“We have been the ladder and held the ladder”: Evolving GeoHealth models for actionable, community-engaged research

Claire Hayhow[1], Dan J. Brabander[1], Rebecca Jim[2], Martin Lively[2], and Gabriel Filippelli[3]

[1]Wellesley College
[2]LEAD Agency
[3]Indiana University - Purdue University Indianapolis

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Abstract

GeoHealth as a research paradigm offers the opportunity to re-evaluate common research engagement models and science training practices. GeoHealth challenges are often wicked problems that require both transdisciplinary approaches and the establishment of intimate and long term partnerships with a range of community members. We examine four common modes of community engagement and explore how research projects are launched, who has the power in these relationships, and how projects evolve to become truly transformative for everyone involved.

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Claire M. Hayhow[1]†, Dan J. Brabander[1], Rebecca Jim[2], Martin Lively[2], and Gabriel M. Filippelli[3]

[1]Geosciences Department, Wellesley College, Wellesley, MA

[2] Local Environmental Action Demanded Agency (LEAD Agency), Miami Oklahoma

[3]Department of Earth Sciences and Center for Urban Health, Indiana University – Purdue University Indianapolis, Indianapolis, IN, USA

Corresponding author: Claire Hayhow (chayhow@wellesley.edu)

†Current Address: Silent Spring Institute, 320 Nevada St. Suite 320, Newton, MA

Key Points:

- The GeoHealth research community often engages actively with civil society in the research enterprise, but in various modes
- The modes of engagement, from researcher-heavy to community-heavy, have very different outcomes
- A new model of training and support is required for the GeoHealth community to more productively engage with civil society

Abstract

GeoHealth as a research paradigm offers the opportunity to re-evaluate common research engagement models and science training practices. GeoHealth challenges are often wicked problems that require both transdisciplinary approaches and the establishment of intimate and long term partnerships with a range of community members. We examine four common modes of community engagement and explore how research projects are launched, who has the power in these relationships, and how projects evolve to become truly transformative for everyone involved.

Plain Language Summary

GeoHealth research is often partnership focused. We describe four common models for community engaged GeoHealth research and highlight the central characteristics of each, while daylighting the lived experiences of LEAD Agency activists. We note a range of outcomes emerge which can foster science-based environmental health policy making and lead to justice focused actions.

1 Introduction

GeoHealth is an emerging research paradigm that seeks to blend earth, environmental, and health sciences while simultaneously informing policy and community action. Increasingly, this research often involves close work with community partners to identify actionable scientific questions that matter. In this setting researchers and community members collaborate and co-produce an expanded range of just and sustainable outcomes. Yet how do researchers learn to daylight the needs of their communities they partner with? What is expertise, and how do we value different kinds of expertise? Who has the power in these relationships? These questions require that geohealth researchers revisit traditional methodologies and training to assure that their work is ethical, transdisciplinary, and centers the needs and goals of the communities most impacted by their research.

GeoHealth research must be framed with environmental justice as a central principle while simultaneously working through ethical models for engagement. Current and forward looking framing of GeoHealth must be: community centered and partnership focused, valued and sufficiently funded, and sustainable. While previous definitions of GeoHealth focus on the intersection of natural sciences and public health, we propose that there is no GeoHealth without community (Figure 1).

What research models exist for geohealth researchers? In this paper, we aim to (1) provide a snapshot of four modes of research inquiry, (2) share essential components of successful community-researcher partnerships while highlighting ways to overcome obstacles to building lasting and transformative partnerships, and (3) daylight community partnerships' experience of these collaboration models.

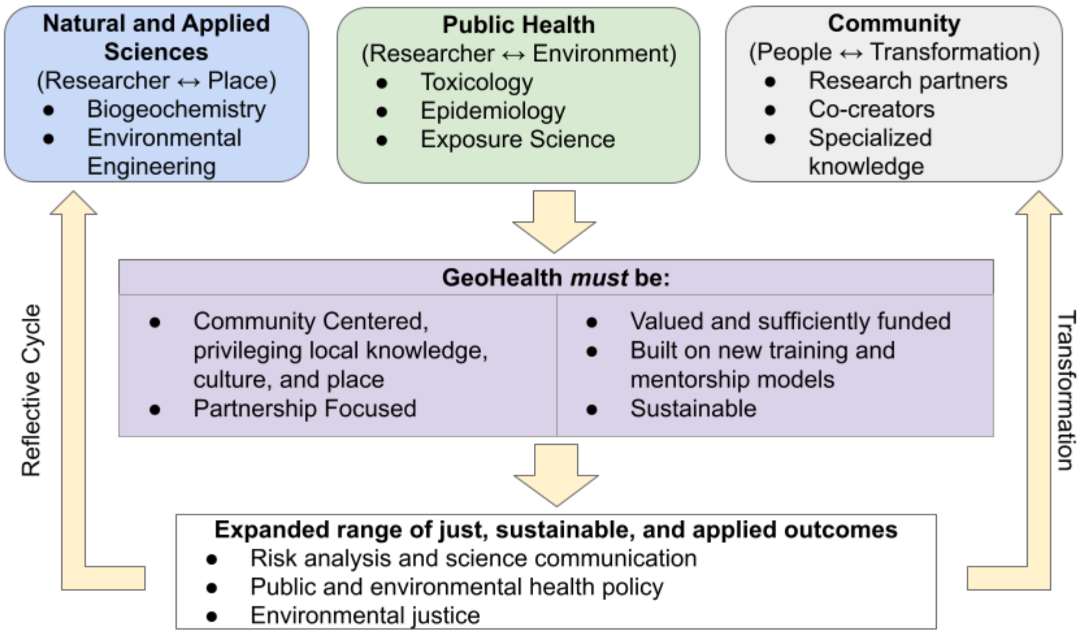

Figure 1. Conceptual framework for GeoHealth research. Goals, stakeholders, and a broader array of research outcomes. Note there is no GeoHealth without community.

2 Modes of GeoHealth Inquiry

Table 1 summarizes four modes of GeoHealth inquiry that community research partners experience. They range from models that do research **on** communities to approaches that forefront research **for** and **with** community partners. We use descriptive terminology borrowed from Bacon et al. (2006) to broadly characterize each framework.

2.1 Parachute Science

Parachute Science in the GeoHealth context is often "big science." It comes with large price tags, networks of research university collaborators, and is often triggered by a very public and urgent GeoHealth crisis (e.g. arsenic contamination of groundwater in Bangladesh; Harvey et al., 2002). Parachute science in a GeoHealth context is defined by wealthy western nation scientists 'parachuting' themselves into low-income foreign communities to collect data while addressing an urgent crisis, then publishing their findings without local scientists as meaningful collaborators. Recently, Stefanoudis et al., 2021 found that after 50 years of coral reef research in Indonesia and the Philippines by western researchers, 40% of the publications had no host nation scientist as a co-author.

We contend that many environmental advocacy groups in wealthy nations can also experience parachute science. Similar to international examples of colonial science, in the US when an urgent GeoHealth crisis is identified (e.g. large percentage of children having elevated BLLs in Ottawa County, OK) research university sciences with federal funding 'drop' themselves into communities to address acute health challenges. A key difference in this context is that environmental injustices are often the root causes of these crises as opposed to large-scale "natural" processes.

Parachute Science places an emphasis on understanding biogeochemical processes operating in the system, generating new knowledge that then can be transferred to understand fate and transport of a contaminant in other regions. However, the challenge we pose to our GeoHealth community is this--is it not possible to entertain technologically appropriate interventions *with* local community partners from the start to make an impact on reducing exposure? Often figuring out the "science" at a processes level takes a long time because the systems we study are open, complex, and several competing ideas often need to be adjudicated. We need to value the creative efforts centered on education and low-cost sustainable interventions as much as (if not more than) the understanding of biogeochemical mechanisms and importantly we need to be accountable for the long-term sustainability of these interventions that are informed by the science we conducted.

2.2 Citizen Science

The term "citizen science," was coined in 1989, in relation to efforts by the Audubon Society to enlist members in a nation-wide program to document acid deposition (Hakley et al., 2021). Since then, many flavors of citizen science have emerged, all of which center on public engagement in the research process, but vary in purpose, motivation, and outcomes, with even the term "citizen" being contentious as it is exclusionary. Citizen science offers the opportunity to crowd-source painstaking measurements and sampling, however these partnerships are typically one-sided. Namely researchers can tap into an interest group's skills to document natural variability (like first appearance of bird species), with little of substance returning back to the individual participant beyond the good will of participating. GeoHealth researchers must engage in holistic approaches with communities.

A collaborative approach provides local expertise, helping researchers pair environmental equitability with resiliency solutions. Engaging communities in the science of their own environmental conditions builds agency among community members to co-design, effective, appropriate, and sustainable local solutions. It is not enough to simply say "job done" when a community science network is deployed--funding and policy changes to help holistically reduce inequities should be built into the process.

The challenge of legacy urban lead and exposure to environmental justice (EJ) communities is an example of a wicked GeoHealth crisis that has been the setting for developing more community facing citizen science models (e.g. Filippelli et al., 2020 and Sharp and Brabander, 2017). These programs have resulted in tens of thousands of soil tests, including in the USA (notable examples are the Safe Urban Gardening Initiative at IUPUI and the LeadLab of Tulane University in New Orleans; Filippelli et al., 2020) and in Australia, where the VegeSafe program is likely the largest citizen science lead program in the world (Taylor et al., 2021). Data from all these programs, including a sampling information guide and a recommendations and remediation tool can be found at (www.MapMyEnvironment.com).

2.3 Brokered Science Model

Linking communities with scientists, Thriving Earth Exchange (TEX) serves as a broker to tackle local challenges related to natural hazards, natural resources, and climate change. In the TEX model "Community Science" forefronts community voices and knowledge. This model of GeoHealth inquiry is in stark contrast with PI driven citizen science. A defining characteristic of TEX projects is that the research question or environmental challenge is inspired by community members. TEX projects have three principal actors: 1) Community Leaders that launch projects with TEX, 2) Volunteer Community Scientists that help refine projects and bring scientific and technical skills to the team, and 3) paid Community Science Fellows that serve as project manager and facilitators. Projects tend to be 6-18 months long with very clear deliverables (for example a new GIS map that can be used to educate community members about flooding risks). TEX projects are about actionable science with outcomes focused on communities' ability to build healthy, resilient, thriving, just, and ecologically responsible futures.

2.4 Participatory Action Research (PAR)

Participatory Action Research (PAR) breaks away from the traditional researcher-researched dichotomy, seeking to build power with community members, through collective empowerment and meaningful action towards community member's goals (Baum et al., 2006). Rather than assuming that scientific research (or knowledge) is objective, PAR "affirms that experience can be a basis of knowing and that experiential learning can lead to a legitimate form of knowledge that influences practice" contextualizing research questions and results in an area's local context (Baum et al., 2006) while challenging prevailing power inequities, within and beyond [their] research" (Sandwick et al., 2018). Sharp (2016) notes three core principles that support PAR's goals of being "useful and non-oppressive":

- Community-Based: Community members identify useful actions and visions for their neighborhoods
- Applied: Research creates local scale solutions that can also be applied at a systems level
- Interdisciplinary: Involving all stakeholders to define, investigate, and craft sustainable policy driven solutions

One emerging model for PAR inspired GeoHealth research is the "Flashlight Model" (Gallagher et al., 2020). This approach blends PAR with community science and promotes shared ownership of the research process. Non-profit organizations partner with academic labs to generate actionable scientific questions that matter, designing studies to address the public health concerns identified by the community. This process allows for "serendipitous science," or science that unfolds in ways the PI could not have anticipated or even articulated without deep community engagement. The Flashlight Model also asserts that "rigorous science should also be accessible science", [...] ideally using a 'just right' analytical approach rather than using exclusive highest precision techniques" (Gallagher et al., 2020). As the GeoHealth discipline evolves scientists must acknowledge the complexity (scientifically, but also socially and politically) of the system being researched, using new research paradigms to generate serendipitous scientific questions and inquiries that lead to just, sustainable, and transformative outcomes.

3 ***"They only cared because we made this personal"***

The LEAD agency is a grassroots organization that has worked for over 20 years to address the issues of the Tar Creek Superfund Site in Ottawa County, OK. There, large mine waste (chat) piles and acid mine seepage contaminate surrounding communities with zinc, lead, and cadmium. This chat continues to be stored in piles that leech toxic metals, but were also used in the foundations of schools and homes, in paint, and in sandboxes and even now is used in road construction. Neuberger et al. (2009) found that over 60% of children under 6 in Picher, OK had lead poisoning (using the outdated national cut-off at 10μg/g).

Collaborations with academics at Tar Creek began after a phone call. In the car ride home from an EPA meeting, a student asked one of the authors (Rebecca) if she thought the student might be lead poisoned. She replied she didn't know, but after finding out the student's father had filled her backyard sandbox with fine chat, thought it was likely. Rebecca called a researcher at the Harvard School of Public Health because she read in a newsletter that he had studied the effects of lead on children past the age of 6. After an initial citizen science project focused on mineralized lead in children's teeth, researchers at Harvard Chan School of Public Health submitted a multi-million dollar NIEHS-Superfund proposal, launching six years of intensive research. In subsequent years, a few participating researchers have remained in relationship with Rebecca and LEAD. LEAD'S experience here highlights the way in which relationships are functionally more important than research models when assessing long-term community benefits. Further research is needed to determine what, if any, correlation exists between particular engagement models and longer-term community benefits.

Three key themes emerge from LEAD's long history with academic collaborators: (1) researchers' motivations for engagement, and assumptions about community members are significant, (2) pathways to community-engaged research are dependent on individuals because research models can be porous, and (3) outcomes of community-engaged research have the potential to be impactful for both individuals and communities.

(1) Motivations for engagement are key when working with community partners. Community science should be driven by empathy rather than pity or charity. Community-engaged researchers should empower local organizers as the experts about their own communities and who should take the lead on how best to make change.

(2) While we have presented four research models of engagement, the boundaries between them are relatively porous. Within any model, researchers and community members may build relationships that lead to PAR research. The variety of pathways to PAR research at Tar Creek demonstrate the importance of personal relationships and leveling the traditional, hierarchical "researcher-researched" model to one of collaborators. Community transformation does not happen through reports or maps, but rather grows with the relationships and trust that is built among individuals.

(3) Community-engaged research has the potential to do "good science" while also having significant impacts on individuals and communities. This model of research is unique in that, due to its transdisciplinary nature and variety of stakeholders present, a participatory approach allows researchers to integrate a variety of systems (scientific and social) to ask new and exciting science questions. Additionally, because community members are personally vested in the outcome, they, working with researchers, ensure that each step of the research is done with care.

4 What will community-engaged research look like in 20 years?

The traditional gap between the needs of Main Street and the Ivory Tower must be bridged in order to maximize co-benefits. But what does an "ideal" future look like from the perspective of university researchers?

First, we must enhance incentives for researchers to engage with communities. This must start with increased recognition of the effort that is involved in building impactful and sustained community-engaged research programs. For example, a laboratory-based scientist might spend much of her pre-tenure time in developing a new analytical tool or technique that is utilized by a small subset of other experts, and is rewarded within the "comfort zone" of promotion and tenure committees. But that pre-tenure scientist is not likely to be rewarded for spending that same amount of time building an engagement program that ultimately might have tremendous impact. We must value (culturally and institutionally) CBPR and PAR.

Second, funding agencies must recognize and value university-community partnerships financially. Currently, obtaining sustained and consistent funding to support a community-engaged program is challenging. University partners typically seek research funding from federal sources that might not have community support as a key priority, and funding is typically of limited duration. Similarly, community organizations typically seek funding from federal, state, or private foundation sources that do not fund original research but instead focus on community action. One way to overcome this is to simultaneously develop multiple types of complementary funding streams, however scientific funding sources must develop funding sources specifically aimed for CBPR projects.

Finally, we need to rethink how we train our graduate students. The gold standard around which most science graduate students are trained focusses on analytical training in the laboratory and/or in the field. Anything outside of this type of training is typically considered "not relevant to the student's academic plan." This model persists because it increases the academic output and publication records of principal investigators, which is necessary to obtain funding for the next set of graduate students. But it is a model is increasingly disconnected from the needs of society. There is no questioning the value of many products of this model, but the space should be open to newer approaches that mentor and train young scientists to develop curiosity and questions that matter about a system. This is certainly done in many undergraduate programs, but not so frequently in graduate programs in the basic sciences.

GeoHealth as a research paradigm is fast evolving, adopting new models for applied research that privileges community outcomes as much as scientific "advances." We as researchers need to work in partnership with communities that we should be serving with our expertise. This will allow us to deliver science that is actionable, environmental justice focused, and sustainable.

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Conflict of Interest
The authors declare no conflicts of interest relevant to this study.

Data Statement
No new data were involved in this study.

Author contributions
All authors contributed equally to this work.

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Table 1.**Modes of GeoHealth inquiry and community engagement along with typical characteristics and outcomes. Note these research models are porous and often a community group experiences these in blended ways.**

Mode of Engagement	**Characteristics**	**Outcomes**	**Power of Investigator**	**Funding Dollars**	**Community Led**
Parachute Science (Contractual)	Large funding levels create transdisciplinary teams of researchers that "parachute" into an affected area.	Immediate increases in public environmental health safety and publishing in high profile journals to create new mechanistic knowledge.			
Citizen Science (Consultative)	Researcher provides data and research questions while contualizing information in exchange for samples distributed over a large geographic area.	Focus on community education and individual behavior change to reduce risk.			
Brokered Science (Collaborative)	Scientific "brokers," such as Thriving Earth Exchange, connect scientists with communities in need of technical expertise to address a particular environmental health concern or question.	Clear community deliverables (ex. Maps, reports) and short term partnerships (8-12 months).			
Participatory Action Science (Co-produced)	Community members and researchers co-discover research questions and work with an explicit focus on how science outcomes can address inequities and create new community networks.	Can lead to serendipitous science and long-term relationships (years) with the aim of creating positive community level transformation