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Using Citizen Scientists to Gather, Analyze, and Disseminate Information about Neighborhood Features that Affect Active Living

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Abstract

Background—Many Latinos are insufficiently active, partly due to neighborhoods with little environmental support for physical activity. Multi-level approaches are needed to create health-promoting neighborhoods in disadvantaged communities.

Methods—Participant “citizen scientists” were adolescent ($n=10$, mean age= 12.8 ± 0.6 years) and older adult ($n=10$, mean age= 71.3 ± 6.5 years), low income Latinos in North Fair Oaks, California. Citizen scientists conducted environmental assessments to document perceived barriers to active living using the Stanford Healthy Neighborhood Discovery Tool, which records GPS-tracked walking routes, photographs, audio narratives, and survey responses. Using a community-engaged approach, citizen scientists subsequently attended a community meeting to engage in advocacy training, review assessment data, prioritize issues to address and brainstorm potential solutions and partners.

Results—Citizen scientists each conducted a neighborhood environmental assessment and recorded 366 photographs and audio narratives. Adolescents ($n=4$), older adults ($n=7$) and community members ($n=4$) collectively identified reducing trash and improving personal safety

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and sidewalk quality as the priority issues to address. Three adolescent and four older adult citizen scientists volunteered to present study findings to key stakeholders.

Conclusions—This study demonstrated that with minimal training, low-income, Latino adolescent and older adult citizen scientists can: 1) use innovative technology to gather information about features of their neighborhood environment that influence active living, 2) analyze their information and identify potential solutions, and 3) engage with stakeholders to advocate for the development of healthier neighborhoods.

Keywords

physical activity; built environment; Latinos; mobile technology; community engaged approach

Background

Disadvantaged populations (e.g., minorities, immigrants, low socioeconomic status individuals) are disproportionately represented among the 60 million Americans classified as obese and thus at risk for chronic conditions such as type 2 diabetes[1]. Engaging in regular moderate to vigorous physical activity, such as brisk walking, has been associated with numerous physical and mental health benefits, including a reduction in the risk of obesity and its clinical sequelae such as diabetes[2]. Despite such evidence, a majority of adults in the United States do not meet national physical activity guidelines, which recommend 150 minutes per week of moderate to vigorous physical activity[3] and low-income, immigrant Latinos report even lower levels of regular physical activity than their non-Hispanic peers[4].

The neighborhood built environment has increasingly been recognized as an important factor in addressing the obesity epidemic[5]. For example, living in more walkable neighborhoods has been associated with lower body mass index among older adults[6]. Disadvantaged populations are more likely to live in neighborhoods that provide little environmental support for physical activity[7]. Environmental and policy approaches that lead to the creation of neighborhoods that better support healthy lifestyles in disadvantaged communities are needed.

This paper describes the Nuestra Voz (Our Voice) pilot study in which low-income, technology naïve Latino adolescent and older adult participants used the Stanford Healthy Neighborhood Discovery Tool (the Discovery Tool) to conduct assessments of built environment features in their neighborhood that help or hinder physical activity. A community engaged approach was used in which participants were provided with advocacy and leadership training, which equipped them to engage with local policy makers to initiate neighborhood improvements relevant to healthy active living. This research evolved out of previous studies conducted by members of the Healthy Aging Research and Technology Solutions (HARTS) Lab at the Stanford Prevention Research Center. The initial development and testing of the approach occurred in the Neighborhood Eating and Activity Advocacy Teams study [8, 9], which spurred the development and testing of the Discovery Tool[10].

This research is important because: 1) in 2014 Latinos will surpass whites as the largest racial/ethnic group in California, and 2) the digital gap between Latinos and whites has been shrinking in recent years[11]. Latinos use technology at similar and sometimes higher rates than do other groups of Americans, and yet are often under-represented in research trials in general [12] and technology studies in particular [13, 14]. Strategies that have been suggested to address this problem include providing low-literacy materials, conducting study-related activities in Spanish, and reassuring participants that immigration status was not relevant to research participation. These strategies were specifically utilized in this study.

Scientific Approach

This work used a community intervention paradigm [15] that encompasses four facets:

1. the identification of specific community issues using a community engaged approach,
2. the utilization of a socio-ecological perspective, [16] which recognizes that behavior is affected by multiple levels of influence, (3) the use of a culturally-relevant and resident-driven “lens” to view both the definition of, and the potential solutions to, the identified issues and lastly, (4) the implementation of efforts to collaborate with, and empower communities to affect change.

Participants in this study were considered “citizen scientists”. Citizen science engages members of the public in the research process – either as contributors, collaborators or co-creators [17–19]. citizen scientists can generate new knowledge by offering innovative insights and can vastly expand the scale of research projects by contributing quality data[20]. Using this type of approach has the potential to enhance both the community-level impact and long-term sustainability. Figure 1 illustrates the approach taken in this study to engage community residents in assessing features of their neighborhood built environment that affect their ability to eat a healthy active lifestyle.

Methods

The Nuestra Voz (Our Voice) study empowered adolescent and older adult Latino citizen scientists to:

1. Gather data about their local built environment using the Discovery Tool (January to June 2013);
2. Review data collectively and identify neighborhood barriers and facilitators to active living (June 2013); and
3. Engage with community partners to improve the neighborhood environment (August 2013).

The Discovery Tool is a neighborhood environmental assessment mobile application, hosted on a 7-inch hand-held electronic tablet[10]. Information gathered using the Discovery Tool includes geo-coded photos and audio narratives, GPS tracked walking routes, and a 25-item survey that includes questions about demographics, use of public transportation, walking

destinations, and other perceived neighborhood environment elements. This study was reviewed and approved by the Institutional Review Boards of both Stanford University and the San Mateo Medical Center.

Participants and Setting

Ten adolescent (mean age=12.8±0.6 years) and ten older adult (mean age=71.3±6.5 years) citizen scientists participated in this study. North Fair Oaks, an unincorporated part of San Mateo County, California, was chosen as the setting for this project because in a previous community-engaged weight loss intervention study among obese, low-income Latinos living in the North Fair Oaks Community, features of the neighborhood environment were noted by those study participants as being barriers to physical activity and healthy eating [21]. North Fair Oaks is bounded by the cities of Redwood City, Atherton, and Menlo Park. The demographic profile of North Fair Oaks residents is starkly different to that of residents in more affluent neighboring cities (Table 1).

Procedures

Recruitment and Assessments—Participant citizen scientists were recruited through local organizations such as the Boys and Girls Club, the Adult Activity Day Center, schools, churches, the County health clinic, and at local community events. Parental consent and adolescent assent were obtained for adolescents and older adults provided informed consent. Prior to conducting the neighborhood assessment, citizen scientists completed an interviewer-administered survey using items adapted from previously validated instruments to assess demographics, type of current physical activity,[22] perceived barriers to physical activity,[23] self-efficacy for engaging in physical activity, [24] neighborhood perceptions, [23, 25, 26] social support,[24, 27] and technology (use[23] and self-efficacy[28]). The Discovery Tool app and all the surveys were available in both English and Spanish languages.

Neighborhood Environmental Assessments Using the Discovery Tool—

Neighborhood assessments using the Discovery Tool were scheduled at times convenient to citizen scientists and were initiated at their home or after-school programs. Each citizen scientist conducted one assessment between January-June 2013. To reduce anxiety about carrying the tablet in their hands, the tablet was placed in a clear plastic case that was suspended around the neck of the citizen scientist using an adjustable strap. Simple instructions were provided by a brief in-app audio tutorial. A researcher accompanied the citizen scientist on a “usual” walk in their neighborhood, during which time the citizen scientist used the Discovery Tool to take pictures and record audio narratives about neighborhood features that they believed either facilitated or impeded active living (20–30 minutes). Citizen scientists were encouraged to record an audio narrative describing the importance of each photograph they took (photo/audio combination), rather than recording photographs or audios alone because the photo/audio combination provided the richest level of detail. Although the researchers accompanied the citizen scientist to observe the process, the citizen scientist chose the walking route and the data to be gathered with no influence on the part of the researcher. Immediately following the walk, each citizen scientist completed a 25-question survey embedded in the Discovery Tool as well as an interviewer-administered

assessment to capture their experiences using the Discovery Tool. Citizen scientists were given a \$10 incentive for participation.

Data Preparation by Research Team—All photos, audio narratives, and geocoded walking routes were downloaded from the tablet. The photo and audio files were coded into 19 content elements using a previously developed coding schema, augmented by additional elements of particular relevance to this setting (such as dogs and graffiti)[10]. These elements were sidewalks, trash, amenities/destinations, street features, private residences, crime/security, aesthetics, crosswalks, parks/playgrounds, graffiti, other people, footbridge, traffic, parking, vacant lots, mobility/access issues, dogs, traffic related safety and those features that did not fit these categories, such as local businesses, mobile homes, etc. In each recording, the citizen scientists could identify more than one element, for example talk about trash and graffiti in an audio narrative or take a picture of a crossing guard and a painted crosswalk. The data analysis reported here is based on the first element mentioned in the audio narratives or the dominant image in the photograph.

Information Reviewed by Citizen Scientists Participants—In June 2013, the researchers facilitated a community meeting to which all citizen scientists were invited. At this meeting the citizen scientists received basic advocacy training, reviewed the collectively gathered photographs, audio narrative transcripts and GPS-tracked walking routes, and prioritized issues to address. The advocacy training was adapted from resources available through the Prevention Institute (such as the Health Equity and Prevention Primer and THRIVE: Community Tool for Health & Resilience In Vulnerable Environments)[29] and the process used was adapted from a community engaged research partnership followed in the Neighborhoods Working in Partnership project[30]. The training was provided by the researchers in a group setting and emphasized realistic goal setting, development of action plans, and strategic identification of potential allies and resources. Each participant received a community advocacy handbook that included definitions, educational materials, and worksheets that had been developed by the research team and that have been shown to have initial utility in fostering community change in other underserved neighborhoods[8, 31]. All written materials and meetings were bilingual (English, Spanish). Sample photos and audio transcripts for each element were displayed around the room to guide the discussion. At the conclusion of the discussion each citizen scientist voted to indicate the issues they felt were most important and feasible to address; and then collectively the citizen scientists brainstormed potential solutions. Three adolescent and four adult leaders volunteered to represent the group in meetings with policy makers. The elected leaders received further training and support from the researchers both as a group and individually (average additional training time per leader =1 hour).

Information Disseminated by Citizen Scientist Participants—In August 2013 a meeting was held to connect the elected citizen scientist leaders with relevant community leaders, policy and decision makers, and community partners. Citizen scientists also worked with the media to more widely disseminate study-related information.

Results

Participant characteristics—The citizen scientists were adolescent (n=10, mean age=12.8±0.6 years) and older adult (n=10, mean age=71.3±6.5 years) Latino residents of North Fair Oaks. Six of the ten adolescents and all the older adults were female. The citizen scientists were modestly educated – all the adolescents were in middle school and 80% of the older adults had less than a 7th grade education. Almost all the adolescents (90%) and 70% of the older adults rated their health as good, very good or excellent. Few of the adolescents owned a cell phone (20%) or smartphone (10%) while almost all the older adults (90%) owned a cell phone. None of the older adults owned a smartphone. Initial self-rated efficacy for using the Discovery Tool electronic tablet-based application (app) without help or instruction was lower for older adults (2 out of 10) compared to adolescents (6 out of 10) (Table 2).

Participant walk data—On average, citizen scientists walked for 36.18±12.0 minutes to conduct the environmental assessment using the Discovery Tool, (range=21.59–70.41 minutes, adolescent mean=37.8±13.43 minutes, older adult mean=34.5 ±10.8 minutes). During these walks, the citizen scientists took a total of 225 photo/audio combinations (range=1–25, adolescent mean=12.9±6.9, older adult mean=9.6±3.3), 102 photos only (range=1–28, adolescent mean=5.5±8.21, older adult mean=4.6±2.6), and 39 audio narratives only (range=0–12, adolescent mean=1.5±0.5, older adult mean=3.0±3.9). (Table 3).

User experience data—Citizen scientists reported positive user experiences with the Discovery Tool (Table 4). On a scale of 1=not at all to 6=very, users reported the device was interesting (5.6±0.9), enjoyable to use (5.7±0.8), and comfortable to wear or carry (5.5±1.1). Citizen scientists generally did not report that carrying the device made them nervous (1.9±1.7), self-conscious (1.5±1.4), or that it was dangerous (1.3±1.3).

Coded data—The majority of recordings (59%) were about only one element, in 30% two elements were noted, in 8% 3 elements were noted and in the remaining 3% 4, 5 or 6 elements were noted. The data analysis reported here is based on the first element mentioned in the audio narratives or the dominant image in the photograph. The majority of audio recordings (52%) were about neighborhood features citizen scientists perceived as barriers to physical activity (n=190), with 23% (n=86) of recordings identifying facilitators of physical activity, and 25% (n=90) being of neutral valence (Table 5). The two elements that were most frequently reported as being barriers to physical activity by both adolescents and older adults were trash (mentioned as the primary barrier in 16% [n=31] of all data recorded by the adolescents and in 15% [n=26] of all data recorded by the older adults) and poor quality sidewalks (mentioned as the primary barrier in 11% [n=21] of all data recorded by the adolescents and in 8% [n=14] of all data recorded by the older adults). Adolescents and older adults reported different elements as being facilitators of physical activity. The adolescents perceived a range of elements as facilitating physical activity – having attractive destinations and amenities to visit (4%, n=7), the aesthetic feel of the neighborhood, for example, attractive plants and well maintained homes (4%, n=8), and elements that fell into the “other” category (6%, n=11), and included such things as trees reducing pollution, the

benefit of the school and the pediatric clinic to the community, the presence of a covered bus stop to shield waiting passengers from the rain, and air pollution. For older adults, good quality sidewalks (6%, n=10) and having attractive destinations and amenities to visit (5%, n=9), were the greatest perceived facilitators of physical activity. Illustrative quotes for these issues are included in Table 6.

Data Review and Issue Prioritization—Four adolescent and seven older adults citizen scientists, four community members, and members of the research team attended the meeting in June 2013 to review the information collected by the study citizen scientists. The priority issues chosen by the group to address were: trash, personal safety and sidewalks. Potential strategies to address these issues were discussed and included actions that residents themselves could undertake (such as reporting illegal dumping, engaging more with city officials), and more complex solutions that would require resources and support from local government or businesses (such as enforcing illegal dumping rules and increasing video surveillance security cameras on frequently travelled paths and bridges) (Table 7).

Data Dissemination—A meeting was held in August 2013 and attended by citizen scientists, community members, researchers and representatives from the local private and public sector including: the local waste management company, the Sheriffs Office, the Board of Supervisors from the local congressional district, the San Mateo County Health System, the Department of Public Works, a healthy community partnership aimed at promoting the health and success of children, youth and families served by the Redwood City School District, called Redwood City 2020, and media outlets. At this meeting, the elected citizen scientist leaders described how they had gathered and reviewed the data and decided which issues to address as well as the potential solutions that had been discussed. Each local representative then spoke briefly about the role their organization could potentially play to address the issues raised by the citizen scientists. Information from this meeting was compiled into a Community Resource Guide that included contact details for relevant local service providers as well as information regarding how to: schedule large item trash pick up services; report illegal dumping, graffiti, and problems with the sidewalks; start a neighborhood watch organization and contact the district Supervisor. This resource guide, as well as information about the process and findings of the study were provided to study citizen scientists and to local community organizations and partners such as the Fair Oaks Clinic, the Adult Activity Day Center and the Boys and Girls Club. The citizen scientists have worked with the media to highlight their work – two articles featuring one of the adolescent's and two of the older adults have been printed in the local press [32, 33] and an article about the study is on the Salud America! Growing Healthy Champions website [34]. Partly informed by the findings of this study, a steering committee with representatives from Environmental Health, the Department of Public Works, the Sheriff's Department, the local for-profit waste management company, and researchers from this project has been formed to address the issue of illegal dumping and trash. The County Manager's Office has: 1) conducted research into best management practices on illegal dumping, 2) engaged with other cities and counties, and 3) explored the use of innovative web-based and mobile application trash reporting and resolution technologies.

Discussion

This study demonstrated that with minimal training, low-income, tech naïve, Latino older adults and adolescents with little prior experience in the use of electronic tablets or advocacy strategies can be empowered as citizen scientists to: 1) use innovative technology to gather information about features of their neighborhood environment that influence active living, 2) analyze their information and identify potential solutions, and 3) engage with public and private sector representatives to advocate for the development of healthier neighborhoods.

This study used: 1) a social ecological perspective that recognizes that individuals are active within an environment that is impacted by social factors, neighborhoods, and policies,[35, 36] 2) a community engaged research approach that seeks to build local community capacity, acknowledges the complex interactions at play, appreciates that collaborative interventions are essential, and recognizes that culture pervades all aspects of community interventions,[15] and 3) an electronically integrated form of photovoice—a strategy that has been shown to enhance community engagement, increase knowledge and awareness of community resources and issues, and empower individuals and communities[37–42]. The community engaged approach, in combination with the simple to use Discovery Tool technology offers a cost-efficient way in which under-resourced communities can inform policy and decision makers about micro-scale environmental information that includes the powerful human stories contextualizing the issues. This equitable approach allows community residents to learn and practice advocacy, leadership and technology-related skills—all of which may increase self-efficacy and be transferable to other contexts.

The results of this study are particularly important given that there is a growing body of observational evidence that indicates that the built environment impacts physical activity in both adolescents [43] and older adults[44]. Rarely, however, have these two generational groups been studied together in such research, or been taught how to work together to change their neighborhood environment. For older adults, lack of access to transport, bad weather, neighborhood safety and lack of exercise programs and equipment have been reported in previous studies as being barriers to physical activity[44]. For adolescents, land-use mix and residential density are the most consistent correlates of physical activity across studies[43]. Low-income neighborhoods often do not support healthy active living because they lack places to exercise, have unattractive features (such as graffiti and trash) and low levels of traffic and crime-related safety[45]. Our study results generally support these previous findings, while adding other types of barriers that generally have been overlooked in lower-income neighborhoods (e.g., dumping of large, bulky objects such as old appliances and mattresses on neighborhood sidewalks, which impede sidewalk access and use).

Existing research about the impact of the built environment on healthy active living indicates that there is often low congruence between perceived and objective measures of the built environment[46, 47]. The Discovery Tool is able to gather both objective (photographic evidence and quantitative within-in app survey responses) and subjective (audio narratives) data. This rich contextual information is useful because, although policy and decision makers often have access to large amounts of data, it is often the personal narratives from community members that are particularly valuable in increasing the acceptance of evidence-

based data, improving health behaviors and overcoming preconceived beliefs and cognitive biases[48].

Because the hallmark of the current research methods focused specifically on current resident perceptions and consensus-building around barriers and enablers of active living in their neighborhood, issues surrounding confounders and bias that are important in epidemiologic studies aimed at capturing objectively defined environmental as well as personal factors become less relevant. In the current data gathering process, residents define what are relevant factors for themselves and their neighbors.

There are a number of challenges in having low-income minority adolescents' and older adults use technology, but this research team explicitly sought to address these challenges. Older adults are often considered as not being able to use technology, whereas research indicates that they don't use technology because they don't perceive a need to do so[49, 50]. In this study, older adults used the technology for something they cared about—making improvements in their neighborhood environment. A noted barrier inhibiting older adults from using technology is that it is often not designed with older adults in mind[49, 51]. The Discovery Tool has been designed and tested with older adults and features large clear print; simple layout; easy-to-use menus, and a help button. The participants in this study were assessed as being technology naïve because only one of the total sample of 20 participants owned a Smartphone, and only two of the 10 adolescents owned a cellphone. It is important to engage Latinos in technology-based studies because in recent years there has been a spike in technology adoption by Latinos, which has resulted in a decrease in the “digital divide” between Latinos and whites[11]. Promoting technology use by adolescent and older Latinos may help reduce the digital and generational divide[51]. Low-income ethnic minorities may have low literacy levels in English and in their home language[52, 53]. The instructions on how to use the Discovery Tool were therefore provided using audio instructions as well as easy-to-read text, and where possible, survey responses were portrayed pictorially.

There are a number of challenges in conducting community-engaged work among low income, minority populations. Recruiting low-income, ethnic minority individuals for technology-based studies that involve interactions with policymakers can be challenging. For example, while in this study 20 residents were willing to use the Discovery Tool, only 11 residents felt comfortable participating in the next steps of advocacy and leadership training, issue prioritization and engagement with community leaders. Low-income populations may be reluctant to participate in research studies because of a lack of trust, yet engaging vulnerable populations in research has been identified as a key component required to reduce health disparities[54]. This research team leveraged existing relationships with the community partner from North Fair Oaks Community Health Center to extend trust between the research team and the citizen scientists and facilitate the conversations with local decision makers. As a result of this research, existing relationships were strengthened and new relationships were forged, which extends the network of individuals and organizations working together to address neighborhood environmental issues in North Fair Oaks. Setting expectations regarding the community meetings (format, purpose, etc.) with both the policy makers and the citizen scientists at the outset of the study also facilitated the dialogue and built trust. It is important to keep citizen scientists safe while they are conducting the

neighborhood assessments, for example, reviewing road safety tips, requiring appropriate clothing, being mindful of unsafe areas, etc. In addition, citizen scientists should be requested not to take identifiable pictures of other people who have not consented to participate in the study.

Strategies to sustain community engaged activities include sustaining relationships and partners, knowledge and capacity, and funding and resources[55]. Sustainability in this study was addressed by: 1) connecting citizen scientists directly with Spanish speaking representatives of public and private sector organizations so that they could build relationships and work to address the issues they had identified; 2) encouraging citizen scientists to take part in existing community initiatives, (e.g., four citizen scientist participants completed a survey conducted by the North Fair Oaks Forward initiative to inform improvements to one of the major roads in North Fair Oaks) and 3) working with a trusted community partner (i.e., the staff at the Fair Oaks Health Center).

Challenges that were not addressed in this pilot study include accessibility and scalability. While the technology used in this study has been specifically designed to be easy to use, the approach adopted is much broader than the technology alone. The community engaged approach requires a number of additional components (for example, holding community meetings, providing advocacy training, building partnerships, disseminating results, etc.). To increase the accessibility of this approach, “best practices” of these additional community engaged components would need to be compiled and made accessible to community residents. One potential mechanism for doing this is to have all the necessary materials (stand-alone, easy to follow guidelines for using the technology and conducting community engaged projects, as well as the Discovery Tool app) accessible on an on-line platform. Citizen scientists could also use the on-line platform to disseminate their activities and findings to others. Salud America! has used this process successfully in their Growing Healthy Change Salud Heroes, which has a process to allow community residents to upload their own stories (<https://salud-america.org/>). Another approach would be to have the materials available at local public service organizations such as libraries or schools.

To increase scalability, a process will need to be developed whereby the data gathered by citizen scientists can be shared with a wide audience, including policy makers, for example, data could be uploaded to a web-based interactive map that is searchable by keywords. The Discovery Tool application is still in the formative stages of development and at present includes tasks that are currently being done by researchers, but could be automated. Increased automation would improve accessibility and scalability. This study should be replicated using larger sample sizes to assess generalizability.

Additional challenges to this type of research include the length of time taken to achieve noticeable environmental or policy change, which can be discouraging for the citizen scientists and difficult for researchers to track. In addition, limited grant funding often precludes active follow-up by researchers for an extended period of time.

New modules of the Discovery Tool are being developed by researchers and tested by citizen scientists, for example, to assess rural neighborhood environments [56] and to investigate

barriers and facilitators to accessing healthful foods[57, 58]. Internationally, the Discovery Tool is being translated into Hebrew to test the cultural relevance of this approach in Israel [59], while the Spanish version used in this study is being modified and tested in Mexico[60].

The Discovery Tool technology-driven community engaged approach used in this research has the potential to: provide a voice to those who may be marginalized, facilitate the articulation of priorities and values, create mutual understanding in a collaborative environment; provide a mechanism for engaging citizen scientists and policy makers; allow community residents to be part of the problem identification process and contributors to solution finding; and inform environmental change to benefit local communities. This type of approach is required to inform the creation of neighborhoods that better support healthy, active living for all.

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Figure 1.
Citizen Scientist Engagement Approach

Table 1

2008–2012 Census Bureau Data for North Fair Oaks, Redwood City, Menlo Park and Atherton

Census Data (2008–2012)	North Fair Oaks	Redwood City	Menlo Park	Atherton
Latino	73.1%	38.8%	18.4%	3.9%
Median household income	\$55,794	\$77,488	\$113,774	\$228,393
Living below the poverty line	25.4%	9.1%	6.5%	4.9%
High school graduate or higher	56.6%	84.8%	92.0%	98.6%

Source U.S. Census Bureau: State and County QuickFacts.⁽³¹⁾

Table 2

Participant Characteristics

	Adolescents (n=10)	Adults (n=10)
Mean age, years	12.8±0.6	71.3±6.5
Female (%)	60%	100%
Educational attainment	100% in middle school	80% < 7th grade
Good or better self reported health (%)	88.9%	70%
Cellphone ownership (%)	20%	90%
Smartphone ownership (%)	10%	0%
Self efficacy for tablet use: (1=not at all confident, 10=very confident):		
• With no help/instructions	5.9±3.3	2.0±2.8
• If device was similar to one you had used before	8.3±3.0	6.8±3.7
• If there was someone to show you what to do	7.0±3.2	9±2.5

Table 3

Descriptive Statistics of Data Recorded by Citizen Scientists using the Discovery Tool

	Adolescents+Adults (n=20)	Adolescents (n=10)	Adults (n=10)
<u>Photo/audio combinations</u>			
Total	225	129	96
Mean±Std Dev	11.3±5.56	12.9±6.95	9.6±3.30
Range (Min, Max)	1,25	1, 25	2,13
<u>Photos Only</u>			
Total	102	55	47
Mean±Std Dev	5.05±5.95	5.5±8.21	4.6±2.63
Range (Min, Max)	1, 28	1, 28	0, 8
<u>Audios Only</u>			
Total	39	9	30
Mean±Std Dev	3.0±3.2	1.5±0.55	3±3.86
Range (Min, Max)	0 ,12	0, 2	0, 12

Table 4

Participants' perceptions of using the Discovery Tool

	Total (n=14)	Adolescents (n=5)	Adults (n=10)
How interesting was it to wear or carry the device?	5.6±0.9	5.2±1.3	5.8±0.6
How comfortable was the device to wear or carry?	5.5±1.1	4.6±1.2	6.0±0
How much did you enjoy using the device?	5.7±0.8	5.2±1.3	5.9±0.3
How nervous did you feel wearing/carrying the device?	1.9±1.7	2.2±1.8	1.8±1.7
How self-conscious did you feel wearing/carrying it?	1.5±1.4	1.8±1.8	1.4±1.3
How dangerous did it feel to wear or carry the device?	1.3±1.3	1.0±0	1.5±1.6

Table 5

Descriptive Statistics of Coded Elements Ranked by Total Frequency [n, (%)]

Coded Elements	Adults and adolescents (n=20)							
	Total		Barrier		Facilitator		Neutral	
	N	%	N	%	N	%	N	%
Sidewalks	63	17%	35	10%	16	4%	12	3%
Trash	59	16%	57	16%	1	0%	1	0%
Other	56	15%	20	5%	14	4%	22	6%
Amenities/ destinations	35	10%	5	1%	16	4%	14	4%
Street features	20	5%	11	3%	2	1%	7	2%
Private residences	18	5%	6	2%	5	1%	7	2%
Crime/security	15	4%	12	3%	3	1%	0	0%
Aesthetics	14	4%	2	1%	11	3%	1	0%
Crosswalk	14	4%	4	1%	5	1%	5	1%
Parks/playgrounds	13	4%	3	1%	5	1%	5	1%
Graffiti	13	4%	13	4%	0	0%	0	0%
Other people	10	3%	0	0%	3	1%	7	2%
Footbridge	8	2%	4	1%	2	1%	2	1%
Traffic	7	2%	5	1%	0	0%	2	1%
Parking	5	1%	3	1%	1	0%	1	0%
Vacant lots	5	1%	3	1%	0	0%	2	1%
Mobility/access issues	4	1%	2	1%	2	1%	0	0%
Dogs	4	1%	3	1%	0	0%	1	0%
Traffic related safety	3	1%	2	1%	0	0%	1	0%
Total and % of total	366	100%	190	52%	86	23%	90	25%

Coded Elements	Adolescents only (n=10)					
	Total		Barrier		Facilitator	
	N	%	N	%	N	%
Sidewalks	31	16%	21	11%	6	3%
					4	2%

Coded Elements	Adolescents only (n=10)							
	Total		Barrier		Facilitator		Neutral	
	N	%	N	%	N	%	N	%
Trash	32	17%	31	16%	1	1%	0	0%
Other	26	13%	9	5%	11	6%	6	3%
Amenities/ destinations	19	10%	4	2%	7	4%	8	4%
Street features	11	6%	8	4%	2	1%	1	1%
Private residences	11	6%	4	2%	3	2%	4	2%
Crime/security	3	2%	3	2%	0	0%	0	0%
Aesthetics	10	5%	2	1%	8	4%	0	0%
Crosswalk	10	5%	3	2%	4	2%	3	2%
Parks/playgrounds	8	4%	1	1%	5	3%	2	1%
Graffiti	9	5%	9	5%	0	0%	0	0%
Other people	6	3%	0	0%	2	1%	4	2%
Footbridge	2	1%	1	1%	1	1%	0	0%
Traffic	3	2%	2	1%	0	0%	1	1%
Parking	2	1%	2	1%	0	0%	0	0%
Vacant lots	3	2%	1	1%	0	0%	2	6%
Mobility/access issues	3	2%	1	1%	2	1%	0	0%
Dogs	3	2%	2	1%	0	0%	1	1%
Traffic related safety	1	1%	1	1%	0	0%	0	0%
Total	193	100%	105	54%	52	27%	36	19%

Coded Elements	Adults only (n=10)							
	Total		Barrier		Facilitator		Neutral	
	N	%	N	%	N	%	N	%
Sidewalks	32	18%	14	8%	10	6%	8	5%
Trash	27	16%	26	15%	0	0%	1	1%
Other	30	17%	11	6%	3	2%	16	9%
Amenities/ destinations	16	9%	1	1%	9	5%	6	3%
Street features	9	5%	3	2%	0	0%	6	3%
Private residences	7	4%	2	1%	2	1%	3	2%

Coded Elements	Adults only (n=10)							
	Total		Barrier		Facilitator		Neutral	
	N	%	N	%	N	%	N	%
Crime/security	12	7%	9	5%	3	2%	0	0%
Aesthetics	4	5%	0	5%	3	2%	1	1%
Crosswalk	4	2%	1	0%	1	1%	2	1%
Parks/playgrounds	5	3%	2	1%	0	0%	3	2%
Graffiti	4	2%	4	2%	0	0%	0	0%
Other people	4	2%	0	0%	1	1%	3	2%
Footbridge	6	3%	3	2%	1	1%	2	1%
Traffic	4	2%	3	2%	0	0%	1	1%
Parking	3	2%	1	1%	1	1%	1	1%
Vacant lots	2	1%	2	1%	0	0%	0	0%
Mobility/access issues	1	1%	1	1%	0	0%	0	0%
Dogs	1	1%	1	1%	0	0%	0	0%
Traffic related safety	2	1%	1	1%	0	0%	1	1%
Total	173	100%	85	49%	34	20%	54	31%

Table 6

Examples of Barriers to and Facilitators of Physical Activity Noted by the Citizen Scientists using the Discovery Tool

	Facilitators of physical activity	Barriers to physical activity
Sidewalks	Nice garden around a nice sidewalk. People's gardens here are very unique and beautiful. <i>Adolescent girl</i>	There are trees blocking the sidewalks and also a piece of furniture. You'd have to go into the street to be able to cross this. <i>Adolescent boy</i>
Trash	The community is very clean, the next day that Starbucks cup will probably be gone. <i>Adolescent boy</i>	The trash sometimes lingers here for months. <i>Adult woman</i>
Other	Bus stops likes this (covered) ...make it easier for people when it's raining to stand. <i>Adolescent girl</i>	It's hard to pass here because of the bad smell. <i>Adult woman</i>
Amenities/ destinations	At the XX Adult Activity Center there are many different types of activities, for example, exercises and folk dancing. <i>Adult woman</i>	This winery attracts lots of drunk people late at night. <i>Adult woman</i>
Street features	Signs everywhere, but sometimes cars can't see them because of the trees. <i>Adult woman</i>	Install speed bumps on my street and more light posts. <i>Adult woman</i>
Private residence	People's gardens here are beautiful. <i>Adolescent girl</i>	The corner homes have dogs that always bark and pedestrians have to walk off the street. <i>Adult woman</i>
Crime/Personal safety	Sometimes there are a lot of police here... sometimes it's safe because they check around here but sometimes it makes me feel like there was something bad that happened around here. <i>Adolescent boy</i>	The main issues that I see are the drug sales and gang activities on and around my street and along the end of the footbridge on xx Road. <i>Adolescent boy</i>
Aesthetics	Plants around here are good for when you're walking because it separates you from the road and gives a new appearance than just being a sidewalk. <i>Adolescent girl</i>	There is graffiti on the walls. Bad words. There are a bunch of little kids that live here and they can easily read this and it should be fixed. <i>Adolescent girl</i>
Crosswalk	There should be more of these designs (a crosswalk that has flashing lights that are illuminated when the crosswalk button is pressed) because it's really safe because the cars do stop for people who cross the street. <i>Adolescent girl</i> *This crosswalk also has a bright yellow crosswalk sign that includes braille text.	The bad thing about this street is that there's no place to cross. And it's a large street so lots of cars pass by. And there's also a bus stop on the other side but there's no way to get to the other side. <i>Adolescent girl</i>
Park or playground	That is XX Park thriving with a lot of people. <i>Adolescent boy</i>	The park should open up again, with a guard watching over, so children can come play. <i>Adult woman</i>
Graffiti	No comments	I think the graffiti is bad because it doesn't help the community at all...a lot of workers that do cement have to fix it...and it doesn't make the neighborhood look any better." <i>Adolescent girl</i>
Another person	The crosswalk lady is very generous to pedestrians. <i>Adolescent boy</i>	No comments
Footbridge	This (pedestrian) bridge is important because it connects both sides. <i>Adolescent boy</i>	It would be good to have more monitoring here [at the bridge]...people come to drink here...at the time that one passes with children. <i>Adult woman</i>
Traffic	No comments	It is not safe to cross [to] the store because there's a lot of cars coming through always... there was a couple of people killed in this intersection <i>Adolescent boy</i>
Parking	Up to date with modern cars, having place to charge cars. <i>Adult woman</i> *Referring to an electric car charging station	It's difficult to make a left on Middlefield Road because sometimes it's a busy road because the cars are parked on the side of the street. Sometimes they block our view. Even though there is a stop sign, you have to drive forward to make sure that it's safe for you to make your turn. <i>Adult woman</i>
Vacant lots	No comments	We see that there's a lot of garbage on the inside of the lot and on the outside...it has been many months...it is all accumulated...and

	Facilitators of physical activity	Barriers to physical activity
		since the lot is closed who knows when they will get rid of it. <i>Adult woman</i>
Mobility access issues	This is a good curb cut. It helps with traction and people with disabilities. <i>Adult woman</i>	This is an issue for persons with mobility disability – no curb cut and the pole is on the sidewalk. <i>Adult woman</i>
Dogs	No comments	The dog in this area likes to try to jump the fence, can be dangerous and hurt someone. <i>Adult woman</i>
Traffic related safety	No comments	"I walk slowly, so I need to watch out real well for cars... the lights turn on for the crosswalk but they cars don't stop." <i>Adult woman</i>

Table 7

Potential Strategies Discussed by Citizen Scientists at the Community Meeting

Primarily Community Driven		Requires Partnering with Others	
Trash			
<ul style="list-style-type: none">• Report illegal dumping• Make signs asking people to clean up after their pets• Form volunteer groups to clean up trash• Encourage good behavior• Increase knowledge about trash pick- up days for larger items (e.g. furniture)	<ul style="list-style-type: none">• Request additional public trash bins from the city• Impose and collect fines for littering• Require and enforce that apartment owners should supply residents with appropriate trash disposal facilities		
Personal safety			
<ul style="list-style-type: none">• Form a neighborhood watch association• Increase attractiveness of neighborhood, for example by replacing graffiti with murals• Work with the city to learn how to fill out forms, start a petition, initiate action	<ul style="list-style-type: none">• Increase police patrols• Open the park and use cameras to monitor activity• Increase security on the footbridge (patrols and cameras)		
Sidewalks			
<ul style="list-style-type: none">• Report unsafe sidewalks to the• Department of Public Works	<ul style="list-style-type: none">• Obtain media support to highlight issues• Fine people who park on the sidewalks illegally		