

Integrating Health into Local Climate Response: Lessons from the U.S. CDC Climate-Ready States and Cities Initiative

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SUMMARY: Public health has potential to serve as a frame to convey the urgency of behavior change needed to adapt to a changing climate and reduce greenhouse gas emissions. Local governments form the backbone of climate-related public health preparedness. Yet local health agencies are often inadequately prepared and poorly integrated into climate change assessments and plans. We reviewed the climate health profiles of 16 states and two cities participating in the U.S. Centers for Disease Control and Prevention (CDC)'s Climate-Ready States and Cities Initiative (CRSCI) that aims to build local capacity to assess and respond to the health impacts of climate change. Following recommendations from a recent expert panel strategic review, we present illustrations of emerging promising practice and future directions. We found that CRSCI has strengthened climate preparedness and response in local public health agencies by identifying critical climate-health impacts and vulnerable populations, and has helped integrate health more fully into broader climate planning. Promising practice was found in all three recommendation areas identified by the expert panel (leveraging partnerships, refining assessment methodologies and enhancing communications), particularly with regard to health impacts of extreme heat. Vast needs remain, however, suggesting the need to disseminate CRSCI experience to non-grantees. In conclusion, the CRSCI program approach and selected activities illustrate a way forward toward robust, targeted local preparedness and response that may serve as a useful example for public health departments in the United States and internationally, particularly at a time of uncertain commitment to climate change agreements at the national level. <https://doi.org/10.1289/EHP1838>

Introduction

The risks to human health of a warmer, more extreme, and variable “new climate normal” (World Bank 2014) are diverse and increasingly apparent. They include illnesses, injuries, and deaths as the direct result of excessive heat and more violent storms, as well as harm caused indirectly through deteriorating air quality; a wider range and greater frequency of insect-, food-, and water-borne diseases; growing risks to food and water supplies; and the enhanced mental stress these risks bring (McMichael 2014; Patz et al. 2014; Smith et al. 2014). Population vulnerability, due to varying exposure and sensitivity, plays a role in who bears the highest risks, while adaptive capacity helps determine who is best able to manage these risks (Smith et al. 2014; Crimmins et al. 2016). The World Health Organization has identified climate change as “the defining issue” for public health in the 21st century, and urged that human health be placed at the center of climate change efforts (WHO 2016, 2017). Public health is a useful lens for conveying the urgency of behavior change needed to reduce greenhouse gas emissions and develop resilience to a changing climate (Maibach et al. 2010; Humphreys 2014). The recent Climate and Health Conference hosted by a group of stakeholders, including former U.S. Vice President Gore, along with the American Public Health Association designation of 2017 as the “Year of Climate Change and Health,” are steps toward framing climate change as a public health challenge.

Yet the growing number of health risks associated with a changing climate—whether well-known, such as heat-related illness (HRI), or less widely recognized, such as the additional

burden of injuries due to storm-related motor vehicle accidents (Liu et al. 2017)—are often inadequately integrated into broader climate change adaptation efforts. Such risks require modeling to guide design of health adaptive policies, such as vulnerability-targeted early warning systems (Ebi and Rocklov 2014) that are incorporated into broader national and local climate adaptation plans (Araos et al. 2016). Similarly, more frequent inclusion of co-benefits to health, such as from reduced chronic cardiovascular and respiratory disease burden due to lower greenhouse gas emissions (Thompson et al. 2016; Watts et al. 2016), could strengthen the effectiveness of national and local climate strategies and plans. While recent progress has been made, climate-related health research still lags behind climate research in other fields, such as transport and energy (Jessup et al. 2013; Verner et al. 2016), and evaluation evidence regarding best practice interventions to manage climate-induced health risks is sparse (Hosking and Campbell-Lendrum 2012; Bouzid et al. 2013).

The health effects of climate change occur at the individual, family, and community levels. Local (referred to as subnational, whether city, state, or other nonnational jurisdiction) governments are therefore the first line of defense; they form the backbone of public health preparedness, surveillance, and response (Frumkin et al. 2008; Maibach et al. 2008). With intimate knowledge of population needs, local governments can often be more agile, innovative, and proactive in addressing these needs than national governments (Barata and Ligeti 2011). However, evidence suggests many local health departments remain at early stages of climate-related adaptation (Roser-Renouf et al. 2016; Araos et al. 2016). The U.S. Centers for Disease Control and Prevention (CDC) Climate and Health Program is one of few programs that builds capacity at the subnational level to assess and respond to the health impacts of climate change, supporting innovative approaches to adapt and protect health in U.S. communities through the Climate-Ready States and Cities Initiative (CRSCI) (APHA 2015). Since 2010, CRSCI has awarded annual grants ranging from \$100,000 to \$250,000 (CDC 2017) on a competitive basis to public health departments in 16 states and 2 cities, with some states passing these funds through to cities, counties, and other localities. The state CRSCI grantees are: Arizona, California, Florida, Illinois, Maine, Maryland, Massachusetts, Michigan, Montana, New Hampshire, New York, North Carolina, Oregon, Rhode Island, Vermont, and Wisconsin; the city grantees

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are New York City and San Francisco (https://www.cdc.gov/climateandhealth/crsci_grantees.htm).

CRSCI is guided by a stepwise risk assessment and management framework called Building Resilience Against Climate Effects (BRACE), which is grounded in the principles of adaptive management, a learning-focused iterative approach developed for interventions in complex systems (Hess et al. 2012). BRACE's five-step framework is oriented toward testing adaptation solutions in the context of locally relevant risks and vulnerabilities, and is designed to help grantees build public health adaptive capacity while managing and minimizing population health impacts (Marinucci et al. 2014; CDC 2014). BRACE's five steps are to *a*) forecast climate health impacts and vulnerabilities; *b*) project climate-related disease burden; *c*) assess relevant public health interventions; *d*) develop climate and health adaptation plans; and *e*) evaluate implementation. At the current stage in CRSCI implementation, grantees have undertaken Climate Health Profile Reports (CHPRs) or similar analytical work that report on locally relevant climate hazards, health impacts of concern, and vulnerable populations (step 1 in the BRACE framework), and are moving toward subsequent steps, including preparation of climate health adaptation plans.

To contribute to dissemination of lessons on building adaptive capacity for local public health departments in the United States and elsewhere, in this brief communication, we present results of a survey of CRSCI grantee CHPRs. The survey was conducted via an online search and review of the 18 grantee health department websites, augmented with other publicly available grantee and CRSCI publications. We reviewed CHPRs and related analyses published between 2014 and February 2017 with a view of synthesizing self-reported hazards, health risks, and vulnerabilities; identifying promising practice; and highlighting future challenges. This survey was done in conjunction with an expert panel review of the CRSCI program convened in early 2016 by Johns Hopkins University investigators under contract to CDC's National Center for Environmental Health. With the goal of providing strategic guidance to the CRSCI program after 5 y of implementation, the expert panel had identified core recommendations for enhancing the CRSCI program in three broad areas:

- Expand and leverage climate and health partnerships, including sharing technical knowledge and building local public health workforce capacity, reducing fragmentation through greater cross-disciplinary integration, and building links across existing programs and toward new partners, for example, reaching out toward cities.
- Refine climate and health assessment methodologies, including simplifying and developing how-to guides for quantitative analyses; recognizing the value of qualitative information, particularly for less-resourced jurisdictions; and placing priority on estimation of health co-benefits from climate change mitigation efforts.
- Enhance climate and health communications, including by employing risks to human health as a useful frame for climate change, proactively evaluating and disseminating promising practice, and communicating in ways that resonate with target populations, including storytelling and linking climate change to other well-known public health messages.

We first summarize features of CHPRs, then highlight examples of promising practice from these reports and grantee websites, followed by implications for gaps, challenges, and future directions. We use the expert panel recommendations as a framework for these illustrations.

Discussion

Our review identified CHPRs or other climate and health profile information in varying formats for all 18 CRSCI grantees. Most

Table 1. Features of CRSCI grantee climate health profile reports.

CHPR features	Number (share) grantees
Prepared and issued by	
- State or city health department	12 (67%)
- Health department with technical partner(s)	3 (17%)
- Technical partner	3 (17%)
Referred to technical partnerships	18 (100%)
Climate impact geographic scope	
- State (or city)-wide	14 (78%)
- Focus regions	4 (22%)
Climate impact selectivity	
- Inclusive impacts	14 (78%)
- Specific ranked impacts	4 (22%)
Reported downscaling climate models	14 (78%)
Vulnerability assessment	
- Developed vulnerability indexes	10 (56%)

Note: CHPR, Climate Health Profile Reports; CRSCI, Climate-Ready States and Cities Initiative.

reports were found on local health department websites, which, in many cases, contained additional climate and health-related resources, including locally conducted epidemiology, vulnerability indexes, risk maps, and risk communication tools. Most CHPRs were prepared and issued by the grantee public health department (alone or with a technical partner), and virtually all CHPRs involved partnership with a university or another specialized agency (Table 1). The following sections are based on self-reported information provided in grantee publications, as referenced.

In addition to addressing the first step of the BRACE assessment process, CHPRs aimed at one or more of the following goals: to serve as a public outreach tool; to guide new, or fine-tune existing, adaptation strategies and interventions; to identify climate change and health data availability and gaps; and to contribute to identifying and developing good practice (e.g., OHA 2014; MIAEH 2016). Reports also aimed to provide baseline data, gaps, and analytical and institutional underpinning for subsequent BRACE framework steps, including projecting climate-related disease burdens and identifying interventions. Several grantees reported carrying out analytical work, including developing toolkits, outreach, and educational material; health department capacity gap assessments; and inventories of potential interventions. CHPRs took different approaches, falling broadly into three categories: *a*) geographically comprehensive assessments, often focused on selected high-priority health impacts, e.g., Rhode Island (RIDH 2015) and Vermont (VDH 2016); *b*) assessments piloted in several counties covering multiple health impacts, often with an emphasis on capacity building, e.g., Oregon (OHA 2014) and Maryland (MIAEH 2016); and *c*) assessments aimed at capacity and data gap identification, focused on informing local health departments, e.g., New York State (NYS DH 2015) or as public outreach, e.g., Wisconsin (WDHS 2017). (Table 1).

Near-term, direct impacts of more frequent and extreme weather, including heat, storms (often defined as winter and/or summer), and flooding, were concerns common to all CHPRs. The most frequently reported specific climate-related health risks across grantees were increased HRI and heat-related mortality and increased storm- and flood-related risks (e.g., injuries, motor vehicle accidents, carbon monoxide poisoning), critical service interruptions (affecting hospitals and pharmacies), and mental health impacts. Grantees identified a range of barriers and constraints within these two impact categories. For example, regarding extreme heat, a standard national definition does not exist for HRI, and few states are legally obligated to report this group of health outcomes (FDH 2015); several states proposed specific

definitions and surveillance approaches. In the case of extreme storms, public health preparedness involves collaboration across departments (e.g., emergency services, public works, transportation, building, and zoning) that can be challenging to implement; many CHPRs identified concrete ways to enhance partnerships across disciplines and services (e.g., [Cameron et al. 2015](#); [MDPH 2014](#)). On the other hand, indirect and longer-term climate change drivers and health risks varied; among commonly reported concerns were worsening air pollution and aeroallergens, water quality and contamination (particularly with combined sewage and drainage infrastructure), and ecosystem changes that modify disease vector patterns. In these categories, additional health risks frequently cited by grantees included pollution-related respiratory disease (including asthma), vector-borne disease (most commonly Lyme disease and West Nile virus), and illness due to contamination of food and water (harmful algal blooms and vibrio). The mix of these concerns differed across geographic, population, urbanization, and climate contexts; for example, health risks in Arizona focused on HRI and air pollution; those in Illinois centered on HRI, vector-borne disease, and allergies; and those in New York City involved HRI, storm-related injuries, and risks from critical infrastructure outages.

Grantees took differing approaches to evaluating population vulnerability. Over half reported developing social vulnerability or other indexes, mapping, and other quantitatively derived tools to assess vulnerability, often with the assistance of a university technical partner ([Table 1](#)). Population characteristics frequently cited as associated with vulnerability included: being elderly, being very young, having a preexisting health condition, having lower income, being a minority, working outdoors, living in vulnerable geographic locations, and lacking protective infrastructure, such as air-conditioning. Several states with larger rural populations identified tribal groups, agricultural workers, and those with private well water as at greater risk. Most CHPR vulnerability assessments provided practical insights into near-term ways to enhance the effectiveness of ongoing interventions. This was most evident in the case of extreme heat, where several grantees reported creating vulnerability indexes based on sensitivity and exposure factors tracked by census block and mapping the results. For example, San Francisco reported using a heat vulnerability index and mapping to improve the effectiveness of heat wave early warning and response plans ([SFDPH 2014](#)). Other illustrations of improved heat response targeting undertaken or planned based on CHPRs include piloting use of risk communication via social media ([Chuang et al. 2015](#)), definition of an HRI indicator to improve disease identification and monitoring ([FDH 2015](#)), enhancing surveillance and voluntary reporting of HRI ([FDH 2015](#); [Fernandez et al. 2015](#); [NYSDH 2015](#); [RIDH 2015](#)), educating outdoor workers on heat safety ([Chuang et al. 2015](#)), identifying education and communication outreach venues ([Cameron et al. 2015](#)), and identifying factors leading to unhealthy heat exposure in city apartment buildings ([Kinney et al. 2015](#)).

Promising Practices

Expanding and Leveraging Climate and Health Partnerships

Networked learning partnerships. As reported in CHPRs, grantees developed networked learning partnerships for multiple purposes. For example, several states collaborate in a northeast regional group to examine the impacts of heat on social and geographic vulnerabilities, with the goal of developing consistent methodologies and sharing knowledge across states ([RIDH 2015](#)). Similarly, a western state collaborative is working to

develop common social vulnerability metrics that can be compared across states ([OHA 2014](#)). Several northeast state grantees have initiated a community of practice to assess regional climate impacts on Lyme disease ([RIDH 2015](#)). Many state CHPRs highlighted training of county public health agency staff as an explicit goal, either through programs directly with these localities or through broader statewide training initiatives.

Partnership across existing programs. Nearly all CHPRs identified local and national partnerships. For example, several grantees had ongoing partnerships with the National Oceanic and Atmospheric Administration, state climate agencies, or locally convened science panels. Other types of partnerships included participation in the National Association of County and City Health Officials (NACCHO) Climate Change Workgroup. A majority of grantees grounded their CHPR in collaboration with local Environmental Public Health Tracking (EPHT) programs, whether to develop baseline assessments of climate relevant health outcomes or to enhance monitoring of climate-related health indicators and outcomes, such as HRI or Lyme disease (e.g., [MDPH 2014](#); [NYSDH 2015](#); [OHA 2014](#)).

Greater cross-disciplinary integration. Several grantee programs also illustrated ways of building integration across state agencies within multidisciplinary adaptation planning. For example, New York State's CHPR outlines a structure with four cross-cutting climate impact teams setting the goal of shifting climate change from an environmental to a public health issue ([NYSDH 2015](#)). In New York City, the health department participates in multiagency planning around the priority of ensuring that urban built infrastructure is more resilient and protects public health ([Kinney et al. 2015](#)). Massachusetts developed interactive mapping of risk factors based on EPHT and other state data sources integrated across agencies in the service of localities and residents ([MDPH 2014](#)). Several states chose to decentralize their program to pilot localities, which developed integrated assessments, adaptation plans, and partnerships across local agencies, for example, the New Hampshire Lake District's focus on Lyme disease ([NH LRPPH 2016](#)).

Refining Climate and Health Assessment Methodologies

Simplifying and developing how-to guides for quantitative analyses. The most data-intensive quantitative analyses of the BRACE assessment framework steps are guided by a CDC Climate and Health Technical Report Series (<https://www.cdc.gov/climateandhealth/publications.htm>) designed to assist grantees in tasks including downscaling climate models to derive finer-scale resolution local climate projections (e.g., [Hess et al. 2014](#); [Schramm et al. 2014](#)) and development of vulnerability assessments (e.g., [Manangan et al. 2014](#)). Through implementation of the CRSCI program, however, collaboration between the health department, universities, and other partners has resulted in new, practice-informed guidance tools. For example, recognizing the need to build familiarity with climate modeling and implications for disease burden projection among public health professionals, the Florida CRSCI program documented cross-disciplinary collaboration between regional climate scientists and public health staff as a guide for other public health departments describing methodologies and providing case studies that address drought, heat, and tropical cyclones ([Conlon et al. 2016](#)).

Focusing on mitigation. A few grantees reported having begun to focus on mitigation by estimating health co-benefits from efforts to reduce greenhouse gas emissions. For example, in Oregon, two health impact assessments were conducted based on regional transport plans that would reduce reliance on light-duty vehicles; quantified health benefits were derived both from increased physical activity as well as improved air quality ([OHA](#)

2014). New Hampshire's assessment suggested considering primary, secondary, and tertiary prevention as a lens to plan interventions connecting public health to other sectors (e.g., transportation, energy, water management) and estimating co-benefits associated with primary and secondary prevention that would reduce chronic cardiovascular and respiratory disease as well as minimize vulnerability (UNH 2015).

Recognizing the value of qualitative methods. Qualitative methods, such as surveys and community-based participatory approaches, can provide valuable information. The CHPR prepared by New York State was among those that used qualitative methods to identify population vulnerability and partnerships. Needs assessment surveys of health department staff knowledge regarding climate and health population vulnerability factors provided insights based on direct experience and highlighted differences in perceptions across stakeholders regarding partnerships; for example, health department staff prioritized collaboration with emergency management services, while external stakeholders considered partnerships with schools and agencies to be more critical (NYS DH 2015).

Enhancing Climate and Health Communications

Health as a frame for climate change. Our review of CHPRs suggests that CRSCI has helped grantees integrate health more effectively into broader climate change efforts. This occurred in different ways, depending on the context. For example, in California, CRSCI appears to have contributed to enhancing an ongoing climate and health program that was already part of a broader climate change initiative implemented by an interdisciplinary team (Maizlish et al. 2017; CalBRACE 2017). In Maryland, the program appears to have helped elevate the local health department's role within a wider multisectoral climate change effort in which health had previously not featured prominently (MCCCAR 2008; MIAEH 2016), while in Michigan, CRSCI seems to have spurred the launch of a new climate and health program with potential to provide leadership on broader climate change efforts (Cameron et al. 2015). In the majority of grantees, the CRSCI-supported program appears to have fallen into one or both the two first categories by raising the visibility of climate-driven health risks and their importance to vulnerable local populations, and better integrating public health within an existing broader climate change effort.

Evaluating and disseminating promising practice. Several CHPRs recognized the need for evaluation of interventions and noted a lack of evidence-based knowledge of good practice. However, grantees demonstrated ways to share promising practice, including in Oregon, where the five local jurisdictions chosen as pilots developed climate health adaptation plans and formed an online toolbox to share effective practice for natural hazard preparedness with other local jurisdictions. These included modules on flooding and wildfires that are based on lessons and communication guidance from past experiences with these hazards (OHA 2014). In a similar way, the CRSCI programs in Florida, California, and Minnesota report creating extreme heat toolkits for local jurisdictions (FDH 2015; Maizlish et al. 2017; MDH 2015). Rhode Island has developed a Lyme disease prevention toolkit based on vulnerable populations and high-risk occupations (RIDH 2015).

Communicating in ways that resonate. Several state grantees reported having begun to communicate in simpler and more direct ways with an emphasis on storytelling. For example, the Florida program developed touchstone event summaries for historic extreme weather events, including the 1990 flood and 2006–2008 drought; using photos, data records, and personal stories, touchstone summaries maintain knowledge of these events in community memory (FDH 2014). Illinois's CHPR highlighted

several personal stories of confronting weather extremes, including the 2013 extreme flood, and developed a video on preparation for extreme weather (UICSPH and IDPH 2016). California has developed case stories of successful activities to reduce climate-related risks in communities (CalBRACE 2017). North Carolina created an educational campaign on HRI (NCDHHS 2015), and Maine developed eighth-grade teaching modules on climate change and health, Spanish-language guidance on how to detect vibrio in locally caught seafood, and cartoon versions of guidance for extreme weather strategies (MCDC 2017).

Future Directions

The CHPRs reviewed suggest that grantee states and cities have developed climate impact and vulnerability assessments that serve several relevant goals, including identifying key climate hazards, associated health risks, and population vulnerability factors. They have also addressed health department training and capacity building and public outreach, and have informed next steps toward development of climate health adaptation plans. This suggests the utility of the BRACE framework and the potential applicability of the CHPR approach for other local governments. CHPRs have also served in a hands-on way to inform refinement and targeting of existing health interventions. This was particularly true for extreme heat early warning systems, among the few climate health interventions that have been evaluated and considered likely to be cost-effective (Bouid et al. 2013; Toloo et al. 2013). Research suggests that vulnerability targeting, such as reported by grantees, is likely key to enhance early warning effectiveness (Lowe et al. 2011; Hess and Ebi 2016). A systematized review of CRSCI grantee extreme heat-related activities, including use of heat vulnerability indexes and mapping approaches, could help identify areas of promising practice, opportunities for intervention evaluation, and scope for scaling up of activities. Some lessons learned in heat early warning may be applicable to other health risks, such as air and water pollution alerts and contagious disease outbreak early warning.

We found numerous illustrative examples in CHPRs and associated CRSCI activities that were consistent with strategic directions suggested by the recent expert review panel, in particular, the development of knowledge networks, progress toward practice-informed guidance on quantitative methods, and integrating public health more centrally within broader climate changes efforts, a key program achievement. In some of these areas, it may be useful to review grantee experience with a view to developing additional toolkits, guidance documents, and identifying scope for case studies. However, we found fewer examples to report in some of the other strategic areas recommended by this expert panel. For examples, we found less evidence of the use of qualitative methods, such as surveys and community-based participatory research; few CHPRs reported a focus on the health co-benefits associated with climate mitigation efforts. And while we identified networking partnerships among grantees and between grantees, nongrantees, and academic, government, and nongovernment partners, the CRSCI program has potential to expand its networks even further toward nongrantees through existing and new networks (e.g., through NACCHO or other organizations). Development of further practice-informed guidance documents (e.g., for co-benefit estimates or for use of qualitative methods for vulnerability assessment) would also be a useful addition and would support dissemination of lessons to other local governments. New communication strategies are also being tested by grantees; evaluation of their effectiveness and sharing lessons of success will be helpful to others. Tools such as these could be shared through an online dissemination channel with an international reach; particularly in the context of scarce resources, this would help to scale up

lessons and make them more widely available to local health departments, both in the United States and worldwide. Also of use would be extending the program reach toward additional cities, increasingly important actors in climate change adaptation and mitigation. Program enhancements would also be useful in areas such as estimating the health co-benefits of climate mitigation efforts, support to climate and health institutional capacity building and lesson dissemination, and systematic evaluation of climate and health interventions.

Conclusion

Through relatively small amounts of grant support over the last 6 y, CRSCI has helped local public health agencies in sixteen states and two cities—whose combined population reaches half of the U.S. total—identify critical climate impacts and vulnerable populations. In the process, the program has helped to integrate health more fully into local climate change efforts. As a result of CRSCI support, these local public health agencies—the backbone of public health climate response capacity—have tools to enhance real-life adaptive capacity and increase the effectiveness of existing interventions, such as heat response plans. They are also better prepared to take the next steps toward developing climate and health adaptation plans. However, the CRSCI program is only a start; vast needs remain in the United States as well as globally. At a time of uncertain commitment to climate change agreements at the national level, the challenge of building adaptive capacity in public health rests in large part at the local level. Subnational governments worldwide have a role to play in adapting to the health risks of a changing climate and enhancing the urgency of needed mitigation policies. As demonstrated with the examples here, the CRSCI program approach illustrates a way forward toward robust, targeted, and resilient local preparedness and response that may serve as a useful model for public health departments in the United States and internationally as the climate continues to change.

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