



1 Article (for special issue on participatory research in health promotion; Accepted with revision)

2 **DO NOT QUOTE OR SHARE WITHOUT PERMISSION**

3 Employing Participatory Citizen Science Methods to Promote Age-Friendly Environments  
4 Worldwide

5 Abby C. King <sup>1,2,\*</sup>, Diane K. King <sup>3</sup>, Ann Banchoff <sup>2</sup>, Smadar Solomonov <sup>4</sup>, Ofir Ben Natan <sup>4</sup>, Jenna  
6 Hua <sup>2</sup>, Paul Gardiner <sup>5</sup>, Lisa Goldman Rosas <sup>2</sup>, Patricia Rodriguez Espinosa <sup>2</sup>, Sandra J. Winter <sup>2</sup>,  
7 Jylana Sheats <sup>2</sup>, Deborah Salvo <sup>2</sup>, Nicolas Aguilar-Farias <sup>6</sup>, Afroditi Stathi <sup>7</sup>, Adriano Akira Hino <sup>8</sup>,  
8 Michelle M. Porter <sup>9</sup>, for the *Our Voice Global Citizen Science Research Network*

9 <sup>1</sup> Department of Epidemiology and Population Health, Stanford University School of Medicine,  
10 Stanford, CA 94305, USA; king@stanford.edu

11 <sup>2</sup> Stanford Prevention Research Center, Department of Medicine, Stanford University School of  
12 Medicine, Stanford, CA 94305, USA; king@stanford.edu, [banchoff@stanford.edu](mailto:banchoff@stanford.edu),  
13 [jennahua3@gmail.com](mailto:jennahua3@gmail.com), [lgrosas@stanford.edu](mailto:lgrosas@stanford.edu), [prespinosa@stanford.edu](mailto:prespinosa@stanford.edu), [sjwinter@stanford.edu](mailto:sjwinter@stanford.edu),  
14 [jsheats@tulane.edu](mailto:jsheats@tulane.edu), [dsalvo@wustl.edu](mailto:dsalvo@wustl.edu).

15 <sup>3</sup> Center for Behavioral Health Research and Services, Institute of Social and Economic Research,  
16 University of Alaska Anchorage, Anchorage, Alaska, USA; dkking@alaska.edu

17 <sup>4</sup> JDC Eshel, Jerusalem, Israel; [smadarso@jdc.org](mailto:smadarso@jdc.org), [ofirb@jdc.org](mailto:ofirb@jdc.org)

18 <sup>5</sup> Faculty of Medicine, The University of Brisbane, Brisbane QLD 4072 Australia,  
19 [p.gardiner@uq.edu.au](mailto:p.gardiner@uq.edu.au)

20 <sup>6</sup> Department of Physical Education, Sports and Recreation, Universidad de La Frontera,  
21 Temuco, Chile; [nicolas.aguilar@ufrontera.cl](mailto:nicolas.aguilar@ufrontera.cl)

22 <sup>7</sup> School of Sport, Exercise and Rehabilitation Sciences, University of Birmingham, Edgbaston,  
23 Birmingham, UK, B15 2TT; [A.Stathi@bham.ac.uk](mailto:A.Stathi@bham.ac.uk)

24 <sup>8</sup> Pontifícia Universidade Católica do Paraná (PUCPR), Polytechnic School, Postgraduate  
25 Program in Health Technology (PPGTS), Curitiba/PR, Brazil, [akira.hino@pucpr.br](mailto:akira.hino@pucpr.br)

26 <sup>9</sup> Centre on Aging, and Faculty of Kinesiology and Recreation Management, University of  
27 Manitoba, Winnipeg, Manitoba, Canada, R3T 2N2; [michelle.porter@umanitoba.ca](mailto:michelle.porter@umanitoba.ca)

28 \* Correspondence: king@stanford.edu

29 Received: date; Accepted: date; Published: date

30 **Abstract:** The trajectory of aging is profoundly impacted by the physical and social environmental  
31 contexts in which we live. While “top down” policy activities can have potentially wide impacts on  
32 such contexts, they often take time, resources, and political will, and therefore can be less accessible  
33 to underserved communities. This article describes a “bottom up”, resident-engaged method to  
34 advance local environmental and policy change, called *Our Voice*, that can complement policy-level  
35 strategies for improving the health, function, and wellbeing of older adults. Using the World Health  
36 Organization’s age-friendly cities global strategy, we describe the *Our Voice* citizen science program  
37 of research that has specifically targeted older adults as environmental change agents to improve  
38 their own health and wellbeing as well as that of their communities. Results from 14 *Our Voice*  
39 studies that have occurred across five continents demonstrate that older adults can learn to use  
40 mobile technology to systematically capture and collectively analyze their own data. They then can

41 successfully build consensus around high-priority issues that can be realistically changed, and work  
42 effectively with local stakeholders to enact meaningful environmental and policy changes that can  
43 help to promote healthy aging. The article ends with recommended next steps for growing the  
44 resident-engaged citizen science field to advance the health and welfare of all older adults.

45 **Keywords:** citizen science; participatory research; older adults; aging; age-friendly environments;  
46 WHO; health promotion; health equity; mobile health; built environment

## 47 1. Introduction

48 *“Never doubt that a small group of thoughtful, committed citizens can change the world; indeed,*  
49 *it’s the only thing that ever has.” Margaret Mead*

50 Over the past two centuries, improvements in an array of social, environmental, and biological  
51 factors, including sanitation, housing, education, and medical care, have led to overall longevity  
52 increases worldwide [1]. It is estimated that by 2050, 1 in 5 people will be 60 years of age or older  
53 [2]. Yet, for a growing number of adults today, longevity increases have not been accompanied by  
54 better health compared to prior generations [3], and this is particularly true among disadvantaged  
55 populations [4].

56 In light of this alarming trend, the World Health Organization has recommended a global strategy  
57 whereby all populations, regardless of geographic region, living conditions, or economic  
58 circumstances, can benefit from evidence-based activities aimed at maximizing functional ability  
59 and health [2]. Among the key strategies described in this call for action is the development of age-  
60 friendly environments, in recognition of the substantial impacts that local environments have on  
61 older adults’ continuing health, mobility, activities, wellbeing, and quality of life [5-7].

62 The central strategies identified in developing age-friendly environments include fostering older  
63 adults’ engagement and autonomy, and facilitating multisectoral action [2]. Relatively few  
64 investigations in the healthy aging arena have systematically activated purposeful and sustained  
65 resident engagement in evaluating, monitoring, and implementing changes to improve the age-  
66 friendliness of their environments, although involvement in such activities is strongly  
67 recommended by the WHO Global Age-Friendly Cities Guide (13). Involving older adults in these  
68 processes can enhance their perceptions of autonomy, empowerment, and collective agency, and  
69 facilitate changes to local policies and environments that will promote age-friendliness at the  
70 neighborhood or community level [8].

71 The growing field of health-related citizen science represents one means of engaging older adults  
72 in contextually-relevant participatory research that can benefit not only their own health, but the  
73 health of their communities [9,10]. Citizen science, broadly defined as nonscientists participating in  
74 the research process to advance science [11], is a centuries-old tradition in some countries, such as  
75 the USA [12]. In the traditional citizen science context, “citizen” has been defined simply as an  
76 inhabitant of a particular town or city (without regard to legal status), and it is that definition that  
77 is employed in this article. Part of the family of approaches collectively referred to as participatory  
78 research, citizen science approaches often have brought systematic, scalable methods of resident-  
79 based data collection to the scientific endeavor.

80 The citizen science field is comprised of different levels of resident engagement that can be placed  
81 broadly into the following three categories [8]: (a) citizen science “for the people”, which typically  
82 is limited to donations by residents of biological specimens or other forms of personal information  
83 to advance biomedical or other types of research; (b) citizen science “with the people”, which has  
84 been used extensively in the natural and biological sciences, including astronomy and ecology, and  
85 usually involves systematic data collection by residents around specific observable phenomena,

86 with the data then sent to scientists or other groups to analyze and interpret (e.g., to municipal  
87 authorities, in the case of mobile apps that encourage residents to photograph local problems, such  
88 as potholes, which can be sent to a specific website); and (c) citizen science “by the people”, which  
89 is viewed as a partnership between residents, researchers, and relevant community organizations.  
90 In this latter citizen science category, residents typically contribute to study objectives and/or  
91 questions of interest, data collection and interpretation, and development of relevant actions based  
92 on the results [8].

93 One example of the “by the people” citizen science approach, called *Our Voice*, provides a relevant  
94 model for engaging and activating diverse groups of older adults in advancing the WHO’s age-  
95 friendly communities initiative [13]. The major aim of this article is to briefly describe this citizen  
96 science approach and highlight results from *Our Voice* research projects around the world that have  
97 tackled specific challenges relating to the built, social and services environments—domains that are  
98 deemed critical to promoting age-friendly and health enhancing communities identified in the  
99 WHO aging and health reports [2,14,15]. The article ends with recommendations for next steps in  
100 using “by the people” citizen science approaches, such as *Our Voice*, to advance the healthy aging  
101 participatory research field.

## 102 2. General Methods and Materials for the *Our Voice* Citizen Science Engagement Model

### 103 2.1. Overview

104 The major goal of the *Our Voice* citizen science model is to empower residents, regardless of  
105 geography, age, or socio-economic and cultural backgrounds, to activate health-promoting changes  
106 in their local neighborhoods and communities in collaboration with relevant community  
107 organizations and academic partners [8,13]. The 4-step *Our Voice* process is summarized in **Figure**  
108 **1**. Prior to starting an *Our Voice* project, the facilitating organization (e.g., research team, community  
109 group, government agency) participates in remote, web-based development of project goals and an  
110 implementation plan. They then receive remote training on program methods and ongoing project  
111 support. The project team members next recruit residents as Citizen Scientists and orient them to  
112 the project and their role. Using a multi-lingual mobile app, called the Stanford Healthy  
113 Neighborhood Discovery Tool™ [16] (described in more detail below), residents capture, through  
114 geo-tagged photographs, audio- or text-based narratives, and route mapping, features of their local  
115 environments that help or hinder a particular domain that can impact healthy living, for example,  
116 neighborhood walkability, food access, personal safety, feelings of support and respect, transport,  
117 or well-being [17-24]. Then, in a facilitated group process, they share their data with other citizen  
118 scientists, prioritize areas of concern, brainstorm feasible strategies and solutions for action, and  
119 identify local stakeholders, policy makers, and other potential allies with whom to discuss the issues  
120 further. Next, they meet with these local stakeholders to present their findings, discuss realistic  
121 solutions, and develop initial action steps for positive change in the identified areas. Typically, a  
122 total of two to three formal group meetings occur (the first with resident participants, then with  
123 residents and relevant stakeholders) as part of the *Our Voice* process. This type of citizen science  
124 process has been found to be highly efficient and minimally burdensome, with “saturation” around  
125 primary environmental barriers and enablers in a particular locale achievable with as few as 8-10  
126 residents [13,25].

127

128  
129

Figure 1. The 4-step *Our Voice* citizen science model [13]. © Stanford University. All rights reserved.

130 As noted above, the *Our Voice* program begins with the Discovery Tool (DT), an easy-to-use mobile  
 131 app that was developed originally for low-income older adults [16]. It has been used with residents  
 132 ages 9 to over 90 years old to document features of their local neighborhoods or other environments  
 133 that impact specific aspects of their health or well-being (e.g., physical activity, food access, personal  
 134 safety, feelings of inclusiveness) [13,16,23,26]. The DT currently has been translated into ten  
 135 languages. Language translation is readily accomplished, given that the design of the app uses  
 136 universal symbols and graphics, with few written words. Data captured by the DT include GPS route  
 137 tracking and geo-coded photos and audio or text narratives of local features, with visual ratings of  
 138 each feature as either positive, negative, or both. This spatial qualitative data method allows for the  
 139 capture of residents' experiences of their community *in situ*. Such data may better reflect  
 140 environmental elements of particular importance to older adults relative to more frequently used  
 141 questionnaires or interviews that typically rely on recall or more global assessments of walkability or  
 142 safety [27]. Successful training in the use of the app typically takes about five minutes. Residents are  
 143 instructed to take photos of locations, not people (if faces or other identifiable data are inadvertently  
 144 recorded, they can be deleted or blurred upon upload to the secure server). After collection, the data  
 145 are uploaded onto a secure Stanford University server, where the photos, narratives, walk maps and  
 146 user ratings are integrated into project reports. The project reports are then returned to the facilitating  
 147 organization for participant distribution and discussion/analysis. The Discovery Tool secure data  
 148 repository goes through annual approval by the Stanford University Institutional Review Board (IRB)  
 149 for the protection of human subjects (IRB protocol #40379). Collaborating research organizations also  
 150 obtain human subjects/ethics approval from their respective academic institutions. Non-academic  
 151 partners collaborate with Stanford under Stanford's IRB protocol #45330.

152 The *Our Voice* citizen science model has been applied or is currently being tested in over 20 countries  
 153 across six continents in response to a range of local issues that can impact health. A major goal of  
 154 *Our Voice* projects has been to engage underserved populations that typically have lacked a voice in  
 155 decision-making related to their local neighborhoods and communities. The promotion of health  
 156 equity is a principal theme of this work. *Our Voice* has been described as a "bottom-up" approach  
 157 to environmental change that can complement or extend more traditional "top-down" policy-  
 158 oriented approaches to change [13].

## 159 2.2. Characterizing *Our Voice* Project Initiatives Aimed at Built, Social and Community Service Environments

160 Using the WHO Age-Friendly Cities guide (13) and checklist (14), we reviewed fourteen *Our Voice*  
 161 projects conducted with older adult populations. We categorized the key barriers and action steps  
 162 identified and local changes proposed and carried out within each of the three major domains and  
 163 related eight topic areas promoted by the WHO as essential to support healthy aging. The key domains  
 164 are the following: a) built environment (e.g., outdoor spaces and buildings, transportation housing);  
 165 b) social environment (e.g., social participation, respect and social inclusion, civic participation); and  
 166 community and health services (e.g., communication and information, community support and health  
 167 services). These domains, along with the specific age-friendly topic areas they address, are

168 summarized in **Table 1**. While many of the domains and topic areas overlap, the three key domains  
169 provide a useful rubric to highlight the potential of *Our Voice* methods to produce specific action steps  
170 and changes that are locally and internationally relevant from an age-friendly perspective. Because  
171 not all projects were conducted in cities, we have substituted “communities” for “cities” at appropriate  
172 places throughout the paper.

173 **Table 1**, below, provides a brief overview and description of some of the varied *Our Voice* older adult  
174 projects that have been completed or are in process.

175

176 Table 1 (heading). **Examples of *Our Voice* older adult projects completed or in process**

Location and Project Focus	Description and Participants	Community Features Identified		Strategies Proposed and Changes Enacted
		Positive	Negative	
<b>BUILT ENVIRONMENT</b>				
<i>Haifa, Israel</i> <sup>1</sup> <b>Age- and activity-friendly cities</b> [1]	Ethnically and socioeconomically diverse adults ages 50 years and older (N=59) from 4 neighborhoods in Haifa	<ul style="list-style-type: none"> <li>• Easy access to commercial and leisure facilities</li> <li>• Attractive buildings</li> <li>• Benches, public restrooms</li> </ul>	<ul style="list-style-type: none"> <li>• Poor sidewalk condition</li> <li>• Street stairs in disrepair</li> <li>• Obstacles to sidewalk use</li> <li>• Neglected lots</li> <li>• Traffic noise, pollution</li> </ul>	<ul style="list-style-type: none"> <li>• Identified safest routes to destinations</li> <li>• Developed a senior-friendly “golden path” walking map</li> <li>• Began to work with Mayor’s office and local organizations and businesses to initiate changes (e.g., improved aesthetics) to support walking</li> </ul>
<i>East Palo Alto, CA (USA)</i> <b>Senior-friendly activity and food environments</b> [16,27]	Assessment and advocacy around food and physical activity environments of local neighborhoods (N=12 ethnically diverse low-income older adults living in senior public housing)	<ul style="list-style-type: none"> <li>• A wide variety of good quality fruits and vegetables available in local stores</li> </ul>	<ul style="list-style-type: none"> <li>• A street outside the housing setting with high pedestrian and vehicular traffic had no designated place to cross safely</li> </ul>	<ul style="list-style-type: none"> <li>• Participants partnered with a local non-profit garden-based education organization, which provided education, gardening tools, and seeds to develop a community garden</li> <li>• Sustained relationships between study participants and city officials, resulting in a more coherent focus on creating an age-friendly community</li> <li>• Allocation of significant government dollars for built environment improvements and public health inclusion in the city’s general plan</li> </ul>
<i>San Mateo County, CA (USA)</i> <b>Food access and transportation</b> [18]	Examination of the factors that facilitate or hinder access to food, and food-related behavior, followed by advocacy for positive environmental and policy-level changes. (N=23 ethnically diverse, food insecure, low-income older adults)	<ul style="list-style-type: none"> <li>• Lower prices</li> <li>• Access and availability of healthy food in the store</li> <li>• Freshness and quality of produce</li> </ul>	<ul style="list-style-type: none"> <li>• Price promotions for unhealthy food</li> <li>• The presence of unhealthy food</li> <li>• The price of items not being displayed within view or at all</li> <li>• Higher prices</li> <li>• Having to visit multiple stores for cheaper prices</li> <li>• Poor personal health</li> </ul>	<ul style="list-style-type: none"> <li>• Local organizations made information available in multiple languages about food assistance and transportation services</li> <li>• At 3 months, 84% of study participants had either shared new information/resources, contacted a local decision or policy maker, and/or signed up for a new service (e.g., SNAP, shuttle service)</li> <li>• At 6 months, a senior advocacy team (SAT) was formed and convened an open forum, presented concerns and solutions to city and county policymakers (N = 5); Within 4 days, improved street signage and curb painted red for better visibility</li> <li>• SAT participated in the State Capital’s Fifth Annual Affordable Senior Housing Resident Advocacy Day in Sacramento, CA</li> <li>• SAT partnered with an elementary school to address pedestrian and bicycle safety concerns due to high-speed traffic</li> <li>• City Transportation and Planning Department installed a device to measure traffic and speed on the street, then later installed pedestrian flashing light signals and modified crosswalk for safety</li> </ul>

Location and Project Focus	Description and Participants	Community Features Identified		Strategies Proposed and Changes Enacted
		Positive	Negative	
<p><i>North Fair Oaks, CA (USA)</i>  <b>Neighborhood walkability and security across generations</b> [25]</p>	<p>Assessment of neighborhood built-environment features that help or hinder physical activity (N=10 low-income Latinx adults, mean age 71 years and 10 low-income Latinx adolescents, mean age 13 years)</p>	<ul style="list-style-type: none"> <li>• Having attractive destinations and amenities to visit</li> <li>• The aesthetic ‘feel’ of the neighborhood</li> <li>• Good quality sidewalks</li> </ul>	<ul style="list-style-type: none"> <li>• Trash</li> <li>• Poor quality sidewalks</li> <li>• Personal safety</li> </ul>	<ul style="list-style-type: none"> <li>• Resident-informed Community Resource Guide was compiled</li> <li>• Resident recommendations included the following: <ul style="list-style-type: none"> <li>• Trash: report illegal dumping, make signs asking people to clean up after pets, form volunteer groups to clean up trash, increase knowledge about trash pick-up days for larger items (e.g., furniture), request additional public trash bins from the city, require and enforce that apartment owners should supply residents with appropriate trash disposal facilities</li> <li>• Personal safety: form a neighborhood watch association; replace graffiti with murals; work with the city to learn how to complete forms, start a petition, initiate action; increase police patrols, open the park and use cameras to monitor activity; increase security on the footbridge (patrols and cameras)</li> <li>• Sidewalks: report unsafe sidewalks to Dept. of Public Works</li> <li>• Residents worked with local media to highlight priority issues, &amp; article about the project appeared in national media</li> <li>• A steering committee of local municipal and service organizations was formed to address issue of illegal dumping and trash</li> <li>• The County Manager’s office conducted research into best management practices on illegal dumping, engaged with other cities and counties around this issue, &amp; has explored use of web and mobile technologies to allow resident reporting of trash</li> </ul> </li> </ul>
<p><i>Cuernavaca, Mexico</i>  <b>Supporting intergenerational active living across socio-economic strata</b> [19]</p>	<p>Testing the acceptability and feasibility of using the Our Voice approach to assess walkability environments in four neighborhoods in Mexico, stratified according to socio-economic status and walkability. (N=32 adults, 9 adolescents)</p>	<ul style="list-style-type: none"> <li>• Presence of parks or recreational facilities</li> <li>• Having destinations to visit</li> </ul>	<ul style="list-style-type: none"> <li>• Poor sidewalk quality</li> <li>• Presence of trash</li> <li>• Negative street characteristics</li> <li>• Unpleasant aesthetics (e.g., graffiti)</li> <li>• Feeling unsafe</li> <li>• Unleashed dogs</li> <li>• Limited disabled access</li> <li>• Lack of crosswalks</li> <li>• Poor quality of parks and recreational facilities</li> </ul>	<ul style="list-style-type: none"> <li>• Discussed creation of a neighborhood committee and campaign to encourage neighbors to use leashes and clean up after their dogs</li> <li>• Adults and adolescents discussed acceptable forms of public art/graffiti together</li> <li>• Neighborhood watch programs recommended to combat crime</li> <li>• Strategies identified to promote increased social cohesion in the neighborhood</li> </ul>

Location and Project Focus	Description and Participants	Community Features Identified		Strategies Proposed and Changes Enacted
		Positive	Negative	
<i>Curitiba, Brazil</i> <b>Neighborhood environmental characteristics and physical activity among older adults</b>	Older adults from neighborhood areas with high and low walkability and SES (N=32)	<ul style="list-style-type: none"> <li>• Presence and quality of sidewalks</li> <li>• Land use mix (proximity of services, e.g., markets, bakery)</li> </ul>	<ul style="list-style-type: none"> <li>• Functional characteristics walking surface/pattern and streets connectivity</li> <li>• Aesthetics issues as bad designed and/or maintained streetscape and presence of physical disorder</li> </ul>	<ul style="list-style-type: none"> <li>• Strategy development in process</li> </ul>
<i>Santa Clara &amp; San Mateo Counties, CA, (USA)</i> <b>Improving walkability around affordable senior housing sites</b>	Older adult residents and neighbors of affordable housing sites, enrolled in a physical activity intervention (N=69)	<ul style="list-style-type: none"> <li>• Murals on electrical boxes</li> <li>• Community Gardens</li> <li>• Flashing light sidewalks</li> <li>• Traffic signs</li> <li>• Park and community centers within walking distance</li> <li>• Clean amenities on walking routes</li> </ul>	<ul style="list-style-type: none"> <li>• Cracked Sidewalks</li> <li>• Overgrown Shrubs</li> <li>• Lack of curb ramps</li> <li>• Lifted manhole covers</li> <li>• Narrow/ No sidewalks</li> <li>• Cars parked on sidewalks</li> <li>• Walking time given to cross intersections</li> <li>• Visibility of bus stop signs</li> <li>• Trash or hazardous waste along walking paths</li> </ul>	<ul style="list-style-type: none"> <li>• Residents wrote letters to describe safety concerns with sidewalk cracks and proposed that if they could not be repaired they at least be marked with paint to make them visible to residents.</li> <li>• Emailed community center staff requesting that they relay their concerns about negative community features to the proper departments; Information was relayed to the Maintenance division</li> <li>• Sidewalk cracks were repaired on a major avenue</li> <li>• Thank-you letters were sent to volunteers at a nicely maintained rose garden</li> <li>• At a local community center, gravel was added to level the ground between a walking track and sidewalk to prevent a walking hazard</li> <li>• Dirt and overgrown shrubs on sidewalk were cleared out</li> <li>• Sidewalk was repainted red to stop cars from parking</li> <li>• A stop sign that had fallen was repaired</li> <li>• Put up a new stop sign at a local park to make entry easier</li> <li>• Put in a cross walk near one of the affordable housing sites</li> <li>• Improved visibility of bus stops signs and phone numbers to call to obtain the bus schedule</li> <li>• Painted sidewalk curve at local community center to prevent falls</li> <li>• Cracked, uneven sidewalk repair at another community center</li> </ul>
<i>Manitoba, Canada</i> <b>Creating an age-friendly campus</b>	Older people (≥65 years) assessed overall age-friendliness of the University of	<ul style="list-style-type: none"> <li>• Fitness programming for older people (including walking paths and places to cycle)</li> </ul>	<ul style="list-style-type: none"> <li>• Several missing handrails, automatic door openers, bench seating along walkways</li> </ul>	<ul style="list-style-type: none"> <li>• Comprehensive physical accessibility scan of campus to identify overlooked areas (completed as part of provincially-mandated legislation and ongoing accessibility audits of campus)</li> <li>• Adding additional bench seating</li> </ul>

Location and Project Focus	Description and Participants	Community Features Identified		Strategies Proposed and Changes Enacted
		Positive	Negative	
	Manitoba's Fort Garry campus (N=10)	<ul style="list-style-type: none"> <li>Libraries</li> <li>Restaurants</li> <li>Positive campus environment</li> <li>Positive customer service experiences</li> </ul>	<ul style="list-style-type: none"> <li>Absent, confusing, or hard to read campus signage</li> <li>Unsafe walking surfaces (tripping hazard)</li> <li>Lack of separation between cyclists and pedestrian traffic</li> <li>Cost and availability of parking for older people with accessibility concerns</li> </ul>	<ul style="list-style-type: none"> <li>Increasing walkway maintenance and reconstruction budget</li> <li>Will vastly improve the quality and amount of signage to building entrances, pedestrian walkways, university roads, and parking lots (currently part of a larger wayfinding project on campus)</li> <li>Adding more pedestrian crossings and dedicated bike lanes</li> <li>Adding more short-term and accessible parking spaces</li> </ul>
<i>Bath, Kent, Keynsham, Wolverhampton, UK</i> <b>Increasing age- and activity-friendliness of diverse communities</b>	Increasing the age and activity friendliness of geographically and socio-economically diverse communities; (N=19 older adults, 66 ± 7 years old)	<ul style="list-style-type: none"> <li>Sidewalk availability and dropped curbs</li> <li>Access to facilities including recreational facilities (museums, shops), daily destinations (parks, green spaces and benches) and public transport.</li> <li>Community spirit (i.e. friendly people, supportive networks, community hubs)</li> <li>Variety of local amenities</li> <li>Signposting of walking/cycling routes</li> </ul>	<ul style="list-style-type: none"> <li>Damaged sidewalks</li> <li>Obstacles on sidewalks (e.g., leaves, trash bins)</li> <li>Aesthetics: Graffiti, unkept gardens, overgrown trees/bushes, flower beds, vandalism</li> <li>Neighborhood safety: lack of signs &amp; lighting, high traffic volume</li> <li>Public crossing characteristics (i.e., long distances between crossings, insufficient crossing duration)</li> <li>Personal Safety: groups of young people, stray dogs</li> <li>Accessibility &amp; Walkability: unreliable public transport, challenges walking on cobbled streets, limited access to parks, shops, benches</li> <li>Air pollution</li> </ul>	<p>Citizen scientists articulated the following goals and strategies:</p> <ul style="list-style-type: none"> <li>Provide accommodations for people with compromised walking abilities or who use walking aids</li> <li>Provide unobstructed access to good quality and safe sidewalks</li> <li>Provide sheltered benches that accommodate different abilities</li> <li>Provide local amenities for coffee, sociability</li> <li>Provide public toilets</li> <li>Advertise the walking/cycling routes</li> <li>Subsidize active forms of travel</li> <li>Enhance roads to reduce traffic volume</li> <li>Put neighborhood watch schemes in place</li> <li>Provide more trash bins to reduce litter</li> <li>Park patrols to help older adults feel safer</li> <li>Provide communal picnic areas to give more of a safe and communal feeling</li> <li>Restrict big lorries to use only bigger roads and motorways</li> </ul>

Location and Project Focus	Description and Participants	Community Features Identified		Strategies Proposed and Changes Enacted
		Positive	Negative	
<i>Temuco, Chile</i> <b>Neighborhood environmental characteristics that promote quality of life and physical activity among older adults</b>	Community-dwelling older adults from neighborhoods with different socioeconomic status and walkability (N=60, ≥60 years)	<ul style="list-style-type: none"> <li>• Availability and proximity of services, goods</li> <li>• Availability of green spaces, sidewalks</li> <li>• Government-funded programs to improve neighborhoods</li> <li>• Bus stop renovations and new signage</li> <li>• Participatory decisions for improving common spaces (public art)</li> </ul>	<ul style="list-style-type: none"> <li>• Sidewalks need maintenance</li> <li>• Some street corners need better signs and measures to reduce vehicle speed</li> <li>• Illegal garbage disposal in some corners</li> <li>• People selling drugs in some areas</li> <li>• Lack of support to maintain surveillance cameras under operation</li> </ul>	<ul style="list-style-type: none"> <li>• Strategy development in process</li> <li>• Several stakeholders have been identified for the implementation of potential solutions such as the Council program for older adults, Regional Secretary of Transport, Council Department of Transport, Regional Secretary of Housing and Urbanism, Regional Secretary of Aging, Police</li> </ul>
<i>East San Jose, CA (USA)</i> <b>Intergenerational approaches to building a healthy community</b>	Collaboration with SOMOS Mayfair organization, and local Public Health Department; (N=50 multi-aged residents)	<ul style="list-style-type: none"> <li>• Public Art</li> </ul>	<ul style="list-style-type: none"> <li>• Low access/utilization of public spaces for PA</li> <li>• Not enough public art</li> <li>• Lack of affordable housing</li> <li>• Abandonment and dangerous infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>• Presented findings to Mayor and City Council</li> <li>• MOU with School District to allow access to a local soccer field</li> <li>• Development of Scavenger Hunt cards to attract local park use</li> <li>• Creation and dissemination of “Walking Loop” cards through new partnership with CA Walks and resident walking groups</li> <li>• New PA programming</li> </ul>
<b>SOCIAL ENVIRONMENT</b>				
<i>Anchorage, Alaska<sup>1</sup></i> <b>Safe and healthy aging for older LGBT residents</b>	Analysis of environmental factors that impact feelings of social isolation (N=8)	<ul style="list-style-type: none"> <li>• LGBT community advocacy organization</li> <li>• Natural beauty of Alaska</li> </ul>	<ul style="list-style-type: none"> <li>• Limited safe public transportation options</li> <li>• Treacherous winter walk/drive conditions</li> <li>• Lack of LGBT-welcoming venues</li> <li>• Fear for personal safety based on historical discrimination</li> </ul>	<ul style="list-style-type: none"> <li>• LGBT elder-friendly events, social opportunities, and meetings held at Anchorage Senior Center, local cafes, and other venues</li> <li>• Increased ridesharing coordination to AARP or SAGE events</li> <li>• Offer of new educational events with Anchorage Senior Center, business leaders and senior services providers</li> </ul>
<i>Cijin, Taiwan<sup>1</sup></i> <b>Senior-friendly places for social and recreational activities</b>	Older adults with mean age 70 years (SD=10), 33% women, all with a high school education (N=15)	<ul style="list-style-type: none"> <li>• Some aesthetics</li> </ul>	<ul style="list-style-type: none"> <li>• No places to socialize</li> <li>• Abandoned buildings</li> <li>• Dysfunctional sewers</li> <li>• Broken sidewalks</li> <li>• Personal safety issues from motorbikes</li> </ul>	<ul style="list-style-type: none"> <li>• Prioritized abandoned buildings and personal safety as particular high-priority issues</li> <li>• An abandoned building was identified to turn into a community center where older adults could safely gather and socialized</li> </ul>

Location and Project Focus	Description and Participants	Community Features Identified		Strategies Proposed and Changes Enacted
		Positive	Negative	

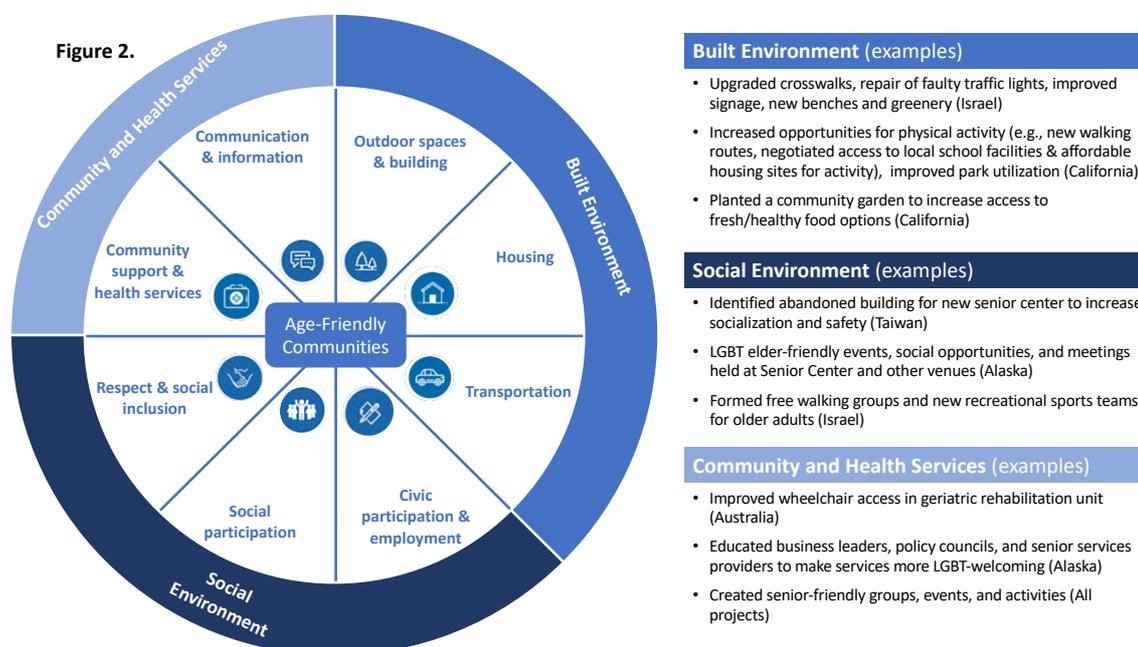
COMMUNITY AND HEALTH SERVICES				
<i>Brisbane, Australia</i> <sup>1</sup> <b>Ensuring a mobility-friendly geriatric medical rehabilitation unit</b>	Older adults in a medical rehabilitation unit (N=10; 8 confined to wheelchairs)	<ul style="list-style-type: none"> <li>• A community garden &amp; coffee shop at rehab unit</li> <li>• Windows providing views of the sky &amp; some greenery</li> </ul>	<ul style="list-style-type: none"> <li>• Swinging vs. sliding doors</li> <li>• Hard-to-reach cupboards</li> <li>• Drab décor</li> <li>• Steeply inclined entryway</li> <li>• Bed curtains provided little privacy</li> </ul>	<ul style="list-style-type: none"> <li>• Moved a patient kitchenette &amp; drinking fountain to more accessible locations</li> <li>• Changing curtains to allow for greater privacy &amp; which brightened décor</li> <li>• Re-arranged furniture to allow greater wheelchair navigation</li> <li>• Lowered paper towel dispensers in bedrooms for easier access</li> </ul>

177

Note. <sup>1</sup> Project results described in further detail below.

178 The age-friendly domains and topic areas are shown in **Figure 2** below, along with some specific  
 179 examples of outcomes identified in *Our Voice* projects included in this paper.

180



181

182 Figure 2 caption. **Topic areas underlying global age-friendly communities, adapted from WHO [14]**

183

184 **3. Results**

185 In this section we present examples of how *Our Voice* has been used to address the three age-friendly  
 186 domains (i.e., built, social, or community and health services environments) and associated age-  
 187 friendly topic areas in different geographic areas globally, including several previously  
 188 unpublished citizen science studies. These examples are also intended to highlight how this  
 189 community engagement model can be used across diverse locales and populations to facilitate  
 190 scalable and sustainable local changes to promote healthy living. Lessons for sustaining resident  
 191 momentum during and beyond the project period are briefly summarized in a subsequent section.

192 **3.1. Enhancing Built Environments to Promote Active Aging**

193 Decades of research have demonstrated the relationship between the physical or “built”  
 194 environments in which we live and activity engagement throughout the life course, including  
 195 walking and recreation [28,29]. From an age-friendly communities perspective, the design of  
 196 outdoor spaces, buildings, and transportation are critically important for assuring their accessibility,  
 197 safety, and attractiveness for older adults, who may face a range of mobility and sensory  
 198 impairments [28,29]. Of specific importance is assuring that public areas are clean, green, and  
 199 include outdoor seating; and that pedestrian walkways are free of obstructions, trip hazards,  
 200 cyclists, cars, or other safety hazards. The following two projects illustrate the use of *Our Voice*  
 201 methods to create age-friendly outdoor spaces for walking and other desirable recreational  
 202 activities.

203 **3.1.1. Improving Neighborhood Walkability for Israeli Older Adults**

204 To evaluate barriers and enablers of neighborhood walkability and walking routes among older  
205 Israeli adults, an initial study using the *Our Voice* Citizen Science method was [27,30] coordinated  
206 by JDC Eshel, the association for the planning and development of services for older adults and  
207 their families in Israel, in partnership with the University of Haifa (with university institutional  
208 review board approval). The study was conducted in neighborhoods in the city of Haifa that  
209 represented the socio-economic diversity of the city [27]. The project team recruited 59  
210 independently living adults ages 50 years and older who were equally distributed across the  
211 neighborhoods. Citizen science participants were recruited through mailed and posted flyers  
212 distributed throughout the neighborhoods as well as word-of-mouth among community members.  
213 Participants were successful in using the DT app to capture relevant barriers to and enablers of local  
214 walking routes in their local neighborhoods [27]. Through subsequent facilitated group discussions  
215 and dialogue with local municipal decision-makers, they also were able to successfully identify the  
216 safest routes to relevant destinations. Together they developed a senior-friendly “golden path” map  
217 and worked with the Mayor’s office and other organizations, including some local businesses, to  
218 initiate changes (e.g., improved aesthetics) to better support walking [30].

219 The successes from this initial evaluation led JDC Eshel to expand the use of *Our Voice* citizen science  
220 activities to 29 neighborhoods across 9 other cities in Israel. The overall goal of the citizen science  
221 initiative is to improve seniors’ local environments in support of walking and related health-  
222 promoting activities. Thus far, 322 residents have engaged in citizen science activities, and over  
223 1,000 residents have participated in various healthy lifestyle activities following this project. The  
224 citizen science participants were ethnically and socio-economically diverse, and in some cases,  
225 youth or young adults were invited to engage in the neighborhood citizen science process with the  
226 older adults (e.g., in Jerusalem, Tel Aviv). (See **Table 2** for summary information on the first 5 cities  
227 that have completed their projects. The remaining cities are in the final phase of their projects.) While  
228 this citizen science initiative is ongoing, successes thus far have included upgrading of crosswalks;  
229 repair of traffic signs and extension of the length of time traffic lights remained green to allow for  
230 easier street crossings; planting of trees and greenery to enhance local aesthetics; addition of fences  
231 along roadways to direct pedestrians to safer places to cross; and installation of benches along routes  
232 to supermarkets and recreational clubs. In addition, formation of free walking groups for seniors  
233 and development of a recreational sports team for older adults at local community centers  
234 addressed an identified need to improve social support for engagement in physical activity. A key  
235 to the project’s success was the active involvement of diverse community stakeholders and decision  
236 makers (e.g., nurses, social workers, municipal welfare departments, city government officials,  
237 directors and personnel from community “golden age” clubs for older adults). Participants also  
238 reported increased feelings of empowerment, collective efficacy, and neighborhood connectedness  
239 across the participating citizen science groups.

240 **TABLE 2** (heading/title): Descriptive information on implementation of Israel *Our Voice* projects in  
241 5 additional cities

City	Neighborhood	City description	Local partnering orgs	Citizen Scientist Population	Partnership and recruitment process	Our Voice Facilitation										
Lod	Sharett	<ul style="list-style-type: none"> <li>74,000 residents</li> <li>72.5% Jewish 27.5% Arab</li> </ul>	<ul style="list-style-type: none"> <li>Municipal Welfare Department</li> <li>JDC Eshel</li> <li>JDC Ashalim</li> </ul>	<p><b>N=30</b></p> <ul style="list-style-type: none"> <li>Participants in a digital literacy course and other club activities Primarily women over age 68</li> </ul>	<ul style="list-style-type: none"> <li>Outreach to working to engage older adults</li> <li>Identification of “good fit” opportunities (i.e., digital literacy course and Better Together program)</li> <li>Development of joint work agreement</li> <li>Approval from City Welfare Department</li> </ul>	<ul style="list-style-type: none"> <li>Organized by the Better Together project liaison together with representatives from the <i>OV</i> project and the older adult club</li> <li>Two meetings for each group, to introduce the project and train the participants</li> <li>Facilitators accompanied citizen scientists on DT walks as needed/appropriate</li> </ul>										
	Ganei Aviv	<ul style="list-style-type: none"> <li>~33% new immigrants from former Soviet Union and Ethiopia</li> </ul>	<ul style="list-style-type: none"> <li>Liaisons from the “Better Together” program for community work with older adults</li> </ul>	<p><b>N=15</b></p> <ul style="list-style-type: none"> <li>Russian-speaking immigrants in digital literacy course and/or other club programs</li> </ul>			Tel Aviv	Shapira	<ul style="list-style-type: none"> <li>8,500 residents</li> <li>Primarily low socio-economic status</li> <li>High population of foreign workers living alongside old-time residents</li> </ul>	<ul style="list-style-type: none"> <li>Municipal Welfare Department</li> <li>Clubs for older adults</li> </ul>	<p><b>N=25</b></p> <ul style="list-style-type: none"> <li>Participants in physical activity groups at a club for older adults</li> <li>Neighborhood activists (non-club members)</li> <li>Equal numbers men/women</li> <li>Most aged 70 or above</li> <li>Some with physical impairments (e.g., using walkers)</li> </ul>	<ul style="list-style-type: none"> <li>Recruitment through “home groups” to maximize comfort</li> </ul>	<ul style="list-style-type: none"> <li><i>Our Voice</i> project lead coordinated via local club liaison and community social worker</li> <li>Engaged younger volunteers as guides to accompany participants, help alleviate technology anxieties, and answer questions</li> <li>Three community meetings to introduce program, recruit, and train on use of DT</li> <li>Created local WhatsApp groups to ensure successful use of the DT and data upload</li> </ul>	Mo'adon Mitchell	<ul style="list-style-type: none"> <li>Old neighborhood with long-term residents, many post WWII immigrants</li> <li>Generally high socio-economic status</li> </ul>	<ul style="list-style-type: none"> <li>The Mitchell Center for older adults, which offers diverse activities and serves as a social center for its members</li> <li>Municipal Welfare Department</li> </ul>
Tel Aviv	Shapira	<ul style="list-style-type: none"> <li>8,500 residents</li> <li>Primarily low socio-economic status</li> <li>High population of foreign workers living alongside old-time residents</li> </ul>	<ul style="list-style-type: none"> <li>Municipal Welfare Department</li> <li>Clubs for older adults</li> </ul>	<p><b>N=25</b></p> <ul style="list-style-type: none"> <li>Participants in physical activity groups at a club for older adults</li> <li>Neighborhood activists (non-club members)</li> <li>Equal numbers men/women</li> <li>Most aged 70 or above</li> <li>Some with physical impairments (e.g., using walkers)</li> </ul>	<ul style="list-style-type: none"> <li>Recruitment through “home groups” to maximize comfort</li> </ul>	<ul style="list-style-type: none"> <li><i>Our Voice</i> project lead coordinated via local club liaison and community social worker</li> <li>Engaged younger volunteers as guides to accompany participants, help alleviate technology anxieties, and answer questions</li> <li>Three community meetings to introduce program, recruit, and train on use of DT</li> <li>Created local WhatsApp groups to ensure successful use of the DT and data upload</li> </ul>										
	Mo'adon Mitchell	<ul style="list-style-type: none"> <li>Old neighborhood with long-term residents, many post WWII immigrants</li> <li>Generally high socio-economic status</li> </ul>	<ul style="list-style-type: none"> <li>The Mitchell Center for older adults, which offers diverse activities and serves as a social center for its members</li> <li>Municipal Welfare Department</li> </ul>	<p><b>N=9</b></p> <ul style="list-style-type: none"> <li>Over 70 years of age</li> <li>Eight women and one man</li> </ul>	<ul style="list-style-type: none"> <li>Recruitment by a national service volunteer at the club</li> <li>Outreach to those comfortable with using mobile devices</li> <li>Offered tutorials and support to others</li> <li>Individualized orientation to <i>OV</i> project and DT</li> </ul>	<ul style="list-style-type: none"> <li>Regular consultation and supervision between <i>OV</i> lead and local project facilitators</li> <li>Two meetings offering DT instruction and thematic analysis of DT data collected</li> <li>National volunteer service and community social worker regularly contacted participants</li> </ul>										

City	Neighborhood	City description	Local partnering orgs	Citizen Scientist Population	Partnership and recruitment process	Our Voice Facilitation
	Hatikva	<ul style="list-style-type: none"> <li>In cluster of three neighborhoods with ~20,000 residents</li> <li>Most foreign-born</li> <li>10%-15% older adults</li> <li>33% on welfare</li> </ul>	<ul style="list-style-type: none"> <li>Municipal Welfare Department</li> <li>Clubs for older adults</li> </ul>	<b>N=14</b> <ul style="list-style-type: none"> <li>Mainly Sephardi</li> <li>12 women and 2 men aged 65 and above</li> </ul>	<ul style="list-style-type: none"> <li>The municipality's community work team selected the neighborhood and engaged the local social worker</li> <li>The social worker recruited participants through the club and among resident activists</li> </ul>	<ul style="list-style-type: none"> <li>Community social worker facilitated process with support of national OV program liaison</li> <li>Social worker &amp; two volunteers personally accompanied participants on DT walks</li> <li>Three community meetings to introduce program, recruit, and train on use of DT</li> </ul>
	Ajami	<ul style="list-style-type: none"> <li>Old neighborhood with narrow, crowded streets</li> <li>Mix of Arabs and Jews</li> </ul>	<ul style="list-style-type: none"> <li>Municipal Welfare Department</li> <li>Clubs for older adults</li> </ul>	<b>N=35</b> <ul style="list-style-type: none"> <li>Arab women aged 65 – 70</li> </ul>	<ul style="list-style-type: none"> <li>Municipality community work team selected the neighborhood club because many women already active</li> <li>Club director, social worker and program liaison led recruitment</li> <li>Recruitment lasted a month</li> </ul>	<ul style="list-style-type: none"> <li>Club director and social worker joined residents on DT walks</li> <li>Ongoing consultation with OV national liaison</li> <li>Two meetings to introduce project, recruit, and select themes</li> <li>Plan to present the findings to the relevant municipality officials</li> </ul>
Bat Yam	Gordon	<ul style="list-style-type: none"> <li>High proportion of immigrants from former Soviet Union</li> <li>Ranked 14th in population and 55th in geographic size</li> <li>3rd most crowded city in Israel</li> </ul>	<ul style="list-style-type: none"> <li>JDC "Better Together" program</li> <li>Local Community Center</li> </ul>	<b>N=10</b> <ul style="list-style-type: none"> <li>Club members/ retirees already active in the club</li> <li>7 women, 3 men</li> </ul>	<ul style="list-style-type: none"> <li>Open invitation to all interested club members</li> <li>Presentation and DT training by the program liaison and the club director</li> </ul>	<ul style="list-style-type: none"> <li>Club director led process together with the program liaison</li> <li>Daily contact and consultation</li> <li>Joined residents on DT walks</li> <li>Two meetings for recruitment, DT training, and theme selection</li> <li>Presentation of findings and proposed solutions to municipal officials</li> </ul>
	Negba		<ul style="list-style-type: none"> <li>Negba Community Center (part of the Community Center company)</li> </ul>	<b>N=10</b> <ul style="list-style-type: none"> <li>Women aged 75+</li> <li>Most already active in club &amp; low SES</li> </ul>		
Petah Tikvah	Menachem Ratzon	<ul style="list-style-type: none"> <li>Over 244,000 residents (fifth most populous in Israel)</li> <li>The population growth rate is 1.6% annually.</li> </ul>	<ul style="list-style-type: none"> <li>Municipal Welfare and Health</li> <li>Clubs for older adults</li> </ul>	<b>N=12</b> <ul style="list-style-type: none"> <li>Women aged 75 +</li> <li>Generally already "active and concerned"</li> </ul>	<ul style="list-style-type: none"> <li>Recruitment by club director</li> <li>Two-week recruitment period</li> </ul>	<ul style="list-style-type: none"> <li>Co-facilitated by club director and club's national service volunteer</li> <li>Facilitators accompanied participants on DT walks</li> <li>Two meetings:</li> </ul>
	Sela			<b>N= 8</b> <ul style="list-style-type: none"> <li>Women</li> </ul>		

City	Neighborhood	City description	Local partnering orgs	Citizen Scientist Population	Partnership and recruitment process	Our Voice Facilitation
	Beit Dani			N=8 • 7 women, 1 man, 70 +	• Participants selected based on enthusiasm and willingness to volunteer	• Recruitment and training • Theme selection • Awaiting meeting with municipal officials
	Smilansky			N=8 • 5 women, 3 men, 70 +		
Jerusalem	Beit Hakerem	<ul style="list-style-type: none"> <li>• High socio-economic status</li> <li>• Relatively homogeneous population of secular native Israelis</li> </ul>	<ul style="list-style-type: none"> <li>• JDC Eshel "Community for Generations" program</li> <li>• City of Jerusalem</li> <li>• Community</li> <li>• Welfare department</li> <li>• Local branch of the scout movement</li> </ul>	<b>N=38</b> <ul style="list-style-type: none"> <li>• 23 older adults (15 women and 8 men)</li> <li>• 15 high school student members of the Scout movement</li> </ul>	<ul style="list-style-type: none"> <li>• The Community for Generations director recruited participants</li> <li>• Reached out to the Scout movement for an intergenerational connection</li> <li>• Recruitment lasted ~two months</li> </ul>	<ul style="list-style-type: none"> <li>• Led by Community for Generations director with help of Scouts' Community Involvement liaisons (high school students)</li> <li>• Sessions initially separated by group, then joint sessions with retirees and students</li> <li>• Collaboration with Scouts extended process to 6 months</li> <li>• DT walks intergenerational; decided together what to document</li> <li>• Aim of building shared vision for the neighborhood, for all ages</li> </ul>
	Har Homa	<ul style="list-style-type: none"> <li>• Mainly young families</li> <li>• Approximately 28,000 residents</li> <li>• Some 1,800 older adults</li> </ul>	<ul style="list-style-type: none"> <li>• Jerusalem municipality</li> </ul>	<ul style="list-style-type: none"> <li>• 15 women aged 68 and above</li> </ul>	<ul style="list-style-type: none"> <li>• Recruitment lasted ~two months and included an initial session to introduce the program</li> <li>• Those interested joined a second session to learn how to use the DT</li> </ul>	<ul style="list-style-type: none"> <li>• Led by club director and program liaison</li> <li>• Direct contact with retirees and accompanied them on DT walks</li> <li>• Two meetings to introduce project, recruit, and select themes</li> <li>• Presentation to officials pending</li> </ul>

243 3.1.2. *Creating Convenient Multi-Generational Physical Activity and Recreation Opportunities in San Jose,*  
244 *CA*

245 In a multi-generational project that included 50 adults and youth in the Mayfair area of San Jose,  
246 CA, the community-based SOMOS Mayfair nonprofit organization partnered with Stanford  
247 researchers and the Santa Clara County Public Health Department to identify barriers and develop  
248 solutions to promote active and safe living in this ethnically diverse, historically underrepresented  
249 area (e.g., 79% of residents speak a language other than English at home). The data that residents  
250 collected using the DT and around which consensus was subsequently built were presented to the  
251 Mayor of the city of San Jose and City Council members. Among the successes that occurred from  
252 this project were the development of a memorandum of understanding with the local school district  
253 to allow residents to access a local soccer field; designation of scholarships for enrichment programs  
254 at the local community center; development of “scavenger hunt cards” to promote use of a local  
255 park; creation of walking routes aligned with historical aspects of their neighborhood and resident-  
256 led walking groups; and physical activity programming in conjunction with National Night Out  
257 activities and the local Viva Parks program. These activities together increased opportunities for  
258 physical activity and improved park utilization as observed and documented by the System for  
259 Observing Play and Recreation in Communities (SOPARC) [31]. The results of this project show  
260 how resident-centered data-driven methods can provide a means through which historically  
261 underserved residents of all ages can work effectively with local decision-makers and researchers  
262 to address long-standing social and environmental disparities that can impact health in their locales.

263 3.1.3. *Other Projects Aimed at Enhancing Built Environments to Promote Age-Friendly Communities*

264 In addition to the above projects, examples from several other *Our Voice* projects that have been  
265 aimed at enhancing local environments to improve access to a variety of desirable physical and  
266 recreational opportunities are summarized in **Table 1**. Briefly, changes accomplished by these  
267 projects include creating a community garden adjacent to senior housing in a low-income northern  
268 California community [17,32]; reducing impediments to walking and addressing waste  
269 management in a low-income Latino neighborhood in the San Francisco Bay area, CA [26]; and  
270 developing local solutions to control stray and roaming dogs in Cuernavaca, Mexico [20]. Other  
271 projects in progress, some of which are described in Table 1, include improving the accessibility and  
272 navigability of the university campus in Manitoba, Canada; increasing the age- and activity-  
273 friendliness of diverse communities in West Midlands, South West and South East England;  
274 promoting environments that support healthy aging in Temuco, Chile and Curitiba, Brazil; and  
275 improving neighborhood walkability around senior affordable housing sites in San Mateo and  
276 Santa Clara Counties, California. In addition, *Our Voice* citizen science projects are being pursued in  
277 these latter counties to foster intergenerational and multicultural sharing around transportation and  
278 transit equity, and to enhance age-friendly cities, including safe routes for seniors programming.  
279 Innovative citizen science work also has been accomplished by Tuckett et al. in Brisbane, Australia,  
280 where older residents have contributed to solutions to enhance local walking infrastructure,  
281 including the repair and improvement of footpaths, and local park use, including municipal  
282 approval for installation of new toilets and exercise equipment [25].

283 3.2. *Enhancing Social Environments to Promote Social Participation, Safety, Respect, and Inclusion*

284 The *Our Voice* projects described above have focused principally on features of physical  
285 environments that impact lifestyle behaviors and similar factors of importance to healthy aging. Yet,  
286 local community features also can strongly impact social environments, including features that  
287 influence perceived safety and satisfaction with local services, and those that foster participation,  
288 respect and social inclusion [33]. These social determinants of health are equally important to  
289 older adults’ daily well-being and quality of life [34].

### 290 3.2.1. Creating Safe, Senior-Friendly Social Spaces in Cijin, Taiwan

291 Taiwan's population is aging at a rate more than twice that of Europe and the U.S. [35]. Yet, it is  
292 currently unclear how best to create age-friendly environments that meet the needs of the older  
293 adult population. The *Our Voice* DT and citizen science process was used to capture older adults'  
294 perspectives about their local environments in a contextually valid manner [36] (institutional review  
295 board approval from Kaohsiung Medical University, #kmuh/irb/af/08E-02). Fifteen older adults  
296 (mean age = 70.3 [SD=9.9], 33% women, all with a high school education) living in Cijin, a small  
297 community in southern Taiwan, used the DT during walks in their village to capture barriers to and  
298 enablers of healthy aging. A total of 78 photos and audio-narratives were collected. Issues that were  
299 identified included lack of public spaces for older adults to gather and socialize, abandoned  
300 buildings, a dysfunctional sewer system, cracked and broken sidewalks, and personal safety issues  
301 related to motorbikes and other factors. During the facilitated resident meeting, residents prioritized  
302 abandoned buildings and personal safety as high-priority issues that they would like to see  
303 addressed. Three weeks after this meeting, residents met with local village officials to share results  
304 and brainstorm potential solutions. An abandoned building was identified to turn into a community  
305 center where older adults could safely gather and socialize. However, turnover of project facilitators  
306 (which included students from a nearby university) contributed to a loss of momentum, and  
307 consequently the early gains that had been made in support of the building remodeling process  
308 stalled. In addition, there was a lack of clarity around which municipal entity—the university  
309 hospital that owned the building or the city of Cijin—was responsible for the remodeling costs. As a  
310 result, the remodeling of the building was not completed. Thus, while older residents were  
311 successful in using the DT and *Our Voice* process to identify local issues impacting healthy aging  
312 and develop, with stakeholders, potentially feasible solutions, this study also underscored the  
313 importance of continuity among project facilitators, and the need to clearly identify “implementers”  
314 with the authority, interest and resources required to accomplish the requested change.

### 315 3.2.2 Promoting Community-wide Respect and Inclusion for LGBT Elders in Anchorage, Alaska

316 Lesbian, gay, bisexual and transgender (LGBT) elders often experience social stigma, loneliness,  
317 social isolation, and discrimination that can result in health disparities [37]. A pilot project  
318 conducted in Anchorage, Alaska with LGBT elders represents the first project to assess the  
319 feasibility of using *Our Voice* citizen science methods focused specifically on promoting respectful,  
320 safe, and inclusive community environments [38]. In partnership with local branches of two U.S.  
321 national organizations supporting older adults, a convenience sample of eight LGBT Alaskan aging  
322 adults (median age=62.5; range=53-71 years) completed baseline and 6-month follow-up surveys  
323 about their health, perceptions of neighborhood social cohesion [39], loneliness [40], and access to  
324 LGBT-friendly services. Following baseline, citizen scientists completed a walk- or drive-about  
325 using the DT to document, through 66 geo-tagged photos and 65 recorded audio narratives,  
326 environmental features that enabled or hindered safe and healthy aging. After completing the DT  
327 assessments, citizen scientists, advisors from the two national organizations (SAGE and the  
328 American Association of Retired Persons [AARP]), and LGBT advocates came together to analyze  
329 and prioritize the DT data. To guide deductive theme generation, the group used the *WHO Checklist*  
330 *of Essential Features of Age-friendly Cities* [15] as a starting point. Participants subsequently met twice  
331 more to finalize key issues, brainstorm and prioritize possible solutions, and plan next steps.

332 The findings suggested that personal safety, respect, inclusion, social participation, and  
333 connectedness were hindered by lack of safe public transportation and information about LGBT-  
334 friendly places. For example, people loitering in front of public buildings, such as the public library,  
335 and youth disrespecting older adults were concerns for all participants but were noted as especially  
336 threatening for transgender elders. All described a heightened sense of vigilance when out in public  
337 or in social settings, such as senior centers, where they felt conscious of or wary about disclosing  
338 their sexual orientation or gender identity.

339 Of particular interest, participants reported meaningful increases in perceived social cohesion and  
340 decreases in loneliness after participating in the project for six months (effect size  $d=.42$  and  $1.03$ ,  
341 respectively). For example, on the loneliness scale, the item with the most improvement was “I often  
342 feel rejected,” which went from 100% indicating that they felt rejected at least some of the time or  
343 often at baseline, to 25% at follow-up. Similarly, the item “There are enough people I feel close to”  
344 improved from half of respondents answering affirmatively, to 75% of respondents indicating that  
345 they agreed with that statement at 6 months. Follow-up assessments also indicated an increased  
346 perception that there are not enough psychological support groups for LGBT people and that  
347 community fear or dislike of LGBT people is a problem in Anchorage. A possible explanation was  
348 that listening to other participants’ experiences during the group meetings heightened individual  
349 awareness of issues that may or may not have matched their own experiences. With respect to social  
350 participation, citizen scientists described a general lack of information about low or no-cost LGBT-  
351 friendly events that could be attended alone or with a companion.

352 Feasible solutions that were identified through the citizen science engagement process included  
353 sharing their *Our Voice* discoveries through presentations to service providers, policy makers and  
354 business leaders, and creation of opportunities to connect with others by offering community  
355 partner-facilitated ridesharing to SAGE Alaska and AARP Alaska-sponsored events. At the end of  
356 the pilot study, citizen scientists expressed interest in sustaining their momentum by developing  
357 partnerships with businesses and community groups with a shared interest in creating a safe and  
358 inclusive city. Citizen scientists felt they could play a key role in helping to raise awareness of age-  
359 friendly needs and solutions to address inequities and, through SAGE Alaska, providing  
360 educational opportunities to senior centers, fitness clubs, and senior service agencies to help  
361 promote greater inclusiveness. The citizen scientists and LGBT advocates also expressed interest in  
362 broadening future efforts to engage LGBT youth in data collection and activities that can enhance  
363 social participation, respect, and inclusion across the lifespan. As of this writing, the citizen scientists  
364 have presented their findings to municipal, state and national audiences, including community  
365 partner board meetings, business leader breakfasts, the Anchorage senior center, and several  
366 scientific conferences [38]. Through SAGE Alaska, Identity, Inc. (a statewide advocacy organization  
367 for LGBT), and AARP Alaska, they have instituted ongoing social opportunities, including a weekly  
368 morning “coffee and conversation” event, held at a local café. They also are encouraging a more  
369 inclusive climate at the local senior center by using the facility for SAGE team meetings and special  
370 events. This exploratory study sets the stage for further, larger-scale investigations of this citizen  
371 science model as a potential method for improving inclusive social environments for all.

372 The above two projects demonstrate the importance, when assessing the age-friendliness of  
373 communities, of paying particular attention to environmental features and social barriers that may  
374 lead older adults to feel unwelcome or fearful [41]. Solutions that are generated should universally  
375 consider the needs of diverse older adults to diminish loneliness and isolation [33].

### 376 3.3. Increasing Access to Age-Friendly Community and Health Services

377 An important, but understudied, age-friendly communities’ domain is one where the built and  
378 social environments collide, i.e., the health and social services sector [42]. The WHO emphasizes  
379 that community and health services, including clinics, hospitals, pharmacies, and social service  
380 settings, must be convenient and fully accessible for people with physical and cognitive disabilities  
381 [14]. Providers should be respectful and recognize the needs of diverse older adults, including  
382 language, culture, and relationships [42]. Communities should also assure that clear and accessible  
383 information about locally-relevant services is available and accessible to older adults, so they know  
384 what is locally available to support their ability to age well [14,42]. The following two examples  
385 emphasize the importance of built and social features to assure that older patients can not only  
386 navigate the physical settings where services are provided, but also can readily find out about  
387 trustworthy, welcoming services that exist within their community.

### 388 3.3.2. *Optimizing Comfort and Mobility in a Geriatric Medical Rehabilitation Setting*

389 In the first *Our Voice* citizen science project occurring in a health care setting, ten patients (8 of whom  
390 used wheelchairs) used the DT to assess features of a geriatric assessment and rehabilitation unit of  
391 a hospital in Brisbane, Australia related to helping the rehabilitation process. Human Subjects  
392 approval was received from the hospital's human research ethics committee. The data collected by  
393 the citizen scientists indicated that a major factor impacting patients' rehabilitation experience were  
394 environmental elements that were unfavorable for wheelchairs. Features that created barriers for  
395 wheelchair users included doors on cupboards and cabinets in bedrooms swinging outward to  
396 open, as opposed to sliding doors; shelves and hanging rails in cupboards that were difficult to  
397 reach; narrow doorways that were difficult to maneuver through for novice wheelchair users; basins  
398 and water dispensers that were difficult to access from a wheelchair; drab décor including curtains  
399 around beds that provided little privacy; and an inclined main entryway to the building that was  
400 challenging to use. Positive environmental features that were identified as enhancing the  
401 rehabilitation experience included the community garden and coffee shop on campus, as well as  
402 windows that provided views of the sky and some greenery for patients who could not leave the  
403 unit. In response to the citizen scientist data and information, the rehabilitation unit has initiated  
404 modifications, including moving a patient kitchenette and water fountain to more accessible  
405 locations; buying and hanging new curtains around beds to provide more privacy and brighten the  
406 feel of the unit; lowering paper towel dispensers in bedrooms; and rearranging furniture on the  
407 balcony to make it easier for patients in wheelchairs to navigate. Other initiatives, such as replacing  
408 furniture in the bedrooms, are being investigated.

409 Future directions relevant to improving the age-friendliness of community and health services  
410 domains include sharing data collected using *Our Voice* methods to inform providers about local  
411 environmental barriers that may impede adherence to treatment plans and prescriptions (e.g.,  
412 difficulties accessing healthy foods, challenges engaging in regular walking, transportation  
413 barriers). One key feature will be providing patients with information about where they are allowed  
414 to be in a clinical setting. One of the barriers to patient mobility in hospital settings is that patients  
415 are often unclear as to where they can appropriately walk. Providing such information can open the  
416 door to additional productive interactions with patients that could not only improve built and social  
417 environments, but also enhance subsequent treatment adherence.

### 418 3.3.2 *Enhancing Communication and Information to Connect Older Adults to Community and Health* 419 *Services*

420 In addition to navigating physical environments in both community and healthcare settings,  
421 enhancing the communication channels used by service providers to reach older adults and,  
422 conversely, used by older adults to locate relevant, competent and quality services, is an important  
423 component of age-friendly communities. Assuring all older adults can access clear, accurate and  
424 up-to-date information about services, events, and opportunities of interest may improve access to  
425 a wide range of supports to meet their needs. An example of how this issue can be addressed was  
426 observed in the Anchorage, Alaska *Our Voice* project described earlier, where LGBT participants  
427 attributed lack of information about LGBT-welcoming service providers, venues, and events as  
428 limiting their social and health-related activities. While "lack of information" itself cannot be readily  
429 photographed using the DT, engagement in the environmental assessment heightened citizen  
430 scientists' awareness of these less-concrete impediments to health.

### 431 3.4. *Maintaining Project Momentum to Achieve Successes and Address Challenges*

432 Maintaining momentum throughout a project to achieve its goals requires a willingness of citizen  
433 scientists and community partners and facilitators to continue to engage over the time it takes to  
434 accomplish proposed changes. Sustaining this participation is challenging, given busy schedules

435 and competing demands on people's time. Also, a clear understanding of who is responsible for  
436 implementing solutions is important, to prevent misunderstandings. Strategies used by the projects  
437 described above include meeting in convenient, familiar settings, providing transportation to  
438 meetings, providing refreshments at meetings, being flexible about meeting attendance (i.e., not  
439 every participant will make every meeting), and identifying a smaller group of spokespeople who  
440 are willing and able to represent the larger citizen scientist group in meeting with stakeholders,  
441 presenting data, and advocating for specific changes.

442 Once the initial project period ends, continuing momentum is also desirable but may be challenging  
443 if involvement from original project facilitators ceases due to turnover or lack of funding.  
444 Participant-generated ideas for continuing the work long-term include transitioning the facilitation  
445 role to community groups with a shared interest or vision; raising awareness of age-friendly needs  
446 and solutions among business leaders and service providers; and spreading use of such citizen  
447 science methods to other local communities and groups. The lessons learned from the projects  
448 described underscore both the promise of using a participatory citizen science approach and the  
449 need for sustained engagement from program facilitators and residents alike in ensuring that the  
450 action steps generated come to fruition. In addition, the improvements in empowerment, collective  
451 efficacy, and social cohesion among older adults described in these projects [13,32] can potentially  
452 be harnessed to achieve further gains in promoting age-friendly community objectives.

#### 453 4. Discussion and Future Directions

454 The growing literature on "by the people" forms of community-engaged citizen science, one type  
455 of which has been reviewed in this article, indicate the promise of this method for promoting age-  
456 friendly neighborhoods and communities in varying cultures and circumstances. These include  
457 improving built environment outdoor spaces and infrastructure that can promote neighborhood  
458 walkability and pedestrian safety; increasing access to a variety of physical activity opportunities;  
459 enhancing the usability of local parks; furthering social connections in a community to better enable  
460 respect and inclusion for all its members; increasing older adult mobility and comfort in health care  
461 settings; and assuring that clear, timely and trustworthy communication and information is  
462 available to older adults so that they are able to more fully access the community and health services  
463 they need. Together, the projects described demonstrate how aging adults from diverse  
464 backgrounds and conditions can learn how to employ mobile technology to capture relevant  
465 barriers to and enablers of healthy living. They then can learn how to successfully engage relevant  
466 stakeholders and service providers to compel meaningful yet realistic age-friendly changes in their  
467 local environments.

468 In addition to the information that has been learned to date, there are a number of future directions  
469 in which this line of research can go to maximize its value and returns, including the following  
470 recommendations:

471 • Continue to expand the scientific rigor, methods, and designs commensurate with this type of  
472 community-enabled research. This includes quasi-experimental pre-post comparison group designs  
473 [21], as well as, when appropriate and feasible, experimental designs comparing the efficacy of  
474 health interventions with and without the addition of "by the people" citizen science methods. One  
475 example of the latter approach summarized in Table 1 of this article is an NIH-funded U.S.  
476 randomized controlled trial, called Steps for Change (PHS #5R01CA211048), which is comparing the  
477 increases in physical activity sustained among midlife and older adults living in and around senior  
478 affordable housing sites in northern California. Participants in this study have been randomized to  
479 receive either a traditional, behaviorally oriented physical activity intervention or that intervention  
480 plus *Our Voice*.

- 481 • Test innovative approaches for capturing, over time, all of the varied impacts of such resident-  
482 engaged approaches—both intended and unexpected—through using systematic methods such as  
483 ripple effects mapping (REM) [43]. REM is a participatory qualitative methodology where  
484 participants and stakeholders visually map together the “snowballing” trajectory of project-related  
485 activities and outcomes that accrue over time [43,44]. To thoroughly capture such effects, which can  
486 occur beyond the formal end of a project, lengthening the duration of project assessment activities  
487 is recommended.
- 488 • Prospectively combine use of the WHO age-friendly checklist and *Our Voice* methods to evaluate  
489 age-friendly features and identify feasible barriers and solutions across all 8 topic areas.
- 490 • Increase both the number and types of inter-generational citizen science projects to build better  
491 communication and understanding between and across generations [20,26,45].
- 492 • Expand the data capture capabilities of this platform through adding mobile sensors and other  
493 assessment tools to the Discovery Tool walks that are occurring around residents’ communities. In  
494 this manner, a more comprehensive picture of the potential health and quality of life impacts of  
495 specific community locales and features can emerge. An example of this is having residents use a  
496 wrist-worn sensor that collects electro-dermal and heart rate activity in helping to identify locations  
497 along a particular walking route that engender increases in arousal or stress [24].
- 498 • Explore linkages to other data platforms through introducing this type of complementary  
499 resident-centric, micro-environmental perspective to computational, epidemiological, and other  
500 “big data” scientists, given that these data are typically missing in “big data” sets. Such resident-  
501 collected data may be particularly relevant for vulnerable populations, including older adults [46].

## 502 5. Conclusions

503 The *Our Voice* Global Citizen Science Research Initiative and Network represent a promising  
504 approach to building age-friendly communities for older adults and other residents, irrespective of  
505 the circumstances, locations, or cultures in which people live. These projects individually and  
506 collectively illustrate the observation, found in other *Our Voice* projects and emphasized by scientific  
507 thought leaders such as the anthropologist Margaret Mead, that small groups of committed  
508 residents working together can make a difference in their communities.

509 A longer-term goal of this global research initiative is to build an interactive world map of resident-  
510 collected data and project results along with other resources that can be shared by researchers, non-  
511 academic and government organizations, and residents alike. This type of collaborative undertaking  
512 can help to advance the vision laid out by the WHO and other organizations in building a true path  
513 to achieving global age-friendly communities along with health equity in under-resourced  
514 communities and beyond.

515

516

517

518

519

520

521 **Supplementary Materials:** The following are available online at [www.mdpi.com/xxx/s1](http://www.mdpi.com/xxx/s1), Video S1:  
522 Our Voice: Citizen Science for Health Equity <https://www.youtube.com/watch?v=sYcYXh51Bl0>.

523 **Author Contributions:** Conceptualization: A.C.K., D.K., L.G.R., A.B., P.R.E., S.J.W.; Methodology,  
524 A.C.K., A.B., S.J.W., L.G.R., J.S.; Data analysis: D.K., L.G.R., A.B., S.J.W., S.S., O.B.N., J.H., P.G., J.S.,  
525 D.S.; Investigation: A.K., D.K., L.G.R., A.B., S.J.W., S.S., O.B.N., J.H., P.G., J.S., D.S., N.A., A.S.,  
526 A.A.H, M.P., C.L.F.; Resources: A.K., D.K., L.G.R., A.B., S.J.W., S.S., O.B.N., J.H., P.G., J.S., D.S., N.A.,  
527 A.S., A.A.H, M.P., C.L.F.; Data curation: D.K., L.G.R., A.B., S.J.W., S.S., O.B.N., J.H., P.G., J.S., D.S.,  
528 N.A., A.S., A.A.H, M.P., C.L.F.; Writing—original draft preparation: A.C.K, D.K., A.B.; Writing—  
529 review and editing: A.K., D.K., L.G.R., A.B., S.J.W., S.S., O.B.N., J.H., P.G., J.S., D.S., N.A., A.S.,  
530 A.A.H, M.P., C.L.F.; Visualization, A.C.K., D.K., L.G.R., A.B., P.R.E.; Supervision: A.K., D.K., L.G.R.,  
531 A.B., S.J.W., S.S., O.B.N., J.H., P.G., J.S., D.S., N.A., A.S., A.A.H, M.P., C.L.F.; Project administration:  
532 A.K., D.K., L.G.R., A.B., S.J.W., S.S., O.B.N., J.H., P.G., J.S., D.S., N.A., A.S., A.A.H, M.P., C.L.F.;  
533 Funding acquisition: A.C.K, D.K., L.G.R., A.B., S.J.W., J.S., D.S., P.G., N.A., A.A.H., M.P.

534 **Funding:** This research was funded in part by The Robert Wood Johnson Foundation Grant  
535 ID#7334; NIH National Cancer Institute grants 5R01CA211048 and P20CA217199; the National  
536 Center for Research Resources and the National Center for Advancing Translational Sciences,  
537 National Institutes of Health through UL1RR025744; U.S. Public Health Service grant #5T32L007034  
538 from the National Heart, Lung and Blood Institute; the Nutrilite Health Institute Wellness Fund  
539 provided by Amway to the Stanford Prevention Research Center; Silicon Valley Community  
540 Foundation award #101518; a grant from the Discovery Innovation Fund in Basic Biomedical  
541 Sciences from Stanford University; a Clinical Translational Science seed grant awarded through the  
542 Stanford University Office of Community Health; the Stanford Center for Innovation in Global  
543 Health; Get Healthy San Mateo County, CA Implementation Funds; National Council for Scientific  
544 and Technological Development (Brazilian study, CNPq- # 441970/2016-8); seed grants from ITRI-  
545 Taiwan, JDC Eshel Israel, the University of Alaska Anchorage, the University of Queensland, the  
546 University Collaborative Research Program of University of Manitoba; and a Stanford Health Care  
547 Community Partnership grant.

548  
549 **Acknowledgments:** We gratefully acknowledge the help and support of the following people:  
550 Matthew Buman, PhD for his contributions and insights in establishing the *Our Voice* Initiative;  
551 Benjamin Chrisinger, PhD for his scientific activities and contributions in advancing the Initiative;  
552 Anthony Tuckett, PhD for his *Our Voice* work and activities in Australia; Randi Garber and Ayelet  
553 Dagan for their *Our Voice* contributions and work in Israel; Camille Llanes-Fontanilla, Executive  
554 Director of SOMOS Mayfair, San Jose and Joanne Ceavey from the Santa Clara County, CA Public  
555 Health for their productive collaborations and support; Irvin Szeto, Jordan Schultz, and Andrew  
556 Martin for their software engineering and programming work and expertise; Kenneth Ronquillo,  
557 Vianna Vo, Kane Zha, Isela Blanco-Velasquez, Ines Campero, and Nicole Rodriguez from Stanford  
558 University, Katelyn Saft from University of Alaska Anchorage, Naomi Wylde and Luke Pearce from  
559 University of Bath, UK, Stephanie Chesser from University of Manitoba, Canada, and Maráisa do  
560 Nascimento from Curitiba, Brazil for their research support activities; and Ken Helander, AARP  
561 Alaska and Julie Schmidt, SAGE Alaska for their Alaska project support.

562 **Conflicts of Interest:** The authors declare no conflict of interest. The funders had no role in the  
563 design of the study; in the collection, analyses, or interpretation of data; in the writing of the  
564 manuscript, or in the decision to publish the results.

565

566

567

## 568 REFERENCES

- 569 1. Luepker RV. Increasing longevity: Causes, consequences, and prospects. In: Yi Z, Crimmins,  
570 E.M., Carrière, Y., Robine, J.M. (eds), ed. *Longer Life and Healthy Aging, International Studies in*  
571 *Population*. Vol 2. Dordrecht: Springer; 2006:91-106.
- 572 2. World Health Organization. *Global strategy and action plan on ageing and health (2016-2020)*.  
573 Geneva, Switzerland: World Health Organization; May 26, 2016.
- 574 3. Beard JR, Officer A, de Carvalho IA, et al. The World report on ageing and health: a policy  
575 framework for healthy ageing. *Lancet*. May 21 2016;387(10033):2145-2154.
- 576 4. Angel RJ, Angel JL, Hill TD. Longer lives, sicker lives? Increased longevity and extended  
577 disability among Mexican-origin elders. *J Gerontol B Psychol Sci Soc Sci*. Jul 2015;70(4):639-649.
- 578 5. Subramanian SV, Kubzansky L, Berkman L, Fay M, Kawachi I. Neighborhood effects on the  
579 self-rated health of elders: uncovering the relative importance of structural and service-  
580 related neighborhood environments. *J Gerontol B Psychol Sci Soc Sci*. May 2006;61(3):S153-160.
- 581 6. Pruchno RA, Wilson-Genderson M, Cartwright FP. The texture of neighborhoods and  
582 disability among older adults. *J Gerontol B Psychol Sci Soc Sci*. Jan 2012;67(1):89-98.
- 583 7. Gibney S, Zhang M, Brennan C. Age-friendly environments and psychosocial wellbeing: A  
584 study of older urban residents in Ireland. *Ageing Mental Health*. Aug 12 2019;Aug 12:1-12.
- 585 8. King AC, Winter SJ, Chrisinger BW, Hua J, Banchoff AW. Maximizing the promise of citizen  
586 science to advance health and prevent disease. *Prev Med*. 2019;119:44-47.
- 587 9. Rowbotham S, McKinnon M, Leach J, Lamberts R, Hawe P. Does citizen science have the  
588 capacity to transform population health science? . *Critical Public Health*. 2017:1-11.
- 589 10. National Academies of Sciences, Engineering and Medicine, Health and Medicine Division,  
590 Board on Population Health and Public Health Practice, Committee on Community-Based  
591 Solutions to Promote Health Equity in the United States. *Communities in Action: Pathways to*  
592 *Health Equity*. Washington, DC: National Academies Press; 2017.
- 593 11. Kelty C, Panofsky A. Disentangling public participation in science and biomedicine. *Genome*  
594 *Medicine*. 2014;6(1):8.
- 595 12. Silvertown J. A new dawn for citizen science. *Trends in Ecology & Evolution*. 2009;24(9):467-471.
- 596 13. King AC, Winter SJ, Sheats JL, et al. Leveraging citizen science and information technology  
597 for population physical activity promotion. *Translat J ACSM*. May 15, 2016 2016;1(4):30-44.
- 598 14. World Health Organization. *Global age-friendly cities: A guide*. Geneva, Switzerland: World  
599 Health Organization;2007.
- 600 15. World Health Organization. *Checklist of essential features of age-friendly cities*. Geneva,  
601 Switzerland: World Health Organization;2007.
- 602 16. Buman MP, Winter SJ, Sheats JL, et al. The Stanford Healthy Neighborhood Discovery Tool:  
603 a computerized tool to assess active living environments. *Am J Prev Med*. Apr 2013;44(4):e41-  
604 47.
- 605 17. Buman MP, Winter SJ, Baker C, Hekler EB, Otten JJ, King AC. Neighborhood Eating and  
606 Activity Advocacy Teams (NEAAT): engaging older adults in policy activities to improve  
607 food and physical environments. *Transl Behav Med*. Jun 2012;2(2):249-253.
- 608 18. Seguin RA, Morgan EH, Connor LM, et al. Rural food and physical activity assessment using  
609 an electronic tablet-based application, New York, 2013-2014. *Prev Chronic Dis*. 2015;12:E102.

- 610 19. Sheats JL, Winter SJ, Romero PP, King AC. FEAST: Empowering community residents to use  
611 technology to assess and advocate for healthy food environments. *J Urban Health*. Apr  
612 2017;94(2):180-189.
- 613 20. Rosas LG, Salvo D, Winter SJ, et al. Harnessing Technology and Citizen Science to Support  
614 Neighborhoods that Promote Active Living in Mexico. *J Urban Health*. Dec 2016;93(6):953-  
615 973.
- 616 21. Rodriguez NM, Arce A, Kawaguchi A, et al. Enhancing Safe Routes to School Programs  
617 through Community-Engaged Citizen Science: Two Pilot Investigations in Lower Density  
618 Areas of Santa Clara County, California, USA. *BMC Public Health*. 2019;19:256.
- 619 22. Moran M, Werner P, Doron I, et al. Detecting inequalities in healthy and age-friendly  
620 environments: Examining the Stanford Healthy Neighborhood Discovery Tool in Israel.  
621 *International Research Workshop on Inequalities in Health Promoting Environments: Physical  
622 Activity and Diet*. Haifa, Israel 2015.
- 623 23. Chrisinger BW, Ramos A, Shaykis F, et al. Leveraging citizen science for healthier food  
624 environments: A pilot study to evaluate corner stores in Camden, New Jersey. *Frontiers in  
625 Public Health*. 2018;6:89.
- 626 24. Chrisinger B, King AC. Stress experiences in neighborhood and social environments  
627 (SENSE): A pilot study to integrate the quantified self with citizen science to improve the  
628 built environment and health. *Inter J Health Geographics*. 2018;17(1).
- 629 25. Tuckett AG, Freeman A, Hetherington S, Gardiner PA, King AC, on behalf of Burnie Brae  
630 Citizen Scientists. Older adults using Our Voice Citizen Science to create change in their  
631 neighborhood environment. *Int J Environ Res Public Health*. Nov 28 2018;15(12).
- 632 26. Winter SJ, Goldman Rosas L, Padilla Romero P, et al. Using citizen scientists to gather,  
633 analyze, and disseminate information about neighborhood features that affect active living.  
634 *J Immigr Minor Health*. Jul 17 2015.
- 635 27. Moran MR, Werner P, Doron I, et al. Exploring the objective and perceived environmental  
636 attributes of older adults' neighborhood walking routes: A mixed methods analysis. *J Aging  
637 Phys Act*. Dec 19 2016:1-36.
- 638 28. King AC, Sallis JF, Frank LD, et al. Aging in neighborhoods differing in walkability and  
639 income: Associations with physical activity and obesity in older adults. *Soc Sci Med*.  
640 2011;73:1525-1533.
- 641 29. Physical Activity Guidelines Advisory Committee. *2018 Physical Activity Guidelines Advisory  
642 Committee Scientific Report*. Washington, DC: U.S. Department of Health and Human Services,  
643 2018;2018.
- 644 30. Moran M, Werner P, Doron L, et al. *Health promoting environments: participatory action research  
645 for health and age-friendly neighbourhoods (Research Report)*. Jerusalem, Israel: JDC Israel  
646 Eshel;2015.
- 647 31. McKenzie TL, Cohen DA. *SOPARC (System for Observing Play and Recreation in Communities)-  
648 Description and Procedures Manual*. San Diego, CA: San Diego State University; January 10,  
649 2006 2006.
- 650 32. Winter SJ, Buman MP, Sheats JL, et al. Harnessing the potential of older adults to measure  
651 and modify their environments: long-term successes of the Neighborhood Eating and  
652 Activity Advocacy Team (NEAAT) Study. *Transl Behav Med*. Jun 2014;4(2):226-227.

- 653 33. Kemperman A, van den Berg P, Weijs-Perrée M, Uijtdewillegen K. Loneliness of older adults:  
654 Social network and the living environment. *Int J Environ Res Public Health*. Jan 31  
655 2019;16(3):E406.
- 656 34. Marmot M. Social determinants of health inequalities. *Lancet*. Mar 19-25 2005;365(9464):1099-  
657 1104.
- 658 35. Lin YY, Huang CS. Aging in Taiwan: Building a Society for Active Aging and Aging in Place.  
659 *Gerontologist*. Apr 2016;56(2):176-183.
- 660 36. Chou Y, Hua J, Banchoff AW, Winter SJ, Liou D, King AC. Harnessing technology and citizen  
661 science to support age-friendly neighborhoods in Taiwan. *Ann Behavioral Med*. 2018;52:S818.
- 662 37. Gonzales G, Henning-Smith C. Health Disparities by Sexual Orientation: Results and  
663 Implications from the Behavioral Risk Factor Surveillance System. *J Community Health*. Dec  
664 2017;42(6):1163-1172.
- 665 38. King DK, Holdorf M, Sudbeck D, Schmidt JP. Safe and healthy aging for LGBT elders using  
666 citizen science: Discoveries from “Our Voice SAGE Alaska”. *Alaska Public Health Summit*.  
667 Anchorage, AK. 2019.
- 668 39. Sampson RJ, Raudenbush SW, Earls F. Neighborhoods and violent crime: a multilevel study  
669 of collective efficacy. *Science*. Aug 15 1997;277(5328):918-924.
- 670 40. de Jong Gierveld J, Van Tilburg T. A 6-item scale for overall, emotional, and social loneliness:  
671 Confirmatory tests on survey data. *Research on Aging*. 2006;28:582-598.
- 672 41. Yang J, Chu Y, Salmon MA. Predicting Perceived Isolation Among Midlife and Older LGBT  
673 Adults: The Role of Welcoming Aging Service Providers. *Gerontologist*. Sep 14 2018;58(5):904-  
674 912.
- 675 42. Brooks-Cleator LA, Giles AR, Flaherty M. Community-level factors that contribute to First  
676 Nations and Inuit older adults feeling supported to age well in a Canadian city. *J Aging*  
677 *Studies*. Jan 19 2019;48(Mar):50-59.
- 678 43. Washburn LT, Traywick L, Thornton L, Vincent J, Brown T. Using Ripple Effects Mapping  
679 to evaluate a community-based health program: Perspectives of program implementers.  
680 *Health Promot Pract*. Oct 26 2018;1524839918804506.
- 681 44. Welborn R, Downey L, Dyk PH, Monroe PA, Tayler-Mackey C, Worthy SL. Turning the tide  
682 on poverty: Documenting impacts through ripple effect mapping. *Community Development*.  
683 2016;47(3):385-402.
- 684 45. Rodriguez NM, Arce A, Kawaguchi A, et al. Enhancing safe routes to school programs  
685 through community-engaged citizen science: two pilot investigations in lower density areas  
686 of Santa Clara County, California, USA. *BMC Public Health*. Mar 1 2019;19(1):256.
- 687 46. Satariano WA. *The epidemiology of aging: An ecological approach*. Sudbury, MA: Jones and  
688 Bartlett Publishers, Inc.; 2006.

689

690