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Public Health Readiness for Citizen Science: Health Department Experiences

Sameer M. Siddiqi, PhD[1], **Lori Uscher-Pines, PhD**[1], **Mary Leinhos, PhD**[2], **Debra Dekker, PhD**[3], **Ramya Chari, PhD**[1]

[1]RAND Corporation, Division of Social and Economic Wellbeing, Arlington, VA

[2]US Centers for Disease Control and Prevention, Center for Preparedness and Response, Atlanta, GA

[3]National Association of County and City Health Officials, Washington, DC

Abstract

Objective.—To examine U.S. health department experiences with citizen science.

Design.—In 2019, we conducted a national survey of 272 local health department (LHD) representatives about knowledge and attitudes, readiness, experiences, and barriers related to citizen science (response rate=45%).

Setting: Local health departments in the United States in 2019

Participants: Local health department (LHD) representatives

Main outcome measures: Knowledge and attitudes, readiness, experiences, and barriers related to citizen science.

Results.—Sixty-two percent of respondents reported LHD experience with citizen science, in areas such as health promotion, emergency preparedness, and environmental health. LHDs in large jurisdictions (78%) were more likely to report staff familiarity with citizen science compared to small (51%) and medium (59%) jurisdictions (*P*=0.01). While 64% reported readiness for citizen science, only 32% reported readiness for community-led activities. We found LHDs using citizen science more for community engagement activities such as public education compared to data collection activities. Respondents indicated that staff education/training in citizen science methods, funding, and partners with relevant expertise were priority needs.

Conclusions: LHDs have leveraged citizen science for community engagement, but barriers to technical uses remain.

Introduction

Citizen science, the use of scientific research methods by members of the public, may be a promising approach for enhancing local health department (LHD) response to emergencies.[1] Citizen science encompasses aspects of traditional community engagement (e.g., recruiting volunteers, distributing educational materials)[2] but expands engagement to research and data collection activities. For example, citizen science moves beyond soliciting public input

through surveys to inclusion of community members in the design or conduct of such methods.

Citizen science has been employed in public health projects that track and mitigate disease vectors,[3] provide damage and needs assessments for disaster response,[4] measure air or water quality indicators,[5] inform health promotion and health equity activities,[6] and engage community members as equal partners in performing research.[7] During the COVID-19 pandemic, researchers deployed citizen science for contact tracing, surface sample collection, drug design, and symptom tracking.[8,9] Citizen science may help expand the capacity and capability of LHD research and data collection functions (e.g., epidemiological investigations, surveillance). Given its focus on community engagement, citizen science could help achieve broader public health objectives, such as improving scientific literacy and building relationships between government and communities.[10]

Despite evidence of its utility, use of citizen science for public health has been slower to develop, especially when compared to fields such as ecology and other environmental sciences. Though the participation of citizens in emergency preparedness and resilience has been encouraged previously by LHDs,[2,11–13] to our knowledge no research has been published on LHD engagement with citizen science and the potential benefits or risks of this expanding form of community engagement. To address research gaps, we conducted a national survey of LHDs in the United States (U.S.) on the subject of citizen science for public health. The survey provided valuable insights into LHD (1) knowledge and attitudes towards citizen science; (2) perceived readiness for and experiences with citizen science; (3) examples of activities; and (4) barriers to engagement.

Methods

Survey sample and administration

Every three years, the National Association of County and City Health Officials (NACCHO) conducts the National Profile of Local Health Departments (denoted as the "Profile study") as a census of LHDs.[14] For our survey, we constructed a sample consisting of a subset (n=600) of the 2,533 LHD representatives (i.e., local health officials, including health directors, officers, or administrators) who participated in NACCHO's 2016 Profile study.[15]

We defined LHDs as an administrative or service unit of local or state government carrying some responsibility for the health of a jurisdiction smaller than the state. We used a stratified random sampling design to select the subset of 600 LHD representatives, with population size served as the basis for stratification. We used population size categories previously defined by NACCHO: <25,000; 25,000–49,999; 50,000–99,999; 100,000–249,999; 250,000–499,999; 500,000–999,999; and 1,000,000. This approach ensures inclusion of enough larger LHDs to facilitate meaningful generalizations. We determined the number of LHDs selected from each population stratum using a combination of two approaches: the probability proportional to number of LHDs in a stratum in the target population of LHDs, and an equal number of LHDs from each stratum. Since only a small number of LHDs in the U.S. serve large jurisdictions, we oversampled larger LHDs.

We performed data collection between January and August 2019. We sent our survey to the local health official for each LHD to be completed by either the official or a designated representative having the knowledge necessary to complete the survey. We instructed respondents to complete the survey on behalf of their LHD.

The survey was approved for fielding by the U.S. Office of Management and Budget in compliance with the Paperwork Reduction Act (OMB Control No: 0920–1236, exp. 06/30/2021). The study was reviewed and approved by the RAND Corporation Institutional Review Board. This activity was reviewed by U.S. Centers for Disease Control and Prevention (CDC) and was conducted consistent with applicable federal law and U.S. Centers for Disease Control and Prevention (CDC) policy.[16] Participants viewed an electronic consent form prior to beginning the survey.

Survey instrument

We developed and fielded two versions of our survey: a core questionnaire with 14 items that all participants received and a supplemental module with 36 additional items that a subset of participants completed. We included the following domains in the core questionnaire: LHD knowledge and attitudes regarding citizen science, readiness for engaging in citizen science, experience with citizen science, and barriers to engagement (see Appendices A and B for the core and supplemental questionnaires, respectively). Table 1 describes the constructs measured within each domain and associated questionnaire version(s). The supplemental module included additional questions on uses of citizen science data (use cases), determinants of activity success, perceived benefits, and perceived concerns about the use or value of citizen science. In total, 272 LHD representatives completed the core questionnaire (45% response rate). All 272 respondents that completed the core questionnaire received the supplemental questionnaire. Of the 272 respondents, 144 completed the supplemental module (53% response rate).

Citizen science definitions

The survey instrument provided the following description of citizen science: "*Citizen science* is a broad term that covers many different types of activities. It has also been called 'public participation in scientific research,' 'community science,' and 'participatory research.' At its core, *citizen science is the use of scientific methods by members of the public to perform research*. Examples of citizen science could be community members providing data to the health department or a university for aggregation or community members independently collecting and analyzing data on a public health issue" (Emphasis in original).

We also differentiated between three citizen science models and provided respondents with the following descriptions that were adapted for a public health audience.[1]

- **"Contributory citizen science** refers to activities initiated by the health department that involve the public as data gatherers only. Examples include community members carrying air quality sensors that report readings to an online database or the health department crowdsourcing health or environmental observations from volunteers."

- • **"Collaborative citizen science** activities are typically initiated or led by health departments or academic experts in partnership with the public. Community members may be involved with problem definition and design, data collection, analysis, or interpretation. An example of a collaborative citizen science activity is when a health department initiates a mosquito surveillance project and asks community members to set up, monitor, and analyze data on community mosquito populations or habitats."

- • **"Community-led citizen science** refers to research or data collection activities initiated, controlled, and managed by community members with little support or input from governmental agencies or academic institutions. Unlike collaborative citizen science, citizens in community-led citizen science retain control over scientific or data collection processes. An example of a community-led citizen science activity is a mosquito surveillance project initiated, maintained, and controlled by community members."

Analysis

We conducted data analyses in R (version 3.5.1)[17] using survey weights to account for differential non-response by population size served. We calculated weights by dividing the proportion of LHDs in a population category among the full sample population by the proportion of LHDs in a population category among all survey respondents. For questions included in the core questionnaire, we prepared descriptive statistics for each variable and corresponding ANOVA F-tests for the size of population served and degree of urbanization (i.e., metropolitan, rural, suburban). For the supplemental module, we provide an unweighted summary of responses to selected questions. We opted for an unweighted summary given the supplemental survey's exploratory focus, smaller sample size, and wide variation in responses between questions. We used inductive thematic analysis to analyze open-ended questions for recurring themes.

Results

The 272 LHDs included in our sample varied by population size served and degree of urbanicity (Table 2). Approximately 47% (n=129) of the weighted sample had a population of less than 50,000, 39% (n=106) had a population between 50,000 and 499,999, and 14% (n=37) had a population more than 500,000. In terms of urbanicity, 46% (n=124) of the weighted sample served urban areas, 29% (n=80) served suburban areas, and 6% (n=16) served rural areas.

Survey findings: core questionnaire

Knowledge and attitudes: Fifty-eight percent (157/272) of LHD respondents believed that overall, LHD staff were slightly to extremely familiar with citizen science as a concept (Table 2). LHDs based in large jurisdictions (78%, 29/37) were significantly more likely to report familiarity with citizen science than those in medium (59%, 63/106) or small (50%, 65/129) jurisdictions (P=0.01).

Regarding attitudes, a majority of respondents (56%, 153/272) reported their LHD would not trust data collected by citizen scientists compared to data collected by professional scientists. LHDs in rural areas (25%, 4/16) were significantly less likely to report their LHD would not trust citizen science data compared to LHDs in urban (58%, 72/124) or suburban (53%, 42/80) jurisdictions (*P*=0.03). Suburban LHDs (63%, 50/80) were less likely to agree with the statement that carrying out research required formal training and education than urban (78%, 97/124) or rural (81%, 13/16) LHDs (*P*=0.03).

Readiness: Sixty-four percent (173/272) of respondents reported their department was ready to engage in citizen science activities (Table 3). Compared to contributory (56%, 152/272) and collaborative (54%, 147/272) models, fewer respondents reported they were fully or somewhat ready to engage in community-led citizen science (32%, 87/272). Respondents based in LHDs serving large populations were significantly more likely to report readiness, compared to those serving small or medium populations (81%, [30/37] vs. 57%, [74/129] or 65%, [69/106] respectively, *P*=0.01). Responses by urbanicity showed no significant differences.

Experience: Sixty-two percent (169/272) of respondents reported their LHD had direct experience with at least one citizen science project (Table 3). LHDs serving urban areas (52%, 64/124) were more likely to report experience with collaborative citizen science compared to those serving suburban (34%, 27/80) or rural (38%, 6/16) areas (*P*=0.03).

We explored LHD experience by public health areas in which citizen science projects were conducted (Table 3). LHD representatives most often reported the following public health areas to have experience with at least one contributory or collaborative citizen science project: health promotion (51%, 82/160), emergency preparedness (50%, 80/160), environmental health (47%, 75/160), and infectious disease (36%, 57/160).

Citizen science activities: All 272 respondents were asked open-ended questions about citizen science activities their LHDs had been involved in, activities they were aware of within other LHDs, or potential activities an LHD could implement. Respondents (28%, 77/272) reported a wide variety of activities conducted by their LHD, including environmental or disease monitoring, community health assessments, collaborative data interpretation and program planning, educational programs, regulatory compliance activities, and technical assistance.

Respondents (29%, 78/272) reported community members could be helpful in collecting data on activities such as: household-level preparedness, emergency communication, vulnerable population needs, environmental quality, community assets, disease vectors, disease symptoms, or disaster impacts.

Barriers to implementing citizen science activities: Respondents reported multiple barriers to implementing citizen science including lack of staffing (71%, 192/272), inadequate staff training (69%, 187/272), uncertain funding (63%, 172/272), and lack of legal/ethical guidance (55%, 149/272), and concern about data quality (51%, 140/272) (Table 4). Rural LHDs (25%, 4/16) were significantly less likely to select "concern about

data quality" as a barrier compared to urban (58%, 72/124) or suburban (44%, 35/80) LHDs (*P*=0.01). No other differences emerged.

Resources for implementing citizen science activities: Respondents reported resources needed to improve readiness for citizen science, including: staff education/training (81%, 220/272), funding (76%, 207/272), and partnerships with organizations possessing relevant expertise (65%, 177/272) (Table 4). No significant group differences emerged.

Respondents reported specific training and education activities could help LHDs engage with citizen science, including training on: using crowdsourced data (70%, 190/272), working with community members (67%, 183/272), and managing community-led data collection (64%, 174/272) (Table 4). Respondents also highlighted guidance that could facilitate citizen science activities, including guidance on legal and privacy concerns (51%, 140/272). LHDs serving large jurisdictions (32%, 12/37) were less likely to select "statistical analysis" as a training need compared to LHDs serving small (52%, 67/129) or medium (38%, 40/106) jurisdictions (*P*=0.01). Large LHDs (19%, 7/37) were also less likely to select "volunteer management" as a training need compared to small (40%, 52/129) or medium (31%, 33/106) LHDs (*P*=0.03). No other significant differences by degree of urbanicity emerged.

Survey findings: supplemental module

The following results represent survey data provided by the 144 respondents who completed the supplemental citizen science survey module.

Use cases: The most frequently reported uses of information gathered from citizen science activities were: conducting public communications (41%, 59/144), supporting community health or needs assessments (40%, 57/144), and providing education (38%, 55/144).

Determinants of success: Seventy-eight respondents identified factors contributing to their LHD's success in citizen science activities, including: the right partnerships were developed or established (83%, 65/78), efforts had organizational support (74%, 58/78), and LHD staff were knowledgeable and trained appropriately (67%, 52/78).

Benefits of citizen science: One hundred twenty-eight respondents identified benefits that could result from citizen science activities including: improved partnerships or collaborative community relationships (48%, 61/128); improved health department visibility and reputation (41%, 52/128); and enhanced community resilience and community preparedness for disaster events (37%, 47/128). Two respondents out of 128 total respondents (2%) reported no benefits.

Concerns about the value of citizen science: One hundred twenty-eight respondents identified potential concerns about citizen science, including: citizen science data quality may be inadequate to inform departmental activities or decisions (70%, 89/128); unverified citizen science data may be used inappropriately for advocacy or political purposes (63%,

81/128); and citizen science may distract from more important priorities (40%, 51/128). Seven respondents out of 128 total respondents (5%) reported no concerns.

Discussion

We conducted the first national survey of LHD experience with citizen science. Overall, we found LHDs have some familiarity with citizen science, varying by size of jurisdiction served. LHDs used citizen science in diverse public health areas, including health promotion, emergency preparedness, environmental health, and infectious disease. While LHDs indicated readiness to engage with citizen science, we found they lacked experience with and readiness for community-led citizen science in particular.

The number of respondents reporting both experience with and readiness for citizen science was high, relative to the reported levels of staff familiarity with citizen science. This finding indicates LHD respondents may have had greater knowledge of citizen science than their staff peers or that staff who had direct experience with citizen science were no longer with the respondent's health department. This could be the case if citizen science activities were not widespread within a health department, but instead localized to select staff or departments.

Citizen science uses, challenges, and needs

LHD respondents reported that information from citizen science activities was used to support a variety of actions aligned with traditional community engagement activities, including public communications and public education.[2] However, the unique contribution of citizen science is to enhance capacity to perform services such as surveillance, epidemiological investigations, and monitoring activities.

A wide variety of citizen science initiatives described in the peer-reviewed literature demonstrate this potential. Citizen science-enabled tick and mosquito collection programs have helped track and predict the distribution of particular species of disease-carrying vectors;[18,19] similar initiatives have tracked environmental hazards that would otherwise prove difficult to monitor, such as local noise pollution events.[20]

Our results show LHDs have not generally pursued citizen science to support such technical activities. Based on answers to questions about trust and scientific credentials, LHDs appear to be less comfortable with citizen science compared to professional scientific activities. As indicated by respondents' concerns, LHDs may be wary of using citizen science for data collection because of perceptions about quality issues. However, these concerns may be limited to certain forms of data collection, as many LHDs reported using citizen science to conduct community health or needs assessments. To mitigate these concerns, trainings in both technical (e.g., crowdsourcing) and research engagement (e.g., community-based research methods) may be beneficial, as noted by respondents. LHDs may consider developing procedures to rapidly validate data generated through community-led citizen science and/or procedures to clarify how data of varying quality could be appropriately used (e.g., less rigorous data could be used as an early indicator). Important determinants of success for citizen science research or data collection efforts included having the

right partnerships in place, buy-in from organizational leaders, and mutual trust between partners.[11–13] Findings also highlight the importance of having knowledgeable and trained staff, as well as committed and capable leaders.

LHDs lack experience with and readiness for community-led citizen science in particular. As new technologies and social networking platforms enable greater public access to data collection tools, LHDs might increasingly find themselves on the receiving end of this form of knowledge exchange. Investing in staffing, partnership development, participatory research methods, and trainings on community-led data collection methods may help LHDs build capacity to engage with community-led citizen science in ways that strengthen community and health department relationships.

Citizen science and community engagement in public health

While respondents reported several challenges to pursuing citizen science, a substantial portion also described a variety of actual and potential uses and benefits of citizen science in public health activities, particularly related to emergency preparedness (e.g., collecting data on household preparedness and environmental quality; improving community understanding of public health risk communication messages). With the COVID-19 pandemic exacerbating public mistrust of government and science, it is critical for public health to pursue effective community engagement for the purpose of identifying and effectively addressing concerns of both communities at large and the underserved groups within them. Building trustworthy two-way relationships with communities may facilitate quality public participation in health department led citizen science, and increase health department awareness of community-led citizen science initiatives and opportunities for early collaboration.

To fulfill the potential of citizen science for both community engagement and data collection, LHDs can first engage in citizen science focused on community-facing benefits (e.g., community education). Once experience is gained, relationships are forged, and process mechanics become familiar, LHDs could begin developing capabilities to perform quality data collection through citizen science.

Study limitations

We note three main limitations of our study. First, our findings may be influenced by self-selection bias, as those who responded to the survey on behalf of their LHD may have been more interested in citizen science activities or have more to report than those that did not respond. Second, our findings may be influenced by response bias, as respondents representing LHDs may not have been familiar with all staff activities and knowledge, particularly if their LHD was less engaged. To address this, our survey questions included a "don't know" response item. Finally, survey results related to rural LHDs should be interpreted with caution given the low number of respondents in this group and potential for under-representation. We note also that our survey was fielded before the COVID-19 pandemic. Future research could assess whether the pandemic influenced changes in attitudes and perceptions towards citizen science.

Implications for Policy & Practice

Citizen science is a growing phenomenon across public health, presenting opportunities and challenges for LHDs. Citizen science may be especially helpful as a mode of community engagement, which may help LHDs improve the relevance and impact of public health services. Our findings suggest LHDs have experience with citizen science, but lack of staff knowledge and resources may hinder ability to capitalize on the public health benefits. LHDs can consider building upon existing engagement activities, like public education, towards more data-intensive endeavors. Staff training in both the technical and research engagement aspects of citizen science may be key for building LHD capacity and improving readiness for all forms of citizen science.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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16. See e.g., 45 C.F.R. part 46; 21 C.F.R. part 56; 42 U.S.C. §241(d), 5 U.S.C. §552a, 44 U.S.C. §3501 et seq.

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Table 1.

Domains and constructs measured in the citizen science survey for local health departments

Domain	Description of constructs within each domain	Inclusion in Core Questionnaire	Inclusion in Supplemental Questionnaire
Knowledge and attitudes	Assessment of staff familiarity with citizen science	X	X
	Trust in citizen science data	X	X
	Belief that carrying out research requires formal training and education	X	
Readiness	Perception of health department readiness to engage in citizen science activities (contributory, collaborative, and community-led)	X	X
Experience	Health department projects using contributory, collaborative, or community-led citizen science models across 14 public health areas: air quality; chronic disease prevention & health promotion; drinking water supply & quality; emergency preparedness, response, & recovery; environmental health & environmental hazards; food safety & security; health care services; healthy aging/elder care; housing; infectious diseases; maternal & child health; occupational safety & health; public safety; recreational water safety	X	X
	Description of citizen science activities and potential uses of citizen science		X
Barriers	Perception of main barriers to engaging with citizen science	X	
	Perception of resources needed to better engage with citizen science activities	X	X
	Perception of types of training or education needed to better engage with citizen science activities	X	

Table 2.

Local health department knowledge and attitudes related to citizen science by population size served and degree of urbanization

Survey question	Overall (n=272)	Population size served (n=272)[a]				Degree of urbanization[b] (n=220)			
		Small (n=129)	Medium (n=106)	Large (n=37)	*P*	Urban (n=124)	Suburban (n=80)	Rural (n=16)	*P*
Staff are slightly to extremely familiar with citizen science	157 (58%)	65 (50%)	63 (59%)	29 (78%)	**0.01** *	80 (65%)	43 (54%)	7 (44%)	0.06 *
Staff are not at all familiar	115 (42%)	64 (50%)	43 (41%)	8 (22%)	**0.01** *	44 (35%)	37 (46%)	9 (56%)	0.06 *
Agency would not trust citizen science data as much as professional data	153 (56%)	73 (56%)	57 (54%)	23 (62%)	0.63	72 (58%)	42 (53%)	4 (25%)	**0.03** *
Carrying out research requires formal training and education	203 (75%)	93 (72%)	80 (75%)	30 (81%)	0.36	97 (78%)	50 (63%)	13 (81%)	**0.03** *

Data are weighted to account for differential non-response by population size served. Cell values may not sum to the totals due to rounding of the weighted data.

[a]
Small = < 50,000 served; Medium = 50,000–499,999 served; Large 500,000 served.

[b]
Of the 272 LHDs included in our sample, only a subset (n=220) were classified in terms of degree of urbanization.

*
Bolding and asterisks denote significant differences at *P*<0.05. *P* values correspond to comparisons across groups within each column section.

Table 3.

Local health department readiness and experience related to citizen science by population size served and degree of urbanization

Survey question	Overall (n=272)	Population size served (n=272)[a]				Degree of urbanization[b] (n=220)			
		Small (n=129)	Medium (n=106)	Large (n=37)	P	Urban (n=124)	Suburban (n=80)	Rural (n=16)	P
LHD is fully or somewhat ready to engage in:									
Any citizen science model	173 (64%)	74 (57%)	69 (65%)	30 (81%)	**0.01**[*]	81 (65%)	49 (61%)	8 (50%)	0.36
Contributory	152 (56%)	63 (49%)	62 (58%)	27 (73%)	**0.02**[*]	71 (57%)	43 (54%)	5 (31%)	0.13
Collaborative	147 (54%)	63 (49%)	57 (54%)	27 (73%)	**0.02**[*]	71 (57%)	42 (53%)	5 (31%)	0.10
Community-led	87 (32%)	41 (32%)	29 (27%)	17 (46%)	0.08	40 (32%)	25 (31%)	5 (31%)	0.97
LHD not ready to engage	99 (36%)	56 (43%)	37 (35%)	6 (16%)	**0.01**[*]	42 (34%)	31 (39%)	8 (50%)	0.36
LHD has experience with:									
Any citizen science model	169 (62%)	76 (59%)	64 (61%)	29 (78%)	0.07	83 (67%)	44 (55%)	10 (63%)	0.17
Contributory	132 (49%)	59 (46%)	52 (49%)	21 (57%)	0.21	66 (53%)	32 (40%)	9 (56%)	0.11
Collaborative	120 (44%)	50 (39%)	48 (45%)	22 (60%)	0.08	64 (52%)	27 (34%)	6 (38%)	**0.03**[*]
Community-led	69 (25%)	30 (23%)	28 (26%)	11 (30%)	0.52	29 (23%)	21 (26%)	5 (31%)	0.74
No experience	103 (38%)	54 (39%)	42 (39%)	8 (22%)	0.07	41 (33%)	36 (45%)	6 (38%)	0.17
Programs using contributory or collaborative citizen science (59%, 160/272)									
	(n=160)	(n=71)	(n=57)	(n=32)		(n=84)	(n=39)	(n=9)	
Health promotion	82 (51%)	36 (51%)	28 (49%)	18 (56%)	**0.02**[*]	43 (51%)	19 (49%)	4 (44%)	0.24
Emergency preparedness	80 (50%)	36 (51%)	32 (56%)	12 (38%)	0.68	41 (49%)	21 (54%)	5 (56%)	0.54
Environmental health	75 (47%)	32 (45%)	29 (50%)	14 (44%)	0.19	38 (45%)	18 (46%)	5 (56%)	0.44
Infectious disease	57 (36%)	25 (35%)	22 (39%)	10 (31%)	0.61	25 (30%)	20 (51%)	3 (33%)	0.67
Programs using community-led citizen science[d] (25%, 69/272)									
	(n=69)	(n=30)	(n=26)	(n=13)		(n=29)	(n=21)	(n=5)	
Health promotion	28 (41%)	13 (43%)	10 (38%)	5 (39%)	0.91	11 (38%)	10 (48%)	1 (20%)	0.61
Environmental health	22 (32%)	6 (20%)	13 (50%)	3 (23%)	0.11	15 (52%)	4 (19%)	0 (0%)	0.10
Emergency preparedness	21 (30%)	8 (27%)	9 (35%)	4 (31%)	0.63	11 (38%)	5 (24%)	0 (0%)	0.41

Survey question	Overall	Population size served (n=272)[a]				Degree of urbanization[b] (n=220)			
	(n=272)	Small (n=129)	Medium (n=106)	Large (n=37)	P	Urban (n=124)	Suburban (n=80)	Rural (n=16)	P
Infectious disease	19 (28%)	6 (20%)	12 (46%)	1 (8%)	0.14	10 (34%)	5 (24%)	1 (20%)	0.88

Data are weighted to account for differential non-response by population size served. Cell values may not sum to the totals due to rounding of the weighted data.

[a] Small = < 50,000 served; Medium = 50,000–499,999 served; Large 500,000 served.

[b] Of the 272 LHDs included in our sample, only a subset (n=220) were classified in terms of degree of urbanization.

[c] Only among those reporting experience with contributory or collaborative citizen science.

[d] Only among those reporting experience with community-led citizen science.

* Bolding and asterisks denote significant differences at P<0.05. P values correspond to comparisons across groups within each column section

Table 4.

Barriers and needs reported by local health departments related to citizen science by population size served and degree of urbanization

Survey question	Overall (n=272)	Population size served (n=272)[a]				Degree of urbanization[b] (n=220)			
		Small (n=129)	Medium (n=106)	Large (n=37)	P	Urban (n=124)	Suburban (n=80)	Rural (n=16)	P
Top ten barriers limiting a local health department's ability to implement citizen science									
Lack of staffing	192 (71%)	94 (72%)	75 (71%)	23 (62%)	0.60	85 (69%)	57 (71%)	9 (56%)	0.49
Inadequate staff training	187 (69%)	91 (71%)	70 (66%)	26 (70%)	0.56	81 (65%)	57 (71%)	9 (56%)	0.43
Uncertain funding	172 (63%)	79 (62%)	67 (63%)	26 (70%)	0.52	77 (62%)	48 (60%)	9 (56%)	0.91
Need legal/ethical guidance	149 (55%)	75 (58%)	52 (48%)	22 (59%)	0.22	70 (56%)	42 (52%)	9 (56%)	0.83
Concern about data quality	140 (51%)	65 (50%)	55 (52%)	20 (54%)	0.81	72 (58%)	35 (44%)	4 (25%)	0.01*
Volunteers require vetting	134 (49%)	63 (49%)	53 (50%)	18 (49%)	1.00	64 (52%)	35 (44%)	5 (31%)	0.25
Value is unclear	119 (44%)	51 (40%)	53 (50%)	14 (38%)	0.25	62 (50%)	31 (39%)	3 (19%)	0.04*
Volunteers need protection	119 (44%)	56 (43%)	47 (44%)	15 (41%)	0.96	52 (42%)	36 (45%)	5 (31%)	0.59
Lack needed partnerships	113 (42%)	55 (43%)	46 (43%)	12 (32%)	0.44	46 (37%)	36 (45%)	6 (38%)	0.61
Need policy changes	86 (32%)	43 (33%)	28 (26%)	14 (38%)	0.19	46 (37%)	20 (25%)	5 (31%)	0.26
Resources needed to improve readiness to engage in citizen science									
Staff training/education	220 (81%)	99 (77%)	89 (84%)	31 (84%)	0.30	103 (83%)	59 (74%)	13 (81%)	0.33
Funding for activities	207 (76%)	100 (78%)	79 (75%)	28 (76%)	0.86	95 (77%)	56 (70%)	11 (69%)	0.59
Partners with expertise	177 (65%)	81 (63%)	69 (65%)	27 (73%)	0.46	79 (64%)	48 (60%)	11 (69%)	0.60
Additional staff	159 (58%)	84 (65%)	55 (52%)	21 (57%)	0.13	71 (57%)	45 (56%)	10 (62%)	0.90
Data infrastructure	155 (57%)	73 (57%)	59 (56%)	23 (62%)	0.65	67 (54%)	44 (55%)	9 (56%)	0.98
Equipment	134 (49%)	59 (46%)	54 (51%)	20 (54%)	0.50	66 (53%)	38 (48%)	6 (38%)	0.46
Top ten training or education needs for engaging in citizen science									
Crowdsourcing data	190 (70%)	88 (68%)	77 (73%)	25 (68%)	0.88	86 (69%)	56 (70%)	12 (75%)	0.88
Working with public	183 (67%)	86 (67%)	73 (69%)	24 (65%)	0.96	87 (70%)	49 (61%)	10 (62%)	0.45
Community-led research	174 (64%)	82 (64%)	69 (65%)	24 (65%)	0.99	80 (65%)	48 (60%)	11 (69%)	0.78
Participatory research	157 (58%)	72 (56%)	63 (59%)	22 (59%)	0.87	70 (56%)	43 (54%)	8 (50%)	0.88
Data quality assessment	149 (55%)	75 (58%)	56 (53%)	17 (46%)	0.37	64 (52%)	42 (52%)	9 (56%)	0.89
Legal and privacy concerns	140 (51%)	68 (53%)	54 (51%)	19 (51%)	0.92	68 (55%)	40 (50%)	9 (56%)	0.80

Survey question	Overall (n=272)	Population size served (n=272)[a]				Degree of urbanization[b] (n=220)			
		Small (n=129)	Medium (n=106)	Large (n=37)	P	Urban (n=124)	Suburban (n=80)	Rural (n=16)	P
Software/programming tools	137 (50%)	69 (53%)	50 (47%)	17 (46%)	0.55	57 (46%)	40 (50%)	9 (56%)	0.66
Ethical issues	120 (44%)	61 (47%)	43 (41%)	16 (43%)	0.54	53 (43%)	36 (45%)	7 (44%)	0.97
Data governance methods	119 (44%)	56 (43%)	48 (45%)	15 (41%)	0.96	52 (42%)	34 (42%)	7 (44%)	0.98
Statistical analysis	118 (43%)	67 (52%)	40 (38%)	12 (32%)	**0.01**[*]	47 (38%)	37 (46%)	8 (50%)	0.31

Data are weighted to account for differential non-response by population size served. Cell values may not sum to the totals due to rounding of the weighted data.

[a] Small = < 50,000 served; Medium = 50,000–499,999 served; Large ≥ 500,000 served.

[b] Of the 272 LHDs included in our sample, only a subset (n=220) were classified in terms of degree of urbanization.

[*] Bolding and asterisks denote significant differences at P<0.05. P values correspond to comparisons across groups within each column section.