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ORIGINAL ARTICLE

US local action on heat and health: are we prepared for climate change?

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Abstract
Objectives Global climate change is increasing the frequency of heat waves, hot weather, and temperature variability, which contribute to mortality and illness. Baseline information on local efforts to reduce heat vulnerability, including public advisories; minimizing greenhouse gas emissions; and mitigating urban heat islands, is lacking.
Methods We designed a survey about local government programs to prevent health problems and reduce heat exposure during heatwaves and administered it to 285 US communities.
Results Of 70 respondents, 26 indicated that excessive heat events are a significant issue for the local government; 30 had established preventive programs. Local government leadership and public health impacts of heat were cited most frequently as extremely important determinants of preventive programs, followed by implementation costs, economic impacts of hot weather, and greenhouse gas emissions mitigation. Cool paving materials and vegetated roofs were common heat mitigation strategies. Fact sheets and case studies were desired guidance for protecting communities during hot weather.
Conclusions New partnerships and financial resources are needed to support more widespread local action to prevent adverse health consequences of climate change and promote environmental sustainability.

Keywords Global climate · Health effects · Temperature · Vulnerability · Adaptation

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Introduction

Climate change, heat and health

The Intergovernmental Panel on Climate Change (IPCC) has confirmed that emissions of greenhouse gases from human activities are increasing overall average temperatures and the frequency of extreme weather events, including heat waves (IPCC 2007). Heat-related death and illness will most affect urban populations and "the elderly, sick, and those without access to air conditioning" (IPCC 2001). People living in cities are at greater risk in part because of the urban heat island effect, in which air temperatures are 1–4°C higher in urban than in rural and suburban areas [Environmental Protection Agency (EPA) 2005a].

Prevention opportunities and action

Public health professionals are being exhorted to document effects and participate in efforts to respond to climate

change through societal change (Haines and Patz 2004; Patz and Khaliq 2002; Schwartz et al. 2006; Staropoli 2002; Sunyer and Grimalt 2006). Indeed, heat-related illnesses are preventable through public health campaigns and community mobilization (Butler 1997; Ebi and Schmier 2005; Kilbourne 2002; McKinley et al. 1986). For example, emergency medical services use was reduced 49% in Milwaukee, Wisconsin during a 1999 heat wave compared to one in 1995, in part due to improved prevention efforts, including: "designated multijurisdictional leadership (on the part of the Milwaukee Health Department); specific roles for more than 20 agencies; springtime preparation, communications tests, and public/professional education efforts; indexing of the plan to local National Weather Service advisory criteria; stepped responses appropriate to early forecasts; partner agency and mass media alerts via fax and e-mail; an emphasis on cooling measures other than air conditioning; and a 24-h hotline and active Internet-assisted heat injury surveillance during advisories" (Weisskopf et al. 2002).

Although similar prevention programs are being instituted in the US, Canada and Europe (Grynszpan 2003; Mattern et al. 2000; PHEWE 2005; Smoyer-Tomic and Rainham 2001), few US cities reported having a comprehensive written heat response plan to protect the vulnerable during hot weather (Bernard and McGeehin 2004). This situation has been changing, however. Local health department directors are increasingly aware of the relevance of climate change to health and the need to devote more resources to anticipating, preventing, and responding to heat-related illnesses (Balbus et al. 2008). Guidance is available for municipalities developing heat-health warning system programs (EPA 2006) and activities intended to increase community resilience to climate change [Climate Impacts Group et al. 2007; National Oceanic and Atmospheric Administration (NOAA) 2006]. An important way to reduce the toll of heat on human health is to minimize urban heat islands by planting trees, installing cool or vegetated roofs and using reflective paving materials (EPA 2005b). These activities are being implemented in several US cities, with guidance from the US country office of the non-profit International Council for Local Environmental Initiatives (ICLEI)-Local Governments for Sustainability, but lack significant resource commitments (Wong 2008).

A comprehensive approach to sustainability and prevention

Determinants of vulnerability to heat-related health effects include: biomedical (underlying disease status); sociodemographic (income, age, race); and community (air-conditioning access, vegetation). Identifying at-risk subgroups by criteria such as health status allows for special efforts to ensure that the most vulnerable individuals, who may be known individually to physicians, relatives, neighbors, or public health authorities, are safe during extreme heat. However, biomedical criteria have limited explanatory power for population patterns of risk during hot weather. Community-level factors, including social and physical aspects of neighborhoods, communities, and cities, also affect vulnerability and merit attention because community and population-level interventions may yield large public health benefits.

During the 1995 Chicago, IL heat wave, for example, people's social contacts, mobility, ability to pay utility bills, and sense of security in their home or neighborhood influenced access to an air conditioned or properly ventilated environment (Klinenberg 2002). Regionally, energy-efficiency standards for air conditioners and energy assistance policies can affect access to a cool environment and the availability of adequate electric power during peak demand periods (i.e. heat waves) [Department of Energy (DOE) 2002; Gladwell 2002; Kovats and Koppe 2003]. Enhanced awareness of the connections between neighborhood security and energy policy and health may inspire prevention efforts that take a broader focus and yield greater benefits than traditional, individual-targeted efforts alone. Such multisectoral efforts may reduce the disproportionate burden of heat-related morbidity and mortality that falls on the elderly, the poor, and those in disadvantaged areas.

This paper describes what local US governments report doing to prevent heat exposure and related health effects.

Methods

Survey design and data collection overview

Drawing from EPA's Excessive Heat Events Guidebook (EPA 2006), we developed the Heat Health Survey, a four page, seven part questionnaire consistently of mostly check boxes and blanks for including dates, that inquired into the actions cities are taking to monitor and alleviate the effects of excessive heat events, and how those actions had changed over time. The goal of this survey was to: (1) create a baseline of information to foster increased preventive action, and (2) serve as an input to both a decision tool for local governments and an epidemiological study evaluating individual and community determinants of vulnerability to heat in multiple US cities. In pre-testing, the survey took half hour to an hour if the respondent was aware of the range of activities, and depending on how many there were to report. The structure of the survey is shown in Fig. 1.

The data collection process took place in two main phases. Phase I surveyed 101 US cities that we identified

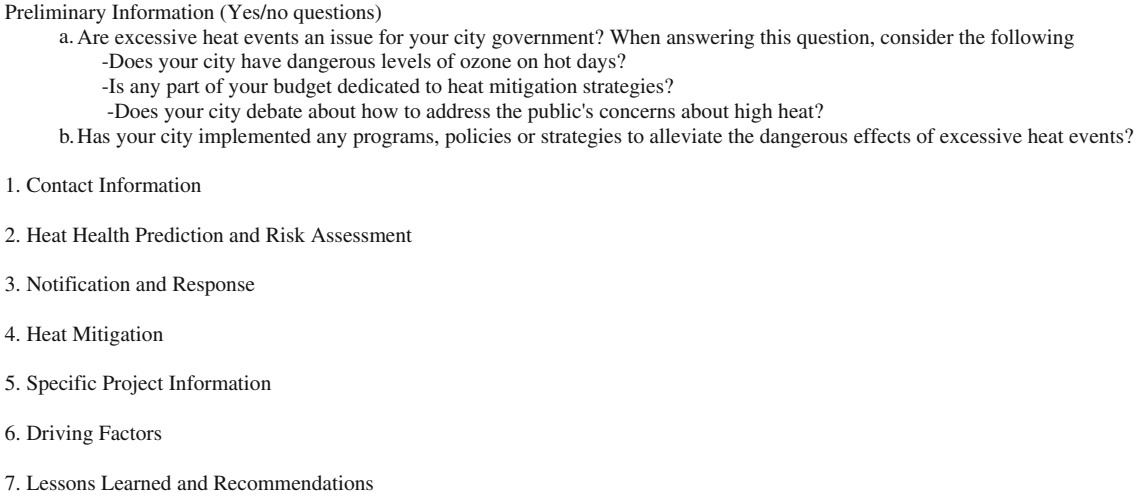

Fig. 1 Heat-health survey structure

on the basis of being large in size and having data available for a planned epidemiologic study of heat and hospital admissions among elderly people. Phase II encompassed a broader selection of cities including members of ICLEI and its climate mitigation program (formerly known as the Cities for Climate Protection Campaign), and a mixture of other cities identified due to their location in hotter climates or climates with temperature extremes, and/or housing a major medical university that might foster prevention activities and awareness. ICLEI staff in the Oakland, California headquarters and in ICLEI Regional Capacity Centers (Seattle, Washington; Denver, Colorado; Chicago, Illinois; Houston, Texas; and Boston, Massachusetts) were involved in the outreach and engagement of cities identified for the survey.

Survey implementation methodology

Phase I: In July, 2007, we were able to distribute the survey to 95 of the 101 cities included in the epidemiological study; we could not obtain contact information for six of the cities. Contacts were identified using the ICLEI member database, internet research, and direct outreach to obtain contact information for local staff contacts in environmental departments, health departments, and emergency services. Where no contact information was available, a contact in the highest level office available was found. For cities where counties appeared to be in charge of emergency services, a second county contact was added. After obtaining health and emergency service contact information for as many cities as possible, we divided the cities into six regions. ICLEI staff located throughout the country contacted officials in their region.

Each contact was sent an e-mail message with a web link to an online version of the survey in addition to an identical Microsoft Word version of the survey. A follow-up e-mail was sent approximately 2 weeks after the original e-mail, and multiple follow-up calls were made over a 3-week period to non-respondents.

Response rate and phase II

This first data collection effort yielded a response rate of 13%, mostly from ICLEI members. We attributed this to several factors. First, existing ICLEI staff contacts were typically in environmental or public works departments and not always involved directly in public health. Specific contacts in health departments and emergency services were often needed for informed responses to the survey. Second, the survey did not clearly provide opportunity for cities that had no heat or health programs to record their response to the survey questions. Finally, tangible incentives for cities to complete the survey were lacking. Although this low response rate is not unique to our survey, with a European study on the same topic yielding only 19 responses out of 52 contacts, at time of press (Kosatsky and Menne 2006), we began a phase II effort to increase the response rate.

Phase II involved a revised strategy for distributing and introducing the survey, without changing the content of the survey questions, and significant expansion of the pool of cities surveyed, adding 184 local governments to the original list of 101. These additional contact targets were drawn from cities with consistently high temperatures, or extremes at either end; cities that experienced the driest conditions; and randomly selected from among ICLEI members and cities with major medical schools. In addition to increasing the sample, we also restructured the survey so that the cities with no heat-related projects would be able to complete the survey quickly by only having to fill out a few

check boxes at the outset and then be directed to the final questions. In order to encourage more cities to take the survey, three incentives were described in the introductory letter: (1) Participants will be invited to workshops hosted by the University of Michigan, Harvard and ICLEI. (2) Respondents will receive a copy of the study's findings and a list of actions a jurisdiction can take to deal with the effects of a changing climate. (3) Federal funding for local preparedness for excessive heat events could become available, and having baseline information framing the information gaps and resource needs of local jurisdictions may increase the likelihood that this issue become a funding priority.

Results

After phase II was completed, a total of 70 surveys were received for a response rate of 25%. 32 of 41 ICLEI members surveyed responded. Some major urban centers cities did not initially respond to the phase II survey. For example, New York City and Philadelphia did not respond and were approached in January, 2008 in an ultimately unsuccessful effort to collect their responses.

Figure 2 shows the geographic distribution of the 70 respondent cities and the 101 cities originally contacted cities. The sample included communities of varying sizes and representing a wide range of climates. Most of the contacts were made with individuals in city governments, but for a few communities, the county or an agency within the city government was the responding entity. We will be able to use this data to evaluate whether community preparedness may modify the associations between heat and hospital admissions for a future epidemiological study using data from the 101 original cities.

We compared respondents versus non-respondents on the basis of several demographic characteristics (population size, population density, mean percent of population below the poverty line (Federally defined) and US Census Region (Northeast, Midwest, South, West) (Table 1) Due to the unusual nature of some of the jurisdictions contacted, it was not possible to compile Census data for all of the 70 contacted communities; only 62 had Census data for the purpose of this comparison. Table 1 shows that the less densely populated communities were less likely to respond than the more densely populated ones. The response rate was highest for Midwestern communities, and lowest for those in the Northeast.

The tabulated responses from the Heat Health Survey are provided in Figs. 3, 4, and 5. The most common activities reported under the category Heat Health Prediction and Risk Assessment were "Regularly review weather forecast information for the purpose of preparing for excessive heat events" (36%) and "Maintain a current and accessible record of facilities and locations that may house individuals who are particularly vulnerable to heat-related illness (e.g. elderly, homeless)." (29%) The least common activities included "Have established criteria for

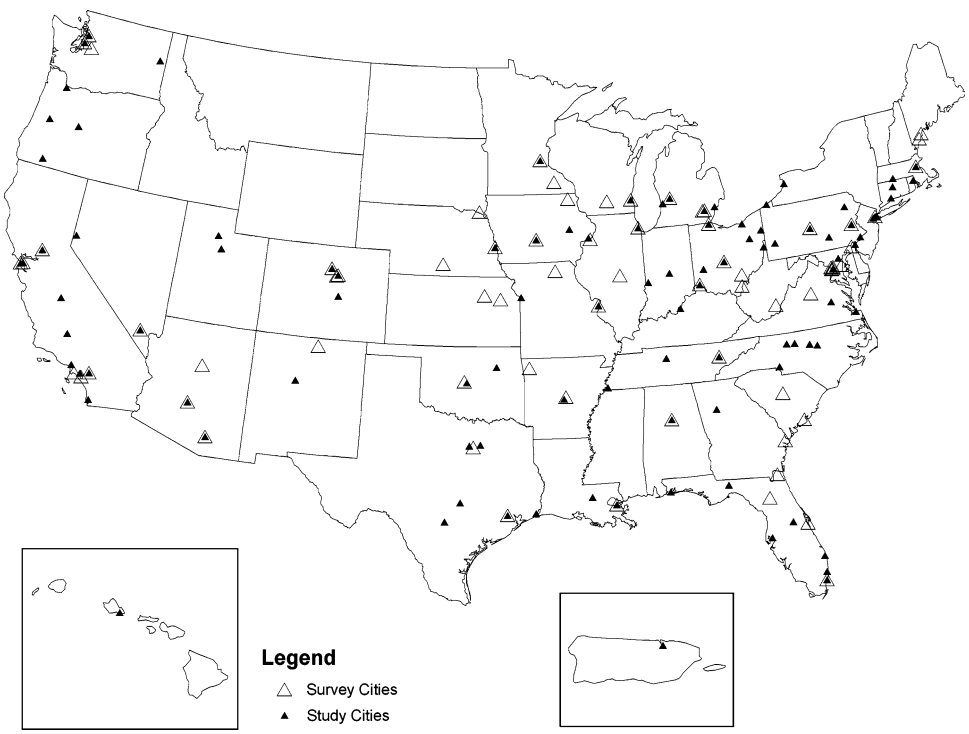

Fig. 2 Map of local governments responding to survey (*clear triangles*) and cities included for epidemiological study (*solid triangles*)

Table 1 Characteristics of respondents and non-respondents to 2007 Heat and Health survey

City characteristic	Responded to survey ($n = 62$)[a]	Did not respond to survey ($n = 204$)	P value (χ^2 or t test)
Geometric mean population (thousands of persons) (95% CI[b])	101.0 (66.7, 152.9)	77.8 (61.8, 97.9)	0.27[c]
Geometric mean population density (per km^2) (95% CI)	1258.6 (1042.1, 1520.1)	966.5 (830.7, 1124.7)	0.03[c]
Mean % below poverty (95% CI)	18.0 (15.9, 20.2)	16.9 (15.9, 18.0)	0.32
Census region			
Northeast	6 (11.5%)	46 (88.5%)	0.068
Midwest	20 (32.8%)	41 (67.2%)	
South	23 (24.0%)	73 (76.0%)	
West	13 (22.8%)	44 (77.2%)	

[a] Only 62 of the total 70 respondent communities had jurisdictional boundaries compatible with US Census 2000 boundaries

[b] Confidence interval

[c] t test performed using log (population) or log (population density)

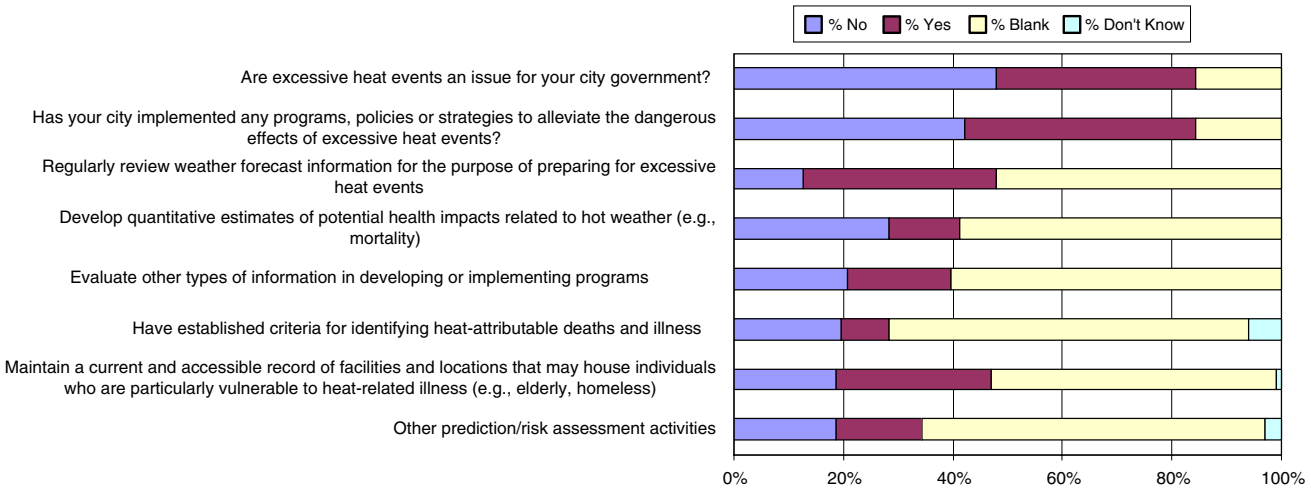

Fig. 3 Survey responses by 70 US localities on health prediction and risk assessment, 2007

identifying heat-attributable deaths and illness" (9%) and "Develop quantitative estimates of potential health impacts related to hot weather (e.g. mortality)" (13%) (Fig. 3).

As for Heat Health Prediction and Risk Assessment, affirmative responses on the specific Notification and Response items asked were received from far less than half of the respondents. The most commonly reported activities included "Coordinate public distribution and broadcast of heat exposure symptoms and tips on how to stay cool during hot weather" (31%); "Increase outreach efforts to vulnerable populations (e.g. elderly, homeless)" (31%); "Designate public buildings or specific private buildings with air conditioning (e.g. shopping malls, movie theaters) as public cooling shelters" (30%); and "Extend hours of operation at community centers with air conditioning" (30%). The least commonly reported activities were "Suspend utility shutoffs" (11%) and "Provide current records of locations that may house individuals who are particularly vulnerable to heat-related illness (e.g. elderly, homeless) to social service agencies" (9%) (Fig. 4).

Respondents were asked what driving factors affected whether adaptation and mitigation programs were in place in a given locality (Fig. 5). The two most important factors cited were local leadership and concerns about public health impacts of heat, with 51% of respondents rating these either "quite" or "extremely" important. Only 9% of respondents rated "Economic impacts of hot weather" and "Greenhouse gas emissions mitigation" as extremely important driving factors.

For the Lessons Learned and Recommendations portion of the survey, the majority of respondents were most interested in learning about activities being undertaken in other cities, challenges they faced, and case studies and fact sheets that could provide specific guidance on how to design and implement effective programs.

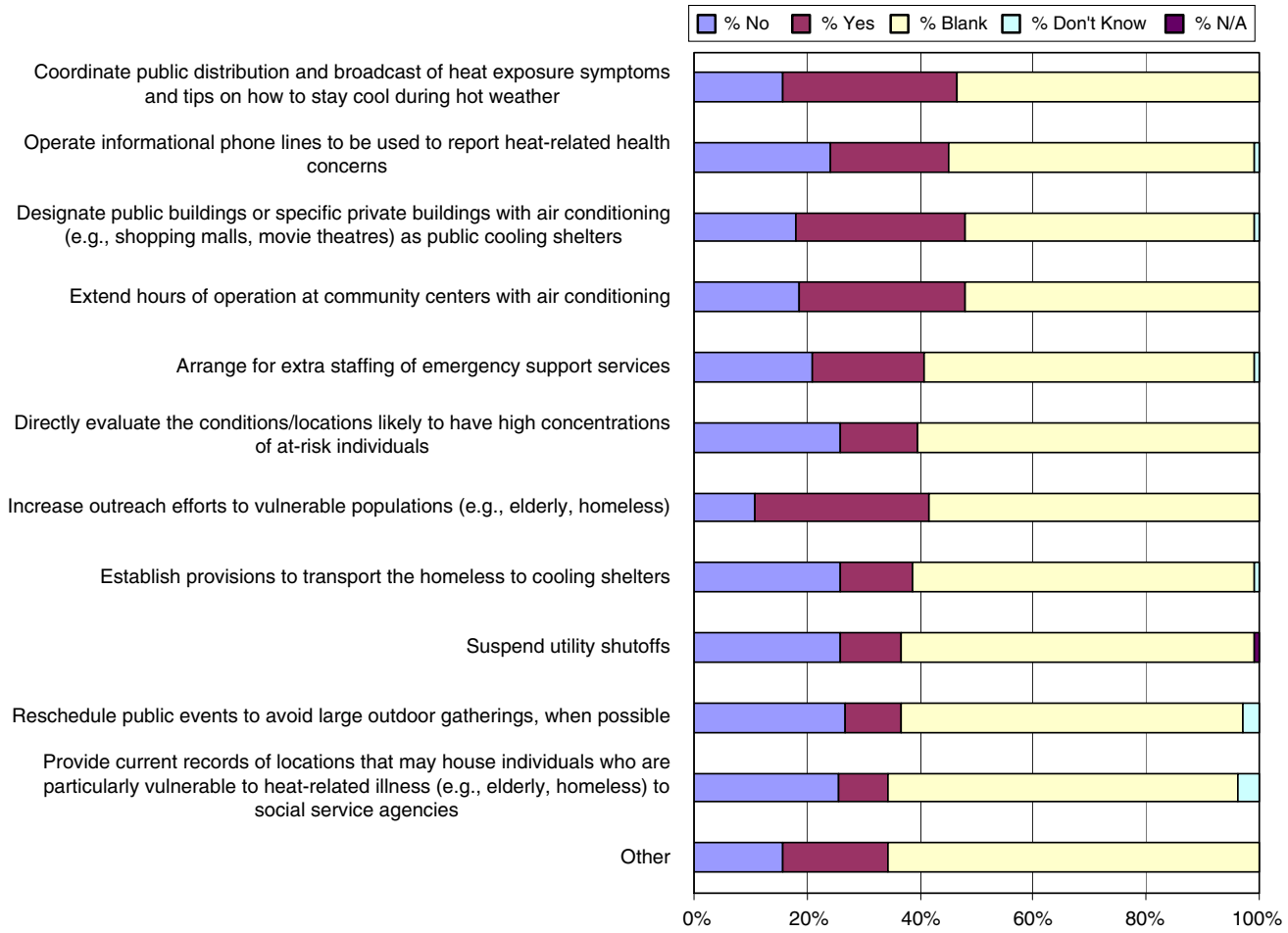

Fig. 4 Survey responses by 70 US localities on notification and response

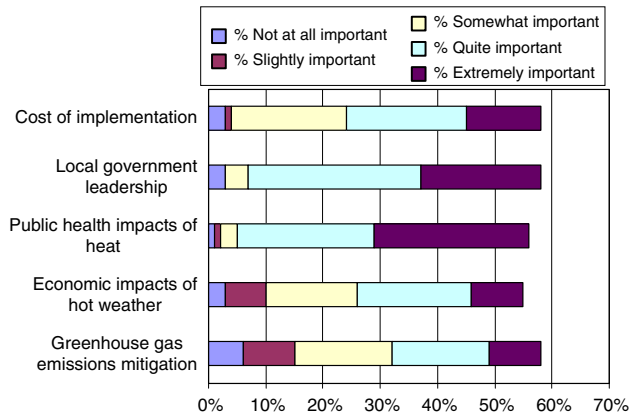

Fig. 5 Survey responses by 70 US localities on driving factors for whether heat adaptation or mitigation programs exist in a given jurisdiction

Discussion

Our survey results suggest that many US communities are not adequately prepared to prevent the effects of hot weather on the health of residents, and several are not undertaking activities, either individual measures or a comprehensive set, to reduce heat exposure and emissions of the greenhouse gases that contribute to global climate change. These results suggest that new activities to motivate establishment of these activities and guidance and financial resources to ensure appropriate implementation are warranted, since the limited evaluations available supports that preventive programs can reduce the toll of heat on illness and death in communities that have them (Butler 1997; Ebi and Schmier 2005; Kilbourne 2002; McKinley et al. 1986).

Limitations of this survey effort include a limited response rate (25%) considering the number of cities originally targeted. This type of survey, which requires time and most likely coordination with staff at other agencies, has yielded a response rate of 37% (19 of 52) in one other effort based in Europe (Kosatsky and Menne 2006), and 61.3% (133 out of 217 contacted) in a more recent survey that targeted US city and county health department directors who were members of the National

Association of City and County Health Officials (Balbus et al. 2008).

However, although both the non-random selection of cities and response rates do not enable us to confidently extrapolate or generalize our findings, they do suggest that many US communities lack comprehensive programs to prepare for heat events. To our knowledge, our project is the first survey to ask detailed questions about the exact type of programs in place in localities, and therefore contributes to the minimal knowledge base about local action in the US.

Based on the high proportion of respondents calling local leadership a driving factor for the existence of programs, we could tentatively conclude that an absence of local leadership, with corresponding resources for program implementation, may be a reason for the absence of programs. A lack of concern or knowledge of risks may also contribute.

A relatively large proportion of blank and 'don't know' responses are seen throughout the survey results. In part, we attribute this to activities falling under the purview of departments other than the ones to which respondents belonged. This could also be interpreted as an indication that important information on these activities is not available to those who should know. In other words, the fact that these programs do not exist or are not widely known about may be because the right people are not working together on the local level. The need for coordination across multiple sectors in developing comprehensive planning for heat waves and other climate change-linked phenomena has been emphasized in guidance publications (Climate Impacts Group et al. 2007; NOAA 2006; EPA 2006), and the Milwaukee heat-health program cited previously included coordination across 20 agencies.

Future plans

Research findings from this survey and additional health studies will be shared with local officials in a series of workshop and other communications, along with guidance on comparing and interpreting data on health effects of climate change. Given our low response rate, we would advise that future surveys provide a stronger incentive for completion and involve health department officials from the outset. Additionally, because our survey responses lacked detailed examples of what people meant by some of the relatively broad categories, including 'Adaptation', convening people to illustrate their ideas with case studies and concrete examples is a next step which will also address a strong need for case studies noted by survey respondents.

We intend to communicate results of this survey and our health research in a manner that acknowledges uncertainties but is responsive to the needs of policymakers and the public (Manning 2003; Patt and Schrag 2003; Webster 2003). The uncertainties will not be completely resolved, but we are likely to be better off with adaptive policies and sequential decision making that respond/s to what we learn than we are if we just wait for resolution that is unlikely to come soon enough for timely action.

We plan to compile information on heath and health and prevention options for incorporation into a web-based decision support tool for local governments, the Clean Air and Climate Protection Planning Assistant (CAPPA), now under development by ICLEI (2008) The current focus of the CAPPA is on specific greenhouse gas mitigation programs, creating comprehensive emissions reduction strategies and quantifying the costs and consequent energy savings of specific actions. However, an environmental health dimension will be added based on information gained from this study and through information on specific programs including heat-health warning systems and urban heat island mitigations, and their economic benefits. These research results can inform local efforts to notify individuals who are particularly vulnerable to hot weather; respond when hot weather and heat waves occur; mitigate the urban heat island effect, and tailor prevention programs to an area's resident composition and prevailing climate, housing stocks and energy use patterns.

New partnerships between researchers and local officials have been called for to meet the challenge of adapting to and preventing global climate change (Ebi and Gamble 2005) as evidence mounts that the magnitude of this problem is vast and urgent action needed. Our interdisciplinary alliance is utilizing data about health, the environment, and community characteristics to develop new tools for these purposes. Our survey and future plans to incorporate such information on community prevention programs into decision tools and epidemiological research are intended to increase capacity to respond to the threat of heat exposure to health in a changing climate.

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Conflict of interest statement The authors report no conflicts of interest.

References

Balbus J, Ebi KL, Finzer L, Malina C, Chadwick A, McBride D et al (2008) Are we ready? Preparing for the public health challenges of climate change. http://wwwedforg/documents/7846_AreWeReady_April2008pdf

Bernard SM, McGeehin MA (2004) Municipal heat wave response plans. Am J Public Health 94(9):1520–1522
Butler RN (1997) Preventing heat-related illness. Geriatrics 52(6):7–8
Climate Impacts Group, ICLEI, Seattle King County (2007) Preparing for climate change: a guidebook for local, regional, and state governments. http://wwwiclei-usaorg/action-center/planning-tools/guidebooks/guidebooks
DOE (2002) Energy conservation program for consumer products; Central air conditioners and heat pumps energy conservation standards; Final rule. Fed Regist 67(100):36368–36408
Ebi KL, Gamble JL (2005) Summary of a workshop on the development of health models and scenarios: strategies for the future. Environ Health Perspect 113(3):335–338
Ebi KL, Schmier JK (2005) A stitch in time: improving public health early warning systems for extreme weather events. Epidemiol Rev 27:115–121
EPA (2005a) Heat island effect. http://www.epa.gov/heatisland/about/index.html. Accessed 11 February 2005
EPA (2005b) Urban Heat Island Pilot Project. http://www.epa.gov/heatisland/pilot/index.html. Accessed 11 February 2005
EPA US (2006) Excessive heat events guidebook. http://www.epa.gov/heatisland/about/pdf/EHEguide_final.pdf
Gladwell M (2002) Political heat. New Yorker, pp 76–80
Grynszpan D (2003) Lessons from the French heatwave. Lancet 362(9391):1169–1170
Haines A, Patz JA (2004) Health effects of climate change. JAMA 291(1):99–103
ICLEI (2008) CAPPA decision support tool: climate and air pollution planning assistant. In: http://wwwicleiusaorg/action-center/tools/decision-support-tool
IPCC (2001) Climate change 2001: impacts, adaptation, and vulnerability: Summary for policymakers. Intergovernmental panel on climate change. http://www.ipcc.ch/
IPCC (2007) Intergovernmental panel on climate change: climate change 2007: the physical science basis summary for policymakers. http://www.ipcc.ch/SPM2feb07.pdf. Accessed 4 February 2007
Kilbourne EM (2002) Heat-related illness: current status of prevention efforts. Am J Prev Med 22(4):328–329
Klinenberg E (2002) Heat wave: A social autopsy of disaster in Chicago. The University of Chicago Press, Chicago
Kosatsky T, Menne B (2006) Preparedness for extreme weather among National Health Ministries of WHO's European Region. In: Menne B, Ebi KL (eds) Climate change and adaptation strategies for human health. Energy, environment and sustainable development. Steinkopff Darmstadt, New York
Kovats RS, Koppe C (2003) Heatwaves: past and future impacts on health. In: Ebi K, Burton I, Smith J (eds) A public health perspective on adaptation to climate change. Swets & Zeitlinger Publishers, Lisse, The Netherlands
Manning MR (2003) The difficulty of communicating uncertainty. Clim Change 61(1–2):9
Mattern J, Garrigan S, Kennedy SBt (2000) A community-based assessment of heat-related morbidity in North Philadelphia. Environ Res 83(3):338–342
McKinley TW, Sikes RK, Godfrey DS, Starling FD (1986) Heat-related illness and death prevention program. J Medl Assoc Georgia 75(7):418–422
NOAA (2006) Climate safe cities. http://wwwclimatenoaagov/indexjsp?pg=/cpo_pa/cpo_pa_indexjsp&pa=sarp&sub=2005_hentschelhtml. Accessed 3 July 2006)
Patt AG, Schrag DP (2003) Using specific language to describe risk and probability. Clim Change 61(1–2):17
Patz JA, Khaliq M (2002) Global climate change and health: challenges for future practitioners. JAMA 287(17):2283–2284
PHEWE (2005) Assessment and prevention of acute health effects of weather conditions in Europe. http://www.epiroma.it/phewe/
Schwartz BS, Parker C, Glass TA, Hu H (2006) Global environmental change: What can clinicians and the environmental health community do about it now? Environ Health Perspect 114:1807–1812
Smoyer-Tomic KE, Rainham DGC (2001) Beating the heat: development and evaluation of a Canadian hot weather health-response plan. Environ Health Perspect 109(12):1241–1248
Staropoli JF (2002) The public health implications of global warming. JAMA 287(17):2282
Sunyer J, Grimalt J (2006) Global climate change, widening health inequalities, and epidemiology. Int J Epidemiol 35(2):213–216
Webster M (2003) Communicating climate change uncertainty to policy-makers and the public. Clim Change 61(1–2):1
Weisskopf MG, Anderson HA, Foldy S, Hanrahan LP, Blair K, Torok TJ et al (2002) Heat wave morbidity and mortality, Milwaukee, Wis, 1999 vs 1995: an improved response? Am J Public Health 92(5):830–833
Wong E (2008) Final report on EPA's Heat Island Reduction Initiative. http://www.cleanairpartnership.org/cooltoronto/pdf/finalpaper_wong.pdf