

# Data to Action: Community-Based Participatory Research to Address Concerns about Metal Air Pollution in Overburdened Neighborhoods near Metal Recycling Facilities in Houston

Elaine Symanski,<sup>1</sup>  Heyreoun An Han,<sup>1</sup> Sheryl McCurdy,<sup>2</sup> Loren Hopkins,<sup>3,4</sup> Juan Flores,<sup>5</sup> Inkyu Han,<sup>6</sup> Mary Ann Smith,<sup>7</sup> James Caldwell,<sup>8</sup> Cecelia Fontenot,<sup>9</sup> Bobbie Wyatt,<sup>9</sup> and Christine Markham<sup>2</sup>

<sup>1</sup>Center for Precision Environmental Health, Baylor College of Medicine, Houston, Texas, USA

<sup>2</sup>Department of Health Promotion and Behavioral Sciences, UTHealth School of Public Health, Houston, Texas, USA

<sup>3</sup>Department of Statistics, Rice University, Houston, Texas, USA

<sup>4</sup>Houston Health Department, Houston, Texas, USA

<sup>5</sup>Air Alliance Houston, Houston, Texas, USA

<sup>6</sup>Department of Epidemiology and Biostatistics, Temple University College of Public Health, Philadelphia, Pennsylvania, USA

<sup>7</sup>Department of Epidemiology, Human Genetics and Environmental Sciences, UTHealth School of Public Health, Houston, Texas, USA

<sup>8</sup>Coalition of Community Organizations (CoCo), Houston, Texas, USA

<sup>9</sup>South Park Area Civic Club, Houston, Texas, USA

**BACKGROUND:** Exposures to environmental contaminants can be influenced by social determinants of health. As a result, persons living in socially disadvantaged communities may experience disproportionate health risks from environmental exposures. Mixed methods research can be used to understand community-level and individual-level exposures to chemical and nonchemical stressors contributing to environmental health disparities. Furthermore, community-based participatory research (CBPR) approaches can lead to more effective interventions.

**OBJECTIVES:** We applied mixed methods to identify environmental health perceptions and needs among metal recyclers and residents living in disadvantaged neighborhoods near metal recycling facilities in Houston, Texas, in a CBPR study, Metal Air Pollution Partnership Solutions (MAPPS). Informed by what we learned and our previous findings from cancer and noncancer risk assessments of metal air pollution in these neighborhoods, we developed an action plan to lower metal aerosol emissions from metal recycling facilities and enhance community capacity to address environmental health risks.

**METHODS:** Key informant interviews, focus groups, and community surveys were used to identify environmental health concerns of residents. A diverse group from academia, an environmental justice advocacy group, the community, the metal recycling industry, and the local health department collaborated and translated these findings, along with results from our prior risk assessments, to inform a multifaceted public health action plan.

**RESULTS:** An evidence-based approach was used to develop and implement neighborhood-specific action plans. Plans included a voluntary framework of technical and administrative controls to reduce metal emissions in the metal recycling facilities, direct lines of communication among residents, metal recyclers, and local health department officials, and environmental health leadership training.

**DISCUSSION:** Using a CBPR approach, health risk assessment findings based on outdoor air monitoring campaigns and community survey results informed a multipronged environmental health action plan to mitigate health risks associated with metal air pollution. <https://doi.org/10.1289/EHP11405>

## Introduction

Communities of color bear higher burdens of chemical exposures,<sup>1–4</sup> which are due in part to the proximity of their neighborhoods to key exposure sources, including hazardous waste sites and industrial facilities—a consequence of the historic exclusionary practices of financial lenders (i.e., redlining).<sup>5</sup> Social determinants of health influence disease and well-being directly<sup>6</sup> and play a key role in determining patterns of human exposure and susceptibility to environmental contaminants.<sup>7,8</sup> Together, inequities in exposures to chemical and nonchemical stressors manifest in disproportionate health outcomes among persons from non-White racial and ethnic groups or with lower incomes.<sup>9,10</sup> A substantial literature suggests that health disparities may be mitigated through

community-based participatory research (CBPR), which increases community involvement in research activities as partners (rather than as study participants) and leads to enhanced feasibility, relevance, and acceptability of interventions.<sup>11,12</sup> Moreover, CBPR has gained greater acceptance in conducting environmental health sciences research.<sup>13–18</sup>

Many municipalities use a nonemergency call service (311) to provide residents a venue for learning about city services, reporting problems, and making complaints. This call service may be especially important in Houston when communicating environmental health concerns because the city is home to the largest petrochemical complex in the world, networks of smaller industries like metal recycling facilities located throughout the area,<sup>19</sup> and active federally or state-designated hazardous waste sites.<sup>20</sup> In response to 311 calls from Houstonians about dust, noise, and traffic generated by some metal recycling facilities operating within the city's limits, the Houston Health Department (HHD) conducted an investigation about the potential health impact of metal aerosol emissions from these types of facilities on air quality.<sup>21</sup> This investigation led to heightened concerns and a collaborative effort among a diverse group of partners to launch a CBPR study, titled Metal Air Pollution Partnership Solutions (MAPPS), to further address them.<sup>19</sup>

In this paper, we describe how we used what we learned from key informant interviews, focus groups, and door-to-door surveys, which were enabled by extensive community, industry, and government engagement, to identify key concerns and needs in

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Address correspondence to Elaine Symanski, Center for Precision Environmental Health, Department of Medicine, Baylor College of Medicine, 6550 Fannin St., Neurosensory NB315, Houston, Texas 77030-3411 USA. Email: [elaine.symanski@bcm.edu](mailto:elaine.symanski@bcm.edu)

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four neighborhoods near metal recycling facilities. Second, we illustrate how the mixed methods findings coupled to health risk assessments that relied on outdoor monitoring data at multiple locations within each neighborhood<sup>22</sup> informed a public health action plan to mitigate metal aerosol emissions from metal recycling plants and enhance community capacity to address future environmental health concerns.

## Methods

### The MAPPS Study

The MAPPS study is a research-to-action project with three components: a science component, a Public Health Action Plan, and an evaluation component (see <https://mapps-metals.org/>). The study was conducted between 2015 and 2020 in three low-income communities of predominantly Hispanic and Black residents living in Magnolia Park (one location on the east side and the other on the west side), South Park, and Fifth Ward/Northside. Employing a CBPR approach, we established a unique partnership among academics, HHD officials, members from Air Alliance Houston, residents, and metal recycling representatives. Guided by Intervention Mapping,<sup>23</sup> a systematic approach to planning health promotion interventions, we developed a logic model (see Figure 1) to guide the project. A community advisory board (CAB) of partners informed the study. Previously, we described the partnership and how it evolved to inform study activities and outcomes,<sup>19</sup> along with our air monitoring campaign and health risk assessments (based on the measured levels of metals in outdoor air).<sup>22</sup> Briefly, we conducted air monitoring at four locations within each neighborhood (i.e., at upwind, fence line, near neighborhood and far neighborhood locations) for 7 h when the wind was forecast to blow downwind from the metal recycling facility into the neighborhood and when no inclement weather was expected. We

found that risks varied by neighborhood and by location within a neighborhood with the highest risks observed at the fence line.

Herein, we present the thematic analysis of the key informant interviews and focus groups and findings from the door-to-door surveys that together were used to assess environmental health needs and perceptions. We also discuss how these results, coupled with the risk assessment findings, were used to develop and implement a public health action plan with our partners. The study was reviewed and approved by the institutional review boards at The University of Texas Health Science Center at Houston and Baylor College of Medicine.

### Assessing Perceptions and Needs about Environmental Health

To learn about resident and metal-recycler views and perceptions about environmental health risks, we applied a multipronged mixed methods strategy<sup>24</sup> by conducting key informant interviews, focus groups, and door-to-door community surveys. We staged our approach by using what we learned from the key informant interviews to develop focus group probes; the themes that emerged following analysis of the focus group transcripts were then used to develop questions for community surveys.

**Key informant interviews.** We developed semistructured interview guides to learn about residents' lived experiences and concerns in their neighborhoods, their views of the metal recycling facilities operating nearby and associated environmental health concerns, experiences with metal recyclers or government officials in addressing the concerns, and their recommendations for strategies to improve environmental health in their neighborhoods. We structured the interview guide for metal recyclers to find out about their work experience, operations and health and safety practices, perceptions about the impact of their facility on the surrounding neighborhoods, and interactions with residents

Process		Outcomes		
Inputs	Activities and Outputs	Short Term (2 years)	Intermediate (3-5 years)	Long Term (>5 years)
Residents Metal recyclers Academia Houston Health Department Air Alliance Houston Funding from grant (R01ES023563) Leveraged resources of partnering institutions and talents, expertise, and insight of residents and metal recyclers	<u>Formative Research:</u> Characterize community concerns <ul style="list-style-type: none"> <li>• #, type of participants in key informant interviews, focus groups, surveys and community forums</li> <li>• Evaluate activities for comprehensive inclusion</li> </ul> Conduct systematic air monitoring <ul style="list-style-type: none"> <li>• Results and interpretation</li> <li>• Evaluate activity for quality control</li> </ul> <u>Multilevel Public Health Action Plan:</u> Draw conclusions and disseminate findings <ul style="list-style-type: none"> <li>• To community - #, type of participants in community forums</li> <li>• To policy makers - #, type of contacts</li> <li>• To metal recyclers - #, type of contacts</li> </ul> Define & disseminate best practices <ul style="list-style-type: none"> <li>• #, type of contact/training</li> <li>• Evaluate by conducting 2nd round of sampling</li> </ul> Enhance community capacity <ul style="list-style-type: none"> <li>• Train targeted community groups on environmental health risks and empowerment through resource awareness (city complaint procedures, elected officials, regulatory agencies) - # and type of participants trained</li> <li>• Train other targeted groups identified by the community</li> </ul>	<u>Formative Research Results:</u> Determination of baseline concentration of metals in air in target neighborhoods Characterization of health risks of community residents Characterization of resident environmental health concerns Increased awareness of environmental health risks among residents, policy makers, and metal recyclers  <u>Multilevel Public Health Action Plan:</u> Residents' knowledge and skills to implement advocacy strategies Knowledge and skills in the application of best practices among recyclers and policy makers Implementation of policies Implementation of best practices	Improvement in the level of change in air quality Contribute a model of community collaborative practice to the scientific literature Enduring relationships between the community, academia, government and industry Sustained cadre of knowledgeable and active community leaders	Reduced environmental exposures for improved quality of life Sustained empowerment and enhanced capacity of the community to successfully address future environmental health risks

Figure 1. Logic Model: Metal Air Pollution Partnership Solutions (MAPPS), Houston, Texas.

and government officials in addressing environmental health problems and ways to address them.

The CAB provided input on the interview guides and assisted in identifying five neighborhood leaders and four metal recycling representatives with management positions for interviews. To be eligible, individuals had to be at least 18 y of age and either reside in the study neighborhoods or work at the study's metal recycling facilities. The interviews were conducted at places chosen by participants and were facilitated by experienced, bilingual (English and Spanish) research team members. Each interview lasted between 1 and 2 h, and participants received a USD \$20 gift card in appreciation for their time. Shortly after we interviewed the first metal recycling representative, the study team and the CAB were informed that the other three planned interviews would not take place because of concerns expressed by management. Following discussions at a CAB meeting, an alternative approach to obtain written responses to a series of questions was proposed and approved.

**Focus groups.** We conducted one English-language focus group with metal recyclers and six focus groups in English or Spanish with residents living in the study communities. We recruited metal recyclers through the CAB metal recycling representatives. Residents were recruited by extending invitations at community meetings or other neighborhood events; door-to-door canvassing; acting on recommendations from CAB members; and distributing flyers at local businesses, schools, churches, and libraries, and through social media. Using what was learned from the key informant interviews and with input from the CAB, interview probes were developed for the focus groups. Resident focus group probes asked about: *a*) likes and dislikes about the neighborhood, changing neighborhood demographics, and relationships among neighbors; *b*) the environmental quality of the neighborhood, previously identified environmental problems, and challenges addressing them; *c*) advantages and disadvantages of metal recycling facilities and other industries operating in the neighborhood; *d*) interactions between metal recycling facilities and the community to better understand metal recycling operations; and *e*) environmental health priorities and ways to address environmental health problems. Metal recycling focus group probes asked about: *a*) benefits of the metal recycling facility to the neighborhood, along with community perceptions of metal recycling facilities; *b*) effective communication with the community; and *c*) training and education on environmental and occupational health related to metal recycling operations. A bilingual research team member helped to moderate the 90-min discussions, and each participant received a USD \$20 gift card.

**Qualitative data analysis.** All interviews and focus group discussions were digitally recorded and transcribed. Three focus groups conducted in Spanish were translated into English by a bilingual team member. We conducted a thematic analysis in line with Lincoln and Guba's credibility and trustworthiness criteria<sup>25</sup> and followed a six-phase approach<sup>26,27</sup> for establishing trustworthiness in each phase of the analysis. A trained research assistant, supervised by a member of the research team, read and reread the interviews and focus group discussions (Phase 1) before conducting initial deductive and inductive coding in ATLAS.ti software (version 7; Scientific Software Development GmbH).<sup>26,28,29</sup> "Dust" and "noise" are examples of deductive codes that were used, which were based on prior complaints to the city's 311 call service and our work with the community. Inductive codes, on the other hand, were those that arose during the process of examining the texts; in our analysis, examples included "unsure of polluter" and "religious leaders as champions." After applying these codes, the research assistant prepared a summary code report (Phase 2). To increase credibility, in addition to methodological triangulation (using

focus groups and key informant interviews), we used researcher triangulation. Specifically, five members of the research team provided input on the report in an iterative process that involved recoding the data with updated codebooks,<sup>27</sup> after which codes were grouped into initial themes (Phase 3).<sup>27-29</sup> The themes were reviewed and revised (Phase 4), and after peer debriefing<sup>27</sup> with the larger research team, defined and named (Phase 5). The summary reports and team meeting notes recorded throughout the thematic analysis process provided an audit trail for the project detailing how consensus about the codes and themes was reached (Phase 6).

**Community survey.** The themes that emerged from the interviews and focus group discussions were reviewed by the CAB, which then informed the domains of questions to include in the survey. Following several iterations, each of which benefited from CAB expertise and insight, the final survey included multiple branching questions ( $n = 46$  questions in total) that covered the following domains: *a*) participant demographics; *b*) awareness of the nearby metal recycling facility, including perceptions about potential benefits and concerns; *c*) outdoor air quality concerns; *d*) whether and how air quality problems in the past had been addressed; *e*) ways for residents to be informed about environmental health risks; and *f*) tools to address such risks in the future. CAB members (one resident and one metal recycling representative) participated in interviewing applicants for field staff positions and making decisions on who to hire as short-term employees of Air Alliance Houston (potential applicants were recruited based on outreach efforts in the neighborhoods and at Texas Southern University, a historically Black university located close to one of the study areas).

Prior to initiating field activities, we developed a 2-d training session. On day 1, we covered the following topics: MAPPS project overview; an overview of human subjects research; and steps for obtaining a Collaborative Institutional Training Initiative (CITI) certificate, after which the field staff completed the CITI training. On day 2, we provided an overview of the Manual of Procedures (MOP) for conducting the survey; interviewer responsibilities and safety protocols; tips on how to interview; informed consent procedures; the survey; and recordkeeping and data safeguarding. Day 2 ended with the staff conducting mock interviews. To increase participation, we distributed door hangers approximately 1 wk prior to canvassing to inform residents that our interviewers would be in their neighborhoods to conduct the surveys.

We learned from the focus groups that residents were largely unaware of local industries (including metal recycling facilities) operating in neighborhoods unless they lived nearby; we also learned from the air monitoring results that levels of metals in the air declined with distance downwind from the metal recycling facilities.<sup>22</sup> Considering these findings, coupled with logistical and financial considerations, we enumerated the sampling frame for the survey as households within a 0.25-mi buffer around each metal recycling facility ( $n = 1,269$  households; Magnolia Park 1:  $n = 319$ ; Magnolia Park 2:  $n = 324$ ; Fifth Ward/Northside: 277; and South Park: 349). Only one resident per household, 18 y or older, was invited to participate. Two-person teams conducted door-to-door interviews in the language preferred by residents (English or Spanish). One experienced field supervisor was assigned to oversee canvassing in each neighborhood. Participation was voluntary, and a USD \$10 gift card was provided to participants on completion of the survey. Each neighborhood was visited two to three times, with a goal of enrolling participants from at least 25% ( $n = 317$ ) of households in the study areas (i.e., Magnolia Park 1:  $n = 80$ ; Magnolia Park 2:  $n = 81$ ; Fifth Ward/Northside: 69; and South Park: 87). Completed surveys were scanned into the TELEform system



(Cardiff Software Inc.). We used SAS (version 9.4; SAS Institute, Inc.) to summarize survey responses.

### **Development of a Public Health Action Plan**

Working with partners, we translated residential air monitoring and inhalation risk assessment results,<sup>22</sup> along with survey findings and drafted neighborhood-specific lay-person reports. Early input from the CAB was that the reports were too technical and too dense; final reports incorporated infographics that were developed using Piktochart (<https://piktochart.com/>) and prepared in English and Spanish. We also developed facility-specific flyers (in English and Spanish) that provided information about whom to contact to report any concerns directly to the metal recyclers and the city's 311 call service. In addition, the HHD took the lead in producing a bilingual (English and Spanish) animated video that explained how best to report neighborhood concerns using the city's 311 call system. Finally, the metal recycler CAB members, working with HHD and other members, developed a process framework for developing different strategies to minimize metal aerosol emissions within metal recycling facilities.

Resident CAB members led "house meetings"<sup>30</sup> to solicit input on the action plan and promote the upcoming MAPPS community forums and environmental health leadership training workshop. Prior to the house meetings, we held training sessions to assist CAB members in conveying messaging regarding the study, articulating the value of having residents attend the community forums and leadership training workshop and explaining how to capture resident questions and/or concerns about the action plan. CAB members invited community members through their existing networks, which had been developed over their years of community engagement and advocacy. In total, 3 house meetings were held with 14 residents living in Fifth Ward/Northside ( $n=3$ ), Magnolia Park ( $n=4$ ), and South Park ( $n=7$ ) (evenly split by gender; 9 residents were Black, 4 residents were Hispanic, and 1 resident was non-Hispanic White). The input by community members was used to focus the content of the lay person-focused reports.

## **Results**

### **Interviews and Focus Groups**

From November 2015 to February 2016, we completed six interviews with five neighborhood leaders from Magnolia Park, South Park, and Fifth Ward/Northside and one metal recycling company professional. In April 2016, three metal recyclers provided written responses to questions. All resident key informant interviewees were Black ( $n=3$ ) or Hispanic ( $n=2$ ); ranged in age from 35 y to 71 y; and lived in their neighborhoods, on average, for 27 y. Most were currently engaged in their communities in holding leadership positions in neighborhood civic clubs, participating in organizations that share goals of supporting healthy communities or provide services like Target Hunger, which provides food assistance. The metal recycler key informants held managerial positions at the facilities, self-identified as non-Hispanic White ( $n=3$ ) or Other ( $n=1$ ), and ranged in age from 32 y to 48 y, and most had attended college ( $n=3$ ).

From October 2016 to December 2016, we conducted six focus groups of five to ten residents each, three in English and three in Spanish and one English-language focus group with metal recyclers ( $n=6$ ). Demographic characteristics of focus group participants are shown in [Table 1](#). Out of 48 residents, 81% were female and most were Hispanic ( $n=32$ ) or Black ( $n=12$ ). For the metal recycler focus group, all six participants were non-Hispanic White and male. Following the thematic analyses of

transcripts from our interviews and focus groups, four major themes emerged: *a*) neighborhood pride and neighborhood stressors; *b*) residents' struggles addressing neighborhood concerns, empowerment, and community building; *c*) mixed (metal recycler and community) perceptions of the advantages of disadvantages of metal recycling facilities operating within neighborhoods; and *d*) barriers and potential solutions to addressing environmental health concerns.

**Neighborhood pride and neighborhood stressors. Neighborhood pride.** Residents liked where they lived because of the central locations of their neighborhoods with access to downtown, bus routes, highways, restaurants, stores, and schools. They also had a sense of community pride because of their connections with other residents. As one participant stated, "Like everywhere, there are people who are good, who are negative. But in reality, most are good. What we have is that we take care of each other" (Spanish Focus Group 2, Resident #6). A neighborhood leader commented on his connectedness to neighbors because of family's ties to the neighborhood, "Well, basically for me...this is like Holy Land for me because it was the property my grandparents established, ok?" and then went on to add:

And I think that is one of the things I feel like what home should feel like. If I am outside, and for instance, like any neighborhood, there may be trouble but if somebody can say, "I know who that is because I know their momma, their sisters, their brothers," and all of that. So, there is a real sense of family even though we might differ on some things. (Neighborhood leader #1, key informant interview)

**Tensions between short- and long-term residents.** There was a sense that short-term residents, who were more likely to be renting, were less invested in the neighborhood. As pointed out by one resident, "... a lot of times, they [renters] are with the mindset that they are here temporarily. They don't really care because, you know, as soon as they make money, they going to move out somewhere else" (English Focus Group 1, Resident #4). A few noted frustrations with owners of rental properties, too: "Now that is one thing now that I do not like about the neighborhood and the owners really do not see to their rentals, keeping the property up" (Neighborhood leader #2, key informant interview).

**Concerns about pollution, abandoned homes, trash, stray animals, and poor drainage.** In terms of negative characteristics of their neighborhoods, there were generally concerns about pollution and its potential impact on health. Many residents spoke of drinking bottled water because of "yellow" (English Focus Group 1, Residents #7 and #8) or "brown" (English Focus Group #3, Residents #2, #5, #6, and #11) tap water. Other issues that were identified included abandoned homes, illegal dumping and trash, rats, stray dogs and cats, standing water from poor drainage, and crime. As stated by one resident, "There's crime and break-ins. It's a tough neighborhood. Dogs loose everywhere from right to left. They come into the yards, you know" (English Focus Group 1, Resident #9). Other residents said, "Of course, we have the boats that come in from all over the world. They bring the rats." (English Focus Group 1, Resident #3) and "So it's just so much. They allow so much. That gas station there is trashy. Nobody makes them pick up anything. They dump all down the street" (English Focus Group 3, Resident #11).

Community members detailed the disrepair of their neighborhood environment and spoke highly of their social connections. The poverty and pollution that people in these communities experienced had not led to the dissolution of family and friend connections.

**Table 1.** Demographic profile of Metal Air Pollution Partnership Solutions (MAPPS) study focus group participants, Houston, Texas, 2016.

	Neighborhood (language used in the focus group)						Metal recyclers (n = 6)
	Magnolia Park (English) (n = 8)	Magnolia Park (Spanish) (n = 8)	South Park (English) (n = 11)	South Park (Spanish) (n = 8)	Fifth Ward/Northside (English) (n = 8)	Fifth Ward/Northside (Spanish) (n = 5)	
Sex							
Female	6	5	10	6	7	5	0
Male	2	3	1	2	1	0	6
Race/ethnicity							
Black	0	0	10	0	2	0	0
Hispanic	8	8	0	8	3	5	0
Non-Hispanic White	0	0	0	0	1	0	6
Native American	0	0	0	0	1	0	0
Missing	0	0	1	0	1	0	0
Age (y)							
18–50	3	1	2	6	5	5	5
51 and older	5	7	9	2	3	0	1
Highest level of education							
<9th grade	0	7	1	7	0	2	0
9th grade–high school graduate	5	1	4	1	6	1	1
More than high school	3	0	6	0	2	2	5
Years living in the neighborhood (residents)							
<5	0	3	0	2	1	1	—
6–10	0	0	0	6	2	1	—
11–30	2	5	4	0	0	3	—
31+	6	0	7	0	5	0	—
Currently in the labor force							
Yes	6	2	3	7	7	0	—
No	2	6	8	1	1	0	—
Missing	—	—	—	—	—	5	—
Participation in the community							
Active	4	2	3	0	3	0	—
Moderate	2	4	6	3	5	2	—
Not active	2	2	2	5	0	3	—

Note: —, no data.

**Residents' struggles. Struggles addressing neighborhood concerns.** Residents observed little to no progress with city projects in their neighborhoods, distrusted governmental agencies to help improve communities, and were dissatisfied with government responses to complaints that were made in the past. As one resident commented, “Yeah. I mentioned it to them, but they don’t do nothing about it. They had told me from the City that they didn’t have no funds” (English Focus Group 1, Resident #8). In addition, another resident, regarding contacting federal, state, and local environmental authorities about a concern echoed frustration as well, “So all of these people that makes you wonder: why am I calling all of you and nobody answers?” (English Focus Group 3, Resident #10).

**Struggles with empowerment.** Residents also spoke of a sense of powerlessness with industrial facilities operating in their neighborhoods. In response to a question about prior environmental health concerns and how they were addressed, one resident discussed how the neighborhood signed an unsuccessful petition to prevent a rock-crushing company from establishing a business in the neighborhood. When asked if any complaints were made afterward, this resident said, “No, we didn’t do anything else because we [are] just a little group of people and they are just a big company and the company’s going to overrule us” (English Focus Group 3, Resident #4). There were also fatalistic comments, such as “I think a lot of times I think, the people...it’s almost like...because you live in an area where there is a lot of industrial...it’s kind of like...the people are like... ‘it’s what I have to live with. I can’t really complain...’ But it’s ok if it’s going to affect you or affect your family” (Spouse of Neighborhood leader #3, key informant interview).

A theme unique to Spanish-speaking resident focus groups was keeping to oneself and remaining silent on neighborhood issues. One resident indicated that it was easier not to complain and added, “Sometimes one prefers to isolate oneself, not to be involved because one can get into trouble” (Spanish Speaking Focus Group 4, Resident #4). This sentiment was echoed by another resident in another focus group:

Whether or not there are problems, we do not know. Sometimes you do not want to get involved. You do not want to say anything because we think we can get in trouble, or our voices are not heard. Then sometimes one says, “I will speak”; sometimes they say, “We listen to you,” but then afterwards, “Where is my voice?” My voice is silenced. ... Mute but eyes open because I see. (Spanish Speaking Focus Group 5, Resident #4)

**Struggles with life stressors.** There was also acknowledgment of the difficulties that many residents face and how these burdens represent barriers to civic duties (like voting) or getting involved in addressing neighborhood concerns. As one interviewee stated,

As I walk the streets and try to reach out to people to make them aware of things that...let’s register to vote; let’s do this; let’s do that. ... And it was kind of sad because I heard people in pain. Not so much that they did not want to do it, but it was just the fact that in their mindset they were so deep in their own pain that they could not see any hope for the future. (Neighborhood Leader 1, key informant interview)

Resident participants expressed frustration with responses from governmental agencies in addressing their concerns. They also felt both a powerlessness in the face of industry activities and a sense of inevitability of problems because of the industrialized nature of their neighborhoods. Residents also mentioned being overburdened by life's stresses that impacted their outlook and inhibited involvement in efforts to improve their communities.

***A contrast in views: mixed perceptions of metal recycling facilities in the neighborhood. Metal recycler self-perceptions.*** Metal recyclers highlighted the environmental benefits of their industry in transforming scrap metal into new products. As stated by one recycler, "And it's everything . . . I mentioned steel, bridges, and structures, but it's everything, it's aluminum cans being made into. . ." (Metal Recycler Focus Group, Participant #4); these remarks were immediately followed by comments from another recycler who added, "Chances are you are eating, when you're with your knives and forks, it's probably come from one of us [General agreement, laughter]" (Metal Recycler Focus Group, Participant #2).

Recyclers also described their facilities as long-established businesses that had positive impacts in the community by providing employment, making in-kind gifts and donations to nonprofit organizations, sponsoring employee volunteer opportunities, and providing an avenue to earn money through recycling. When asked about the negative impacts of facilities in the neighborhood, one metal recycler said, "It's a high traffic area" and added later, "In the summertime, there is just more action. There could be dust; there could be particulates that come out of an open field environment that we do operate in" (Metal Recycler #1, key informant interview). The metal recyclers also generally felt they were quick in resolving residents' concerns. One metal recycler provided this example of how an issue was rapidly addressed:

We were contacted by one of our neighbors concerned with noise early in the morning. . . . When this material was being dumped in our yard, he could hear it in his house as it was the corner of our yard closest to his house. After speaking with our neighbor, we moved this entire pile to the opposite end of the yard to alleviate the problem. (Metal recycler #2, written response)

Metal recyclers also highlighted their partnerships with various city agencies. They mentioned interactions with local police on metal theft prevention and with fire departments' Jaws of Life programs. They also commented on their involvement with entities like the Chamber of Commerce, participation in neighborhood meetings, and sponsorship of events for customers and residents at their facilities. As one metal recycler said,

So, we're all kind of intertwined in the business that we're doing in those neighborhoods and providing service. . . . I know we all do a lot of community outreach. We have customer appreciation days. And sometimes those customer appreciation days aren't just for our customers but people from the neighborhood come and get free lunch and kind of want to know what we're doing. And we're all very open with our customers and our neighbors. (Metal Recycler Focus Group, Participant #5)

**Resident perceptions of metal recyclers.** Some residents were unaware of metal recycling facilities operating in their neighborhoods, particularly if they did not live close by. A few residents noted that advantages of having these facilities in their neighborhoods outweighed the disadvantages, "It benefits more

than it harms. It removes all the trash from the street because of the metals that are thrown out. It has to be taken otherwise the city will be dirtier. It does help more. They have to be removed and they are reused" (Spanish Focus Group 2, Resident #3). In contrast, a few residents saw no benefits, "No, it doesn't benefit us, it benefits them" (English Focus Group 3, Participant # 4). Others had mixed views, as noted by one resident who said,

On the one hand, there can be a benefit since . . . when picking up cars that are not in good condition. Also, those cars that are not in good condition, are contaminating. Then they are taken out of circulation. And that also helps the environment. But they also hurt when the material is crushed, the dust that it releases. When it rains, it goes to the rivers, to the water outlets. (Spanish Focus Group 2, Resident #9)

Residents had environmental health concerns about the metal recycling facilities operating in their neighborhoods. As one participant noted, "And it is regular that I smell the metal. That I'll be in my yard, and I can smell it and I taste it. . . . I know I'm breathing it" (English Focus Group #6, Participant #9). Another resident mentioned fires, "[name of metal recycling company] has had two fires and we are exposed to the smoke. I got a really full panorama of the fire, and it was completely covering my whole. . . my whole block and the blocks before that" (English Focus Group 1, Resident #2). Noise also emerged as a concern, with one resident saying, "The noise is constant. The clattering of the steel from the pile that are being moved from the ferries, from the land to the ferries, or from the land to the 18 wheelers. There's always, always scratching it starts early from 6 in the morning to 4 pm. Constant noise" (English Focus Group 1, Resident #2).

Residents and metal recyclers occasionally expressed similar views about the metal recycling facilities, but more often they differed. The metal recyclers viewed their facilities as benefiting the neighborhoods and mostly interacted with the communities in which they were located through more formal channels (like the Chamber of Commerce). Some residents acknowledged benefits—like opportunities to earn money by recycling aluminum and riding neighborhoods of metal "trash"—and others expressed concerns about the impact of metal recycling facilities on air and water quality and about noise, traffic, and fire hazard potential.

**Resolving environmental health concerns. Barriers to addressing concerns.** Although neighborhood leaders and residents identified issues that needed to be addressed in their neighborhoods, they felt uninformed about ways to report environmental problems. Many indicated that they were unaware of whom to call or the services the city offers to address problems that arise in the community. One resident stated, "I think there is a big disconnect between this extremely industrialized center here and all the governmental agencies. It's a big disconnect because people do not know where to complain. They don't know where to go" (English Focus Group 1, Resident #10). A lack of information was also mentioned as a barrier for residents in directly addressing an environmental health concern with a metal recycling facility: "As far as I know, as far as I've seen, they don't even have their phone number like out on their sign" (English Focus Group 6, Resident #6). Another resident offered a similar suggestion about posting a number to call with concerns: "Yeah, advertising something for the company saying hey, you have questions about us here? Just like those big old trucks like, you don't like our driving, call this number? Like that. Outside those companies" (English Focus Group 6, Resident #2). Like the sentiment expressed by residents, metal recyclers suggested an optimal approach in communicating a concern would be one directed to the facility itself,



I would think they would get a very good response if they brought a concern directly to someone at the plant. So, having that communication, knowing who to call and being able to pick up the phone and make that phone call and contacting that person, saying hey this is going on or that's going on. (Metal Recycler Focus Group, Participant# 4)

**Working together to address problems.** Residents spoke of coalescing efforts to solve problems, as noted by one resident who said, “So that’s what we need to do to unite as a group and have the information that is now being given to us. That’s why I like to get involved in this kind of thing because I like to learn, to see what solutions can be given” (English Focus Group 6, Resident #3) and “. . . on the street where I live . . . we call [them] potholes, the little holes in the street, the people have helped. . . . We are always looking out for each other. . . . We have to be united so that there can be change” (Spanish Focus Group 2, Resident #9). Following discussion of other problems in their neighborhood, another resident added:

Well, there has been a need to meet as neighbors so that they listen to us . . . But now that these problems have already occurred, several neighbors have already gathered to make the complaint so that they see that it’s not just us. It’s the community. (Spanish, Focus Group 2, Resident #4)

**Challenges and needs about knowledge acquisition and enhanced environmental health literacy.** Metal recyclers pointed to their websites as a means by which community members could learn more about the industry and operations in the scrap yard of the metal recycling facilities, “We have a media section, where you can actually extract videos. All of those websites explain what we do, and that It’s actually reducing and helping the environment” (Metal Recycler Focus Group, Participant #6). Residents proposed improvements to company websites, saying they wanted to learn and know more, as suggested by one resident, “They could give us information on their website. [Yes – from another participant] For the company itself, they could give us the air quality information and all that. Then we could go to the website and see” (English Focus Group 6, Resident #8).

Another resident pointed to the need for enhanced literacy about environmental health problems in commenting about a public meeting held by the Texas Commission on Environmental Quality (TCEQ) regarding neighborhood concerns about a cement

facility, “Because you don’t know those technical aspects of things and they don’t necessarily lay that out for the public to get an understanding of what they should be looking for. Nobody is keeping, you know, residents informed of what to look for” (English Focus Group #6, Resident #3). There were also suggestions that greater access to information could be facilitated through face-to-face educational or training programs, which would best be held in central and convenient locations. As noted by one leader, “The church would be good. You can always bring people to church. It’s a great conversation. . . . Then you got classes you would be teaching about the environment, how to recycle stuff. Yes, people would like that” (Neighborhood leader #4, key informant interview).

Barriers to addressing environmental health problems included the need to be better informed about environmental issues; the need for enhanced environmental health literacy; and the need for clear information about where and to whom to report concerns, either to local, state, and federal officials or to local facilities in the neighborhood. Both residents and metal recyclers pointed to the usefulness of company websites, with residents suggesting that more specific information about facility operations is needed and that residents needed training in technical issues related to their environmental health concerns.

### Community Survey

Table 2 provides sociodemographic characteristics of the sampling frames in the four neighborhoods where the survey was administered, along with participation rates. A total of 370 of 684 residents (54%) who were contacted participated in the survey with response rates that varied by neighborhood from 48% to 62%. Table 3 provides a breakdown of survey responses by gender, ethnicity, length of residency, and education level. The average age of participants was 46 y (range 26–64 y), with little variation across neighborhoods. Overall, most respondents were Hispanic (64%;  $n = 235$ ) and female (56%;  $n = 206$ ). Sixty-eight percent of respondents indicated that they have lived in the neighborhood for more than 5 y ( $n = 249$ ) and equal percentages (35%;  $n = 128$ ) of respondents had graduated high school or attended vocational school or college.

The percentages of individuals who indicated that they were familiar with the metal recycling facility in their neighborhood ranged from 85% among respondents in Fifth Ward/Northside to 44% among respondents in South Park (58% overall). Having the metal recycler in their neighborhoods was viewed as beneficial because of opportunities to earn money for scrap metal (77%) and clean up the neighborhood of discarded aluminum cans (65%), whereas the top environmental health concerns were damage to

**Table 2.** Metal Air Pollution Partnership Solutions (MAPPS) community survey: Demographics and survey response rates by neighborhood, Houston, Texas, summer 2017.

	Magnolia Park 1	Magnolia Park 2	Fifth Ward/Northside	South Park
Neighborhood characteristics <sup>a</sup>				
Percentage minority	99% (majority Hispanic)	92% (majority Hispanic)	92% (majority Hispanic)	100% (majority Black)
Percentage low income	60%	67%	67%	66%
Percentage <high school education	51%	41%	51%	39%
Community survey response				
No. of households within 0.25 mi of the metalrecycling facility	319	324	277	349
No. of residents asked to complete the survey	166	150	149	219
No. of participants who completed the survey	88	149	92	105
Survey response rate	53%	57%	62%	48%

<sup>a</sup>Characteristics of the population within 0.25 mi of the metal-recycling facility; data from U.S. Environmental Protection Agency and EJScreen.<sup>31</sup> Low-income is defined as the percentage of the population in households where the household income is less than or equal to twice the federal poverty level. Minority is defined as all but Non-Hispanic White alone.

**Table 3.** Demographic profile of Metal Air Pollution Partnership Solutions (MAPPS) survey respondents by neighborhood, Houston, Texas, Summer 2017.

	Magnolia Park 1 (n = 88)	Magnolia Park 2 (n = 85)	Fifth Ward / Northside (n = 92)	South Park (n = 105)	All neighborhoods (n = 370)
	n (% <sup>a</sup> )	n (% <sup>a</sup> )	n (% <sup>a</sup> )	n (% <sup>a</sup> )	n (% <sup>a</sup> )
Sex					
Female	45 (51.1)	46 (54.1)	52 (56.5)	63 (60.0)	206 (55.7)
Male	43 (48.9)	39 (45.9)	40 (43.4)	42 (40.0)	164 (44.3)
Ethnicity					
Hispanic	74 (84.1)	73 (85.9)	49 (53.3)	39 (37.1)	235 (63.5)
Black	2 (2.3)	1 (1.2)	32 (34.8)	63 (60.0)	98 (26.5)
Non-Hispanic White	5 (5.7)	6 (7.1)	5 (5.4)	2 (1.9)	18 (4.9)
Other	7 (8.0)	5 (5.9)	5 (5.4)	1 (1.0)	18 (4.9)
Prefer not to answer	0 (0)	0 (0)	1 (1.1)	0 (0)	1 (0.3)
Years as a resident in the neighborhood					
<1	13 (14.8)	11 (12.9)	8 (8.7)	9 (8.6)	41 (11.1)
1–5	19 (21.6)	17 (20.0)	15 (16.3)	26 (24.8)	77 (20.8)
More than 5	54 (61.4)	57 (67.1)	68 (73.9)	70 (66.7)	249 (67.3)
Prefer not to answer	2 (2.3)	0 (0)	1 (1.1)	0 (0)	3 (0.8)
Highest level of education					
<High school	36 (40.9)	27 (31.8)	22 (23.9)	26 (24.8)	111 (30.0)
Graduated high school	23 (26.1)	29 (34.1)	32 (34.8)	44 (41.9)	128 (34.6)
Some vocational school or college or more	29 (33.0)	29 (34.1)	36 (39.1)	35 (33.3)	129 (34.9)
Prefer not to answer	0 (0)	0 (0)	2 (2.2)	0 (0)	2 (0.5)

<sup>a</sup>Percentages may not add up to 100% due to rounding.

roads by vehicles going to and from the metal recycler (64%) and the potential impact of metal recycling operations on air quality (62%). One-third of participants (31%) indicated that they had experienced an air quality problem in their neighborhoods (not specific to the metal recycling facilities in their neighborhoods), and, in this group, relatively few (20%) made a complaint to address the issues. Most respondents agreed that the following actions would be helpful in improving the environmental health of their communities: providing information on air pollution and related health effects (93%); increasing communication between residents and local government (90%); providing information to residents about how and where to report air quality problems (85%); and increasing communication between residents and metal recyclers or other industries (81%).

### Data to Action: Finding Sustainable Solutions to Metal Air Pollution

The goals of the action plan were to: *a*) reduce metal air emissions from the metal recycling facilities; *b*) provide information to residents about how to address environmental health concerns; *c*) improve communication among residents, metal recyclers, and city officials; and *d*) provide environmental health leadership training.

**Reduce metal air emissions from metal recycling facilities.** Key elements of the process framework adopted by the metal recyclers in our study to minimize metal aerosol emissions focused on technical and mechanical changes to reduce torch cutting of scrap metal and dust dispersion from the facilities. Each facility implemented elements that were appropriate for their specific circumstances, and plans included a combination of some of the following: adding a shear crane to reduce torch cutting, building a misting unit to reduce air contaminants, employing industrial sweeping services and water spraying trucks on site for dust suppression, building a windscreen and increasing the height of the facilities' fences, and implementing administrative controls, e.g., expanded environmental health training for staff.

**Provide information to address environmental health concerns.** Information to address environmental health concerns was multifaceted and multimedia. The neighborhood-specific

lay-person reports in English and Spanish included information about the goals of the MAPPS study, the methods and results from the air monitoring campaign and risk assessment, the survey results, and key elements of the Public Health Action Plan. The animated video explained how best to report neighborhood concerns using the city's 311 call system. Facility-specific flyers provided information about whom to contact to report any future concerns directly to the metal recyclers, along with information about the city's 311 call service. These materials were initially presented at our community forums, distributed at other community meetings, and made available on the MAPPS project's website and through our partners' social media channels.

**Improve communication among residents, metal recyclers, and city officials.** In addition to the flyers and the video detailing contact information for the facilities and the city's 311 call service, the metal recyclers developed a "Community Communication Protocol" to track interactions with residents who raise environmental health concerns. In addition, we modified a HHD citizen's packet for communicating environmental health concerns. The packet included contact information and office hours for residents to call (or email) about their concerns, instructions on what types of information to report, depending on the nature of the concern (including requests for photographs, where appropriate), and a data sheet for logging calls and follow-up.

**Disseminate findings and the public health action plan at community forums.** We held three neighborhood-specific community forums in fall of 2018 to disseminate study findings and the specifics of the action plan. As part of a "reporting back" effort, the meetings were held at a central location in each study neighborhood, including schools and community centers. To promote the events, we conducted door-to-door canvassing to invite residents in person or by leaving door hangers. Follow-up calls/texts were made to residents who indicated an interest in attending. We also met with the mayor of Houston and worked with his office to announce the forums during a meeting of the city council. The two 1-h forums consisted of an oral presentation and Q&A with panelists, including a city official, a researcher, and CAB members (residents and metal recyclers). Community reports and informational flyers/videos on how to use the 311 call system to report environmental health problems were presented. Two English-Spanish translators were on site to assist attendees



who spoke only Spanish. There were also opportunities for residents to meet and socialize informally with researchers, metal recyclers, and city officials. A total of 44 residents and public officials attended the forums.

**Provide environmental health leadership training.** We invited residents, neighborhood leaders, and metal recyclers to take part in the MAPPS Environmental Health Leadership Training. The three-session training in spring and summer of 2019 focused on the following topics: *a*) What is an environmental health leader? *b*) What is environmental health? What is air pollution? and *c*) How to communicate environmental health concerns using Photovoice,<sup>32,33</sup> a participatory action tool that relies on photographs or videos to tell a story about a neighborhood issue that mirrors real-life experiences and empowers marginalized individuals. We asked for commitments from trainees and trainers to attend all three sessions because this investment was viewed as beneficial to both participants and educators/researchers<sup>34</sup> and to build on content and discussion from each session to the next. Eight residents and two metal recyclers participated in the training. The trainees were asked to hold one or more house meetings to communicate environmental health concerns of their neighborhood using Photovoice with colleagues, family, friends, and/or neighbors. The final training session included trainee presentations on the outcomes of their meetings using storytelling and PowerPoint slides. The trainee presentations focused on industrial sources of pollution in their neighborhood; illegal dumping; neglected/unhealthy abandoned lots; and traffic-related issues, including unsafe intersections and bus stops. Overall, the trainees reported that the house meetings were successful and that using Photovoice was well received. One trainee reported that her child was able to learn “how to use 311” to report environmental issues, and another trainee reported on a successful outcome of her project, i.e., establishing a new environmental health action group with neighbors.

## Discussion

Houston, the fourth most populous city in the United States, is home to many industrial facilities. The Houston–Woodlands–Sugarland statistical metropolitan area ranks third out of 893 urban areas in the country in the total releases of toxic chemicals per square mile.<sup>35</sup> We conducted a CBPR project, stimulated by resident concerns, with collaborators from local industry, local government, an environmental justice community group, and residents to identify and address environmental health concerns associated with metal recycling operations. We conducted systematic assessments, using key informant interviews, focus groups, and surveys to learn about community perceptions and needs regarding environmental health and the industries that operate in their neighborhoods. Findings were coupled to risk assessment results based on monitoring of metals in air to develop tailored, evidence-based interventions developed with residents and metal recyclers. It is important to note that the role of the CAB in the project evolved and expanded as trust grew from serving primarily as consultants earlier on (e.g., in reviewing content of research instruments or identifying potential participants for focus groups) to collaborators in developing elements of, and gathering input on, the public health action plan.<sup>19</sup>

Although metal scrap–recycling industries have a positive impact in conserving natural resources and creating jobs and revenue for municipalities, metal recycling operations can generate dust, noise, and traffic. Such concerns were communicated to the HHD through the city’s 311 system, which led to the MAPPS project that took place over nearly a 10-y period. Early engagement included meetings with potentially affected residents, neighborhood leaders, city officials, and industry representatives while preparing the grant

application, with 6 y devoted to conducting the funded project in four socioeconomically disadvantaged neighborhoods, comprising largely of Hispanic or Black populations situated near metal recycling facilities. We developed neighborhood-specific outreach programs to increase study visibility and participation in study activities. Opinion leaders in the neighborhoods and industry representatives from management were recruited for the key informant interviews, whereas residents who lived in the study neighborhoods and individuals who worked at the metal recycling facilities were recruited for the focus groups. Drawing on and benefiting from lay knowledge and expertise,<sup>36</sup> these target groups were selected to provide different and complementary perspectives of the selected communities and facilities.

The themes that emerged in analyzing the interviews and focus groups helped to structure questions on the community survey, offering advantages because they were framed in terms of the knowledge, beliefs, and experiences of the community.<sup>37,38</sup> For example, the metal recyclers perceived the need for effective communication between themselves and residents in addressing environmental health concerns. There was also consensus among residents about a lack of awareness about whom to contact with environmental health concerns and, consistent with views of residents living in environmental justice neighborhoods elsewhere,<sup>39</sup> dissatisfaction with the city’s response to problems identified in the past. Among individuals who preferred to speak Spanish, there was the further perception that their complaints would fall on deaf ears even if they were to make their concerns known directly.

Throughout the project, we fostered partnerships by employing engagement strategies to interpret the research data; integrate findings; and develop tailored, evidence-based public health action plans to minimize metal air pollution and improve environmental health. We adopted previously identified best practices<sup>16</sup> to ensure a defined purpose for outdoor air monitoring (in our case to conduct a health risk assessment, which in turn informed a public health action plan), clearly articulating roles and responsibilities of all involved parties<sup>19</sup> and presenting scientific information in an accurate, accessible, and culturally appropriate manner first to the CAB and then to the broader community. Our use of a bottom-up approach has been previously recognized as an effective strategy in addressing systemic health disparities.<sup>10</sup> The leadership training tapped into trainee concerns and experiences and provided an opportunity to apply knowledge and skills in identifying and communicating their environmental health concerns to family, friends, and neighbors.<sup>40</sup> Further, this element of the public health action plan and establishing engineering and administrative controls in the metal recycling facilities built on two tenets of collaborations for equity and justice that increase the likelihood of longer-lasting change<sup>41</sup> in arriving at sustainable solutions in the neighborhoods where the study took place.

Adhering to the principles of CBPR, our efforts were focused on each neighborhood as the unit of identity<sup>12</sup> because of their geographic proximity to a metal recycling facility. Yet, there are more than 100 metal recycling facilities in Houston,<sup>21</sup> and many of them operate near low-income communities of color. Thus, our impact was restricted to those areas defined as MAPPS neighborhoods. In addition, we launched a second round of air-sampling investigations to evaluate whether the actions taken by the metal recyclers reduced metal emissions from their facilities. From February 2019 to March 2020, using the same strategy for determining when to sample in each neighborhood as with the first round of air monitoring, we collected outdoor air samples on 16 occasions in 2 neighborhoods. Unfortunately, after that time, no monitoring could occur because of the COVID-19 lockdown

followed by the end of the grant funding period. Nonetheless, our study highlights how scientific findings informed neighborhood-specific action plans, which were developed in collaboration with residents and metal recyclers and included a voluntary framework of controls to reduce metal emissions from the metal recycling facilities. Enhanced lines of communication among residents, metal recyclers, and local health department officials, along with environmental health leadership training, set the stage for all parties to successfully engage one another to address any future environmental health concerns.

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