

# Community-Engaged Science Along the US-Mexico Border: Methodologies for Community Participation in Environmental Research

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**ABSTRACT:**

**Background:** Colonias are unincorporated communities along the U.S.–Mexico border that face systemic environmental and public health challenges. Long-standing infrastructural deficiencies, socio-economic hardship, and historical mistrust have hindered effective community partnerships.

**Objectives:** This study aimed to implement and evaluate a Community-Based Participatory Research (CBPR) approach tailored to promote environmental health equity, build trust, and foster meaningful participation among colonia residents in Hidalgo County, South Texas.

**Methods:** The Juntos para un Mejor Mañana (Together for a Better Tomorrow) program developed a multifaceted engagement strategy, including the formation of three Community Advisory Boards, citizen science activities, family workshops, and training Promotora-Researchers. A community health assessment was conducted with 100 participants, combining survey data with biomarker collection (urine, blood, toenail) to assess environmental exposures.

**Results:** The initiative achieved high participation and retention: 96.2% survey completion, 81% initial urine sample submission, 75% urine resampling after one year, 80% blood sample submission, and 77% toenail sample collection. The program also led to the establishment of sustained community-based activities.

**Conclusions:** CBPR strategies rooted in local partnership and cultural relevance can overcome barriers to participation in environmental justice communities. This model demonstrated strong community agency, high data collection rates, and durable program impact—offering a replicable approach for advancing health equity in vulnerable border regions.

**KEYWORDS:** Community-Based Participatory Research (CBPR), Colonias, Citizen Science, Promotoras de Salud, Border Health

## 1. Introduction

Distrust in governmental institutions is at an all-time high in the United States (US), especially for marginalized, Hispanic communities where fear of perceived immigration status has led to increased isolation.<sup>1</sup> *Colonias* are unincorporated settlements along the Lower Rio Grande Valley of South Texas, and these communities are home to many immigrant and undocumented residents. Residents of *colonias* face serious socio-economic and environmental health challenges, including limited access to clean water and sanitation. Furthermore, *colonia* residents are often unable to access or are ineligible for existing governmental programs aimed to address water quality issues within Texas.<sup>2</sup> Even in cases where residents may be eligible for assistance, there is often a heightened distrust of institutional systems. These are neighborhoods that have historically struggled with severe community health outcomes and continue to stand out as critical areas for focused support and empowerment through research and partnerships.<sup>3</sup>

Historical neglect and discrimination, combined with fears of detention or deportation, have eroded trust in government and academic institutions, making residents understandably wary of outsiders' involvement. This climate has been exacerbated in recent years by the politicization of immigration issues, making it now more essential than ever for researchers to foster trust and demonstrate cultural humility.<sup>4</sup> To navigate these challenges, it is crucial to partner with local organizations and trusted community leaders, and to employ culturally relevant, Spanish-language outreach through community health workers (*promotoras*) and community advisory boards. Strong, diverse partnerships ensure that research activities respect local customs and address community concerns openly. Without trust, residents may be reluctant to participate or may withhold information, compromising data quality and intervention impact. Conversely, when a community is meaningfully engaged and research is

co-designed with their input, participation rises, data becomes more reliable, and health interventions are more likely to be accepted and sustained. Building and maintaining trust, therefore, is foundational to achieving lasting environmental health improvements in communities like the South Texas *colonias*.

Environmental and social issues facing the *colonias* in South Texas are a stark illustration of systemic inequities that occur across the US, particularly through the lens of water pollution. These marginalized communities are disproportionately affected by contaminated drinking water, notably with heavy metals such as lead and metalloids like arsenic, which not only breach safe consumption levels but pose health risks, including increased cancer risk and developmental issues in children.<sup>5,6</sup> Compounding this, agricultural runoff introduces pesticides and fertilizers into the water supply, exacerbating the contamination and highlighting the intersections between environmental hazards and public health.<sup>7,8</sup>

These challenges underscore the critical need for targeted interventions, robust community engagement in environmental monitoring, and culturally relevant policy reforms aimed at safeguarding water quality to advance environmental quality for *colonia* residents. The purpose of this manuscript is to describe the methodological processes utilized in a community-engaged research project focused on addressing household water quality concerns in a historically marginalized, predominately Hispanic community by empowering residents to be engaged partners in their own health interventions.

## **2. Background, Purpose, and Significance**

Starting in 2022, the Juntos para un Mejor Mañana (Together for a Better Tomorrow; TBT) program at the Texas A&M University School of Public Health partnered with Methodist Healthcare Ministries of South Texas (MHM) to address environmental and public health

challenges tied to poor drinking water quality in two colonias in Hidalgo County. The project focused on identifying environmental conditions and exposure pathways for toxic metals and metalloids in household drinking water and developing a targeted intervention. This included systematic collection of potable water samples, biomarkers (toenail, urine, and blood), and a detailed health survey in Progreso and San Carlos to assess contaminant distribution in both the environment and residents. A Citizen Science program for high school students and a parallel family program further supported trust-building and empowerment. The study was approved by the Texas A&M University Institutional Review Board (IRB2022-1244D).

Because of the sensitive nature of biomarker collection and longstanding community distrust, a strong community engagement approach was essential. Early success was demonstrated through high response rates (75–90 percent), co-learning and co-directed research goals set through Community Advisory Boards (CABs), and the graduation of all participating citizen scientists and their parents. Ultimately, the project succeeded due to strong community partnerships, deliberate trust-building, and meaningful co-design of research goals with the CABs and promotoras.

By outlining strategies used to establish successful partnerships built on trust, engage in co-learning with residents, and build local capacity for environmental advocacy, this paper contributes to the growing literature on the application of empowerment theory nested within a Community-Based Participatory Research (CBPR) framework in environmentally and socially marginalized community contexts.<sup>9</sup> This example serves as an important model for efforts in other, similar communities, especially where a lack of trust in outside entities could be a barrier to implementing successful public health interventions.

Empowerment theory emphasizes the importance of building individual and collective capacity at the local level by strengthening self-efficacy and increasing community control

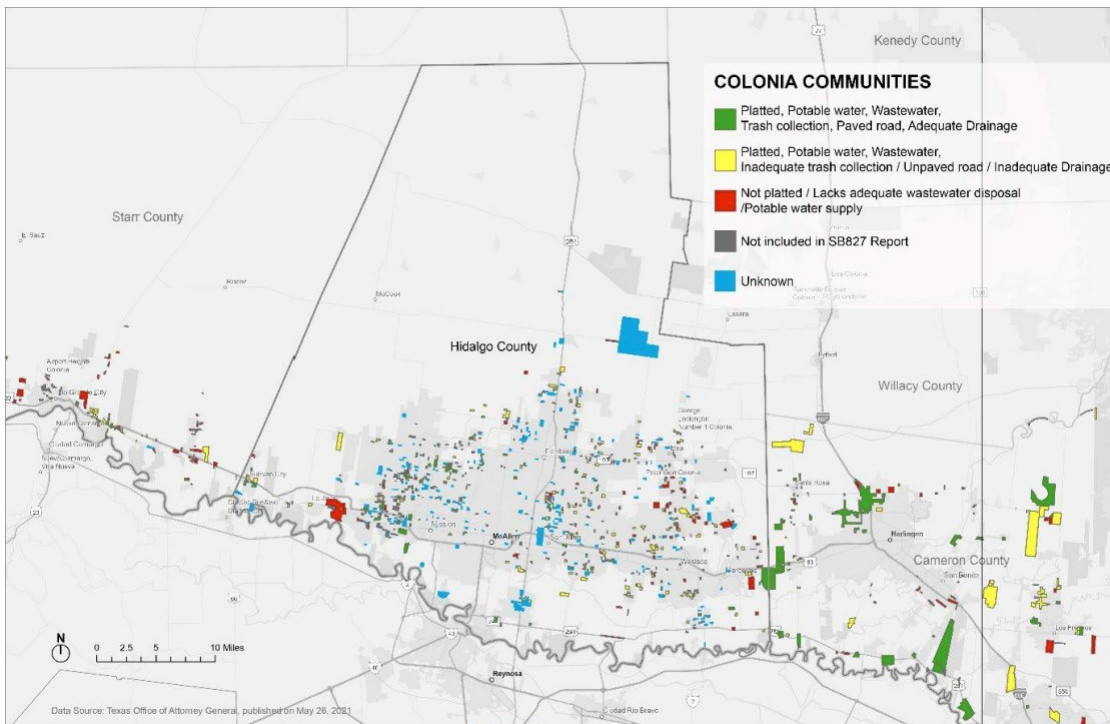
over decisions that affect health and community well-being.<sup>10</sup> There are three main approaches for improving local empowerment within communities: intrapersonal empowerment (knowledge, skills), interactional empowerment (collaboration, shared decision-making), and behavioral/collective empowerment (community action, advocacy), which guided our community engagement approach at every level.<sup>11</sup> Empowerment theory works well with CBPR, which is a framework designed to incorporate a co-learning and co-directed research approach, as well as ensuring equitable participation and shared ownership of resulting data for research projects.<sup>12,13</sup> Using a CBPR approach, guided by concepts of empowerment theory were pivotal for addressing the disparate distribution of environmental harms and benefits in this community. This approach underscores the importance of merging scientific research with community engagement to effectively tackle environmental disparities and ensure community agency in manifesting the communities, environment, and lives they choose. CBPR efforts significantly enhance the sustainability of community interventions and research outcomes by involving community members directly in the research process. This inclusive approach not only allows research organizations to gain insights from local experts about the current conditions and aspirations of the community but also ensures that community leaders and members actively participate in designing and implementing research solutions that directly impact their lives. By doing so, CBPR fosters a sense of ownership, empowerment, and commitment among community members, which is crucial for the long-term sustainability of these efforts. This approach provides applicable, actionable data of importance to local organizations and individuals and ensures co-learning around specific knowledge and tools needed for environmental advocacy and democratizing science.<sup>14,15</sup>

This project has built successful community partnerships and enabled community members to actively contribute towards the cultivation of community empowerment. By articulating specific strategies and disseminating lessons learned, this manuscript aims to provide a detailed guide for future endeavors in similar contexts.

### **3. Methodological Approaches for Community Engagement**

#### *3.1 Site Location – Hidalgo County Colonias*

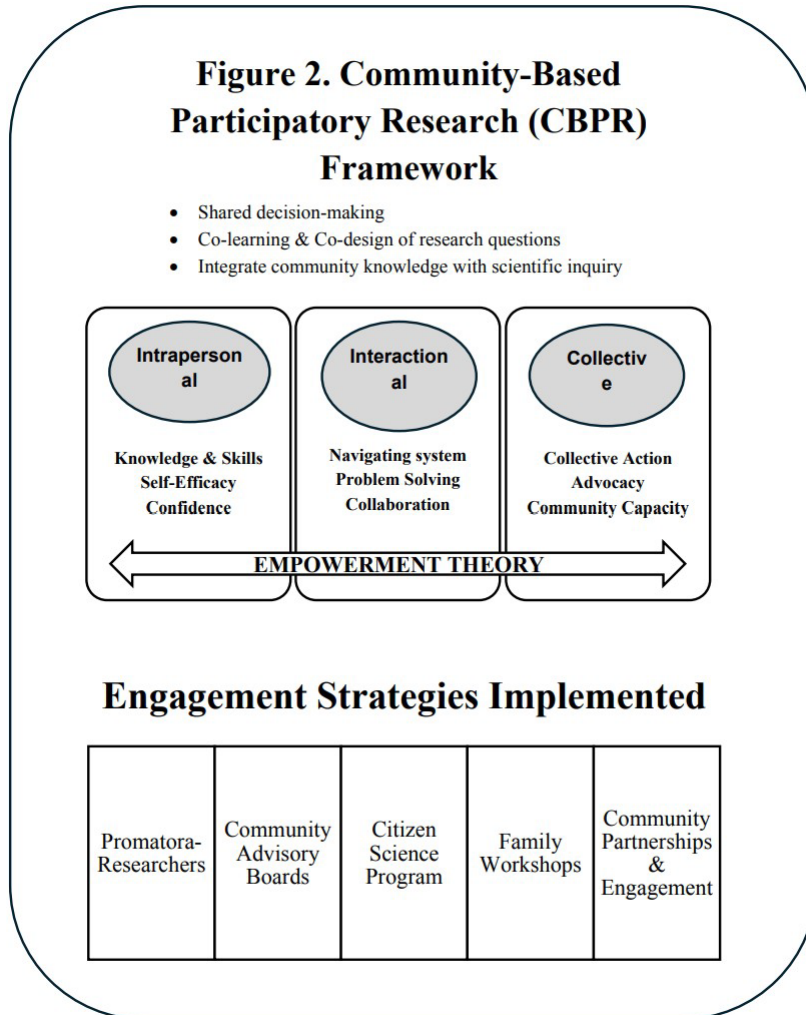
Hidalgo County, located in the Lower Rio Grande Valley of Texas, is home to a significant number of *colonias* experiencing disproportionate environmental burdens, particularly water security.<sup>13</sup> There are approximately 1,000 *colonias* spread across Hidalgo County (**Figure 1**), highlighting the scale of this issue within the region.<sup>16</sup> These communities face unique socio-economic challenges that contribute to a cycle of poverty and health issues associated with negative environmental exposure. Demographically, the *colonias* are predominantly Mexican heritage, reflecting the broader population trends of the Rio Grande Valley. Residents often include both US citizens and immigrants. The challenges of the Hidalgo County *colonias* underscore the need for targeted interventions. This location was chosen due to the identified community health need, paired with a strong desire within the community for this program, reflecting a collaborative approach to addressing these critical issues and fostering sustainable change. Furthermore, MHM serves the South Texas region and highlighted an exacerbated need for health research and intervention around issues of water safety in the *colonias*. Having a strong faith-based partner at the beginning of the project was instrumental in the success of the project due to the importance of faith within the targeted communities. *Colonias* are also demonstrative of similar communities across the US that struggle with poverty-based water security and distrust in authorities, making these neighborhoods an ideal site location for trialing our approach.



**Figure 1.** Colonias in Hidalgo County Texas

Empowerment theory focuses on three main aspects for building empowerment in socially, economically, and environmentally disparate communities: intrapersonal, interactional, and collective.<sup>17,18</sup> Intrapersonal empowerment is focused on how people think about themselves and their own capability or ability to act; so, we employed a number of strategies to build environmental health knowledge, feelings of self-efficacy, and the confidence to engage, ask questions, and participate in decision-making. Interactional empowerment is focused on how people relate to others and navigate systems; for this approach we emphasized collaborative skills, problem-solving, and the ability to both understand and influence institutions and relevant policies. Finally, behavioral/collective empowerment is all about how people come together to create change for their communities; for this approach we utilized the strength of community partnerships and CABs to provide input and skills on data collection and interpretation, as well as collective action for shared environmental health issues. We utilized all three approaches when designing our CBPR outreach and engagement strategy and tried

to incorporate some aspects of each of the three approaches into every community outreach activity, as seen in Figure 2.



### 3.2 The Role of Promotoras and Scientific Literacy Training

At the heart of our engagement strategy was the employment of local promotoras, who played a crucial role in maintaining ongoing communication and facilitating regular meetings with community members. These promotoras were selected due to being deeply rooted in the community and familiar with its cultural, religious, and linguistic nuances. This was a vital first step because they were able to act as a bridge between the research team and the community, ensuring that the community's voice was heard and valued throughout the

project's lifecycle.<sup>19</sup> In the realm of public health research, particularly in addressing the profound health disparities faced by Hispanic communities in this region, the engagement of promotoras as research collaborators has emerged as an effective strategy.<sup>21,22</sup> Promotoras, who share a lived experience with the community, extend their traditional roles beyond mere liaisons to embody the roles of cultural brokers, health advocates, trusted voices, and integral components of the research team. This model not only enhances the cultural relevance of health interventions but also ensures their methodological rigor and community acceptance.

A key innovation applied to this research was incorporating a detailed multi-month training program focused on environmental health for the promotoras. In addition to completing Collaborative Institutional Training Initiative (CITI) Human Subjects training for social and behavioral research certification, training emphasizing the interpretation of environmental data, specifically concerning water contaminants, alongside practical training in collecting and assessing drinking water samples, significantly broadened the scope of their expertise. By equipping promotoras with the skills to tackle complex environmental health issues scientifically, this training addressed a critical aspect of public health and built intrapersonal empowerment for the promotoras-researchers through a gain in knowledge and environmental health skills, while simultaneously preparing the promotoras to go out into their communities and share their knowledge. The dual emphasis on enhancing scientific and cultural competencies ensured that promotoras were well-prepared to engage in sophisticated research activities, while maintaining and leveraging their deep-rooted trust within the community.

Promotoras were instrumental in facilitating community engagement with the CABs, building relationships, raising awareness regarding the study, strengthening community partnerships, and assisting in the development of the study design, as well as the citizen science program. The TBT leadership team used interactional and interpersonal empowerment with the

promotoras by providing the education and tools necessary to encourage the promotoras to take co-leadership at every step of the journey from community engagement to data collection to citizen science program design. In fact, the promotoras were behind the decision to implement a corresponding family program, which was not included in the initial program design, but was a culturally responsive inclusion.

As trusted members of the community, promotora-researchers were well-situated to work with community members out in the field. Survey data was gathered through a door-to-door approach by the promotoras in both Hidalgo County *colonias*, with all interviews conducted in Spanish. A complete census of the locations was attempted. This process was comprehensive, encompassing not only the administration of detailed questionnaires but also the collection of crucial biomarker data. This included the collection of urine samples with a follow-up one year later, as well as blood and toenail samples. The biomarkers were collected to assess short-, medium-, and long-term exposure to heavy metals and metalloids. This approach allowed for pinpointing potential exposure sources when combined with water testing and survey data. While details of the study results are beyond the scope of this report, they will be published at a later date for a comprehensive analysis. The efficacy of data collection hinged on the involvement of promotoras as recruiters, data collectors, and community organizers. The promotoras were also heavily engaged in the collective empowerment of the community, from supporting community-wide outreach to organizing data dissemination events.

### *3.3 Community Advisory Boards*

Community Advisory Boards (CABs) played an important role throughout our environmental research, helping ensure that local voices and concerns were incorporated into decision-making and contributing to more informed and empowered outcomes. The significance of

CABs extends beyond merely acting as a bridge between researchers and community members; they foster intrapersonal, interactional, and collective empowerment through meaningful collaboration by promoting active participation, active learning, and the co-creation of knowledge.<sup>23</sup> Additionally, CABs play a vital role in the dissemination of research findings, facilitating effective communication, enhancing public understanding, and empowering individuals to take ownership of their environment, both locally and internationally.

TBT benefitted immensely from the involvement of three highly active CABs: the Progreso Community Health Advisory Council (PCHAC), Hand in Hand in San Carlos (HHSC), and the Advisory Committee for Health and Community (CASCO) (**Figure 3**). TBT maintains these boards from a previous long-term research endeavor for several years.<sup>24</sup> These boards, composed of between 60 and 80 local community members- including



**Figure 3.** Community Meetings with Progresso Community Health Advisory Council, Hand in Hand in San Carlos, and Advisory Committee for Health and Community

Promotoras/Community Health Workers (P/CHWs), local non-profit directors, business owners, community center directors, church leaders, teachers, farm workers, community residents, and commissioners' staff—were instrumental from the project's inception to its conclusion. The diversity of the CAB members ensured a wide range of perspectives and expertise, enriching the research process and strengthening interactional empowerment through shared communication and problem-solving. Further, the continued participation in the CABs demonstrates genuine interest in engaging and informing the project study design and outcomes.

Each CAB met quarterly each year and the CABs played a pivotal role in ensuring that a research project was consistently aligned with the community's needs and priorities and met quarterly each year. Their involvement was crucial across all project stages—from defining

research questions to disseminating findings—ensuring that methods were culturally appropriate and that the data collected were reliable and relevant, thus emphasizing the importance of collective empowerment through shared decision-making. The CABs' role extended beyond data collection to include analysis and interpretation, providing unique insights that deepened the understanding of the results. In disseminating research findings, they were instrumental in developing communication strategies that made the information accessible, understandable, and actionable for the community from a collective empowerment perspective. This collaborative approach not only empowered community members to tackle environmental challenges but also built trust and fostered sustained engagement in a vulnerable setting, highlighting the strength of intrapersonal empowerment and the CABs' effectiveness in promoting public engagement and ownership of local issues. Furthermore, engagement with the CABs increased the impact of interactional empowerment strategies to navigate local institutions and build on multiorganizational partnerships due to the reliance on local knowledge and relationships.

### *3.4 Community Partnerships and Engagement Efforts*

In the context of environmental health, it is frequently observed that community engagement is notably absent in the least effective approaches and can remain constrained even among well-intentioned groups.<sup>25-27</sup> To facilitate meaningful engagement efforts, research groups must embrace flexibility and commit to co-learning with individuals and organizations, fostering a collaborative environment where knowledge and experiences are shared and valued equally in order to foster interactional empowerment through shared problem-solving. We formed meaningful partnerships with ARISE Adelante,<sup>28</sup> Proyecto Azteca,<sup>29</sup> LUPE (La Unión Del Pueblo Entero),<sup>30</sup> San Carlos Endowment Community Resource Center,<sup>31</sup> San Juan & Advancement Centers,<sup>32</sup> the Progreso Community Resource Center,<sup>33</sup> among many

others (**Figure 4**). By identifying key pillar organizations within the community and aligning with their goals and values, we were able to tap into existing networks for collective empowerment. These collaborations were foundational in establishing data-sharing protocols, providing outreach assistance, and conducting informational meetings throughout the year so that we could promote intrapersonal empowerment strategies of increased awareness and discussion on water security and environmental health concerns within the broader community and build trust and awareness regarding the project. Additionally, our engagement in these partnerships led us to participate in four health fairs and back-to-school initiatives, during which we provided over 480 back-to-school supplies for grade school children. While not directly related to the research project, these activities not only facilitated the practical support of the community's educational needs but also reinforced the importance of integrating community resources and academic research efforts to address local environmental health challenges effectively.



**Figure 4.** Community Partners

Our project's community engagement was characterized by continuous, meaningful interaction, employing bilingual materials and meetings to respect our community's linguistic diversity. Enhanced by educational workshops and forums, these initiatives aimed to inform on environmental health and solicit community feedback, fostering public discussion and building interactional empowerment strategies of strengthened communication and cross-organizational coordination. This approach, coupled with an open-door policy at our project office, cultivated a sense of ownership, participation, and trust among community members. Celebrating community milestones through annual appreciation events further strengthened engagement, acknowledging contributions and reinforcing a collective purpose in community advocacy. These celebrations, alongside our commitment to inclusivity and transparency, have played a pivotal role in building shared trust and encouraging ongoing community involvement, highlighting the significance of collective efforts in addressing environmental challenges.

### *3.5 Citizen Science Program*

The development of a citizen science program, in partnership with the community organization ARISE Adelante and other community non-profits, marks a significant stride towards engaging youth in environmental health initiatives within the communities of Progreso and San Carlos, TX. This innovative program enlisted 14 high-school aged individuals, identified and recruited by both ARISE and the promotoras for their interest in environmental issues, to participate in a structured educational experience designed to deepen their understanding of environmental health, water contaminants, and the application of field instrumentation. The citizen science program was designed to bolster intrapersonal empowerment through the dissemination of environmental health education, incorporate interactional empowerment through learning to collect and interpret data alongside

researchers, and collective empowerment by educating students about collective action and community advocacy techniques.

The curriculum development was led by a trained Promotora-Researcher with Texas A&M University faculty from the School of Public Health overseeing the process. The course was comprised of four 4-hour sessions spread over four weeks (16 hours of in-class/field education), delivering lecture-style training that covered critical areas such as environmental health, public health issues, and the detection of water contaminants using advanced tools like the Palintest's Kemio Heavy Metal Detection system, a USEPA-approved field device, and collective action/advocacy approaches. This theoretical foundation was augmented with hands-on field exercises, enabling the students to apply their learning in real-world contexts. These activities included water sampling, where students had the opportunity to collect and analyze water samples from their communities, thus contributing valuable data and insights to local environmental health assessments. Furthermore, the program incorporated park litter assessments and cleanup activities, visits to water purification plants, and participation in community events and presentations, enriching the students' understanding of environmental stewardship and community engagement.

The culmination of the program was marked by the awarding of a Citizen Science Certificate from Texas A&M University to each participant, recognizing their commitment and contributions to environmental science. A graduation event, held at the Texas A&M University Higher Education Center in McAllen, TX, celebrated the achievements of these young citizen scientists, highlighting the program's role in fostering a new generation of environmental advocates (**Figure 5**). A pre- and post-evaluation was performed for this program to gauge the efficacy of the program and was conducted anonymously to ensure truthful responses.



**Figure 5.** Citizen Science Graduation

### *3.6 Family Workshops*

Based on feedback from our promotora-researchers, we added on simultaneous family workshops for parents. This approach was necessary to ensure cultural sensitivity to familial constraints regarding transportation, but it offered a unique opportunity to strengthen the efficacy of the citizen science outcomes by including a family approach and also allowed us another avenue to empower families on practical public health needs. During the summer and fall of 2023, our family program was designed to foster intrapersonal empowerment through an increase in knowledge and awareness among participants on a broad spectrum of critical topics. These topics encompassed college readiness for their children, detailed information on financial aid and scholarships, an overview of local health services, and opportunities for adult education, alongside introductions to local events. The workshops were thoughtfully structured to accommodate families by offering sessions in both English and Spanish, ensuring inclusivity and comprehensive understanding and bringing in external experts from other community organizations. Experts from institutions such as South Texas College,

Access Clinics, TAMU School of Public Health, and Guajira Clinic were invited to share their insights, adding significant value to the curriculum and incorporating interactional empowerment through shared learning across families and cross-organization collaboration. The strategic design of the program also included a formal course structure, concluding with the awarding of certificates of completion to participating families, alongside their children, at the main graduation event. This collaborative recognition not only underscored the achievements of the entire family but also highlighted the program's holistic approach to the community's collective empowerment and education.

#### **4. Outcomes and Efficacy**

##### **4.1 Benefits to Community**

Implementing a community-engaged research approach focused on empowerment strategies within our study location significantly benefited the community beyond immediate environmental health improvements or research needs. By engaging community members, particularly promotoras, in a comprehensive environmental health program, these initiatives fostered a deeper understanding and active involvement in local environmental issues, thereby amplifying intrapersonal empowerment. By utilizing these community engagement strategies, the project cultivated interactional empowerment and environmental stewardship among residents, encouraging them to take an active role in monitoring and advocating for their environmental health. This heightened engagement leads to a more informed community that is capable of proactively identifying and addressing environmental risks through collective action and advocacy. Furthermore, it elucidated potential environmental issues that might otherwise have been overlooked, through meaningful dialogues in both formal and informal settings by relying on lived experience perspectives. **Table 1** demonstrates the specific ways that empowerment theory and a CBPR framework were incorporated into the

targeted community engagement activities, which was vital to the success of the project's research and public health intervention goals.

In the context of educational opportunities and long-term investment in youth programs, it can be challenging to assess impact. However, short-term evaluations proved important and impactful, with most students reporting a love of getting into their community and understanding environmental impacts. **Table 1** encapsulates the unanimous approval of a Citizen Science Program, where all participants expressed satisfaction in acquiring new knowledge and enhancing their community. Every respondent indicated an increased likelihood of pursuing higher education as a result of the program. One student in particular changed her aspirations from cosmetology to engineering and has since been accepted and enrolled in the Texas A&M University Engineering Department. The propensity to recommend the program was overwhelmingly positive, with all agreeing they would advise others to join. Key skills developed included understanding of environmental health, community betterment, and college preparedness.

This initiative has effectively leveraged state and national opportunities, shifting environmental initiative ownership to local entities, a move away from traditional power dynamics between universities and communities. This empowerment has led to a ripple effect, extending the project's reach and influence, with community organizations like ARISE Adelante taking proactive steps to sustain and expand their efforts. This has included the development of educational workshops that engage local youth in sustainable practices and environmental stewardship, reflecting a commitment to environmental advocacy and expanding the initiative's impact. These efforts have not only educated but actively involved youth in community projects, promoting a broader culture of environmental awareness and activism.

## 4.2 Benefits to Research

The effectiveness of proper community engagement efforts has been well-documented in the literature.<sup>34-36</sup> This program, through a comprehensive and systematic approach to community engagement efforts based on empowerment theory and a CBPR framework, revealed an increase in research benefit. Within the *colonias* it has traditionally been very challenging to receive adequate response rates.<sup>37</sup> However, due to the incorporation of empowerment and CBPR approaches, the project was strengthened enough to overcome historical issues of distrust. The expertise of and training from the promotoras and the extensive efforts on community engagement prior to data collection resulted in high response rates, even for biomarker data collection. Within the initially approached colonia, we recruited individual participants (N=100) we had a response rate for the survey and water testing of 87%, collection of initial urine samples 90% and follow up collection (1 year later) of 75%, blood sample of 80%, and toenail sample collection of 77%. Response rates this high are incredibly rare in the literature and speak to the benefits of this approach for research activities in similar communities.

## 4.3 Summary

**Table 2** summarizes significant CBPR activities for the duration of this project from 2022 to 2024, demonstrating key actions and outcomes that can be replicated in other contexts. Quarterly maintenance of Community Advisory Boards (CABs) enhanced community understanding, trust, and collaboration. Training promotoras in scientific literacy improved data quality and empowered community liaisons. The Citizen Science Program educated high school students on environmental health, while family workshops provided critical knowledge on college readiness and health services. Community outreach through events reinforced support and practical impact, and systematic collection of water samples ensured

scientific rigor. Annual appreciation events and door-to-door solicitation by promotoras fostered trust and high response rates. Finally, community and individual report backs in Summer 2024 enhanced transparency and empowerment, making these efforts reproducible in similar projects.

## 5. Challenges and Steps Forward

Many research groups have discussed the numerous challenges with community engagement. Researcher Benneworth (2018) documents the formidable barriers to effective university-community engagement, which includes the vertical segmentation of university missions, difficulties in managing diverse and informal engagement activities, and the marginalization of community engagement due to a perceived lack of prestige compared to other university roles.<sup>38</sup> Moreover, there is an implication that rigid institutional structures and the lack of inclusivity and adaptability limit the potential of community engagement. Our program actively dismantles these barriers through strategic initiatives emphasizing inclusivity, adaptability, empowerment, and mutual benefit—key factors that foster successful and sustainable university-community partnership. We instituted a clear communication strategy, ensuring the flow of information and concerns from the community to the university and vice versa. This removed the barrier of vertical segmentation by creating a horizontal, inclusive communication structure that values the contributions of all participants equally.

In the journey toward impactful community engagement, this manuscript highlights various strategies to foster genuine connections and sustainable outcomes. However, it is crucial to acknowledge that even the most well-intentioned approaches can encounter significant hurdles if the underlying funding and incentive structures fail to recognize and value these efforts. The essence of our project's success was significantly amplified by having a committed funder in Methodist Healthcare Ministries of South Texas who understood and

actively supported our vision for deep and meaningful community interaction and helped to make it a reality. This partnership was instrumental in navigating the complexities of engagement work, demonstrating that alignment between project goals and funding priorities is pivotal. Equally critical is the need for structural changes within academic institutions, particularly concerning promotion and incentive systems. Current models often overlook or undervalue community engagement efforts, favoring traditional research outputs.<sup>39, 40</sup> To truly embed community engagement within academic culture, universities must recalibrate their reward systems to recognize and incentivize such work.

### **COMPETING INTERESTS**

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**Table 1. Integration of Empowerment Theory and CBPR Across Community Engagement Activities**

Activity	CBPR Principles Reflected	Empowerment Theory Components Reflected
<b>Promotora-Researchers</b>	<ul style="list-style-type: none"> <li>• Co-learning between researchers and community members</li> <li>• Shared decision-making in study design and outreach</li> <li>• Recognition of community expertise</li> <li>• Culturally grounded methods</li> </ul>	<p><b>Intrapersonal:</b> increased environmental health knowledge, confidence, and skills</p> <p><b>Interactional:</b> ability to work with researchers, navigate systems, and represent community needs</p> <p><b>Collective:</b> supporting community-wide outreach and mobilizing neighbors</p>
<b>Community Advisory Boards (CABs)</b>	<ul style="list-style-type: none"> <li>• Joint development of research questions and methods</li> <li>• Equitable partnership and shared governance</li> <li>• Community-led interpretation of results</li> <li>• Continuous feedback loops</li> </ul>	<p><b>Intrapersonal:</b> enhanced understanding of environmental risks and research processes</p> <p><b>Interactional:</b> collaborative problem-solving, institutional navigation, multi-organizational partnerships</p> <p><b>Collective:</b> shaping dissemination strategies, building community capacity for advocacy</p>
<b>Community Engagement &amp; Partnerships</b> (e.g., ARISE, LUPE, Proyecto Azteca)	<ul style="list-style-type: none"> <li>• Long-term relationship building</li> <li>• Mutual benefit and trust-building</li> <li>• Community-driven outreach priorities</li> <li>• Integration of local knowledge and resources</li> </ul>	<p><b>Intrapersonal:</b> increased confidence to participate in environmental discussions</p> <p><b>Interactional:</b> strengthened communication and cross-organization coordination</p> <p><b>Collective:</b> mobilizing networks for events, joint environmental health initiatives, and shared purpose</p>

<b>Activity</b>	<b>CBPR Principles Reflected</b>	<b>Empowerment Theory Components Reflected</b>
<b>Citizen Science Activities</b>	<ul style="list-style-type: none"> <li>• Participatory data collection and interpretation</li> <li>• Community ownership of environmental data</li> <li>• Co-learning of scientific methods</li> <li>• Transparent communication of findings</li> </ul>	<p><b>Intrapersonal:</b> skill-building in water testing and environmental monitoring</p> <p><b>Interactional:</b> interpreting results with researchers, discussing implications with peers</p> <p><b>Collective:</b> community-led dissemination of data and identification of collective priorities</p>
<b>Family Environmental Health Sessions</b>	<ul style="list-style-type: none"> <li>• Culturally and linguistically appropriate education</li> <li>• Two-way dialogue and community feedback</li> <li>• Respect for community knowledge and family-centered learning</li> <li>• Accessible, inclusive engagement</li> </ul>	<p><b>Intrapersonal:</b> increased health literacy and confidence to ask questions</p> <p><b>Interactional:</b> shared learning across families, building relationships with project staff</p> <p><b>Collective:</b> fostering shared understanding of environmental risks and motivating community-level conversations</p>

**Table 2.** Summary of Self-Reported Opinions on Citizen Science Program

<b>Program Satisfaction</b>	<b>Reasons for Satisfaction</b>	<b>Impact on College Aspirations</b>	<b>Likelihood to Recommend</b>	<b>Skills Learned</b>
100% report to agree/strongly agree	Learning new information  Opportunities to improve community	100% report to more likely/more likely to attend higher education	100% of respondents were very likely to recommend the program	Community benefit, environmental health knowledge, college readiness

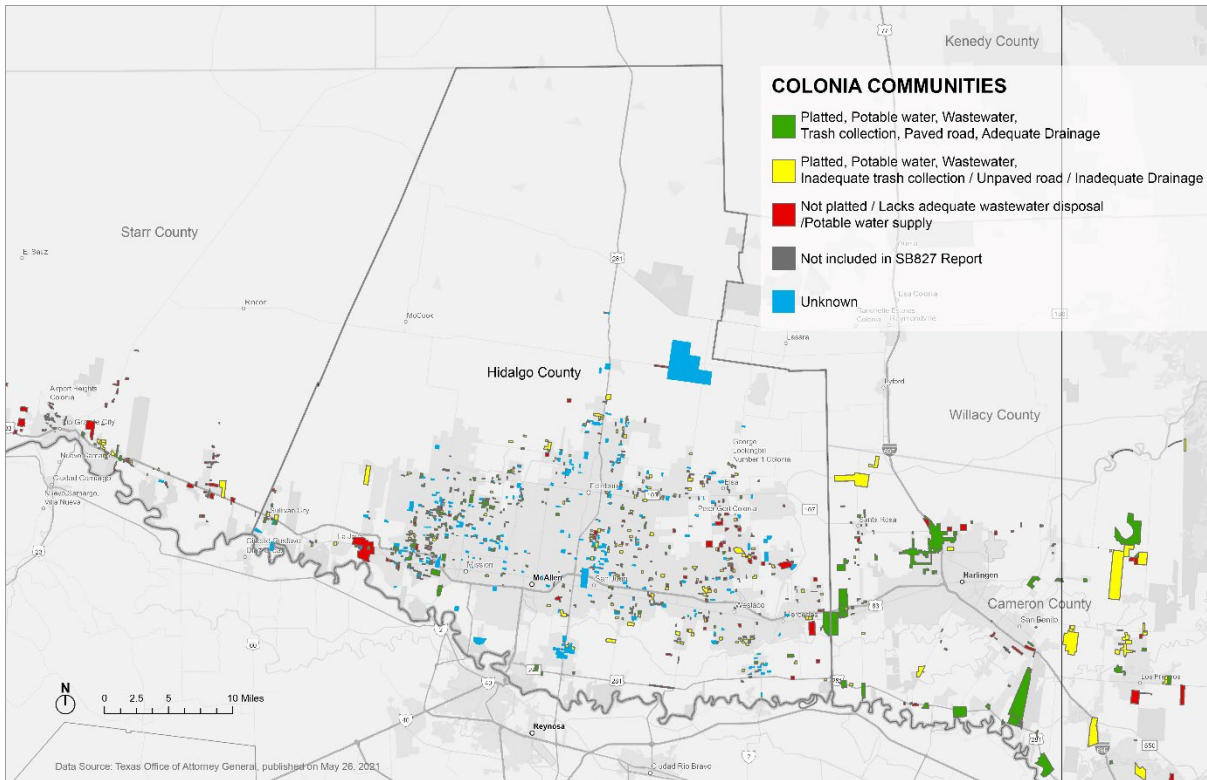
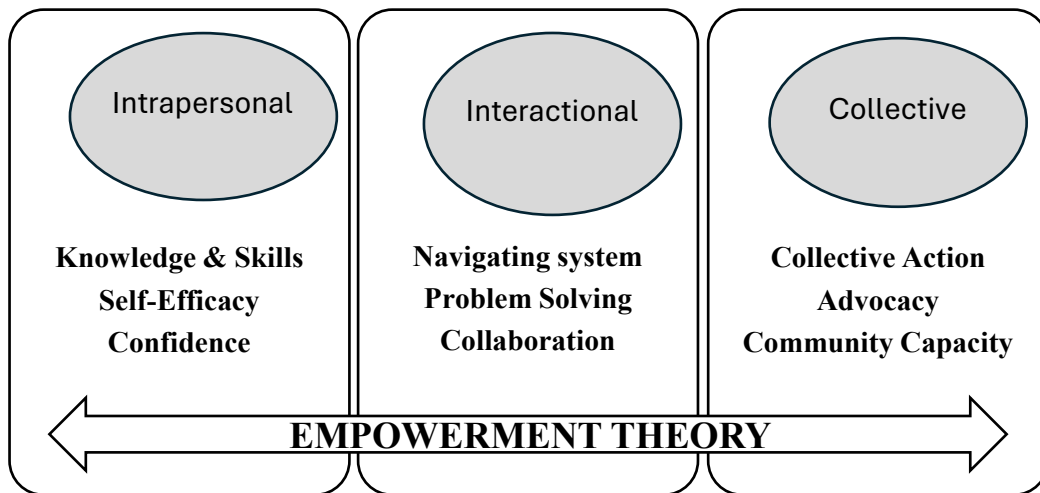


Figure 1. Colonias in Hidalgo County Texas

## Figure 2. Community-Based Participatory Research (CBPR) Framework

- Shared decision-making
- Co-learning & Co-design of research questions
- Integrate community knowledge with scientific inquiry



## Engagement Strategies Implemented

Promotora- Researchers	Community Advisory Boards	Citizen Science Program	Family Workshops	Community Partnerships & Engagement
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**Figure 3.** Community Meetings with Progresso Community Health Advisory Council, Hand in Hand in San Carlos, and Advisory Committee for Health and Community



Figure 4. Community Partners



**Figure 5.** Citizen Science Graduation