Planning to Reduce the Health Impacts of Extreme Heat: A Content Analysis of Heat Action Plans in Local United States Jurisdictions

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Abstract

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Background: The United States is experiencing increasing temperatures and heatwaves due to anthropogenic climate change. Days of extreme heat lead to higher rates of morbidity and mortality and place greater demand on healthcare systems. Certain people, such as those older than 65, minorities, people experiencing houselessness, those with mental health issues, outdoor workers, and those living in urban areas, are more at risk for the health effects of extreme heat exposure. Heat action plans (HAPs) are one way that local jurisdictional public health and emergency management agencies prepare to respond to days or periods of extreme heat to prevent adverse health impacts. While there is evidence that these plans can decrease the health impacts of extreme heat, few studies have examined common content of local U.S. HAPs and characterized their gaps. *Methods:* This study uses content analysis to identify common strategies and gaps for extreme heat preparedness among written HAPs in the U.S. We obtained plans for jurisdictions that serve municipalities greater than 200,000 residents through web searches, outreach, and materials from prior research. We reviewed, coded, and analyzed plans to describe the prevalence of key

components and strategies. *Results:* Across the twenty-one plans evaluated, plans commonly incorporated activation triggers (100%), heat-health messaging and risk communication (100%), cooling centers (100%), surveillance activities (100%), agency coordination (100%), and at-risk population outreach (95%). Gaps existed in the specific applications of these broad strategies. *Discussion:* Practice-based recommendations as well as future areas of research focus on addressing barriers to cooling center use, increasing targeted strategies for at-risk individuals, expanding the use of surveillance data outside of situational awareness, and planning for concurrent disasters.

Introduction

As many regions in the U.S. experience increases in average temperature due to climate change, the occurrence of extreme heat events has increased in frequency and duration.[1,2] Heat is a dangerous hazard and can also combine with other environmental factors such as ozone and humidity to have catastrophic public health consequences.[3,4]

Extreme heat exposure is associated with increased morbidity and mortality.[5–7] One estimate of the impacts of heat exposure in the U.S. from 2004-2018, included 10,527 deaths or approximately 702 deaths annually.[8] Heat-related deaths are frequently underestimated as the cause of death is often not attributed to exposure to heat.[9] As an alternative to death certificates, Shindell et al. created a generalized risk function for premature heat-related deaths based on the relative risk of 10 U.S. cities.[10] When applied to the rest of the country, the authors estimated that there are 12,000 premature deaths annually attributed to heat in the contiguous U.S.

Exposure to high heat is associated with increased emergency department (ED) visits and hospital admissions and is tied to exacerbations of chronic conditions such as heart disease, stroke, diabetes, intestinal infection, dehydration, and acute renal failure.[11] From May to September, an average of 65,000 people in the U.S. visit EDs due to acute heat illness (e.g., heat exhaustion and heat stroke).[12] Like deaths, this number is likely an underestimate, missing cases in which health conditions have been exacerbated by heat.[12] Due to the increase in morbidity and premature death, heat waves are also associated with high costs. One study of the two-week California heat wave in 2006 estimated total health costs, which included value of lives lost, hospitalizations, ED visits, and outpatient visits, to be $5.35 billion, with the majority of costs associated with premature deaths.[13]

High heat has differing impacts based on population and location. Vaidyanathan et al. found that deaths attributed to heat were highest in males, people aged ≥ 65, non-Hispanic Indian/Alaska Natives and non-Hispanic Black people, and those living in rural and large central metropolitan counties.[8] Other populations most at-risk to heatwaves include people who are socially isolated, unhoused, or experiencing mental, cognitive or other chronic illnesses, young children, and those who work outdoors.[12] Urban areas are of particular concern for heat waves because of the urban heat island effect where an urban area experiences higher temperatures compared to surrounding rural areas due to a variety of factors such as building materials, air pollution, traffic, surface area, decreased vegetation, and wind.[14]

Heat action plans (HAPs) are written documents that help manage actions across multiple organizations to prevent adverse health impacts from extreme heat. HAPs broadly contain strategies such as performing surveillance, providing risk communication, supporting social and health care, establishing cooling centers, distributing water bottles and fans, and creating energy assistance programs.[9,15] The geographic scope, timing, content, and participating agencies and organizations vary between HAPs and depend on factors such as the partners involved in creating and implementing the plans, the capacity and resources available to the lead agencies, and the populations that live within the service territories. HAPs have been shown to decrease heat-related mortality to varying extents, although more research is needed on their evaluation and implementation.[16–18] Often a component of HAPs, Heatwave Early Warning Systems (HEWS) or Heat–Health Warning Systems provide alerts sometimes specifically to at-risk populations on heat risk and preventative actions and are activated by temperature or other weather conditions.[15,19,20]

Guidance on and implementation of extreme heat strategies has evolved significantly over the past 30 years and lessons learned from extreme heat events have been used to inform mitigating policy

interventions and recommendations.[14,21] A series of heat waves in the 1990s that particularly affected cities in the U.S drew attention to the health impacts and gaps in response to extreme heat.[22] After the summer of 1993, the city of Philadelphia, where more than 100 excess deaths had occurred over a 10 day period, instituted the first HEWS to communicate health-related protective actions during heat events.[16,23] Epidemiologic studies of the 1995 Chicago heat wave identified people most at risk of dying and called for more targeted interventions, real-time epidemiologic surveillance, education and outreach, and preparedness efforts.[24–27] Other cities followed suit in adopting extreme heat plans leading Bernard and McGeehin to review response plans from ten cities in the U.S in 2004.[28] Based on the findings from this review, the authors recommended that heat wave planning should be organized around identification of a lead agency, contain activation and deactivation criteria based on weather conditions, and incorporate risk communication, targeting of high-risk populations, data collection, and evaluation and plan revision.

Extreme heat planning and evaluation has not been restricted to the U.S. The 70,000 excess deaths across 12 European countries during the summer of 2003 marked a turning point for European heat response policies.[29,30] Multiple analyses of the content and key characteristics of these policies have been conducted at the country level.[19,31,32] In 2011 as part of a scoping review, Lowe et al. analyzed 12 European HEWS and reported thresholds for triggering early warning systems, common strategies, types of messages and modes of communication, and populations identified as at-risk.[19] The authors recommended monitoring at-risk populations, implementing strategies for people experiencing houselessness, and using multiple platforms for risk communication such as email, text, and phone calls. In 2014, Bittner et al. conducted a review of European HAPs and suggested stronger collaboration between agencies and sectors, as well as incorporating surveillance systems and evaluation processes.[33] Casanueva et al. reviewed HEWS

from 16 European nations and highlighted the importance of the trigger used to prompt heat warnings.[15] The authors recommended inclusion of other meteorological variables beyond the mean or maximum temperature such as the minimum temperature, humidity, wind speed, and solar radiation as well as tailoring triggers depending on the content and context of warnings.[15]

In 2021, Kotharkar and Ghosh conducted a world-wide systematic review of HAPs and found that the majority of literature and guidance on extreme heat planning originated from the U.S. and Europe.[34] Within the last decade, however, South-East Asia, the Western Pacific, and Eastern Mediterranean have made strides in heat management. Notably, Ahmedabad, India developed the first South-East Asian HAP in 2013 after multiple heatwaves in 2010. This plan was associated with reduced mortality after its implementation.[35] Building off lessons learned from the implementation of the Ahmedabad HAP, India's National Disaster Management Authority expanded outreach and assistance in 2021 to 23 states and over 100 cities to develop their own HAPs.[36]

Recently, the 2021 Western North America heat wave drew attention to an area of the country previously unaccustomed to and unprepared for the impacts of extreme heat.[21] In April 2022, record-breaking heatwaves occurred in India and Pakistan as temperatures broke 120° Fahrenheit.[37] The timing of these events during the COVID-19 pandemic underscored the importance of emergency management and public health strategies that are able to adapt to concurrent disasters.

National and international organizations such as the Centers for Disease Control and Prevention (CDC), India's Integrated Research and Action for Development, and the World Health Organization have compiled evidence from the literature as well as lessons learned from previous extreme heat events into guidance documents to direct further policy development and

research.[9,38,39] In 2020, the National Center for Environmental Health, an agency of the CDC, released *Heat Response Plans: Summary of Evidence and Strategies for Collaboration and Implementation* as part of their Climate and Health Technical Report Series which reviewed existing literature and reported local and regional programmatic innovations in the U.S. and identified potential components of HAPs. This report did not rate or compare the effectiveness of these interventions.[9]

Guidance has evolved over the past 30 years, but there has not been an updated review of local U.S. HAPs since 2004.[28] This study focuses on the current application of recommendations from heat response research and U.S. government agency guidance in large U.S. cities and counties during extreme-heat emergencies. We incorporate these observed applications into a new set of recommendations to help guide the future development and revision of HAPs.

Methods

Overview

Leveraging previous extreme heat response research and CDC-released guidance on core components of HAPs, this study adapts legal assessment techniques. Legal assessment is a content analysis process used to identify and record aspects of laws and policies, to identify common strategies and gaps in current U.S. local jurisdictional HAPs.[40] When performed in a systematic and replicable way, legal assessment can create datasets that can be used to generate hypotheses and study associations between policies and population health.[41]

Study Population

For the HAPs in this study, we focused on municipalities with greater than 200,000 residents according to the 2019 Census.[42] To obtain the HAPs, we conducted a web search, targeted

outreach to local health departments and offices of emergency management, and used plans previously obtained by a journalist for their own research.[43] In total, this represented 117 municipalities, an estimated 68 million people or 20% of the total U.S. population.[44] Because of instances where county-level emergency management and public health agencies serve multiple jurisdictions with greater than 200,000 residents, we identified 99 unique jurisdictions for inclusion. This focus was informed by prior research that identified larger municipalities as more likely to have developed HAPs based on their size and available resources.[45] No human subjects data were gathered or reviewed for this study as determined by the University of Washington's Human Subjects Division on August 18, 2020 (STUDY00010935).

Heat Plan Collection

An initial sample of plans from a journalistic source was supplemented with HAPs obtained directly from agencies.[43] We then conducted web searches for heat action plans in jurisdictions with 200k+ residents using key words such as "extreme heat," "heatwave," "heat action plan," "heat early warning system," "heat adaptation," and "public health heatwave management" in addition to the local health department, emergency management division, jurisdiction, county or city name. This strategy did not produce any downloadable plans but did provide the initial sampling frame for surveying agencies about their heat action plans. Additionally, we conducted web searches for documents posted on local government, public health, and emergency management websites by visiting these sites and using the search function with the previously mentioned key words. We then searched the linked web pages for downloadable plans.

We then conducted outreach as part of a national electronic survey that was active from September 2021 to January 2022. Surveys were sent to email addresses of representatives at local health departments and emergency management agencies obtained from agency websites or from

follow-up phone calls, including emergency management directors, health directors or officers, and environmental health or public health preparedness coordinators or planners. While multiple representatives for each jurisdiction were contacted, they were asked to coordinate their responses. In total, we sent four reminder emails beyond the initial contact email and extended the active survey window to incorporate further responses.

We conducted data collection for the survey using the online electronic data collection software, REDCap, which is administered by the University of Washington Institute of Translational Health Sciences. As part of the survey, jurisdictions were asked whether they had a written HAP, policy, or procedure, and were asked to upload their most updated document(s).

Inclusion and Exclusion

Inclusion criteria for documents used for analysis were: 1) Standalone HAPs, standard operating procedures, checklists, protocols or annexes to emergency operation or hazard mitigation plans used for extreme heat emergencies, and 2) Created or updated since 2016.

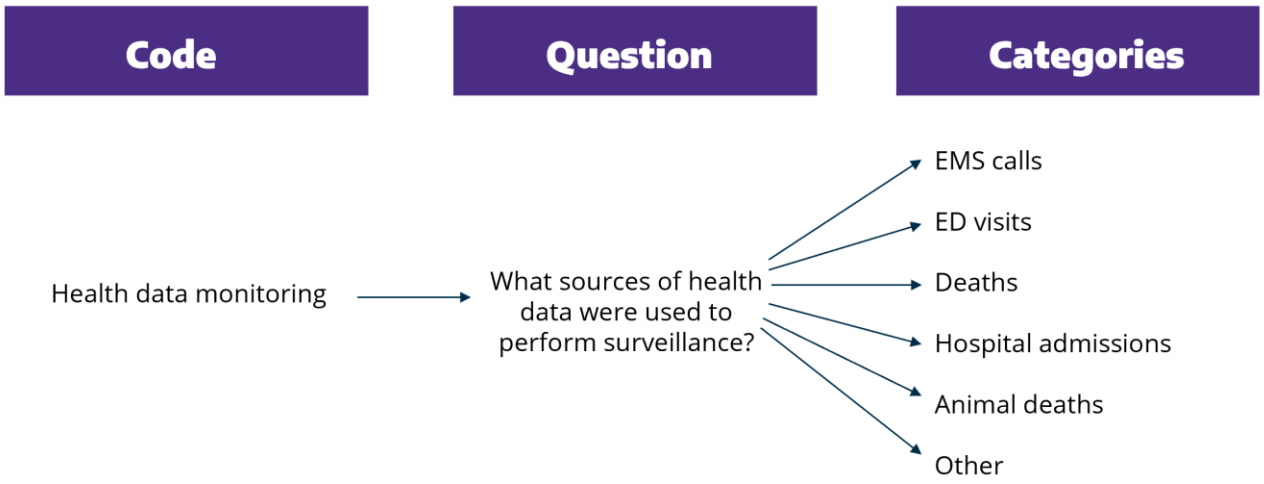
Exclusion criteria were: 1) Emergency operation or hazard mitigation plans that did not include specific actions undertaken to address extreme heat preparedness and response during an extreme heat emergency, or 2) Plans that did not address response to acute extreme heat emergencies but instead focused on long-term planning, such as climate change adaptation.

Content Analysis

We adapted legal assessment and qualitative content analysis techniques and systematically applied categorical classification by coding and identifying answers to coding questions in the text.[47] Coding questions were developed in a binary or categorical format and were linked to specific codes. An example of this process is depicted in Figure 1. Codebook

development to assess these documents proceeded through a combination of methods. The analytical framework and preliminary set of codes were developed through deductive methods using components of HAPs identified by the CDC report and previous research on county-level heat preparedness and response activities.[9,45] After review of a sample of plans, we inductively developed an additional set of codes as well as a set of corresponding coding questions to identify the parts of the plans that deductive codes were not able to capture (e.g., Are cooling center locations predetermined or established ad hoc during emergencies?).[41,48] We used answers to these questions to assess more nuanced details of HAPs.[41]

Figure 1: Development of coding questions from codes



Codes included a definition and directions for use and were applied to HAPs (Appendix A). We documented any revisions or additions to codes and used NVivo for PC software to code the HAPs. When there was ambiguity or there were nuances in the text, records of the coder's decisions were logged in NVivo. Ten percent of HAPs were co-coded by two investigators (J.R. and J.M) independently with results compared and evaluated for discrepancies in order to refine code definitions for future use.[41] Co-coders discussed differences in code application and made

updates to the codebook definitions and examples of application. One researcher (J.R.) coded the remainder of the plans.

Content from within codes was synthesized to illustrate common strategies and gaps in overall plan content.[49] Answers to coding question responses were recorded in a Microsoft Excel database.

Results

Table 1: Characteristics of analyzed plans and jurisdictions

Plan Characteristic	***% (n)***
Type of Plan	
Appendix/Annex	28.6 (6)
Checklist	4.7 (1)
Standalone	66.7 (14)
Year Last Updated	
2016	4.7 (1)
2018	14.4 (3)
2019	42.9 (9)
2020	19.0 (4)
2021	19.0 (4)
Lead Agency	
Office of Emergency Management (OEM)	66.7 (14)
Public Health (PH)	19.0 (4)
OEM/PH	9.5 (2)
OEM/Other	4.8 (1)
Jurisdiction	
City	38.1 (8)
County	42.9 (9)
City/County	19.0 (4)

In total, we obtained and analyzed 21 plans, nine (42.9%) were from prior journalistic research and twelve (57.1%) were from survey responses. We did not identify any plans from web searches. Of the analyzed plans, 14 (66.7%) were standalone, 17 (81.0%) listed the Office of Emergency Management (OEM) as the lead or co-lead of administering the plan, and 13 (61.9%) applied to the county or mixed county and city level (Table 1). While public health agencies had

a role in the implementation of all plans, only six (28.6%) plans listed Public Health as the lead or co-lead agency.

Figure 2 illustrates the geographic distribution of plans included in this study by U.S. Department of Health and Human Services (HHS) administrative regions. Seven out of ten HHS regions were represented in this analysis. Table 2 displays an overview of each of the strategy categories and the number and percent of plans that addressed each of these strategies.

Figure 2: Geographical distribution of analyzed plans by HHS region

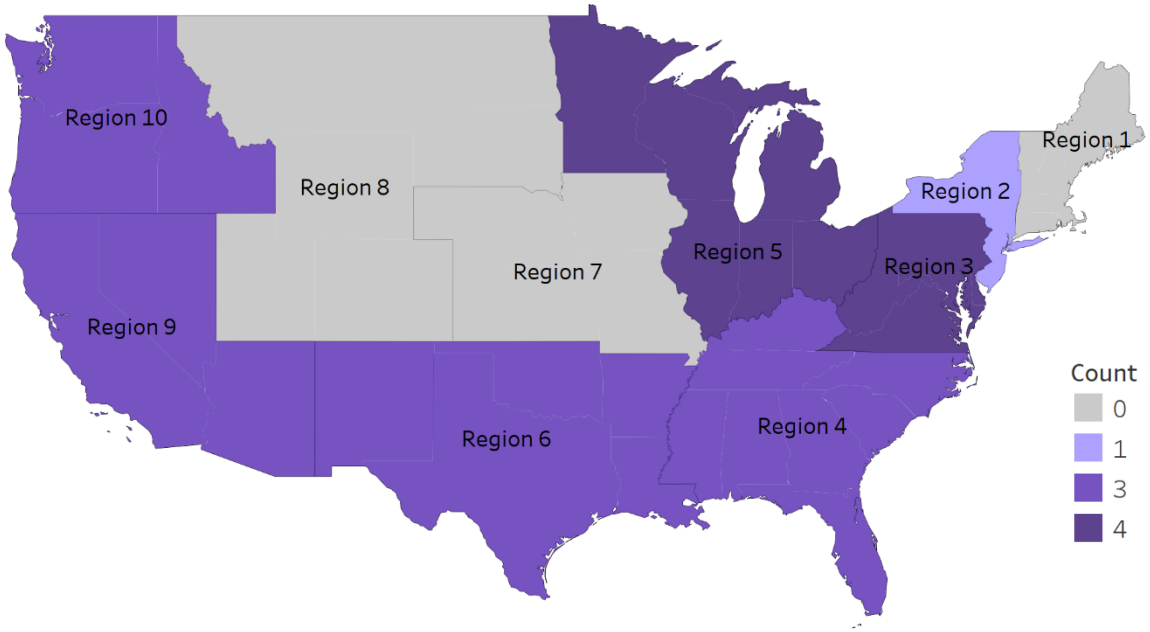


Table 2: The percent and number of plans that included heat action strategies

Strategy	***% (n)***
Scaled Response	81.0 (17)
Plan Termination	38.1 (8)
Risk Communication	100.0 (21)
Surveillance and Monitoring	100.0 (21)
Interagency and Inter-Organizational Coordination	100.0 (21)
Cooling Centers	100.0 (21)
Cooling Shelters	48.0 (10)
Health Interventions	43.0 (9)
Social Care Interventions	66.7 (14)
Targeted Outreach to At-Risk Populations	95.2 (20)
Update and Review	66.7 (14)

Plan Activation, Scaled Response, and Termination

Twenty plans (95.2%) used National Weather Service (NWS) advisories as triggers for plan activation. Seven of these plans used NWS alerts as the sole activation trigger. The other plans combined alerts with other triggers for activation such as epidemiological surveillance thresholds, the heat index, ongoing infrastructure impacts, stakeholder request, animal mortality rates, specific timeframes (e.g., May 1 to initiate risk communication activities or May through October to conduct epidemiologic surveillance). Seventeen plans (81.0%) also included definitions relevant to heat waves such as heat index, extreme heat, heat advisory, excessive heat warning/watch, excessive heat outlook, and heat-related mortality. Most definitions (71.4%) were from the NWS.

Seventeen plans (81.0%) incorporated a scaled response approach in which different levels of agency response were triggered seasonally or based on heat event severity. For example, date-based triggers were used to commence early season risk communication strategies and

epidemiological surveillance activities. Extremely high heat indices were used to trigger the activation of an emergency operating center to coordinate interagency response activities whereas lower heat indices were in some instances used to trigger smaller-scale situational awareness activities between agencies.

Eight plans (38.1%) described response de-escalation either through specific thresholds, such as the expiration or cancellation of heat advisory or excessive heat warnings from the NWS, or deactivation activities such as agency roles and responsibilities and alerting participating organizations and agencies of termination.

Risk Communication

All plans included strategies for communicating risks associated with extreme heat to the public. Recipients of specific communication strategies included at-risk populations (71.4%), community-based organizations (CBOs) (33.3%), government agency staff (33.3%), social and case workers (14.3%), schools and daycare centers (14.3%), healthcare providers (14.3%), and first responders (9.5%). Message content included alerts and warnings, heat safety tips, encouragements to “check in with your neighbor,” reminders to conserve power, and information on service provision such as the locations of cooling centers.

Table 3: Platforms of communication. Percentages calculated only out of plans that identified communication platforms.

Platform of Communication	***% (n)***
Traditional forms of media (tv/radio/news)	83.3 (15)
Call Center	83.3 (15)
Agency Websites	83.3 (15)
Emergency Alert Systems	72.2 (13)
Social Media	66.7 (12)
Email	44.4 (8)
In person outreach	44.4 (8)
Printed Materials (posters, flyers, mailers)	22.2 (4)
Transit billboards	16.8 (3)
Newsletters and Digests	11.1 (2)

Eighteen plans (85.7%) also listed the intended communication platforms for message dissemination (Table 3). The most common forms of communication were traditional media sources such as radio and TV, call centers, government agency websites, emergency alert systems, and social media.

As part of the communication strategy, seven plans (33.3%) included strategies to promote language accessibility in communication materials. Common strategies included creating outreach materials in Spanish or multiple languages, providing closed captioning or sign language for press releases, releasing alerts in plain language according to agency guidelines, or creating information releases in accessible formats.

Surveillance and Monitoring

Table 4: Uses of surveillance data

Use of Surveillance Data	***% (n)***
Situational Awareness	100 (21)
Resource Needs	52.4 (11)
Event Cancellation or Modification	38.1 (8)
Energy Infrastructure Status	26.6 (6)
Reports or Heat Response Review	19.0 (4)
Heat Wave Identification or Plan Activation	14.3 (3)
Demand on Healthcare System	14.3 (3)
Need for Evacuation	4.8 (1)

All plans detailed surveillance or monitoring strategies. However, for two plans, this was restricted to monitoring weather forecasts and NWS notifications rather than in-house data collection. Eighteen plans (85.7%) detailed health data collection, the most common forms of which were ED visits, deaths, hospital admissions, and emergency medical service calls. Sixteen plans (76.2%) explicitly described monitoring weather and other environmental information primarily through the NWS or other weather forecasts. Two

plans also described collecting air quality data. Ten plans (47.6%) included monitoring at-risk populations such as people using shelters and those experiencing houselessness, residents of nursing homes, and people reliant on medical equipment. Plans also described collecting information on cooling center use, fire and police call volume, and utility infrastructure conditions.

Surveillance and monitoring data were most often used for situational awareness during heat events (Table 4). While surveillance methods were used for other purposes related to overall situational awareness during heat events such as resource needs, event cancellation and modification, energy infrastructure status, and the demand on the healthcare system, they were used less frequently after heat events such as in end-of-summer reporting, heat response review, damage assessment, or to track health trends over time.

Interagency and Inter-Organizational Coordination

All plans described coordination between the lead agency and other supporting government agencies (at the city, county, and state, and federal levels) and between the lead agency and non-governmental and private organizations. To manage the coordination between different government agencies and jurisdictions, 16 plans (76.2%) incorporated incident response structures (e.g., the National Incident Management System), or activation of an Emergency Operations Center. Coordination strategies included developing situation reports and hosting briefings, organizing task forces and working groups, pre-establishing points of contact, holding annual and pre-season stakeholder meetings, and using WebEOC or other emergency management software to share information between agencies. These coordination strategies created opportunities for situational awareness, the provision of agency-specific data and identification of concerns, the organization of planning efforts for response and recovery, and the management of resource and mutual aid requests between different organizations, agencies, and levels of government.

Descriptions of coordination between governmental agencies and non-governmental, private, and faith-based organizations involved multi-directional information exchange. The plans indicated that government agencies would provide alerts and updates at the beginning of and during heat emergencies while non-governmental organizations were often described as sources of information for monitoring at-risk populations. Non-governmental organizations were also described as providing services such as staffing cooling centers and conducting door-to-door well-being checks. These activities included communicating resource needs and updates to emergency and public health agencies. Plans described other opportunities for coordination as well, such as development of organizational response plans, inclusion of organizational representatives in task forces, participation in planning activities, and amplifying communication efforts.

Cooling Centers and Shelters

All plans included descriptions of cooling center or shelter implementation. Cooling shelters, meant for overnight stays and most often intended for people experiencing houselessness, were described separately from cooling centers with some plans providing specific definitions for the two. Ten (47.6%) plans referenced cooling shelter strategies such as pre-determined shelter locations and transportation to sheltering sites.

Implementation considerations for cooling centers included provision of resources such as water, seating, first aid, and staffing, as well operational considerations such as finding locations that were accessible for people with mobility impairments. Two-thirds (66.7%) of plans incorporated strategies to provide access to transportation to cooling centers and/or shelters. These strategies included waiving transit fees to cooling centers or providing transportation to specific populations most at-risk for the effects of heat such as those experiencing houselessness, the elderly, or people with disabilities.

Plans described pre-determined locations (42.9%), ad-hoc locations (42.9%), a combination of both (9.5%), or did not specify locations (4.7%) for cooling centers or shelters. Commonly predetermined locations included senior centers, recreation and community centers, buses, libraries, county or city facilities, faith-based or non-profit operated facilities, shopping malls, movies theaters, restaurants and park facilities such as pools, beaches, and spray parks.

Health and Social Care

Ten plans (47.6%) described health system-related interventions such as creating mobile hospitals and clinics, providing first aid and triage at cooling centers and cooling buses at events, stocking appropriate medical supplies for field personnel, providing spiritual and emotional care, requesting additional EMS system capacity, and risk communication to healthcare personnel and first responders. Fourteen plans (66.7%) included strategies for well-being and in-home checks from CBOs, social workers, and other care providers.

Targeted Outreach to At-Risk Populations

All plans identified specific populations most at risk for the effects of extreme heat (Table 4). Twenty plans (95.2%) detailed specific outreach and communication strategies for people at-risk, with 16 plans (76.2%) including one or more general outreach strategies to "at-risk populations" without specifying populations or individuals and 15 plans (71.4%) including one or more outreach strategies to specific populations or individuals (Table 5).

General strategies included partnerships with organizations for communicating risk, identification of at-risk populations, conducting well-being checks, and providing transportation or evacuation to cooling centers and shelters. Specific strategies included water distribution,

financial assistance, building inspections, modification of athletic events, and coordination with school districts.

While five plans (23.8%) explicitly identified low-income residents as at-risk for the impacts of heat, only one plan out of these five incorporated financial assistance programs. Seven plans did not identify low-income residents as a vulnerable population but included financial assistance programs such as suspending utility cutoffs, utility assistance, and distribution of fans or air conditioners.

Table 5: Populations identified as at-risk compared to populations targeted by specific outreach strategies.

At-Risk Population	***% (n) of plans that identify the population as at-risk***	***% (n) of plans that detail strategies for outreach to this population***
Over the age of 65	90.4 (19)	47.6 (10)
Living with Acute/Chronic Illness	90.0 (17)	14.3 (3)
Infants/Children	71.4 (15)	28.6 (6)
Experiencing Houselessness	71.4 (15)	57.1 (12)
Living without Air Conditioning	47.6 (10)	28.6 (6)
Socially Isolated	42.9 (9)	0 (0)
Working Outdoors	42.9 (9)	19.0 (4)
Homebound/Mobility Impaired	38.1 (8)	14.3 (3)
Athletes/People who Exercise Outdoors	33.3 (7)	9.5 (2)
Living with Mental Illness/Cognitive Disorders	28.6 (6)	0 (0)
Taking Certain Medications	28.6 (6)	0 (0)
Low-Income	23.8 (5)	38.1 (8)
Access or Functional Needs	19.0 (4)	0 (0)
Under the Influence of Drugs or Alcohol	14.3 (3)	0 (0)
Pregnant	14.3 (3)	0 (0)
Living in a Nursing Home	9.5 (2)	0 (0)
Limited English Proficiency	9.5 (2)	19.0 (4)
Living on Upper Floors	9.5 (2)	0 (0)
Tourists/Out of Town Guests	9.5 (2)	0 (0)
Undocumented Immigrants	4.7 (1)	0 (0)

Update and Review

Two-thirds of plans (66.7%) described processes for update and review such as updating plans (61.9%), conducting staff or responder training before heat events (28.6%), or conducting post-event review (28.6%). One plan conducted all three of these processes, while nine plans conducted two of these processes. Of the plans that included update procedures, the timing of plan updates varied with about half occurring annually (53.8%), and the others occurring every two years (7.7%) or three years (7.7%), after an event (23.0%), or unspecified (30.8%). Three plans (23.0%) performed updates both after a set of interval years and after an event. Post-event review took the form of after-action discussions, after action reports, hotwashes, and improvement plans. For the plans that did have post-event review, four plans (66.7%) specified incorporating surveillance data into this review process.

Discussion

As heat waves threaten the health and wellbeing of residents in many regions of the United States, HAPs at the local level can bridge the gap between research and practice by incorporating evidence-informed strategies and play a key role in guiding multi-organizational response during extreme heat emergencies. The HAPs reviewed in this study included many of the recommendations from previous research on heat response as well as CDC guidance. Most if not all plans identified a lead agency, provided activation triggers, and described strategies for heat-health messaging and risk communication, cooling centers, surveillance activities, at-risk population outreach, and agency coordination. While plans incorporated most major categories of strategies, applications of these strategies as well as the inclusion of implementation and evaluation components varied. Based on these observed differences between plans we have developed a set of recommendations for the development and update of future HAPs.

While many plans incorporated varied platforms for risk communication ranging from traditional media sources to social media, only 33% of plans included language accessibility in their risk communication strategies and only 9.5% of plans identified people with limited English proficiency (LEP) as at-risk for extreme heat, despite previous research indicating LEP as a risk factor for poor outcomes during disasters.[50] The Federal Emergency Management Agency's whole community approach to disaster management emphasizes knowledge of commonly spoken languages and modes of communication to better understand the needs of the communities within jurisdications.[51] To specifically address LEP, this approach recommends engaging partners such as CBOs, faith-based organizations, community leaders, and advocacy groups. These groups may provide appropriate language translation services or become a trusted source of information that is disseminated through informal networks.[52] This latter benefit is crucial for people with LEP given prior research that has shown that an estimated two million individuals with LEP are not served by traditional forms of media in their native language and that informal networks for relaying information may be especially important during disaster situations.[53–55] While outreach and partnerships with CBOs may not be detailed in plans, future plan updates may identify specific LEP communities within jurisdictions, ensure that key risk communications are translated in a culturally relevant way, and that platforms of communication adequately reach LEP individuals.

All plans identified specific at-risk populations, the most common of which were people who are elderly, people living with acute or chronic illness, infants and children, and people experiencing houselessness. Strategies that named specific at-risk populations were most often aimed at the elderly or experiencing houselessness. Given that other populations are also commonly at risk or need to be included in risk communications, opportunities exist for more specific outreach strategies. For example, only two plans described risk communication to

healthcare providers, who can act as trusted sources of information for their patients, and may provide more targeted outreach to otherwise underserved people with acute or chronic illness, mental illness or cognitive disorders, or taking certain medications.[56]

Plans were mixed in addressing barriers to accessing commonly provided services during heat emergencies. Prior research has suggested that lack of or difficulty accessing transportation is a barrier to cooling center use. CDC guidance recommends that strategies must be paired with cooling center implementation to increase effectiveness.[9] The provision of transportation to cooling centers illustrates this recommendation. While two-thirds of plans included transportation strategies, only half did not include restrictions regarding who could access to this transportation. The other strategies were specific to particular at-risk populations such as those who are elderly, have a disability, or are experiencing houselessness. The plans that made transportation available to the public employed strategies such as waiving transit fees to cooling centers.

Plans lacked discussion of processes for selecting cooling center sites to maximize accessibility for at-risk populations. Mapping cooling center locations can provide planners with information necessary to assess for accessibility.[57–60] The CDC recommends inclusion of mapping into plans such as the locations of urban heat islands or demographic characteristics.[9] Only one jurisdiction incorporated geographical analyses into their plan. Inclusion of mapping into future planning efforts may require partnerships between local, state, and federal agencies and academic institutions. Data and tools necessary for mapping may already be available through state and federal agencies. For example, the HHS emPOWER dataset provides geospatial information on Medicare beneficiaries that are reliant on electrically powered medical and assistive equipment and the National Integrated Heat Health Information System's Urban Heat Island Mapping Campaign provides assistance to communities in mapping their urban heat islands.[61,62]

Research has also identified stigma associated with cooling centers as a barrier to use based on assumptions that cooling centers are meant for people who are elderly or are experiencing houselessness.[63,64] Approaches to addressing this stigma were not readily apparent in the plans. To address the most common barriers to cooling center use, future plan updates can acknowledge these barriers and, to address stigma specifically, modify education and outreach strategies to clarify that cooling centers are meant for anyone without access to air conditioning. Ad-hoc locations that people already frequent outside of emergencies such as community centers, movie theaters, and park facilities can also help reduce the stigma of cooling centers.[64] Further research and evaluation is needed to identify the strategies best used to address stigma.

While all plans included strategies for surveillance and monitoring, few described pathways to use this information to inform implementation activities or for plan evaluation. The CDC recommends that epidemiological surveillance be used to determine people, places, and times that experience the greatest impacts from heat.[9] These data are useful to inform planning efforts and other components of HAPs such as thresholds for activation, update, and review. Epidemiologic data has been used by academic institutions and jurisdictions in collaboration with the NWS to revise heat advisory levels.[65–67] These uses of surveillance data occur outside of active emergency situations, yet current applications focus on immediate use for situational awareness. Use of surveillance system data for planning and recovery efforts presents an opportunity to increase and bolster plan monitoring and evaluation, a neglected component of HAPs. Effective use of surveillance data after a heat emergency, at the end of the summer, or during regularly schedule updates in local plans may require the development and dissemination of guidance and templates as well as technical assistance from state and federal agencies or national associations. Use of this data presents opportunities for public and academic partnerships. For example, Phillips

et al. identified mobile home park residents as most at risk of heat-related morbidity and mortality in Maricopa County using spatially granular data provided by the county health department. They found that these residents were also underserved by financial assistance programming before and during heat emergencies.[68] Partnerships formed during this engaged research process led local agencies and organizations to re-examine their financial assistance programs.

The ongoing COVID-19 pandemic as well as the increasing frequency and severity of weather hazards due to climate change has demonstrated the necessity of integrated planning for concurrent emergencies and disasters. Some events, such as wildfires and associated smoke, are more closely linked to extreme heat. Concurrent emergencies, such as pandemics and wildfires, are of particular interest because there may be conflicting guidance and public health interventions with strategies for extreme heat. For example, pandemic guidance to stay home and socially distance may conflict with congregate cooling centers, and for some, COVID-19 has created fear of public spaces.[69,70] Similarly, interventions for wildfire smoke such as closing windows and doors may conflict with guidance for home cooling during extreme heat events.[71] While some organizations have begun to issue guidance for concurrent emergencies, additional research and evaluation is necessary to assess their effectiveness and explore unintended consequences. The CDC has developed guidance on operating cooling centers during the pandemic that can be incorporated into future plan updates.[69] Additionally, state and federal agencies may adapt and disseminate guidance to jurisdictions on modifying programming and communication materials for other concurrent emergencies.

Notably absent in the HAPs analyzed were long-term planning strategies such as building green roofs or performing tree canopy assessments to strategically plant trees which the CDC recommends as a component of HAPs. This may be likely due to the emergency response focus of

the plans.[72] These strategies may be housed in hazard mitigation or climate change adaptation plans. Partnerships at the local level between emergency management and city planning and sustainability are an important component of extreme heat response. Additional research is necessary to explore integration of such longer-term planning strategies in hazard mitigation and climate change adaptation plans.

Our study included only plans available online and shared by local jurisdictions. The COVID-19 pandemic likely limited the capacity of local health jurisdictions to respond to our survey and provide their HAPs. This convenience sampling approach limits the generalizability of our results to other jurisdictions; however, the key strategies and gaps identified through this analysis were from the plans of large, well-resourced jurisdictions expected to have been the farthest along in terms of plan development. This study sheds light on strategies planned by jurisdictions that have the resources and staff to address extreme heat programming and can inform future research focused on regional variations between urban and rural jurisdictions as well as different geographical areas of the U.S. Due to the limited sample size of plans included in this study, more granular statistical analysis between regions was not possible.

Plans included in this study may also not be the most recent plans or inclusive of all heat adaptation activities within a given jurisdiction. Some plans included in this analysis were gathered by a journalist in 2019. While we also reached out to these same jurisdictions to provide their most up-to-date plan through our survey, none responded with a more recent plan. Moreover, plans may not reflect all extreme heat programming performed by jurisdictions or changes in policies especially considering the impacts of the COVID-19 pandemic. Notably, while our assessment identifies strategies included in plans, our methods preclude assessment of prior implementation, implementation readiness, or effectiveness of the strategies. Future research is needed to assess

implementation, as well as to draw connections between HAPs, their component strategies, and public health impacts.

Finally, plans that were not specific to heat, such as comprehensive emergency management plans, were excluded. Strategies outlined in these plans, such as mass care, may have application in heat emergencies but were excluded as the conditions and extent to which these strategies would be employed during a heat emergency were not apparent.

Conclusion

Heatwaves are deadly, climate-driven disasters with unequal impacts throughout society. HAPs are a policy tool that engage multiple stakeholders in extreme heat planning processes and can help guide response during emergencies. This study provides insight into the current strategies and gaps in jurisdictional extreme heat planning in the U.S. While many plans incorporate components identified by prior research and government guidance, opportunities exist to increase language accessibility, implement more strategies targeted to specific at-risk groups, address barriers to cooling center use, incorporate surveillance data into planning, and include considerations for concurrent disasters. Responsive plan updates can be accomplished through partnerships, the development of new guidance and templates, and technical assistance.

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procedures; 3) automated export procedures for seamless data downloads to common statistical packages; and 4) procedures for importing data from external sources.[46] REDCap at ITHS is supported by the National Center For Advancing Translational Sciences of the National Institutes of Health under Award Number UL1 TR002319. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health. Special thanks to Joanne Medina for her assistance in the co-coding phase of the analysis.

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Appendix A: Codebook

Code	Subcode	Definition	Instructions
Surveillance		Describes any action to monitor data before or during declaration of a heat emergency (subcodes include health, at-risk population, weather, other hazards)	Code mention/subsection of any data monitoring and reporting as well as details on activation of monitoring if this is not done constantly. Code the specific data source, information collected, as well as the office/entity to which this data will be reported. Code any uses of this data. Code specifics on alerting requirements

Surveillance	Health data monitoring	Describes actions to monitor, assess and report health data. Could include emergency room data, 911 calls, death certificates, pediatric urgent care.	Subcode any sections in the surveillance/monitoring/reporting code that pertain to health data monitoring and reporting. Subcode the source of data as well as the information collected
Surveillance	Weather monitoring	Describes actions to monitor and report weather data. Data most often originates from National Weather Service or NOAA.	Subcode any sections in the surveillance/monitoring/reporting that pertain to weather data (special weather statements, short term forecasts, advisories/warnings)
Surveillance/ monitoring/ reporting	Other hazards	Describes actions to monitor other hazards that may combine with excessive heat to exacerbate health effects (ex. Ozone/poor air quality)	Subcode any sections in the surveillance/monitoring/reporting that pertain to hazards other than high heat
Surveillance/ monitoring/ reporting	At-risk populations monitoring	Describes actions to monitor and report data on at-risk populations.	Subcode any sections in the surveillance/monitoring/reporting that pertain to at-risk populations.
Review/ evaluation		Describes any action that the managing agency takes to evaluate the effectiveness of the plan as well or to review/update the plan.	Code mention/subsection how often the plan is updated and any specifics on studying effectiveness of plan.
Heat wave definitions		Describes how the plan defines a heat wave including information on the source of this definition and any factors that are incorporated into the definition besides temperature.	Code mention/subsection on definition of heat wave or any other emergency heat states as well as the origin of this definition.
Heat wave definitions	Source of definition	Describes the source of the plan's heat wave definition.	Subcode the source of the heat wave definition (could include NOAA, state-wide, city-specific heat health watch systems, other)
Adaptation to climate change		Describes any actions in the plan to adapt to climate change.	Code specific actions related to climate change rather than only the mention of worsening conditions due to climate change.

Health interventions		Describes any specific actions in the plan to address health consequences of heat emergences.	Code any mention/subsection on specific actions, beyond the mention of the types of health consequences, other than opening cooling centers (could include preparing health services, opening up health clinics, having front line health workers such as health and social service providers reach out to clients/patients during extreme heat)
Needs assessment		Describes any action to conduct a needs assessment before, during, or after the declaration of a heat emergency.	Code the mention/subsection that describes conducting a needs assessment. Include information on when the needs assessment is conducted, which agency is responsible for conducting, where the agency will conduct the assessment, and any specifics on what they will assess.
Outreach or education		Describes any action to conduct outreach or education to the public on heat emergencies before, during, or after an emergency is declared. Also includes any coordination with the state.	Code who was targeted (at-risk populations, healthcare workers, people who work with the homeless, the state), specific actions performed or information disseminated, and how the plan defines at-risk populations. Actions include water distribution, well-being checks, door-to-door contacting
Outreach or education	At-risk populations actions	Describes any action specifically for outreach to at-risk populations as well as how the plan defines at risk populations	Subcode any sections from the outreach or education to the public code pertaining to at-risk populations. Include which populations are defined as at risk and what specific actions are aimed at at-risk populations
Outreach or education	Interagency coordination	What are the names that the managing agency is coordinating with (e.g. the state, federal or other local agencies and organizations)	Subcode any sections from the outreach or education code that pertain to coordination with the state or other agencies. Include specific actions and descriptions of how this is done.
Outreach or education	Communication of risk	Describes any action to provide information to the public on extreme heat	Code mention/subsection describing the platform of distribution, languages materials are provided in, specifics on information communicated, activation of communication, and specifics on educational programs.

Outreach or education	Communication platforms	Describes the platform on which information about heat emergencies is distributed to the public.	Subcode any sections in the communication of risk code pertaining to platform of communication. Could include Social media, News alerts, City homepage, Press conference, Text alert system, Flyers and posters, Email messages, Joint events with other groups, Telephone hotlines, Door-to-door campaigns, Telephone calls, other.
Outreach or education	Language	Describes the languages that outreach materials are provided in.	Subcode any sections in the communication of risk code pertaining to language of outreach materials.
Cooling Centers		Describes actions specifically involving activation of, opening, running, and closing cooling centers during a heat emergency. Could include information on locations for cooling centers, description of any extended hours, services provided at cooling stations, staffing of cooling stations, number of centers, facility requirements, operational requirements, agency responsible for setup and maintenance	Code any mention/subsection on activation and operation of cooling centers.
Cooling Centers	Locations/criteria	Describes any specifics on cooling center locations or criteria for these locations.	Subcode any sections from the cooling centers code that describes location.
Cooling Centers	Services	Describes any services (beyond providing a cool space) given at cooling centers (could include providing water, place to lie down etc.)	Subcode any sections from the cooling centers code that specifies any services provided beyond cooling.
Cooling Centers	Providing transportation	Describes any transportation the city/county provides before/during/after a heat emergency. This transportation is usually to a cooling center and is usually provided to at-risk populations	Code the mention/subsection that describes who will provide transportation, to whom they will provide transportation, and where they will provide transportation.

Activation of heat plan	General/Process	Describes the prompt for activating the heat plan, who activates the plan as well as any advisories/warnings for the city/county, and criteria for terminating the plan	Code mention/subsection for the prompt for activating heat plan, any tiered responses within the plan to different temperature thresholds (include what the threshold is and the levels of response), who activates advisories/alerts.
Activation of heat plan	Tiered response	Describes any differences in response based on specific levels of temperature	Subcode the activation of heat plan code for mention/subsection of a temperature dependent tiered response, activities associated with each response, and temperature (or other) thresholds. Include details such as cancellation of outdoor events.
Activation of heat plan	Termination of plan	Describes the events that lead to the termination of the plan including specific actions or thresholds.	Subcode the activation of heat code plan for mention/subsection on terminating the heat plan (associated actions and triggering events).
Assistance with relocation		Describes any specific actions to relocate people during the heat event. Might include where to relocate, who relocates, who is relocated besides transportation, financial, cooling centers	Code any mention/subsection on relocating people or other actions taken to assist people (besides, transportation, financial, cooling centers). Include mentions of specific populations that are helped as well as the triggering events to relocate people
Assistance with relocation	Sheltering	Describes any specific actions to provide shelter during a heat event	Subcode the assistance with relocation code for specifics on providing shelter (shelter location, triggering events, agency responsible) as well as any mention of sheltering for special populations (e.g. homeless population)
Assistance with relocation	Electrical outages	Describes any relocation assistance due to power outages.	Subcode the assistance with relocation code for mention of relocation during power outages. Include who is relocated, who does the relocating, where people are relocated and triggering events.
Financial assistance		Describes any financial assistance provided to individuals before, during, or after a heat emergency. Might include help paying utility bills, help purchasing a fan or air conditioner, other	Code any mention/subsection on financial assistance for individuals. Include specifics on help with utilities (preventing disconnection, paying bills), and items (rather than financial assistance) provided to individuals

Financial assistance	Utilities	Describes any action taken by the city/county to suspend disconnection of power and/or other utilities during a heat emergency, or to help pay utility bills.	Subcode the financial assistance code for specifics on preventing disconnection of utilities. Include the agency responsible for outreach to the power company, any triggering events, and when this is lifted.
Financial assistance	Personal fans/air conditioners	Describes any fans/air conditioners the city/county provides for individuals before or during declaration of a heat emergency.	Subcode the financial assistance code for the specific item provided (fan/air conditioner), who provides, to whom do they provide, triggering events.
Financial assistance	Other financial assistance	Include any other actions to provide financial assistance other than assistance described in other codes.	Subcode the financial assistance code for specifics on any assistance other than monetary
Staff changes		Describes any staff changes before, during, or after a heat emergency.	Code any new hiring or training for staff during or before heat emergency, specifics on training, positions that will be hired
Staff changes	Staff hiring	Describes new staff that is hired because of a heat emergency (could be before, during, or after)	Subcode the staff changes code for specifics on staff hiring. Include the agencies that will hire, the positions to be filled, whether permanent or temporary, triggering events.
Staff changes	Staff training	Describes any efforts to train staff (at lead agency and/or health department) before, during, or after a heat emergency.	Subcode the staff changes code for specifics on the staff that is trained, what training is provided, when the training is provided, who performs the training.
Lead Office		Describes office or agency coordinating implementation of plan	
Health department		Describes any roles or responsibilities of departments of health	Code health department roles and responsibilities. Co-code with other codes such as cooling centers, surveillance, outreach or education.
COVID-19		Describes any changes made to the plans that relate to COVID-19.	May apply to operation of cooling centers, home wellness checks or other in-person services
At-Risk		Describes any populations identified as vulnerable or at-risk	Generally, at the beginning of the plan. May be coded-separately than the sub-code at-risk populations actions.

Appendix B: Coding Questions

Coding Question	Type	Categories	Associated Code
Scaled response?	Binary	Yes/No	Tiered response
Termination of response?	Binary	Yes/No	Termination of plan
Transportation to cooling centers and shelters?	Binary	Yes/No	Providing transportation, Assistance with relocation
Role for the Health Department?	Binary	Yes/No	Health department
Follow an incident response structure?	Binary	Yes/No	Incident Response Structure
Staff training?	Binary	Yes/No	Staff training
Interagency or interorganizational coordination?	Binary	Yes/No	Interagency coordination
Use of cooling centers?	Binary	Yes/No	Cooling centers
Use of cooling shelters?	Binary	Yes/No	Sheltering
Health interventions?	Binary	Yes/No	Health interventions
Social care interventions?	Binary	Yes/No	At-risk populations actions, Communications of risk, Communication platforms
Targeted outreach to at-risk populations?	Binary	Yes/No	At-risk populations actions, Financial assistance, Sheltering, Providing transportation
Perform plan update?	Binary	Yes/No	Revew_evaluation of plan
Perform plan review?	Binary	Yes/No	Revew_evaluation of plan
Communication materials provided in other languages?	Binary	Yes/No	Language
What is the source of the activation triggers?	Categorical	NWS alerts, date, epidemiological thresholds, heat index, stakeholder request, animal mortality rates, power outages, other	Activation, Tiered Response
What cooling center locations were identified by the plan?	Categorical	Senior Center, recreation center, bus, library, government facility, faith-based/nonprofit, community/day/recreational center, shopping malls/movie theater/restaurants, park facilities, schools, senior center, pool, other	Cooling center, Location criteria

Are cooling center locations ad-hoc or predetermined?	Categorical	Ad-hoc, predetermined, both, unspecified	Cooling center, Location criteria
To whom is transportation to cooling centers or shelters offered?	Categorical	People experiencing houselessness, people who are elderly, people with disabilities, all, other	Cooling center, Providing transportation, Assistance with relocation
In what form was financial assistance provided?	Categorical	Utility moratorium, financial assistance, AC/Fan distribution	Financial assistance, Utilities, Personal fans or air conditioners
What was the source of heat wave or other heat related definitions?	Categorical	NWS, CDC, NOAA	Heat wave definition, Source of definition
How often were plan updates conducted?	Categorical	Annual, 2 years, 3 years, post-event, not specified	Review_evaluation of plan
What forms of surveillance or monitoring information were gathered?	Categorical	Health, Weather, At-risk, Other	Health data monitoring, Weather monitoring, At-risk populations monitoring, Other hazards
What "other" forms of data were monitored?	Categorical	Cooling centers, utility system conditions, first responder calls, 311/211 call volume, available hospital beds, other	Other hazards
What sources of health data were used?	Categorical	EMS, ED, deaths, hospital admissions, animal deaths, other	Health data monitoring
How was surveillance and monitoring data used?	Categorical	Resource needs, reports/event review, situational awareness, utilities, load on healthcare system, tracking over time, damage assessment, evacuation, heat wave ID/activation, event cancellation	Surveillance_monitoring_reporting
What strategies for coordination between agencies were used?	Categorical	Situation reports, briefings, task forces, working groups, points of contact, stakeholder meetings, WebEOC, other	Interagency coordination
What strategies for coordination between lead agency and organizations were used?	Categorical	Response plans, task forces, planning activities, other	Interagency coordination

What languages were communication materials provided in?	Categorical	Spanish, Sign language/closed captioning, other	Language
What platforms for communication were identified?	Categorical	Alerts, traditional media, printed material, call center, email, social media, websites, newsletters, text/phone, in person, transit	Communication platforms
Who were communication materials aimed at?	Categorical	At-risk, social/case workers, daycare centers/schools, community-based organizations, first responders, agency staff, medical facility/healthcare providers, other	Communications of risk
Who was identified as at-risk?	Categorical	Over age of 65/elderly, acute/chronic illness, infant/child, houselessness, no AC, socially isolated, working outdoors, homebound/mobility impaired, athletes, mental illness/cognitive disorder, medications, low-income, access/functional needs, drugs/alcohol, non-English speaking, living on upper floors, tourists, undocumented	At-risk
What populations were recipients of direct outreach?	Categorical	Over age of 65/elderly, acute/chronic illness, infant/child, experiencing houselessness, no AC, working outdoors, homebound/mobility impaired, athletes, low-income, non-English speaking	At-risk population actions, financial assistance, providing transportation, assistance with relocation
Who were recipients of communication strategies?	Categorical	At-risk populations, CBOs, Staff, Social/Case Workers, Schools/Daycare, Healthcare providers, First responders, other	Communications of risk