

The Role of Health in Urban Climate Adaptation: An Analysis of Six U.S. Cities

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ABSTRACT

Climate change threatens the health of urban residents in many ways. This qualitative study aims to understand how six U.S. cities are considering health adaptation when responding to climate change; 65 semi-structured interviews were conducted with salient stakeholders across six U.S. cities (Boston, Massachusetts; Los Angeles, California; Portland, Oregon; Raleigh, North Carolina; Tampa, Florida; and Tucson, Arizona), and transcripts were analyzed to identify common themes. Each city's (or county's) most recent climate action plan was also analyzed. This study found that interviewees' ability to understand the connection between climate and health was a major determinant for health adaptation implementation. In addition, institutional fragmentation in governance made it difficult to incorporate health concerns into broader climate planning. However, cross-sectoral collaborations and considerations of health cobenefits were shown to help overcome these barriers. These findings offer valuable insight regarding how policy makers and practitioners can safeguard public health from the effects of climate change.

1. Introduction

The impacts of climate change on human health are complex and widespread (Crimmins et al. 2016). Direct effects include excess morbidity and mortality from extreme events, such as heat waves, storms, and wildfires as well as indirect impacts that are mediated through changes in environmental conditions, such as increasing pollen counts and shifting distribution of vectors (Luber et al. 2014). These changes in climate may increase the incidence of certain respiratory diseases, foodborne and waterborne diseases from altered ecosystems, and allergic diseases, among others (Haines and Patz 2004). All of these climate-related phenomena are expected to pose major direct and indirect health risks to those living in U.S. cities. In addition, these impacts have the greatest effect on certain populations who are more vulnerable, including children, the elderly, pregnant women, the poor, and those with preexisting health conditions (Balbus and Malina 2009).

Over 80% of the U.S. population lives in urban environments (U.S. Census Bureau 2012). Large cities are more vulnerable to climate-related health risks than other less populous locations (Luber et al. 2014; Cutter et al. 2014). Extreme heat events are the leading cause of weather-related mortality in the United States and are especially dangerous in cities with urban heat islands, which further increase ambient temperatures by absorbing heat into asphalt, concrete, and buildings (Habeeb et al. 2015; Luber and McGeehin 2008). Based on death certificate data, more than more than 9000 Americans have died from heat-related causes since 1979 (U.S. Environmental Protection Agency 2016). With climate change and absent of adaptation activities, the United States is projected to experience even more incidences of heat-related mortality, with some estimates as high as thousands to tens of thousands of excess deaths per year by the end of 2100 (Sarofim et al. 2016; Wu et al. 2014).

Threats to public health from climate change, such as extreme heat, can be mediated through the management of risks by multiple sectors, including energy, water,

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biodiversity, and urban planning. For example, blackouts and brownouts caused by energy shortages during heat waves can lead to more heat-related deaths (Kinney et al. 2015). To decrease this risk, nonhealth sectors can adapt their systems to be more resilient to heat by improving electrical grid management practices or incorporating passive cooling into urban buildings (Gill et al. 2007; Miller et al. 2008). In addition to heat, climate change poses many other multisectoral challenges to urban environments, including the health risks related to poor air quality, extreme weather events, and others (Fann et al. 2016; IPCC 2012). However, there is not a robust evidence base that explores how different sectors are explicitly engaging in health adaptation.

Little research to date has qualitatively investigated how cities are addressing health risks from climate change (Bouzid et al. 2013; Clarke and Berry 2012; Ebi and Semenza 2008; Eidson et al. 2016). Instead, the literature to date has focused on theoretical frameworks that lack empirical investigation of whether or not communities are implementing them (Ebi et al. 2005; Ebi and Burton 2008; Frumkin et al. 2008). The Centers for Disease Control and Prevention (CDC)'s Climate and Health Program has facilitated most of the work on health adaptation through its grant program with state and local health departments. Similar to other climate adaptation frameworks, the CDC developed a health-specific iterative framework called Building Resilience Against Climate Effects (BRACE), which embeds climate observations and projections into traditional public health planning to inform suitable interventions that reduce risk (Marinucci et al. 2014). This framework is currently being piloted in 18 U.S. states and cities, with the goal of sharing guidance and success stories for public health departments nationwide.

Yet, research surveying local public health officials on their climate-related programmatic activities show that very few public health departments have taken specific action to adapt to the impacts of climate change (Maibach et al. 2008). Some health departments indicated their intent to integrate adaptation into existing programmatic activities: primarily emergency preparedness (71%) and vectorborne infectious disease programs (53%). However, many health departments cite budget constraints and limited subject matter expertise as major barriers to establishing health adaptation initiatives (Rosser-Renouf et al. 2016). Other studies found uncertainties with climate projections, socioeconomic conditions, and population growth to be additional limiting factors (Huang et al. 2011; Lesnikowski et al. 2013).

A cobenefits approach is a common strategy to promote action because it incorporates adaptation (measures

that decrease climate-related vulnerabilities) and mitigation (measures that reduce greenhouse gases) policies to produce win-win scenarios (Frumkin and McMichael 2008). For example, introducing more green space by adding nonallergenic greenery in urban settings helps to reduce ambient temperatures and subsequent heat morbidity and mortality risks (Younger et al. 2008). Cobenefits like these have been shown to improve several critical areas of interest, such as the environment, economics, and health (World Health Organization 2011). However, there is substantially more research to support cobenefits for mitigation policies rather than adaptation strategies. These latter strategies have focused on increasing social capital and improving urban design (Cheng and Berry 2013). Yet, there is little empirical evidence exploring how cities are implementing strategies that result in health cobenefits.

This study investigates how six cities that vary in size, region, demographic composition, and climate risks are considering health in climate adaptation planning. It provides a qualitative analysis of stakeholder motivations and perceptions toward health adaptation.

2. Methods

This study is based on 65 in-depth stakeholder interviews in six U.S. cities (Boston, Massachusetts; Los Angeles, California; Portland, Oregon; Raleigh, North Carolina; Tampa, Florida; and Tucson, Arizona) and included an additional analysis of each city's most recent climate adaptation plan. A qualitative approach most effectively assessed activities involved in adaptation at the municipal level, while also maximizing the potential to capture data on how health adaptation functions across diverse sectors within the cities. It mirrors the methodology used in Carlson and McCormick (2015) and builds on their findings to better articulate the role of health in adaptation more specifically.

a. City and interviewee selection

The six cities were selected to represent variation across a number of characteristics, including geographic region, degree of adaptation planning and implementation, demographics, and climate vulnerabilities. These demographic characteristics varied in terms of population size, racial diversity, age of populations, and socioeconomic status. Cities were selected to ensure that the most threatening climate risks existed within their jurisdictions, such as sea level rise, hurricanes and storms, drought, and heat waves. While this selection process did not follow one represented in the literature, the risks and demographics considered were those discussed in the U.S. National Climate Assessment

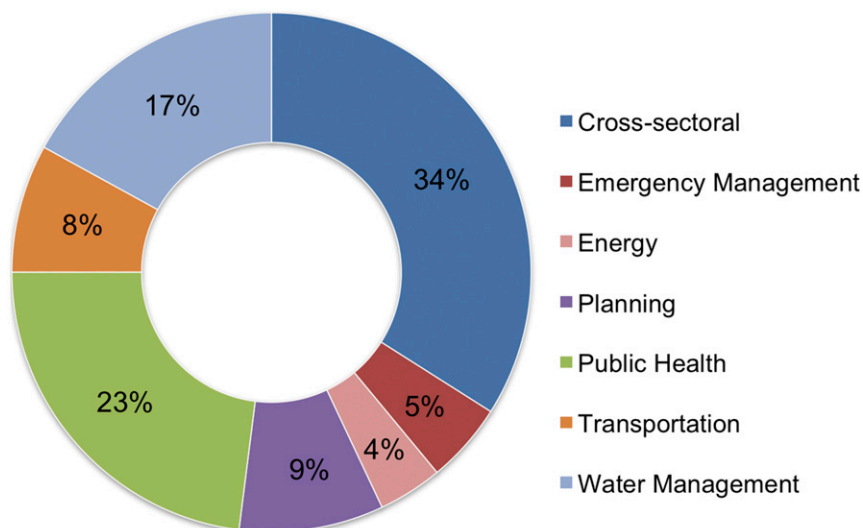


FIG. 1. Interviewee characteristics broken down by sector ($n = 65$).

(Melillo et al. 2014). In addition to their climate vulnerabilities, most of the study cities were receiving federal funding through the National Science Foundation's Urban Long-Term Research Area (ULTRA) or the CDC's Climate-Ready States and Cities Initiative. While these cities represent a diverse sample, more research should be done in order to fully understand the implications of across-city variation. A snowball sample method was used to identify salient stakeholders across sectors in each of the study cities. The interviews were representative of a wide range of sectors, as represented in Fig. 1. In addition, the interviewees were affiliated with a diverse set of organizations: nongovernmental (25%), city government (23%), county or regional governments (18%), academia (18%), state government (13%), and private (3%).

Interviews were conducted between 2011 and 2012 and followed a semistructured design to gather data on four overarching topics: 1) interviewee background and expertise, 2) perceived climate vulnerabilities, 3) adaptation planning and adaptation implementation, and 4) resource needs. All interviews were recorded and transcribed, and participants were de-identified for anonymity.

b. Data analysis

Transcriptions were analyzed using QSR NVivo 10, a qualitative data research software (QSR International 2014). Major codes included health impacts, planning, implementation, motivation, perceptions (of climate stressors and health risks), and cobenefits. These codes were intentionally broad in order to capture the diverse ways in which stakeholders conceptualize health adaptation. The qualitative analysis utilized grounded theory,

an inductive research methodology that follows a set of systematic analyses, such as coding schemes, to reveal overarching conceptual themes and conclusions (Charmaz 2014).

In 2016, an additional analysis of the study cities' climate-related planning documents was conducted to incorporate more recent advancements in each city (City of Boston 2014; City of Portland 2015; City of Raleigh 2013; City of Tucson 2011; County of Los Angeles 2015; Hillsborough County Government 2011). We identified the initial year that a plan was created and then assessed if and how public health was included in the plans (see Table 1). All cities had a climate action plan at the city or county level with the exception of Tampa. Hillsborough County's energy and sustainability plan (Hillsborough County Government 2011) was used as a surrogate for Tampa's climate action plan.

3. Results

a. Motivation for and barriers to health adaptation

There were several motivations for and barriers to integrating health into climate adaptation. Individual-level motivation was moderated by one's basic understanding of the relationship between public health science and climate science. In some instances, stakeholders did not fully understand how extreme events were associated with climate change and how they can affect health. For example, one interviewee from the disaster preparedness community said, "I don't understand, at least intuitively, I don't understand the public health risks." This particular respondent did understand

TABLE 1. Analysis of the six cities' most recent climate action reports. The additional report analysis was conducted to better understand how the study cities have progressed in health adaptation since the time of the interviews (2011–12). Where city-level plans did not exist, county-level plans were used as surrogates. The table provides a short summary of each report and how they explicitly integrate information on climate and health.

	Report title	Publication year	Year of initial climate plan	Level of coverage	Health-relevant content	General description
Boston	Climate action plan	2014	2011	City level	Heavy emphasis on crosscutting themes, including equity and public health (both impacts and adaptation).	Serves as a comprehensive update to the 2011 plan with a larger focus on preparedness. Does not directly discuss cobenefits.
Los Angeles	Community climate action plan	2015	2007	County level	Outlines a mitigation and adaptation strategy that maximizes cobenefits for health and other sectors.	A thorough assessment of greenhouse gas emissions and sectoral impacts, including a section on health.
Portland	Climate action plan	2015	2009	City level	Heavy emphasis on cobenefits and equity (including health impacts and health adaptation).	Builds on several assessments to produce a comprehensive short and long-term climate mitigation and adaptation strategy.
Raleigh	Climate energy action plan	2012	2012	City level	Only mentions health in regards to air quality.	Heavily focused on assessing and providing recommendations for the transportation, energy, and infrastructure sectors. No discussion of cobenefits.
Tampa	Energy and sustainability plan	2011	2011	County level	Brief mentions of health risks and cobenefits in regards to air quality.	Primarily focuses on assessing local greenhouse gas emissions to inform a sustainable energy strategy (including case studies and recommendations). A brief discussion of climate change is captured in an appendix.
Tucson	Climate mitigation report (phase one)	2011	2011	City level	Brief mentions of health risks and cobenefits.	Provides mitigation recommendations and is heavily focused on greenhouse gas emissions and climate vulnerabilities. No information on phase two could be found.

the risks of sea level rise but did not understand its impact beyond the immediate physical impact.

In general, respondents (health and nonhealth professionals) were hesitant to take action unless they trusted the quality of climate science or felt highly confident in their understanding of the science. As one environmental scientist said:

Compared to the other sectors like agriculture, water resources, [and] transportation, public health's been relatively underserved by the climate community, and we're learning more and more that the health impacts of climate change are going to [...] potentially be significant.

Institutional barriers also impeded the motivation for health adaptation across cities and many sectors. Several health interviewees felt the broader climate community

did not perceive them as being a key stakeholder in adaptation planning discussions. One health sector interviewee said:

It took two years to get some people to understand that public health had a role. [...] And things are really starting to come along and change for public health. Public health has initially, I think, [not been] really considered a viable player in terms of climate change activities. And quite frankly, we came on to the scene very, very, very late. And our awareness kind of was pretty late in coming.

In some cases, this was a result of institutional barriers between and within departments, which hindered broader engagement. One local government official said, "How do you deal with something that's actually threatening your way of life? And right now it's all in little silos."

City reports did not reflect a sector-specific approach to climate. Rather, most cities included a discussion on adaptation or preparedness that transcended sector-specific concerns. Only Boston and Portland had an extensive adaptation strategy, both of which considered health adaptation. All six cities included health in their reports but varied in the degree to which they prioritized health. For example, Raleigh's plan only includes general statements, such as, "Raleigh's leadership can simultaneously improve the long-term health of local residents and regional ecological systems" (City of Raleigh 2013, p. 10), whereas Los Angeles County's plan dedicated an entire section to assessing their specific climate-related health vulnerabilities.

b. Collaborative methods for health-inclusive adaptation

The study cities leveraged the expertise of multiple disciplines and sectors to overcome some of these institutional barriers and better integrate health adaptation into their citywide climate adaptation strategies. Some health practitioners emphasized the importance of collaborations with neighboring jurisdictions and other sectors to ensure successful health adaptation. One expert articulated the need to first establish a common ground across different disciplines:

You don't really break through those silos unless you get people talking and come up with some common vocabulary. I can go off and talk about exposure to a public health person, but they're going to look at me and be like "what the hell are you talking about?"

Interviewees felt the data on climate and health were dispersed across many different scientific and professional disciplines, and leveraging it for adaptation was more efficient when applying an interdisciplinary approach. As one environmental planner explained:

There's all these great collaborations happening across county lines, and I think there's a real opportunity for many of the communities [...] to work collaboratively with other sectors and other local governments in order to develop some more extensive adaptation strategies that can have great impact on the community.

Another health practitioner explained how these sorts of interdisciplinary collaborations were critical to their recent climate and health vulnerability assessment:

Without that partnership, we can't [adapt]. A lot of climate change adaptation strategies are planning strategies. Planning intervention strategies. So, to not partner would mean that we wouldn't adapt well.

City climate action plans showed varied results in terms of collaborations. Boston, Los Angeles, Portland, and

Tucson included a public health expert on their respective writing teams or steering committees. This might explain the lack of a robust discussion of health impacts or health adaptation in Raleigh and Tampa's plans. Boston's plan explicitly identified the need for better collaboration with the public health sector to include climate preparedness in existing health programs aimed at vulnerable populations.

c. Cobenefits from health adaptation

Many interviewees both within and outside of the public health community were prioritizing the positive gains for health when responding to climate change. Most clearly, they felt that it humanized the issue of climate. One health scientist shared his/her experience:

Of [all] the things I've done in my career research-wise, this climate and health thing is by far the biggest [...] [and] widest appeal because, you know, it takes two problems [...] and makes it very immediate for most people.

Health cobenefits were a common approach to integrating health into climate adaptation because they can simultaneously address a myriad of urban vulnerabilities across sectors while also improving public health. One nonhealth stakeholder said:

We just did a rain garden and we actually helped mitigate the urban heat island effect in this little microspace. Trees in the urban environment help to reduce the urban heat island effect, and, in our case, we like them because they help intercept rainfall and so it provides some management of rainfall within the urban context besides the cooling of the urban environment.

Originally, this interviewee was focused on reducing a school's flood risks but later learned students were also experiencing issues from heat. As a result, (s)he developed a rain garden to control stormwater runoff and also reduce heat exposures. Additionally, this intervention provided an opportunity to educate youths on environmental health issues and solutions. Though this individual was not a public health expert, (s)he was well aware of the benefits from different adaptive measures and was able to tailor the intervention to target the largest gain.

Public health professionals found that cobenefits were not only effective in reducing climate-related risks, but also addressed other societal challenges within their communities. As one public health stakeholder states:

One of the [...] advocacy points that we tended to mention from the Health Department's perspective was this idea of cobenefits and health inequity. [...] If I [...] give myself a scenario like, "OK, let me look at this

particular area, if it gets hotter there, what is that going to mean? There are a lot of old people there, and there's no aging and disability services. Coronary reports show that people go to the hospital when it gets hot, so I can go to the city and say here's a cobenefit right?"

Health cobenefits were explicitly considered in four (Los Angeles, Portland, Tampa, and Tucson) plans, but the discussions varied in their length and depth. Los Angeles and Portland assessed and ranked the benefits for several sectors and impacts areas including energy, environmental quality, and health. Raleigh did not include a discussion of cobenefits and instead highlighted the overall economic gains from creating a more sustainable energy sector. Boston's plan did not explicitly discuss health cobenefits but instead chose to integrate benefits throughout their in-depth discussions of mitigation and adaptation strategies. As such, cobenefits appear to be an approach or framework that is increasingly adopted in cities, although to different degrees and in diverse ways.

4. Discussion

This qualitative study provides empirical evidence for how some U.S. cities are adapting to the health risks from climate change. Our findings demonstrate that cities face a number of challenges to protecting the public's health from climate change. The lack of information on health impacts at the city level limits the ability for local experts and policy makers to reach a well-informed solution. We also found that there were clear misunderstandings of how climate change affects existing health risks. This may be because of the lack of collaboration and information sharing across sectors and within the public health community. While some of the study cities are in states that are advancing health adaptation through the CDC's BRACE framework, large-scale evidence of the integration with other sectors and the implementation of health adaptation is still lacking ([American Public Health Association 2015](#)).

Another obstacle to health adaptation was the institutional exclusion of public health in climate adaptation planning processes. Some of the health practitioners felt they had to fight to be included in relevant conversations and had to prove the value of their expertise. Our results indicate an interdisciplinary approach to health adaptation is one way to overcome some of these barriers and catalyze the inclusion of health. Therefore, narrowly focused activities that do not take an interdisciplinary approach or create cross-institutional alliances may impede interventions. This approach has been widely discussed in guidelines and frameworks but

has yet to be demonstrated empirically for the health sector ([Ebi et al. 2005](#); [Ebi and Burton 2008](#); [Frumkin et al. 2008](#)).

In addition, this study highlights how health cobenefits can play a role in catalyzing the planning and implementation of health-based adaptation. Cobenefits can occur across an array of areas including adaptation, mitigation, sustainability, the built environment, and economics. Literature on public attitudes toward climate change has shown health cobenefits to score highly on utility as a communication tool for taking action against climate change ([Maibach et al. 2010](#)). While the public health sector does not need to be at the forefront of these activities to achieve health adaptation, it can be an invaluable contributor to larger climate adaptation efforts. Past research has identified different response strategies for a variety of sectors that lead to health cobenefits ([Cheng and Berry 2013](#); [Younger et al. 2008](#)). However, there has been little evidence to suggest how cities are implementing these strategies. This study provides empirical evidence to suggest how cities are valuing health cobenefits from a variety of interventions across different sectors.

This analysis of six cities' climate action plans demonstrated that cities are still at very different stages in implementing adaptation interventions. Cities are becoming more and more aware of the utility of cobenefits when looking to implement both climate mitigation and adaptation activities. While progress has been made since the time of the interviews in 2011–12, some cities are farther behind than others in their adaptation processes and have not published any significant updates for several years. Raleigh, Tampa, Tucson, and other cities that have yet to fully incorporate adaptation into their climate action plans could look to the guidance and advancements made by the other study cities as models for climate adaptation planning.

Based on the three overarching themes that were identified through this analysis (expertise building, collaborations, and health cobenefits), we developed a set of examples demonstrating how local health departments can consider health adaptation through the lens of the three themes. [Table 2](#) outlines a series of examples of activities that cities can implement in order to follow the recommendations based on our research. To build expertise, cities can use publicly available data resources provided by the federal government or from other sources of their own locale to assess risks and opportunities. To encourage collaboration across sectors within a city, regular meetings should be held that engage diverse stakeholders, including collaborations between health experts and communicators. Finally, taking a cobenefits approach can mean including health

TABLE 2. Examples of approaches to health adaptation based on thematic findings. The following activities are intended to show a few examples of how city health departments can begin to approach health adaptation based on the study's three key themes: lack of information/expertise, working collaboratively within/across departments, and health cobenefits.

Expertise building	Collaborative approaches	Health cobenefits
Use publicly accessible data and tools to assess major vulnerabilities and adaptation options.	Hold quarterly meetings that engage the full health department (community health, infectious disease, disasters risk reduction, etc.) to identify major cross-departmental vulnerabilities and opportunities.	Develop adaptation strategies that consider a variety of inequalities, such as wealth and well-being, to better address issues of social and environmental justice.
Review CDC's BRACE Framework and their supplemental guidance documents.	Integrate health representatives into committees working on climate and sustainability that involve other city departments (transportation, urban planning, environment, etc.).	Identify and promote the major health benefits of green design, such as increasing tree canopies or constructing bike lanes.
Collaborate with environmental offices and local universities to better understand the jurisdiction's major climate vulnerabilities.	Partner with local academics (i.e., meteorologists, epidemiologists, ecologists) to develop early warning systems for the city's major health risks, such as a heat early warning system.	
Assess, where possible, the economic valuation of adapting the health system to avoid future impacts from climate change.	Public health practitioners should collaborate with local communicators or trusted messengers, for example, partnering with local broadcasters to notify risk of climate-related health risks, such as high mosquito season alerts.	

as a factor in urban design and other programs targeted at reducing greenhouse gas emissions.

While this study strengthens our understanding of how to approach health adaptation, the findings should be interpreted with a few considerations. Since the semistructured interviews were conducted without specific standardized questions, there were limited opportunities to study between-city differences without compromising the anonymity of participants. However, the semistructured interview design allowed us to decrease interviewer bias by empowering the participants to steer the conversation and identify their perceived climate vulnerabilities, such as health. While the delay between interviews and publication may mean that more in-depth interviews are necessary to further advance our understandings, the delay also allowed for the opportunity to see how cities are evolving, or not, in their approach to health adaptation based on their climate action plans. For the climate action plan analysis, we felt the most localized information would best complement the data collected from our interviews. As a result, the analysis did not include other state-level or county-level climate action plans, which may have contained additional information on health adaptation, and instead prioritized city-level plans. However, we did leverage county-level plans for both Los Angeles and Tampa as there were no formal in-depth or recent climate action plans available for those cities at the time of the analysis.

5. Conclusions

Addressing health is critical to climate change adaptation planning. However, health has been systematically marginalized in assessing vulnerability and developing adaptation options (McCormick 2016). This study suggests several steps that cities should take to ensure that the public's health is protected from pending risks. First, cooperation across multiple levels of government will be critical to integrating health into adaptation. When convening agencies and offices, city planners should ensure that health representatives are involved. While this step seems simple, it has the potential for profound differences in outcomes if health is truly considered alongside the concerns of multiple sectors engaged in planning. Second, cities developing climate adaptation plans should consider stressing cobenefits as a way of incorporating health adaptation activities. A cobenefits approach can often capitalize on scarce resources and help mainstream climate concerns into a diversity of programs. In fact, without such mainstreaming, emergent health risks may go unforeseen, and, at worst, some programs may fail in the context of a changing climate. Third, while we are unable to see exactly how local stakeholders account for or discount the larger context of state or regional plans within which they work, we recommend that city governments be cognizant of local and state health departments as they develop and implement climate action

plans. Only by doing so can these plans effectively capitalize on one another. Finally, and possibly most importantly, the public health community should work to provide information on local climate impacts to stakeholders across urban locales. This information should be the basis for addressing risks to infrastructure or vulnerable populations.

The results of this study also imply several opportunities to advance the scientific evidence on health adaptation. Cities need more evidence-based information on the suite of response strategies suitable to address their vulnerabilities. As stakeholders become more interested in mitigating and adapting to climate change, training materials that promote cross-sectoral engagement could catalyze these actions. Future research on how cities are using a cobenefits approach would offer improved insight into how cities are addressing health and other climate concerns. Both health and nonhealth professionals will need this information to develop well-informed adaptation plans. The study cities provided several examples on how they are approaching health adaptation, and these practices should be shared more widely so other cities across the country can follow their lead.

Urban environments face a barrage of competing challenges and political agendas. However, the reality of climate change is ever present and growing. Climate change has been referred to as the greatest public health threat facing current and future generations (Costello et al. 2009). Cities will need to be better prepared to respond and ensure the appropriate preventative care measures are in place.

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REFERENCES

- American Public Health Association, 2015: Adaptation in action: Grantee success stories from CDC's climate and health program. APHA Doc., 14 pp., https://www.apha.org/~media/files/pdf/topics/environment/adapt_in_action.ashx.
- Balbus, J. M., and C. Malina, 2009: Identifying vulnerable subpopulations for climate change health effects in the United States. *J. Occup. Environ. Med.*, **51**, 33–37, doi:10.1097/JOM.0b013e318193e12e.
- Bouzid, M., L. Hooper, and P. R. Hunter, 2013: The effectiveness of public health interventions to reduce the health impact of climate change: A systematic review of systematic reviews. *PLoS One*, **8**, e62041, doi:10.1371/journal.pone.0062041.
- Carlson, K., and S. McCormick, 2015: American adaptation: Social factors affecting new developments to address climate change. *Global Environ. Change*, **35**, 360–367, doi:10.1016/j.gloenvcha.2015.09.015.
- Charmaz, K., 2014: *Constructing Grounded Theory*. 2nd ed. Sage, 416 pp.
- Cheng, J. J., and P. Berry, 2013: Health co-benefits and risks of public health adaptation strategies to climate change: A review of current literature. *Int. J. Public Health*, **58**, 305–311, doi:10.1007/s00038-012-0422-5.
- City of Boston, 2014: Greenovate Boston: 2014 climate action plan update. City of Boston Rep., 80 pp., https://www.cityofboston.gov/eos/pdfs/Greenovate%20Boston%202014%20CAP%20Update_Full.pdf.
- City of Portland, 2015: Climate action plan: Local strategies to address climate change. City of Portland Rep., 162 pp., <https://www.portlandoregon.gov/bps/article/531984>.
- City of Raleigh, 2013: Sustainability report 2013. City of Raleigh Rep., 12 pp., <http://www.raleighnc.gov/content/extra/Books/Sustainability/2013SustainabilityReport/>.
- City of Tucson, 2011: Climate mitigation report—Recommendations. Action Climate Tucson Rep., 46 pp., https://www.tucsonaz.gov/files/sustainability/act_phase1report_final_6dec11.pdf.
- Clarke, K. L., and P. Berry, 2012: From theory to practice: A Canadian case study of the utility of climate change adaptation frameworks to address health impacts. *Int. J. Public Health*, **57**, 167–174, doi:10.1007/s00038-011-0292-2.
- Costello, A., and Coauthors, 2009: Managing the health effects of climate change. *Lancet*, **373**, 1693–1733, doi:10.1016/S0140-6736(09)60935-1.
- County of Los Angeles, 2015: Unincorporated Los Angeles county community climate action plan 2020. County of Los Angeles Rep., 180 pp., http://planning.lacounty.gov/assets/upl/project/ccap_final-august2015.pdf.
- Crimmins, A., and Coauthors, Eds., 2016: *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*. U.S. Global Change Research Program, 312 pp., doi:10.7930/J0R49NQX.
- Cutter, S. L., W. Solecki, N. Bragado, J. Carmin, M. Fragkias, M. Ruth, and T. J. Wilbanks, 2014: Urban systems, infrastructure, and vulnerability. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, T. C. Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 282–296, doi:10.7930/J0F769GR.
- Ebi, K. L., and I. Burton, 2008: Identifying practical adaptation options: An approach to address climate change-related health risks. *Environ. Sci. Policy*, **11**, 359–369, doi:10.1016/j.envsci.2008.02.001.
- , and J. C. Semenza, 2008: Community-based adaptation to the health impacts of climate change. *Amer. J. Prev. Med.*, **35**, 501–507, doi:10.1016/j.amepre.2008.08.018.
- , J. Smith, and I. Burton, Eds., 2005: *Integration of Public Health with Adaptation to Climate Change: Lessons Learned and New Directions*. Taylor & Francis, 320 pp.
- Eidson, M., K. A. Clancy, and G. S. Birkhead, 2016: Public health climate change adaptation planning using stakeholder feedback. *J. Public Health Manage. Pract.*, **22**, E11–E19, doi:10.1097/PHH.0000000000000243.
- Fann, N., and Coauthors, 2016: Air quality impacts. *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*, A. Crimmins et al., Eds., U.S. Global Change Research Program, 69–98, doi:10.7930/J0GQ6VP6.

- Frumkin, H., and A. J. McMichael, 2008: Climate change and public health: Thinking, communicating, acting. *Amer. J. Prev. Med.*, **35**, 403–410, doi:10.1016/j.amepre.2008.08.019.
- , J. Hess, G. Luber, J. Malilay, and M. McGeehin, 2008: Climate change: The public health response. *Amer. J. Public Health*, **98**, 435–445, doi:10.2105/AJPH.2007.119362.
- Gill, S. E., J. F. Handley, A. R. Ennos, and S. Pauleit, 2007: Adapting cities for climate change: The role of the green infrastructure. *Built Environ.*, **33**, 115–133, doi:10.2148/benv.33.1.115.
- Habeeb, D., J. Vargo, and B. Stone Jr., 2015: Rising heat wave trends in large US cities. *Nat. Hazards*, **76**, 1651–1665, doi:10.1007/s11069-014-1563-z.
- Haines, A., and J. A. Patz, 2004: Health effects of climate change. *JAMA*, **291**, 99–103, doi:10.1001/jama.291.1.99.
- Hillsborough County Government, 2011: Hillsborough county government energy and sustainability plan: Overview and proposals. Hillsborough County Government Rep., 54 pp., <http://www.epchc.org/documentcenter/view/152>.
- Huang, C., P. Vaneckova, X. Wang, G. Fitzgerald, Y. Guo, and S. Tong, 2011: Constraints and barriers to public health adaptation to climate change: A review of the literature. *Amer. J. Prev. Med.*, **40**, 183–190, doi:10.1016/j.amepre.2010.10.025.
- IPCC, 2012: *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*. C. B. Field et al., Eds., Cambridge University Press, 582 pp.
- Kinney, P. L., and Coauthors, 2015: New York City panel on climate change 2015 report chapter 5: Public health impacts and resiliency. *Ann. N. Y. Acad. Sci.*, **1336**, 67–88, doi:10.1111/nyas.12588.
- Lesnikowski, A., J. Ford, L. Berrang-Ford, M. Barrera, P. Berry, J. Henderson, and S. J. Heymann, 2013: National-level factors affecting planned, public adaptation to health impacts of climate change. *Global Environ. Change*, **23**, 1153–1163, doi:10.1016/j.gloenvcha.2013.04.008.
- Luber, G., and M. McGeehin, 2008: Climate change and extreme heat events. *Amer. J. Prev. Med.*, **35**, 429–435, doi:10.1016/j.amepre.2008.08.021.
- , and Coauthors, 2014: Human health. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, T. C. Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 220–256, doi:10.7930/JOPN93H5.
- Maibach, E. W., A. Chadwick, D. McBride, M. Chuk, K. L. Ebi, and J. Balbus, 2008: Climate change and local public health in the United States: Preparedness, programs and perceptions of local public health department directors. *PLoS One*, **3**, e2838, doi:10.1371/journal.pone.0002838.
- , M. Nisbet, P. Baldwin, K. Akerlof, and G. Diao, 2010: Reframing climate change as a public health issue: An exploratory study of public reactions. *BMC Public Health*, **10**, 1–11, doi:10.1186/1471-2458-10-299.
- Marinucci, G. D., G. Luber, C. K. Uejio, S. Saha, and J. J. Hess, 2014: Building resilience against climate effects—A novel framework to facilitate climate readiness in public health agencies. *Int. J. Environ. Res. Public Health*, **11**, 6433–6458, doi:10.3390/ijerph110606433.
- McCormick, S., 2016: Assessing climate change vulnerability in urban America: Stakeholder-driven approaches. *Climatic Change*, **138**, 397–410, doi:10.1007/s10584-016-1757-3.
- Melillo, J. M., T. C. Richmond, and G. W. Yohe, Eds., 2014: *Climate Change Impacts in the United States: The Third National Climate Assessment*. U.S. Global Change Research Program, 841 pp., doi:10.7930/J0Z31WJ2.
- Miller, N. L., K. Hayhoe, J. Jin, and M. Auffhammer, 2008: Climate, extreme heat, and electricity demand in California. *J. Appl. Meteor. Climatol.*, **47**, 1834–1844, doi:10.1175/2007JAMC1480.1.
- QSR International, 2014: NVivo qualitative data analysis software, version 10. QSR International, accessed 1 February 2014, <http://www.qsrinternational.com/nvivo-product/nvivo-mac>.
- Roser-Renouf, C., E. W. Maibach, and J. Li, 2016: Adapting to the changing climate: An assessment of local health department preparations for climate change-related health threats, 2008–2012. *PLoS One*, **11**, e0151558, doi:10.1371/journal.pone.0151558.
- Sarofim, M. C., and Coauthors, 2016: Temperature-related death and illness. *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*, A. Crimmins et al., Eds., U.S. Global Change Research Program, 43–68, doi:10.7930/J0MG7MDX.
- U.S. Census Bureau, 2012: Urban, urbanized area, urban cluster, and rural population, 2010 and 2000: United States. Accessed 5 November 2015, <https://www.census.gov/geo/reference/ua/urban-rural-2010.html>.
- U.S. Environmental Protection Agency, 2016: Climate change indicators in the United States, 2016. EPA Rep., 4th ed., 96 pp., https://www.epa.gov/sites/production/files/2016-08/documents/climate_indicators_2016.pdf.
- World Health Organization, 2011: *Health in the Green Economy: Health Co-Benefits of Climate Change Mitigation—Transport Sector*. World Health Organization, 156 pp., http://extranet.who.int/iris/restricted/bitstream/10665/70913/1/9789241502917_eng.pdf?ua=1.
- Wu, J., Y. Zhou, Y. Gao, J. S. Fu, B. A. Johnson, C. Huang, Y.-M. Kim, and Y. Liu, 2014: Estimation and uncertainty analysis of impacts of future heat waves on mortality in the eastern United States. *Environ. Health Perspect.*, **122**, 10–16, doi:10.1289/ehp.1306670.
- Younger, M., H. R. Morrow-Almeida, S. M. Vindigni, and A. L. Dannenberg, 2008: The built environment, climate change, and health: Opportunities for co-benefits. *Amer. J. Prev. Med.*, **35**, 517–526, doi:10.1016/j.amepre.2008.08.017.