribute to transformational justice by providing an overview of community problems, identifying critical needs, soliciting potential solutions, and evaluating progress toward collective goals through repeated measures. These methods provide qualitative and quantitative data that can be used to design organizing campaigns and interventions, and support policy arguments.

The Richmond health survey (Cohen et al. 2016) offers an example of how to apply many CER principles. The survey was prompted by local concerns about exposure to multiple sources of pollution (especially from petrochemical facilities) and elevated levels of cancer in a predominantly minority low-income fenceline residential community. The research partners included the community organization Communities for a Better Environment (CBE) and academic researchers from Brown University and the University of California, Berkeley. This research team generated hypotheses and brainstormed survey questions in community meetings, aiming to identify health problems about which residents wanted community-wide data. The research partners then trained community members to recruit participants and administer the survey with study staff, canvassing neighborhoods on foot and contacting participants from previous studies in the area, which helped to increase awareness of the study. The research found an association between residents' poor health and cumulative stress from multiple sources of pollution (Cohen et al. 2012). CBE disseminated this finding to the community and used this evidence of cumulative impacts as a tool in its organizing campaign for increased regulation of local facilities and against the expansion of a local oil refinery.

However, there are also ways in which surveys can fail to align with principles of justice in CER. Many community members who respond to surveys are unlikely to be involved in helping to design them; this raises the possibility of researchers and community organizations extracting data from residents to advance the research partners' agenda, rather than enlisting respondents as co-creators of meaning. Because the most marginalized members of communities are often least likely to respond, this self-selection bias may mute their voices in survey data. Researchers can fail to respect local cultures and ways of knowing by mistranslating questions into local languages, using questions that are not validated through piloting with community respondents, or relying too heavily on closed-ended questions informed by researchers' narrow assumptions and meanings. These limitations can produce results that misrepresent community conditions, perceptions, and priorities, distorting interventions and actions based on the conclusions.

CER can mitigate these problems by involving diverse elements of the community in each stage of the research. Cohen et al. (2018) draw several relevant lessons from their community-based cross-sectional survey in France. They urge CER teams to design questions that allow respondents to discuss household and community issues, and that honor local knowledge. Research partners can hold open meetings to report data and use focus groups to check researchers' interpretation of the data. Residents and relevant experts can co-interpret survey data and collectively brainstorm actions that might be taken in response to findings. Each of these steps increases research partners' accountability to the larger community and the community's participation in co-constructing the meaning of survey data.

ENVIRONMENTAL MONITORING

Environmental monitoring involves taking samples from one or more locations to measure hazards in any environmental media. CER has documented contaminants in soils and other environmental media near hazardous waste sites (Brown and Mikkelsen 1997; Ramirez-Andreotta et al. 2015). CER has also measured exposure to air pollution (Commodore et al. 2017) from sources such as diesel bus depots (Kinney et al. 2000), ports (e.g., Garcia et al. 2013), and industrial hog farms (Wing et al. 2008). Additional CER has monitored water contamination (Buytaert et al. 2016), including from landfills (Heaney et al. 2013), sewage (Heaney et al. 2011), and multiple threats to Indigenous peoples' water sources

(Cummins et al. 2010; Wilson, Mutter, et al. 2018). Studies using cell phones and other devices as sensors have measured noise pollution in sites such as public housing (Haklay and Francis, 2018).

Environmental monitoring methods have many strengths for CER. As monitoring technology has become cheaper and more sensitive, it has allowed communities to gather their own data, rather than relying on government or industry (English, Richardson, and Garzón-Galvis 2018; Johnston et al. 2020). Community members can collect environmental samples after appropriate training on data collection protocols and labeling (World Health Organization 2014). This increases communities' power to set the research agenda by selecting which contaminants and environmental media are of greatest concern to residents. Many CER studies fill gaps in existing data sets by producing more localized and time-sensitive data about emissions than polluters and government agencies report, forcing them to recognize local knowledge not previously admitted in the regulatory process. For example, in the 1990s, EJ activists adopted simple air monitors using buckets and plastic bags to capture air samples, which could be sent to a laboratory for analysis. Soon, "bucket brigades" were documenting short-term spikes and long-term violations of emissions limits by oil refineries and chemical plants around the world (see chapter 7). Environmental sensors such as these can shift power to communities to pinpoint the sources of pollutants, trace their movements, correlate emissions with health symptoms, and hold polluters and regulators accountable for addressing violations.

However, high thresholds for scientific proof of harm limit the power of environmental monitoring in regulatory forums. Typically, communities must prove that they are adversely affected by environmental hazards by establishing a continuum from contaminant source identification to presence in the ambient environment to exposure and entrance into the human body (Johnston et al. 2020). Regulatory agencies and courts have been slow to accept community environmental monitoring data as valid evidence, sometimes requiring expert testimony to validate the protocols and instruments used in CER (Wyeth et al. 2019). Some contaminants may be unknown or difficult to measure with existing equipment. The most sensitive and accurate sensing technology and the training required to use it are still too costly for many community organizations.

BIOMONITORING

Biomonitoring, sometimes called body burden research, evaluates the presence and concentration of a chemical (or its derivative) in the human body (Paustenbach and Galbraith 2006). As biomonitoring has become more sensitive, affordable, and available, it has become an important tool for documenting the presence and extent of chemicals not normally present in human bodies (Shamasunder and Morello-Frosch 2016). This has expanded researchers' ability to assess the impacts of environmental chemicals and other exposures on human health by supplementing measures of substances external to the body (in food, water, or air, for example) with measures of internal exposures (in breast milk, urine, blood, and tissue) (Morello-Frosch et al. 2015b). The type of biomonitoring used depends on the persistence of the contaminant of concern: for example, a lipophilic chemical with a half-life of two years can be accurately measured in breast milk, while a polar chemical with a half-life of 12 hours will be better characterized in urine. Biomonitoring has provided a more complete picture of the "exposome," an analogue to the human genome that includes all exposures from social and physical environments over an individual's lifetime (Wild 2005). Biophysical monitors, such as skin conductance and heart rate monitors, can provide additional individual-level evidence of the health effects of environmental stressors.

Biomonitoring allows communities to collect their own data about substances related to health conditions that most concern residents, such as risks posed by chemical emissions from industrial sources and consumer products (Adams et al. 2011; Morello-Frosch et al. 2015b). Residents can participate by co-defining research questions with scientists and donating samples of hair, nails, urine, or blood. Studies can respect participants' desire to control their own data by allowing residents to access their personal exposure levels, which prior epidemiological research has generally resisted (see chapter 5). For example, in response to environmental health advocacy, California's biomonitoring program now requires that individual data be communicated to study participants who want this information (Morello-Frosch et al. 2015a). Biomonitoring can also build respect for local knowledge by validating community complaints of environmental health effects that often go undocumented in official public health data. Because biomonitoring can provide objective evidence of substances' presence in the body, it can help communities meet the burden of proof that links exposure with health impacts. By measuring chronic and acute exposures to hazardous substances, and tracing health effects, biomonitoring can be used to question whether acceptable exposure limits in current regulations are in fact safe. It can also assess whether vulnerable communities are exposed to greater risks, stresses, and harms than environmentally privileged communities, building pressure for action.

Several factors limit the use and impact of biomonitoring. Obtaining biosamples depends on building a high degree of trust with research participants, given the sensitive nature of these materials. Analyzing samples requires expert training, and may demand specialized and expensive equipment. Many regulatory and industry scientists have resisted accepting biomonitoring as a legitimate source of data, limiting this methodology's ability to transform environmental health science and public health policy (Shamasunder and Morello-Frosch 2016).

Some studies combine biological and environmental monitoring. For example, in Canada the Aamjiwnaang First Nation community in Ontario, the Occupational

Health Clinics for Ontario Workers, and University of Ottawa biologists collaborated to use bucket brigades and body burden testing among Aamjiwnaang people living near chemical plants, filling gaps in government data collection and building pressure for stronger regulation of emissions (Sabzwari and Scott 2012). Another valuable example is the "Truth Fairy Project," in which East Yard Communities for Environmental Justice collaborated with academic partners to investigate the impact of toxic metal exposures around a closed lead-acid battery smelter in a predominantly Latinx neighborhood of Southeast Los Angeles (Johnston et al. 2020). The study combined analysis of soil in local yards and residents' baby teeth (as biomarkers of lead exposure) to demonstrate an association between soil lead levels and lead ingestion (prenatal and postnatal). The research informed residents about toxic metal exposures and provided evidence to support organizing for legislation that funded removal of lead-contaminated soil from neighborhoods around legacy smelters.

COMMUNITY MAPPING

All environmental exposures entail a spatial component—that is, they exist within, between, around, and across specific social and geographic places. Thus, being able to map out sites and sources of environmental concern, as well as their spatial patterns and distributions, is perhaps the most fundamental component of CER for EJ. How environmental exposures, risks, assets, and opportunities are (mis) represented through map-making—and how maps are then used—plays a critical role in pursuit of EJ. While some EJ research uses mapping and screening tools created by state regulators and environmental scientists (see chapter 7), we focus on mapping that involves primary source data gathering using a CER approach.

Mapping helps communities pursue many goals, such as

- researching and representing cumulative environmental exposures and social vulnerabilities,
- educating the community about historic and current environmental injustices,
- identifying community assets that can help advance EJ,
- targeting health interventions and resources to high-priority places and groups,
- designing local infrastructure,
- mobilizing residents to launch campaigns,
- communicating information to decision makers, and
- supporting advocacy in permitting, development, remediation, and policy processes.

Mapping also presents some dangers for research partners (Corburn et al. 2017). Creating and updating maps can demand significant time and resources, especially if this involves purchasing proprietary mapping tools and learning to use complex software. In some cases, communities may choose not to publicize potentially stigmatizing data (such as levels of pollution or disease) or sensitive cultural information (such as Indigenous sacred sites, which have been subject to vandalism and looting). Monitoring technologies used to generate some data for mapping can undermine participants' privacy rights if researchers do not obtain fully informed consent. In addition, official data used in mapping may be incomplete or inaccurate—a "garbage in, garbage out" problem—so community members may need to ground truth this information by checking it against their own experience and investigations. Other data, including the names and boundaries of the community itself, may reflect dominant outsiders' representations of the community—a "hegemony in, hegemony out" problem—so community members need to be vigilant and reflexive about defining themselves at each step. Because maps, like all data, do not speak for themselves, their ability to contribute to change relies on how well they are used to support organizing and advocacy.

Geographic Information Systems (GIS)

Many CER studies employ geographic information systems (GIS). GIS software acquires, stores, tracks, checks, and displays various forms of data that have geospatial attributes, that is, they can be geographically located and mapped. GIS platforms range from expensive proprietary software (such as ArcGIS), to open-source platforms (like QGIS), to free web-based mapping tools (like MapServer and OpenStreetMap), to platforms for mobile devices (such as Kobo Toolbox). GIS can support a variety of EJ research methods. Studies that employ environmental monitoring can, for example, passively or manually collect samples (such as airborne pesticides, soot, or heavy metals) from geolocated sampling locations via handheld Global Positioning System (GPS) devices (Gibbs et al. 2017) or outfit community residents with sample-collecting devices (such as mobile air monitors) to track participants' exposures across locations (Ma et al. 2020). Researchers can also employ GIS to administer surveys remotely and then manually geolocate the results later via computer-based GIS software; administer surveys in person using mobile devices that automatically record location data; or administer surveys remotely using an ecological momentary assessment approach that prompts respondents via their mobile devices when they are in certain locations (Mennis, Mason, and Ambrus 2018).

GIS using GPS technologies can also take an "activity space" approach to assess an individual's environmental exposures (Cagney et al. 2020). This approach to measuring air pollution, for example, would measure air quality not just at a person's residence, but throughout their entire "activity space," as they travel from home to work, stores, parks, and so on. These methods can also account for the duration and temporality of exposures throughout the day, month, or year, rendering more thorough and accurate assessments of exposures—from pollutants

(Park and Kwan 2020) to greenspace access (Bell et al. 2015), food environments (Widener et al. 2018), and more.

Participatory GIS

GIS methods that allow for deeper community participation in research are commonly called participatory GIS (PGIS), participatory action mapping (PAM), or public participation GIS (PPGIS). PGIS takes a community-driven, user-friendly, and procedurally and epistemically inclusive approach to mapping—one that "ideally places the control of access and use of socially or culturally sensitive spatial data in the hands of the communities who generate it" (Verplanke et al. 2016, 309). PGIS can represent people's local spatial knowledge to inform participatory decision making, communication, and advocacy, and entails "an explicit attempt to use digital mapping technologies to give voice, amplify, and represent local needs—especially of marginalized groups" (Haklay and Francis 2018, 299).

EJ research partnerships have applied PGIS to research topics ranging from conservation and sustainability (Ramirez-Gomez, Brown, and Fat 2013; Nicolosi, French, and Medina 2020), to aspects of urban planning (Boll-Bosse and Hankins 2018). In one promising example, Jelks and colleagues (2018) worked with ten community researchers to examine environmental concerns in an Atlanta watershed, using a customized app with GPS and photo/video capabilities to spatially and visually document concerns in real time. The study filled gaps in official environmental data and generated evidence that residents then used to engage officials to remediate the problems.

Qualitative GIS

Qualitative GIS, or QGIS, also holds promise for EJ research. QGIS integrates various forms of qualitative data—such as photos, audio, and video narratives—within traditional quantitative-based GIS platforms. The goal is to spatialize—and geographically visualize—non-quantitative representations of place-based knowledge and experience that, as described by Jung and Elwood (2010), help address the "inadequacy of absolute Euclidean geometries as a means for representing the abstract, inexact, and socially situated ways that people understand the world" (66).

Expressions of QGIS include geo-narratives (Bell et al. 2015) and geo-ethnographies (Matthews, Detwiler, and Burton 2005) of people's experiences of place, and have included the use of "walk-along interviews" to elicit "spatial transcripts" (Martini 2020). Dennis and colleagues (2009) worked with youth in Madison, Wisconsin, using QGIS to map participants' photos and interview narratives about environmental health and safety issues, producing maps that guided community-based interventions. QGIS can also be combined with augmented-reality platforms, which allow users to position mobile devices to access place-based digital content. For example, Butts and Jones (2021) worked with students and local partners to develop augmented-reality tours to decolonize dominant environmental and social histories of Florida's Paynes Prairie State Park—exposing the history of land dispossession of local Seminole tribes and the slow violence of climate change. Using the project's EcoTour app (www.shannonbutts.com/ecotour), park visitors point their mobile phones at landmarks to encounter information drawn from Seminole oral histories, historical photos and maps, and other archival data, which provide a "deep mapping" of how the park was shaped by a history of environmental injustices.

Counter-mapping

Counter-mapping is mapping that "questions the assumptions or biases of cartographic conventions, that challenges predominant power effects of mapping, or that engages in mapping in ways that upset power relations" (Harris and Hazen 2005, 115). It can involve various forms and practices of spatial representation, whether through PGIS, QGIS, or other approaches, digital or analog. Counter-mapping is generally a community-led mapping process undertaken as a mode of resistance to settler-colonial extractivism, dispossession, and environmental degradation.

> [Counter-mapping] allows a group to combine their own low-tech methods with the state's techniques and manners of representation in order to re-insert themselves and their lived experiences and perspectives, underscore their unique relationship to landscapes, challenge their disadvantaged circumstances, and get their territorial and customary claims to resources recognized by dominant settler societies. (Kidd 2019, 960)

Core to counter-mapping is the understanding that maps, as visual codifications of spatialized power, "are neither neutral nor unproblematic with respect to representation, positionality, and partiality of knowledge" (Harris and Hazen 2005, 101). Importantly, counter-mapping both counters *and creates*—it is productive and generative of new ways of interpreting and representing environmental conditions and experiences. Accordingly, counter-mapping can play an especially critical role within EJ communities enmeshed in the dynamics of exposure (mis)representation and contestation. Often, technocratic and administrative processes and norms for monitoring environmental risk fail to capture the nuanced contexts of daily exposures as experienced by community members. Counter-mapping has contested official processes that omit and obscure—by defect or design—important community knowledges relevant to identifying, contextualizing, and mitigating environmental risks, and to uncovering environmental assets within EJ geographies (Dalton and Stallman 2018). Counter-mapping has been used to document ecological and natural resource conservation and disruption (Harris and Hazen 2005); to visualize Indigenous land rights and dispossession and help communities to resist settler colonialism, extractive industries, and environmental degradation (Hunt and Stevenson 2017; Willow 2013); and to contest and contribute data to policy discourse related to disinvestment and lack of greenspace in Black neighborhoods of Detroit in the late 1960s (Dalton and Stallman 2018) and the spread of gentrification in San Francisco in the 2010s (Maharawal and McElroy 2018).

STORYTELLING

Storytelling and narrative analysis are widely used in CER and organizing for EJ (Houston and Vasudevan 2018). Common expressions of storytelling for EJ include digital storytelling, oral histories, "toxic bios," and counter-storytelling—none of which are mutually exclusive, and all of which can involve other methods discussed here.

Digital storytelling presents data from multiple sources in a narrative format, often using technologies that allow for broad sharing and access. One example of EJ digital storytelling is work completed by Johnston and colleagues (2020). They worked with youth co-researchers, who used personal air-monitoring devices (the AirBeam), PGIS (via smartphone GPS), and photographs to spatially and visually document their daily PM2.5 exposures. In another project, First Nations members in British Columbia used digital storytelling to challenge established policy narratives that divorced health from community interactions with local lands and waters, and demonstrated how residents understood human and natural health as intertwined (Gislason et al. 2018).

Oral histories, when participatory, involve residents as co-researchers in the study design and in gathering, editing, and analyzing individuals' EJ stories—something modeled well by the CER collaboration between DataCenter, Pacific Institute, and the Winnemem Wintu tribe in California. Winnemem researchers gathered and analyzed personal stories and used cell phone GPS to map sacred sites, demonstrating their historical importance for healing and spiritual ceremonies (DataCenter 2015c). In other examples, Adams and colleagues (2018) worked with residents of an Oklahoman "fenceline community" to examine perceptions of long-term petrochemical exposure, and Castleden and colleagues (2017) worked with Indigenous elders in a Mi'kmaw community along the eastern Canadian coast to identify, contextualize, and historicize concerns related to contaminants from a pulp mill. Elsewhere, Armiero and colleagues (2019) engaged EJ storytelling through the curation of stories related to environmental activism and contamination, so-called "toxic bios." They describe their approach as "guerilla narrative," "meaning the sabotage of toxic narratives, which silence injustice, through the coproduction of a counter-hegemonic storytelling" (10).

Counter-storytelling has conceptual roots in notions of counter-narrative or counter-hegemony, and counter-storytelling traditions of critical race theory. As articulated by Delgado (1989), counter-stories "can show that what we believe is ridiculous, self-serving, or cruel . . . can show us the way out of the trap of unjustified exclusion . . . can help us understand when it is time to reallocate power" (2415). As with counter-mapping, EJ communities often practice counter-storytelling to expose dominant histories and narratives as unjust, oppressive, and self-serving, while offering new stories that point toward justice. The aforementioned digital storytelling project by Gislason and colleagues (2018) with First Nations communities in British Columbia is one such example. In another example, Spiegel and colleagues (2020) worked with adults and youth of the Tsleil-Waututh Nation to examine environmental concerns related to the Trans Mountain oil pipeline in Canada. Tsleil-Waututh researchers developed a counter-story to oil industry narratives of progress, using photography and testimony to narrate the pipeline's threats to local food sovereignty, health, and cultural bonds with the watershed, and to imagine alternatives.

Stories are a grassroots form of making meaning: community members can often contribute to storytelling without extensive training, and EJ stories may be more compelling than academic research for mobilizing people to act (Newman 2012). Storytelling lends itself to communicating complex causality in a form that can be more memorable than scientific data (Griffiths 2007). Part of the power of storytelling lies in its ability to generate collective, relational, and affective narratives of community concerns, priorities, histories, and futures. Ganz (2011) describes how these public narratives can fuel community organizing by connecting a "story of self" (focused on one's calling) and a "story of us" (linking the individual to the community's calling) to a "story of now" (that mobilizes people to take collective action for change). EJ narratives integrate many types of knowledge—personal and collective, local and expert, cultural and scientific, practical and theoretical—into coherent accounts of injustice and justice backed by illustrative evidence. EJ storytelling is therefore a means of providing testimonial evidence—not only for research, but also for organizing, public testimony, and litigation (Evans 2002).

However, in the absence of accompanying scientific data, testimony and other stories may be dismissed as anecdotal evidence drawn from unrepresentative samples. Policy makers and regulators trained in scientific and positivist paradigms may be especially suspicious of stories as overly "emotional" and "irrational." Counter-stories, such as those in the Indigenous examples mentioned above, especially require skillful translation and framing to communicate across cultural and ideological boundaries.

PARTICIPATORY MEDIA, COMMUNITY ARTS, AND PHOTOVOICE

Participatory media and arts-based research methods can be used for data collection or dissemination, or both (Coemans and Hannes 2017; Gubrium and Harper 2013). In data gathering, research participants can communicate their experience through photography, video, and other media. As a vehicle for disseminating data, art can replace or supplement traditional academic publications to express findings through street murals and other public installations, exhibitions of images or artifacts, and dance, theater, music, and other performances. In addition, community arts events can communicate and dramatize information about organizing or public health campaigns. There is a growing literature on using arts-based approaches to CER with marginalized populations (Coemans and Hannes 2017), with Indigenous peoples (Hammond et al. 2018), and for health-related research (Boydell et al. 2016). Additional reviews summarize the use of particular media and approaches in community arts research on EJ issues, such as adaptations of Augusto Boal's Theatre of the Oppressed (Sullivan and Parras 2008), feminist EJ zines (Velasco, Faria, and Walenta 2020), and collaboratively written "policy novels," which weave explanations of environmental policies into fictional storylines (Van der Arend 2018).

In an especially extensive collaboration, informal recyclers in Canada and Brazil represented their work and needs in a long-term participatory video partnership with community organizations, local governments, the University of Victoria, and the University of São Paulo. The project trained participants, who are often stigmatized as "scavengers" and harassed by authorities, to produce brief documentaries for local officials, explaining how informal recyclers perform valuable services by recovering and recycling materials that have been dumped in landfills and streets. Campaigns used these videos to decriminalize informal recyclers' activities in Canada (Gutberlet and Jayme 2010) and integrate this work into the formal recycling sector in Brazil (Tremblay and Jayme 2015).

Photovoice is a particularly well-developed method in CER for EJ, which has informed other uses of media and arts for research. Photovoice is a hands-on, photography-based research method designed to help community residents—as co-researchers—identify and discuss important community issues and take social action (Catalani and Minkler 2010). Residents use cameras/smartphones to visually document aspects of their community that represent—literally and/or symbolically—their concerns and perspectives on a particular topic, then write short narratives that contextualize each photo. While photovoice processes vary, residents typically discuss and analyze their work collectively, curate photography exhibits, and present their research to community and policy leaders (Petteway 2019).

Photovoice has been used broadly for EJ-related research on topics ranging from food and tobacco environments (e.g., Leung et al. 2017; Petteway, Sheikhattari, and Wagner 2019) to built and social environments (Petteway 2019; Sampson et al. 2017). It has also been used to explore more traditional EJ exposures. For example, Madrigal and colleagues (2014) worked with youth co-researchers in a California Latino farmworker community, training them in environmental health and using photovoice to document their environmental concerns and community assets. Similarly, Schwartz and colleagues (2015) used photovoice with Mexican American adults and youth to explore issues related to asthma and pesticide exposure in an agricultural community. In Nevada, Willett and colleagues

(2021) worked with youth scientists to explore the EJ concept of slow violence as manifest in inadequate urban infrastructure, public services, and climate-related disasters (such as wildfires). EJ researchers frequently combine photovoice with other research methods and forms of data. These multimethod studies have paired photovoice with air monitors and PGIS to document particulate exposure (Johnston et al. 2020), with indoor air quality monitors to study risks from woodsmoke (Evans-Agnew and Eberhardt 2019), and with PGIS and X-ray mapping of daily place-based environmental exposures (Petteway et al. 2019).

Reviews of the literature find many potential benefits of using participatory media and arts techniques for EJ research (Coemans and Hannes 2017; Gubrium and Harper 2013; Wilson, Aber, et al. 2018). A core strength is that arts and media offer comparatively accessible and inclusive methods for involving youth and adults across a range of cultural and ethnic communities in conducting and owning their own EJ research. Community media and arts can center and amplify participants' expression of their lived expertise and embodied knowledge of EJ in their communities. These methods excel at communicating the place-based and experiential nature of EJ exposures through research that is simultaneously affective and visceral, and material as well as symbolic. In doing so, media and arts methodology introduces new knowledges that can complement, contextualize, contest, and counter existing EJ data narratives, much like counter-mapping and counter-storytelling. As they discuss their work in progress, many arts and media groups resolve to take collective action to address their conditions. Like storytelling, community arts and media can strengthen community bonds as part of rituals and ceremonies, and imagine alternative futures.

Participatory media and arts also present some challenges similar to those of storytelling methods (Wilson, Aber, et al. 2018). It is difficult to include representative samples of a community in the small groups typical of these projects. Participants often must commit significant time to create, discuss, and present their work. Professional research partners must be careful to avoid imposing their aesthetics and interpretations of residents' work and conditions on community partners (Evans-Agnew and Rosemberg 2016). While research using community arts and media has presented ample evidence that these methods build research capacities and solidarity among participants, this does not always translate easily into transforming policies or practices.

BIG DATA

Big data refers to the growing availability of large data sets produced by a variety of novel sources. This approach is distinguished by its use of complex data analytics to examine an unprecedented volume of records from a variety of sources, often with greater velocity of data gathering and analysis (Grayson, Doerr, and Yu 2020). Given the diversity of these sources, and the fact that they can be combined to yield novel insights, big data is more of a broad methodological approach to research than a focused method. The opening of previously restricted databases, availability of low-cost sensors specifically designed for community scientists, and new open-source data analytical techniques have made big data studies more possible and practical for CER on EJ issues. Examples of big data sources that may be used in EJ research include crowdsourced community science projects, genomic databases, government databases, networks of environmental sensors, satellite remote sensing networks, social media activity, mobile app and web searches and clickstreams, locational data, financial transactions, and records of scanned barcodes.

Many CER projects that involve big data rely on crowdsourcing, "an online, distributed problem-solving and production model that leverages the collective intelligence of online communities for specific purposes" (Brabham et al. 2014). For example, Dodson et al. (2020) used crowdsourcing in a biomonitoring study to track self-reported consumer behaviors related to products containing phenolic compounds (e.g., BPA, parabens). Sun and Mobasheri (2017) crowdsourced volunteered geographic information from a cycling app to examine potential air pollution exposure during active commutes; Picaut et al. (2019) completed similar work using a smartphone app and GPS to crowdsource environmental noise measurements. Crowdsourcing has also been used as a part of multimethod EJ-related work. For example, Barrett et al. (2018) combined crowdsourcing with traditional GIS data to examine asthma hot spots and inhaler use, while Kim, Lieberman, and Dench (2015) used a crowdsourcing approach involving traditional GIS and photos to examine tobacco retail environments.

However, not all crowdsourcing projects aggregate the "collective intelligence" of active crowdsourcing participants, such as the "wisdom of the crowd" model. Instead, many projects revolve around the use of passive surveillance and data collection (e.g., via smartphone GPS) or volunteered reports of environmental behaviors or observations. An example of an EJ monitoring system that has employed crowdsourcing and community involvement is the Identifying Violations Affecting Neighborhoods (IVAN) system in California's Imperial Valley (https://ivan-imperial.org/air). IVAN was created by state regulators to measure particulate matter concentrations and provide real-time air quality reporting to the public. Community members helped to identify air-monitoring sites and learned to maintain the monitors, which are validated and calibrated to official environmental agency reference monitors to ensure reliability. An environmental justice task force made up of regulators and residents reviews the data at monthly meetings to inform their plans to reduce pollution. Over time, the IVAN website began to solicit and map crowdsourced public complaints about illegal dumping, emissions, and other environmental violations, inspiring the launch of additional IVAN networks around the state.

Big data offers many attractions for CER on EJ. Big data can provide CER partners with access to much more specific measurements of household and individual exposures to environmental hazards and benefits, helping communities develop interventions where they are needed most. Large numbers of community members can contribute data, building a critical mass of residents who understand EJ issues and are invested in organizing to address them (Kaufman et al. 2017). Building larger samples of participants who contribute their environmental and health data repeatedly can enable CER to establish the causes of environmental health inequities and harms (Alexeeff et al. 2018), and force regulators and polluters to stop dismissing residents' experiential knowledge of health impacts as anecdotal evidence (Mennis and Heckert 2018). Large samples may also speak to power in another way: officials who know that many of their constituents have participated actively in community science studies may be more likely to pay attention to the results.

Limitations and concerns regarding big data in EJ research have been discussed elsewhere (Mah 2017), with ample cause to be concerned that big data algorithms can function as a discriminatory "weapon of math destruction" without concerted efforts to render them transparent and legible to the public (O'Neil 2016). In this regard, D'Ignazio and Bhargava (2015) introduce the notion of "popular big data" to articulate a vision for how to render big data more inclusive, transparent, and transformative for everyday people—and perhaps counter big data's tendency to (re)produce discrimination and other harms. And no discussion of big data can be had without deep engagement with notions of data justice (Heeks and Shekhar 2019), and concerns of (re)colonization vis-à-vis data extractivism and commodification. Vera and colleagues (2019) draw from feminist, Black feminist, and decolonial theory to outline a reflexive framework for environmental data justice (EDJ) that explicitly calls attention to "extractive data logics" and the "structural whitewashing of environmental data." Mapping the contours of power in database scope and ownership, as well as the bounds of database uses, remains a crucial matter of procedural, epistemic, and distributive justice.

SMALL DATA

Given the challenges of reconciling research involving big data with CER principles, many of the methods we have discussed in this chapter show the value of *small data* in advancing EJ. D'Ignazio and colleagues (2014, 116) describe small data as follows:

> a practice owned and directed by those who are contributing the data. . . . The essence of Small Data is that such communities may not just participate in, but can actually initiate and drive such data investigations towards the better understanding of an important local issue.

Notions of voice, representation, decolonizing, and power are core to small data. A small data approach typically affords communities more control in setting the research agenda, determining data priorities and collection methods, data collection and analysis, and data ownership. This approach presents a counterbalance to what D'Ignazio and Bhargava (2015) refer to as the "empowerment problem" of big data orientations, which exude extractivist and settler-colonial proclivities of epistemic erasure and dispossession that can function to silence and disempower communities.

In regard to investigating environmental factors, D'Ignazio and colleagues (2014) suggest that "a bottom-up, participatory, grassroots approach to . . . data collection addresses the key issues of inclusion, accountability, and credibility, by building public participation into the data lifecycle" (116). The small data approach of *popular epidemiology* was one of the first important methodological innovations of the EJ movement in the U.S. (Brown 1992, 1993). This approach to environmental research is grounded in, animated by, and (co)led by those who are experiencing the exposure(s) in question—with the explicit priority to take local social action based on findings to mitigate and repair harms. Coming to prominence in the early 1990s, popular epidemiology arose from communities' efforts to compile their own evidence of environmental exposures in order to contest—much in the spirit of counter-mapping and counter-storytelling—pervasive governmental and corporate apathy and narratives of harmlessness. Residents became their own scientists, acting as epidemiologists-activists to fight for both epistemic and environmental justice. Privitera and colleagues' (2021) work examining concerns related to petrochemical exposures via use of "toxic autobiographies" is one recent expression of this approach.

Small data orientations deliberately incorporate information and communication technologies (ICTs)—such as mobile phones and web-based mapping platforms—to enhance the democratic and community-led nature of the research process and action based on research findings. Small data studies can take many forms and employ multiple methods discussed in this chapter. The key is that they are community chosen, community led, and focused on (co)producing community knowledges that are excluded from status quo technocratic research practices, and the data are "owned and directed by those who are contributing [it]" (D'Ignazio, Warren, and Blair 2014, 117).

CONCLUSION

Because power and property relations are encoded in research methodologies, choosing methods also involves choices about justice. In CER for EJ, justice is best served by employing methods that shift power and ownership to communities, so they can share fully in the resources, data, and capacities required to do research. Collaborations should maximize community partners' and participants' role in choosing methods, gathering and interpreting data, and determining how information is disseminated. Methodological decisions must recognize the validity and multiplicity of local, experiential, and cultural knowledges, and communities' right to control data about themselves. The ultimate aims are to employ methods that help shift research institutions from extracting and exploiting data about EJ communities to co-creating knowledge with them for environmentally just policies and practices. For most community partners, EJ research is a means to the larger ends of structural and systemic change, especially for health, right relations with nature, cultural and economic flourishing, and racial justice. In this sense, all research is a methodology for transformation.