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California Heat & Health Project

A Decision Support Tool



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All errors, omissions, corrections needed are solely the responsibility of the authors.

Executive Summary

Introduction

California is facing a warmer climate over the next century. More frequent and severe heat events will pose considerable health risks to our communities and, in particular, to the state's most vulnerable populations. There is growing evidence that the character of heat waves in California is also changing. Heat events are becoming progressively more humid, lasting longer than average, and occurring in areas not accustomed to heat waves. Based on current climate change projections, a typical California summer in 2100 is predicted to be 4-5°F warmer than today, and extreme heat days are predicted to increase from currently around ten a year to 25-50 by 2050, and upwards of 100 by the end of the century. As heat waves grow more deadly and prevalent, California residents will encounter more health risks, and the most vulnerable populations will experience the worst impacts.

Climate change will also challenge the efficacy of traditional intervention strategies, and local agencies may struggle to effectively mitigate heat health impacts. The extent to which heat impacts health and well-being will largely be determined by the ability to commit local resources and capacity to implement interventions and raise public awareness.

California's Fourth Climate Change Assessment and Heat Health Impacts

Within this context, California recently began the state's Fourth Climate Change Assessment¹ – a state-mandated research program to assess climate change impacts in California. Better understanding the public health impacts of climate change is one of the state's identified priorities. This research project was undertaken as part of California's Fourth Climate Change Assessment, with the goal to identify what type of decision support tool can best support local public health and emergency preparedness stakeholders to better manage and mitigate the public health impacts of extreme heat. This first phase of the project combined an extensive literature review and a User Needs Assessment (UNA) to better understand local policies and processes in responding to extreme heat events and the current tools and resources stakeholders use to inform their planning and response activities. The project included numerous key informant interviews, a survey of over 100 local health and emergency preparedness stakeholders, and an extensive literature review.

Heat Planning Processes

The ability to anticipate and mitigate heat-related illness and death requires coordinated planning and response across both public health and emergency management agencies at the local level. Current planning processes related to extreme heat are fragmented and inconsistent across counties, leading to response processes that differ widely based on the level of resources and capacity within each region. California's policies and protocols for emergency response provide guidance for local agencies to

¹ California produces periodic scientific assessments on the potential impacts of climate change in California and reports potential adaptation responses. Required by [Executive Order #S-03-05](#), these assessments influence legislation and inform policy makers. For more information on California's previous climate change assessments please visit:

http://www.climatechange.ca.gov/climate_action_team/reports/climate_assessments.html

develop successful extreme heat response plans. Yet, responsibility for managing and mitigating the public health impacts of extreme heat events rests entirely with local agencies and no one person or agency is responsible for developing and implementing that response. While informed, localized planning and response is necessary to improve health outcomes during a heat event, many California regions lack critical resources and capacity to proactively plan for and organize an effective response.

Current Heat Alerts

The National Weather Service (NWS) issues a regional heat alert when the daytime high nighttime low heat index exceeds a specific threshold for a given region. The threshold levels used for issuing these alerts have been called into question. Historically in California, heat-related illnesses and deaths have been reported in the absence of heat alerts being issued (Guirguis et al., 2014). When heat alerts are issued, they currently reach multiple local practitioners in a number of formats but, the decision to declare a heat emergency and activate a local response is a complex one. While it is undeniably shaped by individual perceptions of urgency and the severity of potential health implications, this choice is largely dependent upon the willingness and ability of local practitioners and officials to commit the necessary resources to mitigate the health impacts of extreme heat. Perceptions and readiness are influenced by a wide array of competing local priorities – many of which are also linked to climate impacts – that necessarily take precedence over planning for, and in some cases, responding to extreme heat events.

Heat Health Interventions

Additionally, when a local response is activated, there is only so much that public health and emergency preparedness practitioners can practicably do to mitigate heat health impacts. Key priorities and common interventions include alerting the public of the risks and suggested precautions through multiple communication channels. If a jurisdiction has the resources to provide cooling centers or to mobilize a team to check on individuals who the county has determined may be vulnerable to heat illness, then these actions can also be taken. However, the most effective precautions necessitate significant changes in behavior and disruptions to daily routines that many California residents do not always have the luxury to adopt. Making the decision to take steps to protect individual and family health based on warnings and alerts assumes a level of trust in government that some public health practitioners cite as lacking or declining in multiple regions of California. These interventions also require not only access to cool spaces and quality drinking water but, importantly, they demand that individuals have the time and ability to access these interventions. Therefore, these interventions are unlikely to reach all affected populations equally and effectively.

Part of the behavior change challenge is the need to raise public awareness about the severity of the potential health implications of extreme heat, and the medical, social, environmental and economic conditions that pre-dispose them to heat vulnerability. Effective short term response solutions must include information and access to resources but also strive to enable individuals to take advantage of the short-term interventions that are most effective in preventing heat illnesses. Understanding of the multifaceted economic, social and environmental barriers to behavior change is key to raising awareness about the exigence of mitigating heat health illness and death in California. This understanding should then inform and help prioritize efforts to develop longer term interventions, such as those that address

opportunities to cool the built environment and increase accessibility to cool spaces, especially in areas where vulnerable individuals and populations are located.

Key Findings from the Literature Review and User Needs Assessment

- **Extreme heat will continue to negatively impact public health, especially for California’s most vulnerable individuals, regions and populations.**
 - Changing climatic conditions point to increased extreme heat events in California and poor health outcomes.
 - Populations and individuals most susceptible to heat illness and death include the elderly, children, low-income households, those with pre-existing medical conditions and residents who are socially and linguistically isolated within their own communities.
 - Regions that are especially vulnerable to extreme heat include those California communities not currently acclimatized to increased temperatures and heat events but who will experience increased high heat days, such as coastal communities.
 - A number of studies have found strong spatial correlations between the built environment, socioeconomic vulnerability, and heat mortality, implying that communities of color and low-income populations are disproportionately exposed to heat-island risk factors.

- **Although the public health impacts of extreme heat events are well documented, many regions in California are not prioritizing extreme heat as an urgent risk to public health.**
 - All disasters are local: While the state provides guidance and can provide support when requested, the organizational and financial burden of planning for and responding to extreme heat is placed on local agencies.
 - Many of the regions who are vulnerable to the health impacts of extreme heat are the least able to plan for and respond to this hazard given a lack of local resources and capacity, competing priorities and a lack of urgency
 - Many counties that have experienced extreme heat events and heat-related illnesses have never declared a heat emergency nor activated a local response

- **Heat response is very decentralized and inconsistent from county to county with multiple decision centers with loose coordination. Responsibilities for both planning and response are spread across multiple agencies and multiple plans with no clear “owner”.**
 - Roles and responsibilities in the aftermath of a heat event are contingent upon the organizational structure of county agencies as well as on whether extreme heat has been prioritized as a hazard of concern.
 - Proactive, coordinated long-term planning that integrates extreme heat as a hazard of concern into local planning processes is key to mitigating the public health impacts of extreme heat
 - More research is needed to evaluate the effectiveness of both long- and short-term interventions in both rural and urban settings. We also need to better understand how long-term interventions that focus on improving the heat resilience of the built

environment could enable improved short-term interventions (e.g. less need for/reliance on air conditioning).

- **There are multiple, complex barriers to improving health outcomes during and following an extreme heat event.**
 - Given that many short-term solutions require disruptions to daily routines, avoidance of outdoor work and relocation to cool spaces, the most vulnerable populations often have less ability to change their behavior to adopt these precautions.
 - A key challenge consistent in many regions in California is a lack of sufficient resources and capacity to proactively plan for and respond to extreme heat events.
 - Heat alerts are improving but are just one piece of a complex decision-making process that may or may not lead to effective local response.
 - Economic inequities play a significant role in determining what actions individuals can take to protect their own health and the health of their families. Low-income residents and those living in poverty do not have equal access to potentially life-saving resources such as air conditioning or potable drinking water.

- **Short-term response activities are limited in scope and prioritize communication and outreach to vulnerable communities but do not always address equitable access to resources.**
 - Heat-related illness surveillance systems, which enable the ability to track, monitor, and evaluate real-time impacts of heat are not widespread
 - One of the most common and effective short term interventions – increased use of air conditioning – increases vulnerability to heat-induced power outages and can worsen global climate change conditions by increasing greenhouse gas emissions
 - Access to in home air conditioning and/or cool public spaces is not widespread in California with many low-income residents facing economic barriers that prevent them from using air conditioning during a heat event

- **Local agencies need to develop successful short-term interventions and policies that focus on raising awareness *and* enabling all community members to actually take these precautions.**
 - This may require additional participation and support from agencies outside of public health and emergency management to provide subsidies for energy and water use as well as to support energy assurance.
 - Short-term response solutions are very limited and their overall effectiveness is variable. Therefore, even if local agencies are doing exactly what they are supposed to do, it may not be enough to mitigate heat-related illnesses.
 - While many counties work with Public Health and other departments to identify individuals who are most vulnerable to heat illness, it remains very difficult to identify and conduct effective outreach to all of these individuals

Conclusion and Proposed Tool Design

Our research shows that the threshold levels used for issuing heat alerts are often inadequate, but short-term response activities are not directly hindered by insufficient heat alerts from the National Weather Service (NWS). Instead, the efficacy of on the ground response to extreme heat events is shaped by a complex set of decisions and actors that vary greatly across regions based on the availability of local resources and capacity. Given these circumstances, it is unclear whether improvements to short term forecasting of heat waves can be effectively integrated into heat response processes at the county level.

Our research also shows the limitations of emergency response to prevent the health impacts of heat waves. The greatest strides can be made through interventions planned well ahead of time, such as changes in the urban design and social programs. Therefore, we conclude that a new online decision support tool is best geared towards informing mid and long-term interventions to reduce the public health impacts of extreme heat.

By designing a tool that is focused on informing long-term planning to mitigate the public health impacts of extreme heat, we hope to enable better integration of climate, land use, and population projections and subsequent estimates of heat impacts into local planning processes. Our tool will cover the entire state of California and therefore will also provide state officials with the opportunity to better understand which regions are at highest risk of poor health outcomes to prioritize future research and funding efforts. The ability to compare risks and potential outcomes across counties will also position local practitioners to leverage scarce resources by sharing information and best practices across agencies and geographies. Given the multi-faceted nature of heat vulnerability, we also hope that this tool will empower local practitioners to better communicate the urgency of this issue to build much needed support for improved planning and new solutions.

Introduction

California is facing a warmer climate over the next century. More frequent and severe heat events will pose considerable health risks to our communities and to vulnerable populations. There is growing evidence that the character of heat waves in California is also changing. Heat events are becoming progressively more humid, lasting longer than average, and occurring in areas not accustomed to heat waves. Based on current climate change projections, a typical California summer in 2100 is predicted to be 4-5°F warmer than today (CAT, 2013), and extreme heat days are predicted to increase from currently around ten a year to 25-50 by 2050, and upwards of 100 by the end of the century (Pierce et al., 2012). In California cities, extreme temperatures could cause two to three times more heat-related deaths by mid-century (UCS, 2006). In major California cities, mortality for the over 65 age group could increase by more than ten times by the 2090s (Sheridan, 2011). As heat waves grow more deadly and prevalent, California residents will encounter more health risks.

In this context, local agencies are struggling to effectively address and mitigate the public health impacts of extreme heat. Despite the improvement of heat forecast and warning systems in California, as well as our knowledge of interventions that can mitigate impacts on health such as air conditioning and reduced outdoor activity, extreme heat continues to affect many people across the state. As average temperatures and the duration and severity of heat events increase, humid heat waves, accentuated by nighttime heat, are increasing health risks for many Californians.

Purpose of this Project Extreme heat in California is already a substantial threat to public health, and heat waves are projected to increase dramatically in magnitude and frequency in the coming decades. Although the National Oceanic Atmospheric Administration (NOAA) generates short- and medium-term climate forecasts for the United States, public health warnings tailored to California's local and regional conditions are not available. This project, under the California Fourth Climate Change Assessment, proposed to develop a decision support tool for public health officials using probabilistic short- and medium-term weather/climate forecasts designed to assist the public health sector with adapting to climate variability and change.

The first phase of the project, presented in this report, was to identify what type of tool and what data can best support local public health and emergency preparedness stakeholders to better manage and mitigate the public health impacts of extreme heat. The findings will inform the development of the decision-support tool designed to assist the public health and emergency preparedness sector with adapting to climate variability and change in 2017.

Methodology

Our approach combined an extensive literature review and a User Needs Assessment (UNA) to better understand local policies and processes in responding to extreme heat events as well as the tools and resources stakeholders currently use to inform their planning and response activities. Our efforts were informed by regular discussions with our project Technical Managers at the California Public Health Department Office of Health Equity. Key goals of the UNA and literature review included:

- Better understand how heat and heat and health related information is received and processed across local public health and emergency management agencies
- Identify the key data gaps that may be preventing effective response with specific focus on existing heat alerts and social, economic and medical indicators of heat vulnerability
- Outline roles and responsibilities and planning processes for extreme heat stakeholders for both long-term planning and short-term response

The UNA consisted of individual and group interviews and an online survey of over 100 public health and emergency preparedness stakeholders which was distributed through our contacts at the California Office of Emergency Services (Cal OES), the California Conference of Local Health Officials (CCLHO), Public Health Nursing Directors of California and the County Health Executives Association of California (CHEAC). Survey questions were informed by individual interviews and presentations and discussions with public health groups² across the state. Following analysis of the survey results, our team conducted approximately 20 additional individual interviews with stakeholders from local and state agencies involved in responding to extreme heat events.

This report highlights key findings from our UNA and literature review and provides a framework for the next phase of the project, tool design. Section one discusses the impacts of heat on human health. Section two outlines existing plans and policies at the state and local level in preparing for and responding to an extreme heat event. Sections three and four discuss California's heat alert system and short- and long-term interventions to mitigate the public health impacts of extreme heat. Section five identifies key information gaps and challenges and provides recommendations to inform the design of a decision support tool.

² Our team presented and held group discussions with members of the California Conference of Local Health Officials (CCLHO), the California Directors of Public Health Nursing, the Bay Area Climate and Health Working Group and the San Joaquin Valley Public Health Consortium.

Section 1. Heat and Health

Section Summary

- *In the United States, heat is responsible for more deaths than any other natural hazard and is responsible for the majority of weather-related emergency department visits. Among natural disasters in California, heat is responsible for the most deaths in the last 30 years.*
- *The changing character of heat waves in California will not affect all regions equally. While the state is, on average, warming, the highest relative temperature changes are predicted to occur along California's coasts, where most of the state's population is clustered.*
- *Elderly populations across California, which are expected to grow significantly in the near-term, are the group most susceptible to heat related illness and death.*
- *A number of studies have found strong spatial correlations between the built environment, socioeconomic vulnerability, and heat mortality, implying that communities of color and low-income populations are disproportionately exposed to heat-island risk factors.*
- *The 2006 heat wave was abnormally humid, with very high nighttime temperatures that hindered physiological recovery at night – a trend that is expected to worsen as climate change persists.*
- *As evidenced by the 2006 heat wave, communities not adept with dealing with extreme heat will likely continue to account for the highest incidents of heat-related illnesses. These populations, which are not acclimated to such heat events, are more vulnerable to the same temperatures than populations in hotter regions which experience heat events more frequently.*
- *Nearly 90 percent of all victims of the 2006 heat wave lived in zip codes where more than 50 percent of the population was below the Federal Poverty threshold. Among these deaths, comorbidities were common.*
- *There are multiple mechanisms and phenomena exacerbated by climate change (e.g. the Urban Heat Island effect, poor air quality and humidity) that will negatively impact health outcomes during and following extreme heat events in California.*

Heat Impacts and Projections in California

Climate change threatens health in myriad ways, including increases in vector and water-borne diseases, decreases in air and water quality, and impacts from more extreme weather events such as droughts, flooding and hurricanes. One of the most immediate health effects stemming from climate change will be from increased temperature and longer periods of more severe extreme heat (Balbus *et al.* 2016). The relationship between human health and extreme heat is well-established (Astrom *et al.*, 2003), and there is strong evidence to suggest that climate change will increase the global number of heat-related deaths (Hales *et al.*, 2014). In the United States, heat is responsible for more deaths than any other natural hazard (NOAA, 2016), and is responsible for the majority of weather-related emergency department visits (Knowlton *et al.*, 2011). Among natural disasters in California, heat is responsible for the most deaths in the last 30 years. Other natural disasters in recent history, such as the 1989 Loma Prieta and the 1994 Northridge earthquakes, and the 2003 Southern California Firestorms each resulted in 20-70 deaths (Cal OES Contingency Plan for Excessive Heat Emergencies, 2014), whereas the 2006 heat wave killed more than 600 people and resulted in over 1,200 hospitalizations, 16,000 emergency department visits, and nearly \$5.4 billion in costs (Knowlton *et al.* 2009).

Current climate change projections for California show that a typical summer is predicted to be 4-5°F warmer by 2100 than today (Heat Adaptation Workgroup, a subcommittee of the Public Health Workgroup, 2013). Increasing average temperatures (Stocker *et al.* 2013) increase the frequency and severity of extreme heat events (EHE) (Pierce, D. W. 2012). Extreme heat days are predicted to increase from currently approximately ten a year to 25-50 by 2050, (Pierce, D. W. 2012), resulting in as many as two to three times more heat-related deaths by mid-century in California cities (Luers *et al.* 2006). The 2006 heat wave was abnormally humid, with very high nighttime temperatures that hindered physiological recovery at night; a trend that is expected to worsen in the future (Gershunov, Cayan, and Iacobellis 2009).

However, the changing character of heat waves in California will not affect all regions equally. While the state is, on average, warming, the highest relative temperature changes are predicted to occur along California's coasts, where most of the state's population is clustered (Pierce, D. W. 2012). These coastal populations have shown to be more sensitive to heat events in part due to their lack of acclimatization (Gershunov and Guirguis 2012). As evidenced by the 2006 heat wave, central coast communities accounted for the highest rate of heat-related illnesses (Knowlton *et al.*, 2009). These populations, which are not acclimated to such heat events, are more vulnerable to the same temperatures than populations in hotter regions which experience heat events more frequently. In 2006, sensitivity to heat, or the threshold at which heat illnesses began to appear—in the Central Valley 33 °C -42°C and for Coastal regions: 27°C-36 °C (Gershunov and Guirguis 2012) —drove differential outcomes across geographies.

Disparate Regional Impacts

Nearly 90 percent of all victims of the 2006 heat wave lived in socio-economically deprived areas – defined as more than 50 percent of the population in their zip code living below the Federal Poverty Threshold. Among these deaths, comorbidities were common: 46 percent of the victims suffered from a cardiovascular disease and 23 percent from a psychiatric disease (Trent, 2007). Latino/Hispanic groups along the North and Central Coast were found to be particularly sensitive (Knowlton *et al.*, 2009), possibly due to occupational exposure of crop workers where “effects tend to occur during outdoor labor as a result of accumulated heat load over a longer time period with little opportunity for rest” (Li *et al.*, 2015). Although California workers have experienced severe heat-related illness and death during heat waves in recent years (evidenced by the 2006 heat wave) , reports are believed to be under-reported and not well captured in existing data retrieval programs (Centers for Disease Control and Prevention, 2016). Other groups have also been found to be more susceptible to heat-related illnesses, such as infants and young children (Schwartz, 2005), athletes (Vanos *et al.*, 2010), people with pre-existing illnesses (Barrow and Clark 1998; Stafoggia *et al.* 2006), pregnant women (Basu *et al.*, 2016) and the homeless (Bassil and Cole, 2010).

Yet no demographic group is perhaps more susceptible than the elderly, who disproportionately suffer health complications during HHEs (Bunker *et al.*, 2016). During the 1995 Chicago heat wave, elderly individuals living alone represented a significant portion of the deceased (Klinenberg 2003). In California, individuals over the age of 65 were found to be particularly affected in the 2006 heat wave, comprising

52 percent of all heat-related hospitalizations, though they only represent 11 percent of the state's population. On average, across all counties, the 65 and over age group is expected to grow by 145 percent by 2020 (California Department of Finance, 2014), potentially increasing the number of patients in need of medical attention during and following future heat waves. Extreme temperatures could cause two to three times more heat-related deaths by mid-century (UCS, 2006), but heat-related mortality for the over 65 age group could increase greater than ten times by the 2090s (Sheridan, 2011).

In parallel, urbanization together with the growing development of impervious areas for commercial and residential space produces a positive feedback loop that exposes more individuals to the added risk of urban heat island (UHI) effects. A number of studies have found strong spatial correlations between the built environment (described more in this report's *Interventions* chapter), socioeconomic vulnerability, and heat mortality (Uijeo, 2012), implying that communities of color and low-income populations are disproportionately exposed to heat-island risk factors. In September 2015, The California Environmental Protection Agency (CalEPA) released an urban heat island index (UHII) for California that quantifies the exacerbation of both heat and air quality pathways in urban climates, which shows summer urban temperatures are 1 to 6°C greater than surrounding rural areas (Dean, 2015).

Mechanisms and Phenomena Affecting Health

Humidity

An important part of the human body's self-regulation of temperature is to cool itself through sweating. Humidity limits the body's ability to cool; therefore, humidity coupled with a heat wave poses an increased health risk, especially when coupled with stagnant air masses. In consequence, several California regions, including the Central Valley and the North Coast are more prone to heat illness during extreme humidity (Gershunov and Guirguis, 2012). Humidity and pockets of stagnant warm air are uncharacteristic in most of the state's climate, but more humid, nighttime-dominated heat waves have been observed over the last 60 years and are predicted to intensify over the coming century (Pierce *et al.*, 2012). The heat wave that struck California in 2006, which killed more than 600 people and resulted in over 1,200 hospitalizations, and 16,000 emergency-department visits (Knowlton *et al.*, 2009), was abnormally humid, with very high nighttime temperatures that hindered physiological recovery at night. These trends are expected to worsen in the future (Gershunov *et al.*, 2009). Coastal, foothill, and mountainous communities, not accustomed to dealing the combination of heat and humidity are particularly susceptible.

Nighttime Temperature

During warm seasons, lower nighttime temperatures can offer humans respite and recovery. Heat waves may be accompanied by nighttime extremes, higher in urban areas, as compared with proximate rural areas, due to urban heat island (UHI). Nighttime temperatures have also been shown to contribute to excess morbidity and mortality (Hémon and Jouglé 2003; Grizea *et al.* 2005), limiting the opportunity for physiological recovery and prolonging the period of time for which HRIs can occur. The physical mechanisms causing daytime and nighttime heat waves may differ and relative warming is often stronger at night than during the day (Easterling *et al.* 1997; Vose, Easterling, and Gleason 2005).

Consistent with most global models, warmer nights are also trending upwards in California (Lobell, Bonfils, and Duffy, 2007). High nighttime temperatures also increase the energy demand as residents are more likely to increase their use of air conditioning. Temporary increases in energy consumption can lead to power outages (Alawar, Bosze, and Nutt, 2005), affecting those dependent on electrified life supporting machines such as ventilators or electric powered oxygen machines (Klinger, Landeg, and Murray, 2014).

Urban Heat Island Effect (UHI)

The Urban Heat Island effect is a phenomenon routinely observed whereby urban areas exhibit higher temperatures than nearby rural or suburban areas at the same time, especially at night. Cities with more impervious surfaces (including more cement, asphalt, roof cover, etc.) tend to be hotter than their nearby rural areas. Impervious surfaces, which include concrete and metal, dominate land cover in urban landscapes and amplify the severity and duration of heat waves within cities. Heat islands are typically less intense in drier climates (Zhao et al., 2014), yet this is not true for all cities (Kenward et al., 2014) and urbanization in conjunction with rising temperatures appear to increase heat more than climate change alone and rural-urban temperature differentials continue to grow. This effect also poses serious health risks from exposure to high levels of ground-level ozone.

Poor Air Quality

The health impacts of poor air quality are also exacerbated by increases in temperature. Air pollution has been shown to exacerbate heat-related morbidity and mortality in some instances when anomalies in high temperature and air quality (particulate matter and ozone) are correlated (Fischer, Brunekreef, and Lebret, 2004; Gosling et al., 2009; Stedman, 2004; Touloumi et al., 1997; Katsouyanni et al., 2001). The same weather conditions can increase concentrations of particulate matter (PM). This effect is pronounced in urban settings where pollutants from emissions are more prevalent. Unlike particulate matter from emissions-based sources, ozone is not released into the air directly, but instead forms under the presence of heat and sunlight through a combination of nitrogen oxides (NO_x), volatile organic compounds (VOCs), and carbon monoxide. Even as emissions of these pollutants are decreasing, ozone dependence on temperature indicates that increasingly hotter summers have the potential to elevate average ozone concentrations.

Winds and Wildfires

Not all factors that impact heat-related illnesses are urban-centric. The Santa Ana winds, which form in cold weather at high altitudes in the mountains in between the Sierra Nevada and Rocky Mountains, blow warm, dry air across southern California. The Santa Ana winds are projected to decrease in frequency and average wind speed, but, of the winds that remain, will become hotter and drier, which will contribute to wildfires (Pierce, D. W., 2012) Wildfires can adversely affect human health directly, i.e. through burns, creating occupational risk for fire fighters, but also indirectly through heightened mental stress and displacement of affected communities.

Section 2. Planning for Extreme Heat in California

Section Summary

- *Heat response is very decentralized and inconsistent from county to county with multiple decision centers with loose coordination. Responsibilities for both planning and response are spread across multiple agencies and multiple plans and plans are not formally (or informally) linked.*
- *Many of the rural, inland regions who have and will continue to experience an increased number of extreme heat events are the least able to plan for and respond to this hazard given a lack of local resources and capacity, competing priorities and a lack of urgency.*
- *Many counties that have experienced extreme heat events and heat-related illnesses have never declared a heat emergency nor activated a local response. Some UNA respondents noted that they did not know if their jurisdiction had a heat plan nor had they ever reviewed the state's Heat Contingency Plan.*
- *Roles and responsibilities in the aftermath of a heat event are contingent upon the organizational structure of county agencies as well as on whether extreme heat has been prioritized as a hazard of concern.*
- *Local responsibility leads to inconsistent and ad hoc responses based on the variances in local resources, capacity and ability to prioritize extreme heat as a hazard of concern. No one person or agency is responsible for planning and/or preparing for extreme heat at the local level.*
- *Short-term response activities are limited in scope and prioritize communication and outreach to vulnerable communities*
- *All disasters are local: while the state provides guidance and can provide support when requested, the organizational and financial burden of planning for and responding to extreme heat is placed on local agencies.*
- *Planning for heat as a stand-alone issue is not required (nor funded) at the local level.*

California's Policy and Protocols on Heat Preparedness

California's Office of Emergency Services (Cal OES) Excessive Heat Contingency Plan³ (EHCP) provides guidance for state and local government agencies involved in preparedness and response to extreme heat events. The plan outlines various responsibilities for Cal OES and local agencies during three phases of activation; 1) Seasonal Readiness, 2) Heat Alert and 3) Heat Emergency.

Specific guidance for both state and local agencies is contingent upon activation of one of three phases and ranges from implementing communication and outreach activities to monitoring medical reports of heat related illnesses and deaths. During any of these phases, Cal OES responsibilities include coordination response activities between state and local government agencies, mobilizing resources and initiating actions in advance of local requests as well as supporting the actions of local governments according to the Standardized Emergency Management System⁴ (SEMS). SEMS includes five

³ <http://www.caloes.ca.gov/PlanningPreparednessSite/Documents/ExcessiveHeatContingencyPlan2014.pdf>

⁴ In an excessive heat emergency, as in all other disaster response in California, statewide coordination of resource support to local government is carried out through the Standardized Emergency Management System (SEMS). SEMS incorporates the National Incident Management System (NIMS).

organizational levels which are activated as necessary: field response, local government, operational area, regional, and state.

Within this system, if it is determined that local resources are not adequate, requests are then made to the next higher emergency response level to try to bridge the gap and ensure local communities are able to respond and recover. A local agency would first request help from the county, then the region, then the state and finally, at the national level if the emergency required. It is important to note though that when a regional or state level agency is requested to provide resources at the local level, eventual payment for these resources will come from the local level. Therefore, many small, less-

resourced counties who are in most need of additional resources do not see requesting these as a viable option because they know they do not have the funds to pay for them and it is ultimately going to be more affordable to rely on local resources.

Additionally, during our interviews with public health and emergency preparedness stakeholders, we found that many of these counties with smaller populations may not meet necessary thresholds (e.g. number of people in need of medical attention) for the state to step in, even if they have requested help and lack adequate capacity to respond in the event of a heat emergency. These local agencies are then forced to work with available resources which has led to inadequate response as well as distrust in the state's ability to fill resource and capacity gaps at the local level.

The ECPH also outlines responsibilities for the California Department of Public Health (CDPH) following the issuance of a heat alert. The ECPH does not consistently specify which division within CDPH is responsible for each of these actions, nor, in the case of data collection, whom this data should be shared with or what purpose it will serve.

CDPH Responsibilities After a Heat Alert is Issued:

- Disseminate information specific to the heat alert event to local health departments via conference calls and/or the California Health Alert Network (CAHAN) and, in coordination with EMSA, disseminate information specific to the heat alert event to the MHOACs, RDMHCs, RDMHS, and LEMSAs via conference calls and/or CAHAN.
- Contact and coordinate, via conference calls and the California Health Alert Network (CAHAN), with the following: local health departments; CDPH executive staff and programs (i.e. Licensing and Certification, Emergency Preparedness Office (EPO), and the Office of Public Affairs (OPA)).
- CDPH Licensing and Certification notifies Skilled Nursing Facilities (SNF) and Intermediate Care Facilities (ICF).

Because [our county is] sparsely populated it seems that things have to hit us harder for us to get help. Proportionally, we have to be devastated before we can get help from the state. We could declare a heat emergency locally but we still probably wouldn't get much help from the state. We've largely been on our own during past disasters. We've come to recognize that we have to help ourselves. When a landslide caused an entire neighborhood to slide off of a hill we didn't qualify for help because we didn't hit the threshold of 24 occupied homes (many of the homes had been foreclosed so not occupied)." (Health Officer – Rural County in Central CA)

- CDPH Licensing and Certification – Monitors heat-related unusual occurrences reported by long term care facilities in affected areas until they are resolved.
- CDPH Operations collects local health-related information from local health departments in affected areas.
- CDPH Licensing and Certification – provides the reporting process long term care facilities must follow to report any unusual occurrence related to the extreme heat and any facilities that report problems with information on caring for patients/residents during extreme heat conditions.
- CDPH, EMSA, and Cal OES contact local emergency management, local emergency medical, and local public health offices to determine the adequacy of transportation for vulnerable populations

Responding to Extreme Heat at the Local Level

The chart below is included in the State’s EHCP as an example of a local government EOC organization during activation in response to an extreme heat event. The organizational chart clearly puts the responsibility for overall emergency response organization on each Local Office of Emergency Services department but also provides quite a bit of flexibility for each County to determine which agency is best positioned to take on other responsibilities. In California, local response should be structured based on the guidance outlined in the Standardized Emergency Management System⁵ (SES) and the understanding that all disasters are local and therefore, local agencies must determine when and how to activate a response.

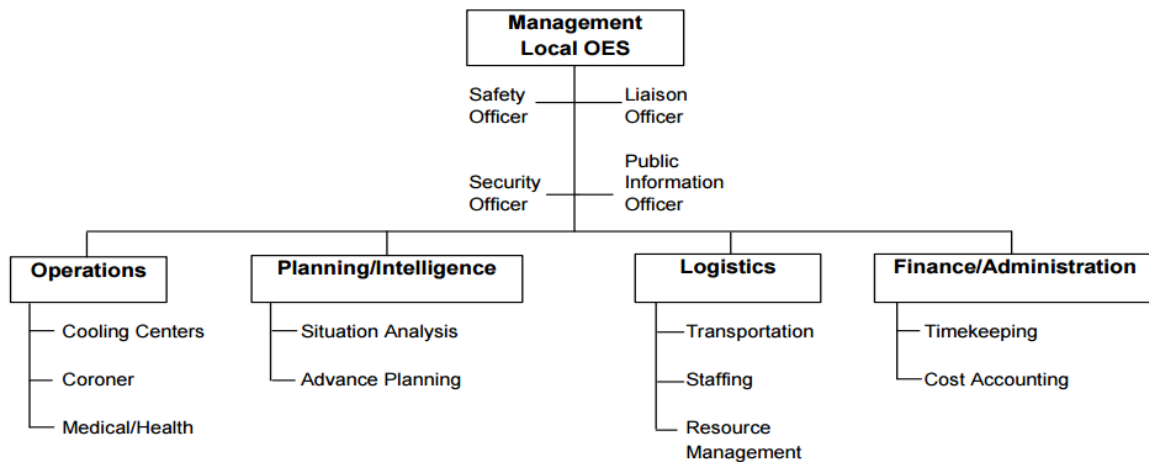


Figure 1. Local Government EOC Organizational Chart Example. Source: Cal OES Contingency Plan for Excessive Heat Emergencies, 2014

⁵ <http://www.caloes.ca.gov/cal-oes-divisions/planning-preparedness/standardized-emergency-management-system>

The EHCP also provides a list of example of actions that local governments should consider taking in the event that any of the three phases for extreme heat are activated; Phase I – Seasonal Readiness, Phase II Heat Alert and Phase III – Heat Emergency.

Seasonal Readiness (May – August)	Heat Alert	Heat Emergency
<ul style="list-style-type: none"> • Initial notifications of key stakeholders • Review of existing plans • Verification of use/availability of key facilities • Updating/validating notification processes • Initiating awareness campaigns • Orientation and training plans and procedures 	<ul style="list-style-type: none"> • Initial coordination call and periodic or daily calls as needed among the key state agencies and the potentially affected operational areas and regions with weather and power updates • Increasing public information efforts • Contacting local public health and other officials to ensure contact with those most vulnerable to excessive heat • Confirmation of roles, identify specific local needs • Confirm details of agency participation, staffing • Stand-by and activation (if needed) of state-owned facilities as cooling centers 	<ul style="list-style-type: none"> • Coordinating calls will increase as needed • Activation of the SOC • Fielding requests for mutual aid and state assistance • Mobilizing cooling centers • The Governor may declare a state of emergency in the affected area

Figure 2. Three Phases of Activation. Source: Cal OES Contingency Plan for Excessive Heat Emergencies, 2014

Phase 1 activities focus on planning processes and raising community awareness while Phases II and III are more specific and response oriented. Given the variances in local capacity and resources across counties in California, these lists also encourage local governments to determine, on their own, which department or agencies should be responsible for each action. The EHCP clearly states that these actions are not required but provided as guidance. While the state’s Extreme Heat Contingency Plan (EHCP) outlines suggested actions for local agencies following a heat alert, the ability to respond is based largely on the resources and capacity available within the affected jurisdiction. Therefore, there is little consistency in how each California county prepares for and responds to extreme heat events. The chart below is included in the state’s EHCP and provides an example of suggested local activities for the Heat Alert Phase.

<u>Local Activity</u>	Responsible Dept./Agency	Applied (✓)
Send extreme heat emergency related notifications to CA State Warning Center (CSWC).		
Distribute information specific to the extreme heat emergency event at hand to local jurisdictions.		
Cities and counties should standby or begin activating pre-identified cooling centers and work with volunteer groups to identify additional cooling centers that may be needed; identify ADA compliant centers so that persons with access and functional needs could be taken to those facilities; coordinate planning with local transportation providers.		
Enter cooling center information into the Extreme Heat Emergency Web Portal on the local office of emergency services and state Cal OES website for public availability.		
Activate Extreme Heat Emergency Plan .		
Release pre-scripted extreme heat emergency protective measures to all media sources, and remind them of the need to be broadcasting in accessible formats.		
Activate telephone extreme heat emergency hotlines.		
Alert neighborhood volunteer groups, volunteer and service groups, CERT, disability organizations, social services agencies, medical facilities, and care homes.		
Notify para-transit or other local transportation of the potential need to transport individuals to cooling centers.		
Coordinate and brief all emergency responders on actions to be undertaken and responsible departments/agencies.		
Coordinate with local utilities to assess power restrictions or limitations.		
Plan transportation services and ways for individuals to request the transportation if utilities fail. Para-transit potentially does not have phone line capacity to field calls because they still must provide regular services, if possible.		
Activate transportation resources, including para-transit and private accessible transit services to assist those without transportation, including service animals, to get to and from cooling centers.		
Request mutual aid as needed through SEMS if weather forecast indicates an extreme heat emergency may be imminent.		

Figure 3. Local Guidance for Phase II – Heat Alert

While the state’s EHCP provides guidance, there are requirements for other plans to be developed and adopted at the local and county level that could address extreme heat. These include Climate Action Plans, Adaptation Plans, Safety Elements of General Plans, Emergency Response Plans, Health Hazard Mitigation Plans and Local Hazard Mitigation plans among others. Our interviews highlighted the fact that no one person or agency is responsible for planning for or responding to an extreme heat event. Extreme heat is a “blurry” issue from the perspective of some of the Health Officers we spoke to. Public Health stakeholders often try to define an issue as “injury” or “illness” to then determine who is

responsible and how to respond. Extreme heat falls into both categories to some extent and, combined with the fact that it could be addressed in multiple local plans, this creates ambiguity about who is responsible for both long-term planning and mitigation as well as response in the event of a heat health emergency.

This ambiguity also causes confusion and inconsistency in how extreme heat planning and preparedness is (or isn't) funded. In order to be eligible to receive Federal Emergency Management Agency (FEMA) funding to address hazards like extreme heat, each county in California is required to develop and adopt a Local Hazard Mitigation Plan (LHMP) which outlines hazards of concern for that region. While many of California's 58 counties are behind in updating their LHMP's, all counties aside from Inyo County have an adopted plan. In order for an LHMP to be adopted and approved, Cal OES must first approve the plan and ensure that a specific list of elements is addressed. Once Cal OES approves the plan, it is then sent to the Federal Emergency Management Agency (FEMA) for approval. FEMA's approval then positions a county to be eligible for FEMA funding to prepare for, mitigate and respond to a local emergency.

Counties are also required to develop and approve an Emergency Response Plan (ERP). ERP's however are only required to be approved by each County's Regional OES Coordinator so there is little standardization across plans and no formal linkage to a county's LHMP. Other relevant, required planning documents include a Health Hazard Vulnerability Assessment (HVA) which all county Public Health Department are required to develop and update regularly. These plans are meant to enable Health Departments to assess the probability of hazards in their county and then to determine the potential magnitude of the medical and health impacts of these hazards keeping in mind available local resources. HVAs are developed by Public Health Departments and are not formally linked to ERPs or LHMPs.

The biggest challenge when talking about medical emergency management is just drawing those lines of responsibility and understanding who is doing what at the local level – otherwise you have duplication. (OES – County Emergency Manager)

A county may also have a stand-alone plan Extreme Heat Contingency Plan which, in most cases, is developed by the county's Public Health Department. These plans are not required and are typically not formally linked to the ERP or the LHMP and there may or may not be any overlap in specific planners and practitioners who are involved in any of these planning processes. Each of these Heat plans vary widely in level of detail and reflect significant differences in local resources and capacity as well as organizational structure. While some of these documents are stand-alone plans focused only on heat emergencies, other counties include a small section on Heat within another larger Emergency Preparedness Plan.

Fresno County’s Heat Emergency Contingency Plan⁶ describes County operations during heat related emergencies and outlines specific tasks and responsibilities for their Health Officer, Public Information Officer, and the Departments of Public Health, Social Services, General Services, Sheriff’s Department and the County Office of Emergency Services (see textbox). Fresno’s plan also calls on their Department of Public Health to collect data on heat related illness and death and to create a post heat event report following every heat event which should inform ongoing improvements to the plan. While Fresno’s plan provides significant detail on roles and responsibilities, it does not include example outreach materials nor does it identify populations who are most vulnerable to heat illness. Fresno County is home to approximately one million people, has a full-time Health Officer.

Fresno County’s Heat Emergency Contingency Plan

Fresno County’s Heat Emergency Contingency Plan¹ describes County operations during heat related emergencies and outlines specific tasks and responsibilities for their Health Officer, Public Information Officer, and the Departments of Public Health, Social Services, General Services, Sheriff’s Department and the County Office of Emergency Services. Fresno’s plan also calls on their Department of Public Health to collect data on heat related illness and death and to create a post heat event report following every heat event which should inform ongoing improvements to the plan. While Fresno’s plan provides significant detail on roles and responsibilities, it does not include example outreach materials nor does it identify populations who are most vulnerable to heat illness. Fresno County is home to approximately one million people, has a full-time Health Officer and approximately 400 employees in their Public Health Department. While San Francisco is a much smaller county in terms of land area, they serve a similar sized population to Fresno and their plan reflects the same organizational structure with a focus on outlining roles and responsibilities for multiple departments. San Francisco’s Extreme Heat Response Plan¹ also details specific modifications to be made to the Department of Public Health’s Emergency Operations Plan given the unique nature of an extreme heat event. These modifications include increased efforts to work with other City Departments, such as the Department of the Environment as well as regional policy groups such as the Association of Bay Area Health Officials (ABAHO).

While San Francisco is a much smaller county in terms of land area, they serve a similar sized population to Fresno and their plan reflects the same organizational structure with a focus on outlining roles and responsibilities for multiple departments. San Francisco’s Extreme Heat Response Plan⁷ also details specific modifications to be made to the Department of Public Health’s Emergency Operations Plan given the unique nature of an extreme heat event. These modifications include increased efforts to work

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http://www.co.fresno.ca.us/uploadedFiles/Departments/Public_Health/Divisions/PPC/content/Articles/content/Heat_Health_and_Safety/Heat%20Plan%20Final%202012.pdf

7

<https://extxfer.sfdph.org/gis/ClimateHealth/Emergency%20Planning/Emergency%20Heat%20Plan%20130830.pdf>

with other City Departments, such as the Department of the Environment as well as regional policy groups such as the Association of Bay Area Health Officials (ABAHO).

Colusa County has a population of approximately 21,000 people and their Health Officer also serves as their Public Health Department Director. Colusa County's Heat Plan does not outline responsibilities for specific departments but instead states that "should more than four (4) individuals seek out a cooling center for more than short-term periods of time the Department of Health and Human Services will be contacted to open a shelter. The American Red Cross may be contacted by DHHS to staff the facility depending on personnel availability". The two-page Colusa County plan then goes on to list public facilities in the County with air conditioning as well as public swimming pools and includes an example of heat emergency outreach materials developed by the Centers for Disease Control (CDC).

Case study: King County

King County's Extreme Heat Emergency Plan is structured as a guide for local practitioners and residents with the primary goal of educating the public about how to prevent heat related illnesses. The plan includes bilingual example outreach materials targeted to high risk populations such as older adults and athletes as well as a list of all target high risk populations and medical conditions and medications that increase risk of heat illness. The plan also includes maps of cool spaces in each city in King's County and media outlets to contact to distribute heat information. The following example outreach letter to medical caregivers is included in King County's Plan:

Re: Heat Injury Prevention Dear Colleagues,

The two-week heat wave of 2006 caused 140 deaths in California. () There's little doubt that the actual number of heat related deaths were much higher. Almost all of the deaths occurred in people over age 50 and in those with various chronic medical conditions. Heat related deaths are preventable. Working with a number of community partners the health department has produced The County Extreme Heat Emergency Plan. You can view the plan on line at <http://www.countyofkings.com/Health/index.html>. You and your office can be of great help in helping your patients prevent heat injury.*

Time permitting, you can counsel your patients at risk for heat injury and encourage them to adopt preventive practices. I've enclosed a brochure with some recommended interventions. I would appreciate your making the brochures available through your office. If you find that you need more brochures, they can be obtained by calling Luann at 559-582-3211 x 2605. I've also enclosed some brochures regarding the County Sheriff's Are You Ok? Program. Socially isolated elders have been found to be at increased risk for heat illness. If you can think of other ways we might prevent heat injury in older, sick people, please give me a call. Other comments or concerns regarding our plan are welcome. We see the plan as a work in progress.

Sincerely,

Michael Mac Lean, M.D.

Health Officer

** Later estimates of the impacts from the 2006 heat wave were much higher. Knowlton et al., (2009) estimated as many 600 deaths and over 1,200 hospitalizations were directly related to the 2006 heat wave (Authors' note)*

Beyond planning, some counties have attempted to better position themselves to address all disasters and emergencies by forming Disaster Councils. These Councils are comprised of any practitioner in the county that has any responsibility under emergency operations and often include stakeholders from local OES offices and Public Health. Marin, Sonoma, San Mateo, Los Angeles and San Francisco county are some of the regions that have Disaster Councils in place and they tend to meet on a quarterly basis.

Each county should also have a Hospital Preparedness Program (HPP) and should have someone assigned as their HPP Coordinator. HPP Coordinators are being asked to convene Healthcare Coalitions in each county to ensure that risks to local health care systems are being addressed on a regular and coordinated basis. One of the Health Officers we spoke to noted that these Coalitions would be an ideal place to discuss how the county should address and prepare for the health impacts of extreme heat.

The table below outlines the state and local planning documents relevant to planning for and responding to extreme heat. Plans in bold are required to be developed and adopted while others are examples of plans that some California counties have developed to plan for and/or address the public health impacts of extreme heat.

Plan	Responsible Agency	Required
State Level		
Extreme Heat Contingency Plan	Cal OES	✓
Hazard Mitigation Plan	Cal OES	✓
Emergency Response Plan	Cal OES	✓
California Public Health and Medical Emergency Operations Manual	CDPH	✓
County Level		
Emergency Response Plan	County OES	✓
Health Hazard Vulnerability Assessment	County Public Health Department	✓
Stand-Alone Extreme Heat Plan or Section on Extreme Heat	County Public Health Department	
City and/or County		
Local Hazard Mitigation Plan	City/County – Various Departments	✓
Safety Element of General Plan	City/County – Various Departments	✓
Climate Action Plan	City/County – Various Departments	
Climate Preparedness or Adaptation Plan	City/County – Various Departments	

Figure 4. Planning for Extreme Heat

Local Response to Extreme Heat Emergencies: Roles and Responsibilities

Each of California’s sixty-one local Public Health Departments (which include 58 county departments and three city departments from Berkeley, Long Beach and Pasadena) are required to appoint a physician Health Officer. Health Officers often play multiple roles⁸ and this is especially true in many of California’s smaller, more rural counties. While each California county is legally required to fund a full-time Health Officer, some Officers are only funded on a part-time basis or oversee more than one county⁹ due to limited funding for County Public Health operations. Health Officers may or may not be specifically designated by ordinance adopted by the governing body of the County to proclaim a local emergency.

Like planning, local roles and responsibilities for emergency response in California depend largely on the existing structure, resources and capacities of each local jurisdiction. For example, in some of California’s smaller counties, Public Health and Social Services Departments are combined while Emergency Management is overseen by the Sheriff and/or Fire Department rather than a separate Office of Emergency Services. Public Health and Emergency Services agencies at the local level both can play key roles in responding to extreme heat events. Typically, Emergency Services agencies (OES) are tasked with overall coordination and response management but will coordinate with a local Health Officer to determine if a local response to avert heat illness and morbidity is warranted. Once the decision to activate a response is made, OES leads response activities (such as coordinating with cities to set up cooling centers) while Public Health Departments track health outcomes and distribute outreach information. The following chart provides examples of some of the responsibilities that OES agencies take on once a heat response is activated:

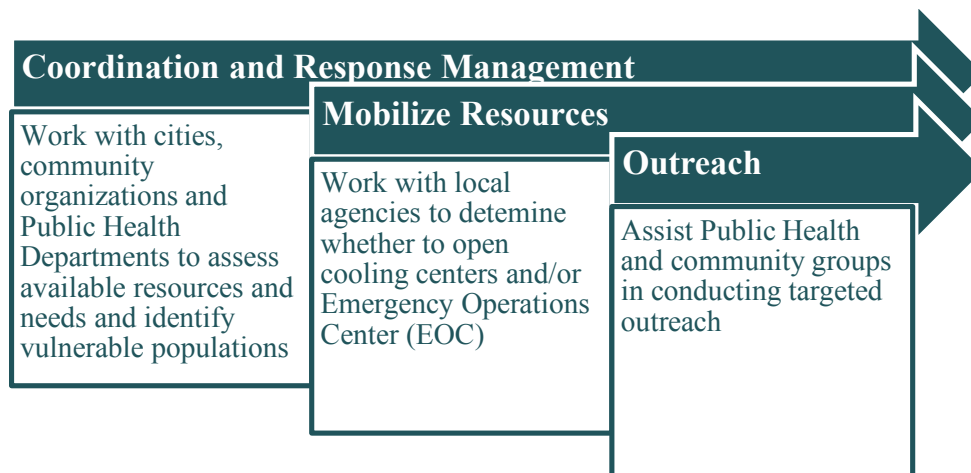


Figure 5. Emergency Management Responsibilities Following a Heat Alert

⁸ <http://www.cdph.ca.gov/programs/cclho/Documents/HOResplnEmergencies.pdf>

⁹ Dr. Richard Johnson serves as Public Health Officer for Alpine, Mono and Inyo counties.

Public Health and Social Services Departments should coordinate with their local OES and are primarily responsible for managing communication and outreach activities both leading up to and in the event of an extreme heat event. OES typically depends upon their local Public Health and Social Services agencies to issue public announcements and draft and distribute outreach information to those populations most vulnerable to heat illness. Because Social Services and Public Health nurses keep detailed information on their clients' pre-existing conditions and other indicators of vulnerability, OES also tends to rely on this local data to identify individuals who are at high risk of heat illness. The following chart provides examples of actions led by local Public Health Departments in the event that an extreme heat response is activated.

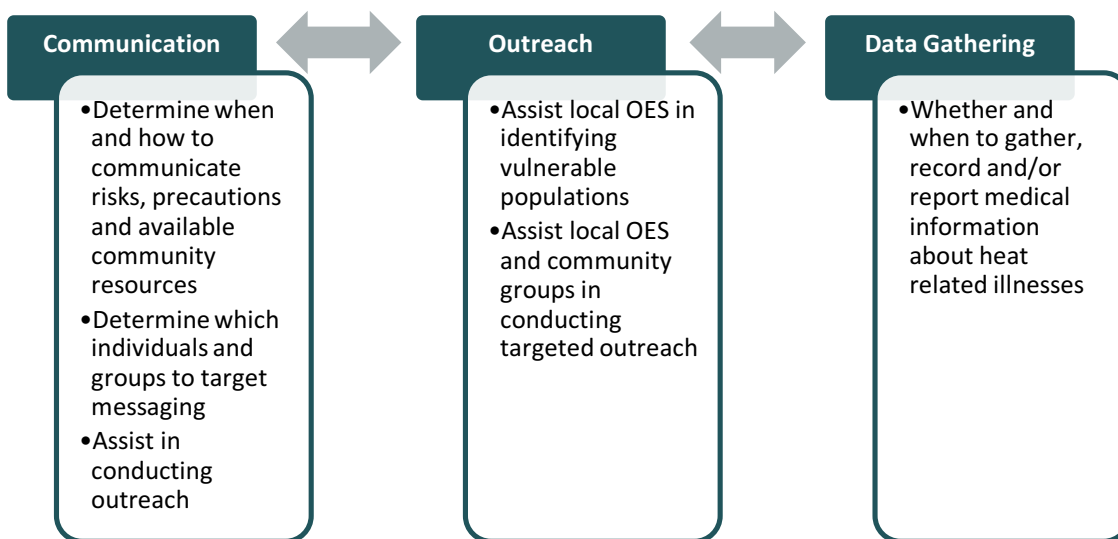


Figure 6. Local Public Health Department Responsibilities Following a Heat Alert

While there are a limited number of decisions to be made after a heat alert is issued, each county in California differs in terms of who makes these decisions and how actions are implemented. For example, some Health Officers serve more than one county and their authority within each differs. This means that in one county, a Health Officer may have the authority to declare a health emergency and activate a response to a heat alert and in another, they would first need approval from the local OES and Health and Human Services offices before declaring a health emergency, and therefore play a much smaller role in overall response.

Section 3. Current Heat Thresholds, Alert Systems and Tools

Section Summary:

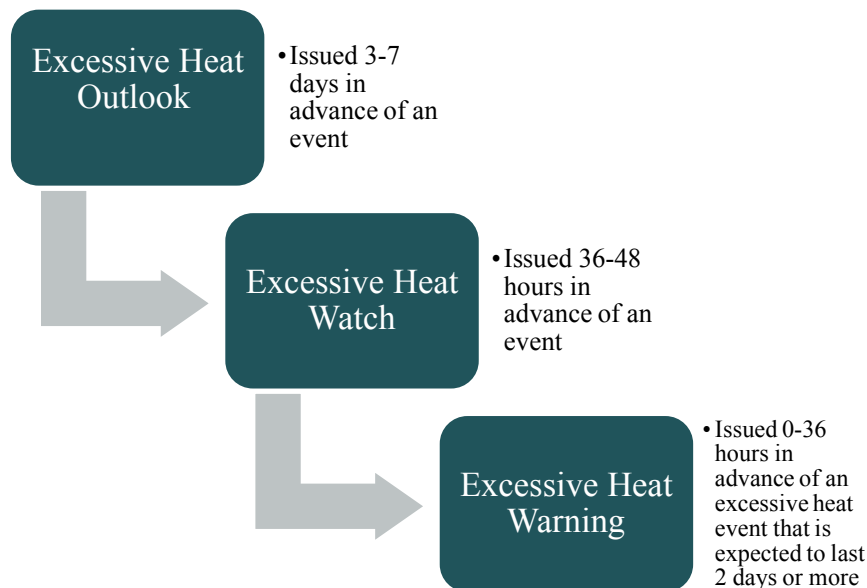
- *While a heat wave is a meteorological event, its severity cannot be assessed independently of human impacts, and many of California's heat health events have occurred below thresholds used to issue alerts*
- *California's NWS offices initiate alert procedures based on expert judgment of station meteorologists, often absent of historical exposure-response rates or input from public health experts or epidemiologist.*
- *Consideration for the human health response to heat improves the relevancy of local heat thresholds, and enables the evaluation of future impacts attributable to more frequent and intense heat waves.*
- *The benefit of using exposure-response relationships to define local heat thresholds is to identify health events that may begin to occur well before a climatological threshold, or even a statistical threshold for mortality or morbidity, is crossed.*
- *NWS alerts are being received by multiple stakeholders in both public health and emergency management agencies. The key question is what a local jurisdiction can actually do to prevent and mitigate heat-related illnesses once the alert has been issued?*
- *None of our interviewees felt that their biggest barrier in responding to heat alerts was a need for more climate data. Overwhelmingly, a lack of resources and capacity to respond at the local level was cited as the key barrier to improving health outcomes.*
- *In order to account for the complex relationship between heat and health as well as differences in populations, climates, and levels of acclimation, alert systems should move beyond the single threshold approach and consider multiple trigger points when deciding to activate intervention measures.*
- *One of the key challenges in effectively identifying and targeting individuals is the ability to capture the movements of transient populations such as the homeless and migrant outdoor working populations.*
- *Most survey respondents reported that the NWS alert system works well and is continuously improving. Some noted that they would like to receive alerts directly.*
- *Most respondents felt that they could access sufficient data on vulnerable populations though many acknowledged that this information is not consolidated and is often housed in multiple agencies.*

Heat Thresholds

There is no universal definition of what constitutes a heat wave, and definitions are sensitive to scale and context. Some definitions are based on climatic conditions: duration of high temperatures, anomalies from a baseline, high temperatures crossing a threshold of the 95th percentile of the warm months spanning past decades, and may be augmented with seasonality and humidity. The principal entity for defining, tracking, and issuing heat wave warnings, the National Weather Service (NWS), defines a heat wave as two continuous days where the daytime high and nighttime low heat index exceeds a specific climate threshold. Thresholds can vary by region and climate, but utilize heat stress thresholds (e.g., 80° and 105°F) specific to the human body's ability to thermo-regulate (Robinson et al., 2001). It was under this criterion, that NWS issued only six heat alerts from 2000 to 2009 in California, despite evidence showing heat events resulting in negative health outcomes occurred 19 times during this period (Guirguis et al., 2014).

Beginning in the 1990s, NWS used multiple heat index thresholds (i.e., 80°, 85°, 90°, 95°, 100°, 105°, 110°F) when determining whether to issue an alert depending on time of season and locale.¹⁰ However, these absolute, climate-focused thresholds are still operational, and communities living in cooler climates that are not physiologically or technologically acclimated to extreme heat will subsequently suffer, as oncoming heat waves may not trigger an alert yet still generate significant heat health impacts (Basu and Malig, 2011). NWS' climate-focused thresholds consider the duration, and severity of nighttime and daytime temperatures. Excessive heat warnings, watches, advisories are often based on local climatological conditions guided by local expert opinion about the relative probability and extent of oncoming heat waves. For example, many California NWS offices will initiate alert procedures when the daytime heat index exceeds 105°-110°F for at least two consecutive days, but thresholds may vary slightly depending on the local climate and the expert judgment of station meteorologists, rather than that of a public health expert or epidemiologist. Currently, NWS issues three types of alerts based on these thresholds; an excessive heat outlook, an excessive heat watch and an excessive heat warning.

Figure 7. National Weather Service Alerts



Other threshold definitions are based on the human response to heat, by assigning relationships between temperature and increases in morbidity or mortality, most commonly referred to as heat “exposure-response” relationships (CDC, 2014), a function that establishes the temperature at which negative health outcomes occur, otherwise known as “thresholds,” or more aptly, “trigger points” (Pettiti et al., 2016). Alerts and intervention measures might be activated when thresholds are exceeded or one or multiple trigger points are reached. The benefit of using exposure-response relationships to define local heat thresholds is to identify health events that may begin to occur well before a climatological threshold, or even a statistical threshold for mortality or morbidity, is crossed.

¹⁰ <http://www.nws.noaa.gov/om/heat/ww.shtml>

Guirguis et al., (2014) defined heat waves in such a manner by utilizing multiple regression analysis to assess correlations between daily maximum temperature (Tmax) and patient discharge (PD) data, over a 15-day window, which allowed them to identify the temperature threshold at which a local population was affected by past heat waves in California. Similar investigations (Hess et al., 2014) have found such relationships are evident in both urban and rural contexts. Greene et al. (2011), conversely, used multiple meteorological variable conditions such as visibility, dew point, air temperature, cloud cover, wind speed and direction to assign air mass types and set thresholds for mortality. Similarly, Kalkstein (2004) examined multiple meteorological variables to evaluate different air mass types and measure the relative departure from historical and recent norms. Pettiti et al., (2016) in their investigation of temperature-mortality and -morbidity relationships in Maricopa County, Arizona, instead focused on better articulating the multiple classes of outcomes resulting from exposure to extreme temperature: minimum risk temperatures, increasing risk temperatures, and excess risk temperatures, which represent different “trigger points” at which heat-health intervention measures might be activated. While each approach varies slightly in their evaluation goals, heat waves were defined and thresholds were set according to the historical health response to heat and other interacting variables in a particular region.

Alert Systems

Across California, the NWS tracks potential heat threats and issues warnings and alerts anytime between 12 hours and 7 days in advance. Seasonal readiness is based on monthly and 90-day outlooks provided by NOAA’s Climate Prediction Center (CPC) to issue general temperature outlooks for regions and the probability that a region will, on average, experience above, below, or equal chances temperature anomalies for the outlook period. If a threshold is exceeded within the outlook period, then local agencies are alerted by regional staff at NWS and informed about the approximate timing, magnitude, and spatial extent of the oncoming heat wave. Outside of the state’s largest cities, NWS warnings and alerts constitute the entirety of information provided to local stakeholders. Based on our direct communication with NWS staff and local NWS information recipients, there is no indication that these alerts include estimates of the expected heat-attributable mortality of morbidity, which may have led to missed warning or false positives in the past. For many, especially those working in rural counties, no additional information is provided and identification of heat vulnerable individuals and groups is the responsibility of local agencies.

In 2007 that the NWS and the National Oceanic and Atmospheric Administration (NOAA) released for the first time a heat information system specifically tailored to local urban areas. The Heat Health Watch/Warning System (HHWS), which covers cities with populations that exceed 500,000, is currently available for five California cities: Bakersfield, Fresno, Los Angeles, San Jose, and San Francisco. Unlike NWS heat warning systems, HHWS deciphers the characteristics of past weather conditions that led to excess mortality and uses those relationships to make predictions with forecast meteorological data (Sheridan, 2004), including dew point, pressure, cloud cover, and wind information as additional inputs in deciding whether to activate heat notification and response programs (Kalkstein *et al.*, 2010). This

more customized system considers the local exposure-response relationship, the intensity of heat and the variability of the summer climate, which is closely related to urban population vulnerability.

Hajat et al. (2010) sought to determine the accuracy of a handful of HHWS' by collecting 20 years of mortality and weather data from four cities, Chicago, Montreal, London and Madrid, all of which have HHWS systems. Authors found that across all four cities, the temperature-mortality approach most accurately identified the days with the greatest excess mortality in the cooler cities that were assessed, London and Montreal. In contrast, for a hotter city such as Chicago, the "synoptic" approach, which uses large-scale weather variables, was largely in agreement with the temperature-mortality thresholds, which suggests that the additional climate variables included in the synoptic method (dew point, barometric pressure, wind direction and speed, and cloud cover) are more important indicators of mortality in hot cities than in cooler ones.

Bustinza *et al.*, (2013) evaluated the effectiveness of a similar system in Quebec, Canada, "a system for monitoring and preventing health impacts from meteorological extremes" (SUPREME),¹¹ which is a decision-support tool designed for surveillance and prevention of health impacts during extreme weather events. Weather information is fed directly to public health officials during heat events, along with maps of vulnerable populations, air quality data, important cooling areas, with notification options via email and SMS feeds. Since its implementation, researchers cited modest reductions in health impacts (33 percent increase in crude death rate and 4 percent increase in crude emergency room visits) during the July 2010 heat waves, as compared with previous, pre-SUPREME heat waves in 1987 and 1994 (Bustinza et al., 2013).

These studies do not overstate their findings as they cite a range of factors, other than the HHWS, that make it difficult to attribute an improvement in health outcomes due to better HHWS'. Many confounding factors could have modified the results, including the rate of AC ownership, increased public awareness and perceived risk, prevention interventions, and individual adaptation. These changes, or a combination of them, likely influenced their results, preventing a causal inference conclusion regarding the impact of HHWS'. Yet the utilization of exposure-response relationships to determine the health risk of oncoming heat events has helped avoid missed alerts and may be useful for decision-makers to adapt and improve prevention measures.

In 2016, the Minnesota Department of Public Health's Environmental Health Division released the Minnesota Extreme Heat Toolkit.¹² The toolkit provides resources for local stakeholders to evaluate the magnitude of potential health consequences from extreme heat in context of their local area and outlines steps that communities can take to prevent heat-related illnesses and deaths in the short- and long-term. For smaller counties with fewer resources, the toolkit provides instructions on how to merge census data to identify neighborhoods with a cross-sector of heat-related risks. The tool also provides the location of cooling areas such as cinemas, libraries, shopping malls, and their proximity to vulnerable populations all across the state. While the toolkit does not provide real-time integrated assessments of

¹¹ Système de surveillance et de prévention des impacts sanitaires des événements météorologiques extrêmes" (SUPREME)

¹² <http://www.health.state.mn.us/divs/climatechange/docs/mnextremeheattoolkit.pdf>

potential impacts (i.e., syndromic surveillance), the sources can help local stakeholder identify those most vulnerable to heat impacts and plan ahead of HHEs.

While a heat wave is a meteorological event, its severity cannot be assessed independently of human impacts. And from a climate change perspective, the lack of a unified index can cause confusion when discussing the complexities involved in evaluating and projecting the frequency and intensity of heat extremes in a changing climate. When heat waves are evaluated based on aspects of human health, they're also more likely to be regional (Smith et al., 2013), making the prediction of health impacts in specific locations possible (Tong et al. 2010; Metzger et al., 2010). Including local and historical health responses to heat can help inform definitions of local heat waves and the use of indices in operational warning systems. HHWS and integrated decision-support tools such as SUPREME, along with supplemental information resources made available in Minnesota's Extreme Heat Toolkit have all better equipped local stakeholders to prepare, plan, and reduce heat-related health impacts in these cities.

Decision-Making at the Local Level: Alert Systems in Practice

While warning systems alone do not prevent heat-related illnesses and death, existing heat alert systems provided by the National Weather Service (NWS) currently lack, both, locally relevant heat-health thresholds and contextual information that can help support public health officials in responding to and planning for HHEs.

Current heat thresholds are not always relevant for communities living in cooler climates that are not physiologically or technologically acclimatized to extreme heat and where seasonal or local temperature anomalies often fall below thresholds, yet still generate significant heat health impacts. The historical empirical relationship between HHE and heat alerts in California (Guirguis et al., 2014) indicates a lack of consideration for local population response, seasonality, and levels of acclimatization.

Conversely, the exposure-response relationships approach to determining thresholds relies on observed locally-specific temperature-mortality and -morbidity relationships. While this approach is a robust means to quantify human health impacts from extreme temperature, results can vary widely across heat events and diagnoses depending on the temperature metric used (e.g., duration and severity of max temperature, nighttime low, heat index, or some combination) (Pettiti et al., 2016). To account for the complex relationship between heat and health, including populations, climates, and levels of acclimation; alert systems should move beyond the absolute threshold approach and consider, both climate- and population-specific and multiple trigger points when deciding to activate intervention measures. The NWS will continue to serve as the key source of information for initializing response. Yet these systems are limited in information and provide no guidance about how to identify local vulnerable populations or the suitable range of adaptation responses.

As a response, the NOAA/National Weather Service's (NWS) Western Region (WR) is piloting the Heat Impact Level (HIL) Project, an effort to incorporate high resolution climatology to heat warning products and services. This experimental project is distinct from the former patchwork of official NWS heat products and services because it provides guidance on the potential *impacts* of oncoming heat waves as opposed to the mere characteristics of heat hazards. Levels of impact are determined by the high

resolution digital forecasts of low and high temperatures and their departure from local climatology, including the time of the year and the duration of the event.

At the national level, efforts are also underway to resolve some of the information gaps discussed in this report. In June 2015, the White House announced the creation of the National Integrated Heat Health Information System, a clearinghouse for heat-related information which will be tested and piloted for a small number of cities starting in 2016 though the actual timeline for release of an operational system is unknown. There are also efforts underway by NOAA to downscale nation-wide 8-14 day outlooks and develop 14-30 day outlooks (Spinrad, 2015), but it may be several years before these become available for operational use.

The ideal warning system has no universal activation threshold or trigger, but rather, levels of activation based on heat wave timing, exposed population, and a range of interacting meteorological variables. These components would reduce the possibility of false alarms or missed heatwaves. Warnings and alerts should also include nomenclature that can be clearly understood by the public, local stakeholders and decision-makers, and understandable criteria for alert thresholds. Threshold criteria should consider local climate including potential anomalies and additional risks such as humidity, stagnant air, and early season heat. Communication of these anomalies should be adjusted to reflect community characteristics and specific target groups. It can be difficult for public health and emergency preparedness practitioners to quantify and locate individuals vulnerable to heat-health impacts, including morbidity, without a broader yet locally specific set of criteria for which individuals and groups within their jurisdiction might be negatively affected.

Roles and Responsibilities in Extreme Heat Response

Each county in California should have designated positions in multiple departments who directly monitor and receive heat alerts from NWS. In some counties, their Public Health Officer is responsible for receiving the alert and then determining whether to activate appropriate response. In other counties, Public Health Officers are less involved in this process and the alerts will go directly to the local agency that is designated as the Office of Emergency Services/Management and/or the alert will be distributed through Public Health Emergency Preparedness (PHEP) or California Health Action Network (CA HAN) coordinators. For example, 45 percent of survey respondents working in public health departments but not at the Executive level, receive NWS alerts from their state or local OES agency while another 40 percent said they were alerted by their CAHAN coordinators while 10 percent said they were not notified at all.

*From my regional perspective – no data gaps exist...
The more specific and accurate weather data is, the
better we can target our prevention and response.
We have wonderful mapping tools now and loads of
data. Adoption and use of these tools are critical.”
(OES – Regional Administrator)*

Emergency management stakeholders, not public health stakeholders, bear primary responsibility for receiving and distributing NWS issued heat alerts. Regardless of who directly receives or is required to monitor the NWS alert within a county, it is then up to county level practitioners to declare a local heat emergency and activate a level of extreme heat response. Many of the

emergency management stakeholders who responded to our survey noted that the alert and activation system “works well” and that they do not see a need for more accurate or timely alerts.

Yet, multiple public health practitioners that we spoke to noted that this amount of local control leads to a heat response process that is “ad-hoc” and inconsistent across counties in California. For example, the choice to cancel an outdoor High School graduation ceremony to avoid heat-related illness is made based on a number of local factors (how many people are expected, whether there is capacity to provide medical assistance if necessary etc.) which means that the same level of alert results in varied responses and inconsistent health outcomes in different areas. While most interviewees noted the need to tailor local responses to a specific region’s unique challenges and population, this level of local control and dependence on only local resources makes it difficult to ensure similar health outcomes across counties.

Current Tools and Data Gaps

Our initial outreach for the User Needs Assessment (UNA) focused on better understanding the data gaps that exist for stakeholders responsible for responding to and mitigating extreme heat. Our survey included a question focused on understanding if and how respondents use online, interactive tools that are already available to them when identifying vulnerable populations and/or individuals during a heat event. Thirty percent of all respondents reported that they do not currently use any tools to identify vulnerable populations during a heat event with some noting that they were not aware of the example online tools¹³ and that they would be interested in learning more about them. Twenty-seven percent of respondents reported using some type of tool to identify vulnerable populations while 29 percent reported that they rely on “internal mapping” (data gathered at the local level and maintained by local agencies) instead of tools. Many respondents and interviewees noted that they appreciated that this internal mapping is tailored to the specific needs of their individual jurisdiction and that they could trust

¹³ See full list of example tools in Appendix. Respondents noted using the following tools and data sources not included on the list: NWS Heat Impact levels, census data, County Cool Zone, Aging and Adult Services and Mental Health client registration data and HHS empower Map.

this data is updated regularly. This was especially important to smaller counties who have found that some online tools do not incorporate data specific enough to be relevant for their jurisdiction.

Interviewees confirmed this perspective with some noting that lack of adequate resources and staffing capacity (specifically within Public Health Departments) makes it difficult to “use” tools unless a specific, funded project enables them to spend time on this type of planning and/or research. Interviewees also highlighted the fact that their Public Health Nursing programs house a wealth of valuable data on vulnerable populations given the fact that they work directly with individuals who have pre-existing medical conditions that increase their vulnerability to extreme heat impacts. Many interviewees stated that they know where all of their vulnerable populations are and/or if they needed more information, they could easily access it by reaching out to the relevant agency who is mandated to house this data (typically Public Health and Social Services Departments). Some noted that it could be helpful to consolidate data on vulnerable populations for their jurisdiction but only if it was regularly updated given how quickly this information changes. (See textbox for selected comments from survey respondents).

In Their Words: Selected Quotes from Survey Respondents

"We utilize internal mapping and database based on information from a variety of grants within the department that may have information not available in the other tools. Experience has shown that some of the tools listed do not have specific enough information for small counties due to small "n"."

(County PH – Management Analyst)

"Maps, PH & DHA all maintain databases for segments of the vulnerable populations including homeless. The information is reasonably accurate and assists us with reaching and informing these segments."

(OES – Chief, County OES)

"I prefer mapping tools to give us the common operating picture as opposed to raw data... we leverage all sorts of other data to give us the entire picture and potential cascading impacts of the incident."

(OES – Regional Administrator)

"Our internal data as we manage and know when it is updated. We need to look at the other tools, and also understand when the data is updated. "

(Police/Sherrif/Fire– Asst. Emergency Manager)

"Contact [information] for these vulnerable groups are constantly changing and trying to keep a contact data base up to date is sometimes difficult."

(Public Health Nursing Director)

"Public Health groups have extensive information on at risk populations – but this is a gap that is never going to be fully closed. There is a huge challenge is just identifying these populations. We have access to data on anyone getting services from health and human services (e.g. WIC, CCS, CSS). For information on homeless individuals we go through law enforcement. We know that we don't have a comprehensive list all in one system but it's easy for us to reach each group if needed. There is a challenge in identifying vulnerable/special populations only because these definitions keep changing, not due to a lack of information"

(OES – County Emergency Manager)

"One challenge [in our rural county] is targeting outreach to very remote areas of the county. Would be helpful to have more information on these places and individuals who live there."

(Health Officer)

We also asked survey respondents and interviewees to tell us if there is any information that they do not currently have access to that would be helpful to have to plan and prepare for extreme heat events.

1. What information do you not currently have access to that would be helpful in planning and preparing for extreme heat events? (click all that apply)
 - a. Long-term projection (in years or decades) of extreme heat events in your county/jurisdiction
 - b. Short-term projection (in weeks) of extreme heat events in your county/jurisdiction
 - c. Probability of the severity of an extreme heat event in your county/jurisdiction
 - d. Local information on vulnerable populations in your county/jurisdiction (zip code or census tract level data as opposed to county level data)
 - e. I don't need any additional information
 - f. I don't know

Based on the list above, 41 percent of all respondents noted that it would be helpful to have local information on vulnerable populations. This result conflicted somewhat with respondents open-ended

“[We need] a standardized tool for heat-related illness surveillance a few days after heat waves that include excess cardiac events (which go up during or after serious heat waves) as well as standard heat exhaustion, heat stroke that could be used by Local Health Jurisdictions (LHJ) voluntarily and feed in to statewide or regional view when needed.”
(Health Officer)

responses and what we heard in interviews. While many respondents and interviewees noted that they are aware of the locations of those individuals with pre-existing medical conditions, they indicated that they do not have adequate information on the locations of outdoor workers or homeless individuals within their jurisdiction. They also noted the difficulty in keeping this type of data up to date as well as the fact that they are not confident that they

could ensure that all individuals within their jurisdiction who are (or could become) vulnerable to extreme heat impacts could be identified and/or located during a heat event. One respondent noted that having access to this type of information in a tool format (combined with data on heat-related illnesses) following a heat event would enable local Health Departments to combine data to create a regional overview of heat health impacts.

Approximately one quarter of all survey respondents noted that they would benefit from having access to both short- and long-term projections of extreme heat events in their jurisdiction (options a and b above) as well as the probability of the severity of an extreme heat event (option c). Sixteen percent

“I either have these types of information or don't believe long-term projections are relevant.”
(Hospital Preparedness Program – HPP-Coordinator)

of respondents reported that they do not need any other information to plan and prepare for extreme heat events and another 14 percent reported that they don't know if more information would be helpful. These results may reflect the fact that the majority of survey respondents likely do not regularly assess or interpret this type of data. One OES interviewee with previous experience working in a local Public Health Department noted that people who responded to our survey are not the ones who would monitor online data resources. He shared that, while working at the Public Health Department he did not monitor the weather in any way. Now that he is working at the County OES office, this information is "on my screen 100 percent of the time".

"I don't think any data gaps exist. We [local OES] monitor NOAA and NWS and Cal OES does coordination calls with us. There is a ton of information and things that start happening when weather takes a turn." (OES – County Emergency Manager)

Overwhelmingly, interviewees noted that their challenges in responding to extreme heat events were less related to data access or insufficient tools than they are to lack of resources and capacity for targeted, effective outreach as well as significant limits on what actions they can actually take to mitigate these impacts in their communities. A Public Health Nursing Director in one of California's large but under-resourced counties noted that even though they are doing all that they are mandated to do – releasing information on how to recognize and avoid heat illness and even physically checking on many of the individuals that are most vulnerable to these impacts – they understand that many of the people they serve either don't have access to air conditioning in their homes or cannot afford to turn it on. Cooling center access and barriers to use is also an issue. While they are confident in their ability to reach and even locate most of the residents in

“Challenges are primarily lack of resources. Red Cross outreach is no longer an option for local heating and cooling centers. The Red Cross has done this in the past but with the cuts in staffing to their programs they don't have enough people to do this anymore – especially because they do so much for fire (e.g. setting up shelters for people who have lost their homes). So, we have to use what limited resources each County has.” (OES – County Emergency Manager)

their county that are most vulnerable to the health impacts of extreme heat, they are very limited in what resources they can offer them to help mitigate these impacts. For example, some counties do not have the ability to provide transportation to cooling centers and/or they do not own any facilities that are equipped to act as a cooling center. Therefore, they can only point residents in the direction of a private facility with air conditioning (e.g. a shopping mall) which may not be located in areas where the most vulnerable individuals can easily access them. Interviewees also noted the fact that cooling centers often don't provide

amenities such as food or entertainment which can be barriers to ensuring that they are widely utilized.

A Health Officer in a very small and rural county noted that most of the people she serves cannot afford air conditioning and that the county itself doesn't have the capacity to set up or staff cooling centers. She hesitates to advise community members to open their windows to cool off their non-air conditioned homes because she knows that most can also not afford to put screens on their windows and opening them during a heat event would make them more susceptible to West Nile Virus. This same Health Officer also serves as the county's Emergency Management Director (each position is only funded half time).

"The truth is we know where the fields are in this state [where the outdoor workers are located]. Those growers technically have to provide cooling centers but they are not going to do that until you absolutely make them. Until Cal OSHA drives through and requires that these growers show them their cooling stations you are not going to see them. This [targeted intervention] has to be legislated into existence." (CDPH)

She noted that "We [the Health Department] are as poor as the people we serve" and, although her region frequently experiences triple digit temperatures, she cannot prioritize planning or preparing for heat events given the multitude of public health challenges she is responsible for dealing with. Although she was able to identify climate change as the county's top priority for health planning, this decision was mostly driven by the need to address an increase in cyanobacteria that is affecting water quality and is being exacerbated by the drought. Managing the health impacts of recurring catastrophic wildfires in the region require much of her attention as well. Many public health interviewees stressed that when

"We have most of the info we need. We do have those thresholds and triggers to know when people are likely to be getting into trouble. As long as we receive timely weather forecasts (this has gotten better over the years) we are good. The key issue really is funding and capacity." (Health Officer)

Health Departments are dramatically under-resourced, response is driven by the hazards that pose the most immediate threats to the larger population and health care delivery systems – if extreme heat is not posing an immediate threat, it is very difficult to prioritize resources or time to plan or prepare for it, regardless of the quality of data available.

Section 4. Interventions to Mitigate the Public Health Impacts of Extreme Heat

Section Summary

- *Given that many short-term solutions require disruptions to daily routines, avoidance of outdoor work and relocation to cool spaces, the most vulnerable populations are often the ones who have less ability to change their behavior to adopt these precautions.*
- *Health officials in multiple rural California regions cited distrust in government by many of their residents as a key barrier to effectively implementing short-term interventions.*
- *In urban and peri-urban areas, the challenge in accurately identifying the location of transient homeless populations can make outreach efforts and preventive action difficult. In rural regions of California, protecting the health of outdoor workers during a heat event remains a challenging and urgent issue*
- *Strong social capital can have a positive influence on healthy behaviors and perceptions that help enhance resilience to weather-related emergencies*
- *The most common short-term intervention – greater air conditioning use – increases our vulnerability to heat-related power outages and decreases community resilience to climate change statewide by contributing to greenhouse gas emissions.*
- *Short-term response solutions are very limited and their overall effectiveness is not well documented. Therefore, even if local agencies are doing exactly what they are supposed to do, it may not be enough to mitigate heat-related illnesses.*
- *More research is needed to evaluate the effectiveness of both long- and short-term interventions. We also need to better understand how long-term interventions that focus on improving the heat resilience of the built environment could enable improved short-term interventions (e.g. less need for/reliance on air conditioning).*
- *Economic inequities play a huge role in determining what actions individuals can take to protect their own health and the health of their families. Low-income residents and those living in poverty do not have equal access to potentially life-saving resources such as air conditioning or even sufficient quality drinking water.*
- *Simply raising public awareness about suggested pre-cautions is not a solution. Local agencies need to develop successful short-term interventions and policies that focus on raising awareness and enabling all community members to actually take these pre-cautions. This may require additional participation and support from agencies outside of public health and emergency management to provide subsidies for energy and water use as well as to support energy assurance.*
- *Many of the long-term interventions that are being implemented or considered are targeted to urban areas. There is less focus on developing solutions to abate extreme heat in rural areas.*

Challenges and Opportunities in Developing Effective Response to Extreme Heat

Efforts to build heat resilience vary widely across the state. Cities such as Los Angeles, San Francisco, and Fresno have dedicated significant resources to green infrastructure and sophisticated heat and health surveillance systems. Yet, many counties do not have the resources or capacity to proactively address heat-related risks. Interoperability and data limitations often affect the ability of under resourced jurisdictions to evaluate the local threat of oncoming heat waves to those that are most vulnerable. The impacts of climate change in California will continue to widen gaps in readiness and capacity, especially for areas of the state not historically accustomed to heat.

Successful interventions must be targeted and informed by multiple indicators of heat vulnerability. Heat health risks are, to a large extent, a function of social vulnerability, and a large number of both intrinsic and extrinsic factors that can exacerbate risks for individuals and groups. Yet, many public health and emergency preparedness practitioners do not currently have access to adequate information about the location of vulnerable individuals. Results from our UNA suggests that there is a lack of detailed geospatial data at the local level that would help practitioners identify the medically vulnerable, homeless, and individuals engaged in outdoor labor.

As climate change and urbanization continue to accelerate the degree and temporal variability of extreme heat, there is a need for targeted outreach to those populations/regions that do not have experience with extreme heat events. In urban and peri-urban areas, the challenge in accurately identifying the location of transient homeless populations can also make outreach efforts and preventive action difficult. In rural regions of California, protecting the health of outdoor workers during a heat event remains a challenging and urgent issue. Some respondents noted the need to mandate (and enforce) protections for workers. Many of these challenges cannot be adequately addressed without a willingness to prioritize and commit local resources. Yet, lack of urgency and insufficient local resource capacity remains a key barrier to effectively mitigating the health impacts of extreme heat.

“We need to focus on long-term interventions and not being overly dependent on air conditioning as our only option. In many rural counties, we are all working individually to get off the grid because there are too many eggs in one basket.” (Health Officer)

In addition to these data limitations, the effectiveness of interventions is highly variable, and some intervention strategies (e.g., door to door outreach, automated phone notifications, green urban design) have been found to be more effective than others (e.g., cooling centers, in-home air conditioning, public information announcements) (NCCHE, 2008). Evaluation of these interventions in California has been quite limited and concerns persist as to whether the most vulnerable groups are being adequately identified and reached (Bassil *et al.*, 2010).

Short-Term Interventions

Common short-term response efforts to prevent and mitigate heat related illness include alerting individuals to stay hydrated, avoid strenuous outdoor activity, spend time in cool, air-conditioned spaces and take cool showers (Brücker 2005; McGeehin and Mirabelli, 2001). Public health and emergency preparedness practitioners understand that some individuals are more vulnerable to HRI than others and therefore make efforts to target specific populations through public communications, and door-to-door outreach to encourage individuals to take appropriate pre-cautions. In order to incite such behavioral changes, the public needs not only to be warned, but the severity of risk from extreme heat also needs to be communicated (Janis, 1962). Studies have shown that differences in age, income, gender and ethnicity, alter how individuals perceive and respond to warning systems, such as those issued for heat (Perry and Lindell, 1997).

At the community-level, common short-term response efforts include, but are not limited to: enforcement of workplace safety guidelines, water collection and distribution, running seasonal public awareness campaigns, suspending utility shutoffs, rescheduling or cancelling outdoor school events including athletic practices and competitions, and opening or expanding access to homeless shelters and cooling centers. Exposure to extreme heat; however, is sometimes unavoidable and access to air conditioning remains an important short-term mitigation strategy. Certain groups that have access to central air-conditioning have been found to experience significantly less mortality than those groups who did not (Kilbourne et al., 1982; Rogot, Sorlie, and Backlund, 1992)

During heat episodes, cooling centers can serve as an important resource for low-income and homeless individuals and those without residential AC or access to air-conditioned buildings or cool spaces (e.g., shaded areas). While cooling centers are an important component of existing heat plans, and remain a promising option for cities and rural populations with sufficient access to personal or public transportation; sufficient assessments have yet to be performed to establish their true impact. In Maricopa County, Arizona, heat episodes are both frequent and deadly, and only three out of 52 county cooling centers were fully utilized and nearly half were at 25 percent capacity across multiple heat episodes during the early summer of 2014. Utilization rates may have varied depending on services provided (food/ snacks, health and human services, water, clothes, etc.), and interestingly, the primary motivation for facilities to become cooling centers was a previously established sense of community (MCCDPH, 2014).

Effective short term interventions to mitigate the health impacts of extreme heat are highly dependent on individual behavior change. Through our UNA, respondents noted the difficulty of convincing individuals in any region that extreme heat is a significant health risk and/or that they are vulnerable. “Alert fatigue” is a potential issue but there is also a need to raise awareness about the health implications of extreme heat and to distinguish between very hot weather and extreme heat.

While residential air conditioning use and risk reduction has been well-documented (Anderson and Bell, 2009; Kilbourne et al., 1982; Ostro et al., 2010), it may not serve as an effective long-term strategy in regions susceptible to power brownouts and blackouts, which pose a serious threat to those individuals on life-sustaining devices. Additionally, many respondents noted that access to in-home AC is actually not a good predictor of whether an individual will be able to use this resource given

operating costs that many California residents are unable to afford. One respondent in a county that experiences consistent episodes of very high heat days noted that individuals have been identified after dying in homes equipped with AC because they couldn't afford to turn it on. Many respondents cited the need for robust energy subsidy and rebate programs and opportunities prior to an extreme heat event to ensure that those who have in-home access can benefit from this resource.

More AC use will also affect air quality as well as increase greenhouse gas (GHG) emissions while California's residential energy mix still relies on fuel combustion. The report, *Preparing California for Extreme Heat: Guidance and Recommendations (2013)* outlines key research needs including, "Evaluate strategies that could provide protections against heat and air pollution to vulnerable populations that

"The biggest issue we have is that when we open cooling centers or encourage people to use public air conditioned places they are very underutilized unless they are places people regularly go to like the library. It would be helpful to have best practices and different ideas that are successful. Barriers to utilizing places in the past have been transportation, not allowing pets, not providing entertainment, and staffing and space limitations during the hottest parts of the day."

(Public Health Emergency Preparedness – PHEP – Coordinator)

Example suggested precautions to avoid heat illness:

- Use your air conditioner at least four hours a day or visit air conditioned buildings.
- Take cool showers.
- Run fans with a mist.
- Open your windows for a few hours in the evening when the temperature cools down.
- Drink water – at least three to four quarts a day. Don't rely on your thirst to tell you when to drink.
- Wear cool, light-colored clothing.
- Go for a swim.
- Ask your health care provider if your medications or health conditions increase your risk to excessive heat.

From Kings County Extreme Heat Emergency Plan

are not based on energy intensive air conditioning". Further research is needed to understand how long-term interventions that focus on improving the heat resilience of the built environment could enable alternative short-term interventions (e.g., less need for/reliance on air conditioning).

There are also limitations to relying on AC in publicly cooled spaces. Fraser et al. (2016) investigated accessibility of official cooling centers in Los Angeles, CA and Phoenix, AZ and found only a small fraction of households had access, 3 percent and 2 percent, respectively. Multiple counties rely upon government-run cooling centers as part of their official heat planning and response protocol. There is a need to optimize the locations of cooling center networks considering spatial variability and incidents of HRIs, as well as transport and mobility considerations. Use of other public and commercial cooling resources remains a more promising option as their dispersal is generally consistent with population clusters, yet equitable access remains a key issue for rural regions.

Planning for Heat in Fresno County: Addressing Environmental Health Vulnerability at Home

Fresno County Public Health Nurses know that many of the clients they serve cannot afford access to air conditioning in their homes or, if they have it, cannot afford to turn it on. In response to this and other deficiencies in building quality that impact public health, this county has implemented a program through a partnership with the local utility and community based groups to do a home vulnerability assessment for each public health client receiving home visitation. When an individual qualifies for any public health home visitation program (e.g. NFP, Healthy Start, etc.) in this county, they are automatically enrolled in this program which provides for an on-site inspection, assessment of risk and recommendations for improving environmental health issues such as mold, carbon monoxide and proper weatherization. The tenant is then referred to the utility to receive information about subsidies they are eligible for to implement the improvements. The program has been in place for approximately two years but an assessment of the overall effectiveness has not yet been completed.

Long-Term Interventions

Long-term preventative strategies focus on how to decrease heat impacts through improvements in the built environment and strengthening social capital at the neighborhood level. Over the long term, efforts to build heat resilience through changes in the built environment include improved building standards that result in cooling of internal and external environments; land use cooling strategies: urban heat island mitigation through use of cool pavements, cool and green roofs, increased tree canopy cover, greater green space and green infrastructure, and urban stream restoration (CAT, 2013).

The established relationship between the impacts of land use/cover on surface temperatures is an important environmental factor which could influence the overall temperature of an urban center, and subsequently the degree of health impact. Studies show that one important factor affecting urban heat island patterns in cities is the amount of vegetation in relation to the impervious surfaces in a given area (Lo and Quattrochi 2003; Yuan and Bauer, 2007, Liang and Weng, 2008), making tree canopy and green space expansion efforts (Christopher *et al.*, 2012; Loughner *et al.*, 2012) one of the most promising opportunities for mitigating the amplification of oppressive temperatures in dense urban environments.

Living conditions, including the quality of housing and access to green space are also critical factors in minimizing health impacts associated with heat waves. The potential thermal comfort of housing has direct linkages to excess risk during heat waves (Evans, *et al.*, 2003; Howden-Chapman, 2004; Lawrence, 2004) while urban, well-vegetated parks can help improve air quality (Nowak, 2005), and provide a refuge of cooling during heat episodes (Spronken-Smith *et al.*, 1999).

Technologies for alternative roofing systems are also being implemented as a heat reduction strategy. Roofs that can lower surface temperatures thereby decreasing subsequent sensible heat flux to the atmosphere come in two forms: cool roofs, designed to increase the albedo (proportion of reflected radiance or light) by use of reflective materials (typically white paints, elastomeric, polyurethane or acrylic coatings); and green or living roofs, which are partially or completely covered with vegetation. The installation of green roofs have resulted in significant reductions in air surface temperature have in urbanized regions of China (-0.11 +/- 0.10 K) and the U.S. (-0.14 +/- 0.12 K) (Zhang *et al.*, 2016), yet further analysis is needed to investigate the scale to which cool roofs and green roofs affect solar albedo and latent heat (Santamouris, 2014).

Other sources of resilience may arise from within communities. A strong social network, one with a high degree of community engagement and connectivity, is an important characteristic of any resilient community (Gunderson and Holling, 2002). Strong social capital can also have a positive influence on healthy behaviors and perceptions that help enhance resilience to weather-related emergencies. Those communities also benefit from an element of togetherness, not as common in neighborhoods suffering from significant differences in age and income (Szreter *et al.*, 2004) or linguistically isolated communities (Nawyn *et al.*, 2012). Following the 1995 Chicago heat wave, several victims were found deceased and alone in their homes (Killenberg, 2003). Yet the effectiveness of social capital is sensitive to context, and in some instances, there are opportunities for misconception and adverse social norms to persist, ultimately leading to decreased heat adaptability (Wolf *et al.*, 2010). In some cases, awareness strategies such as “buddy systems” and targeted outreach by neighbors have been shown to be effective substitutes to organized outreach campaigns (Seguin, 2008), but there is little evidence in the heat literature to suggest which components of social capital are universally needed to reduce heat vulnerability.

Evaluating the effectiveness of various interventions can be difficult across heat episodes, seasons, and communities (Bassil and Cole, 2010). No two extreme heat events are identical and therefore make it difficult to compare the effectiveness of different interventions. Most responses to heat events necessarily involve multiple, simultaneous interventions, which makes it difficult to attribute the effect of any single intervention to a reduction in HRIs or mortality. Effectiveness of various interventions may differ among communities and population groups especially within rural and urban communities. Many of the long-term interventions that are being implemented or considered are targeted to urban areas, there is less focus on developing solutions to abate extreme heat in rural areas. There are also concerns as to whether the most vulnerable groups are being adequately identified and reached through current intervention strategies (Bassil *et al.*, 2010). Some strategies have been found to be particularly effective when targeting the most vulnerable groups (e.g., direct community outreach, automated phone notifications, green urban design) (NCCEH, 2008). Some counties are coordinating with sustainability

programs and others to implement actions to debilitate urban heat islands. Many of these actions also help to reduce GHG emissions (e.g., weatherization, changing building codes to require cool roofs, increasing tree canopy) and illustrate the value of aligning climate and health goals.

While social capital remains a difficult factor to accurately measure and evaluate across California, there are opportunities for investigations of fine-scale variation in social and environmental neighborhood contexts to temperature-mortality relationships in cities with distinctly different climates, demographics, and acclimatization. Results can help target resources and identify interventions specific to these contexts.

“We [the Health Department] are as poor as the population we serve. We don’t even have the resources to apply for more funding.”

(Health Officer)

For example, through the CDC-sponsored Cal BRACE project (Building Resilience against Climate Effects), CPDH is currently partnering with ten local health departments to estimate the disease burden associated with changing heat waves. Building on the concepts, empirical analysis, and social theories presented in the last decade of heat vulnerability literature, indices, such as the evaluation provided by the CalBRACE project, are important starting points for determining how vulnerability varies across space and where interventions are most needed today.

Conclusion

This literature review and UNA highlighted multiple, widespread challenges in improving short term response to extreme heat events including a lack of resources and capacity to adequately serve all vulnerable populations, difficulty in identifying and effectively communicating with all individuals vulnerable to extreme heat, and inconsistent, sometimes untested, local protocols and processes for responding to extreme heat events.

Our results also pointed to the difficulty in prioritizing extreme heat as a public health planning issue among many other competing priorities, even in regions with a recent history of dangerous extreme heat events. While we acknowledge the need to address critical resource and capacity needs at the local level, we understand that these challenges require additional local funding and potentially state level organizational support to affect public health outcomes. We also understand that, without significant efforts to mitigate GHG emissions, reduce urban heat Islands through improved planning, and cool our existing buildings and housing stock, even the most well-resourced short-term response efforts will likely fall short in the long-term in most California communities.

Although there are a wide range of challenges associated with improving health outcomes during extreme heat events, only a few of these issues are best addressed through an online decision-support tool. Our UNA participants noted that improved and expanded access to climate and heat vulnerability data might inspire more action at the long-term planning level and possibly help to “make the case” for prioritizing extreme heat as a priority climate hazard. Participants also pointed to the critical resource, governance, economic, social equity and local capacity issues that will ultimately need to be addressed in order to improve near-term health outcomes and the effectiveness of local response. Given that addressing these challenges requires cross-agency collaboration, evaluation of current policies and protocols and new funding sources, an online-decision support tool is likely not the ideal instrument to advance improvements in short-term response.

Therefore, based on the results of our literature review, UNA, and the insights provided by potential tool users in both public health and emergency management, **the tool will focus on informing long-term heat-related planning decisions as opposed to short-term extreme heat response.** The target user group for this long-term planning tool will include practitioners in local departments such as sustainability, housing, transportation and public health that focus on integrating climate change hazards, such as extreme heat, into local planning processes¹⁴. It will integrate climate projections out to mid-century with data on a wide variety of heat vulnerability indicators at the local level to provide these practitioners with long-term visibility on the public health implications of extreme heat. Our revised goals for the tool based on the results of the user needs assessment include:

- Provides actionable information for users to inform long-term climate, land use, housing, hazard and preparedness, public health and sustainability policies and planning;

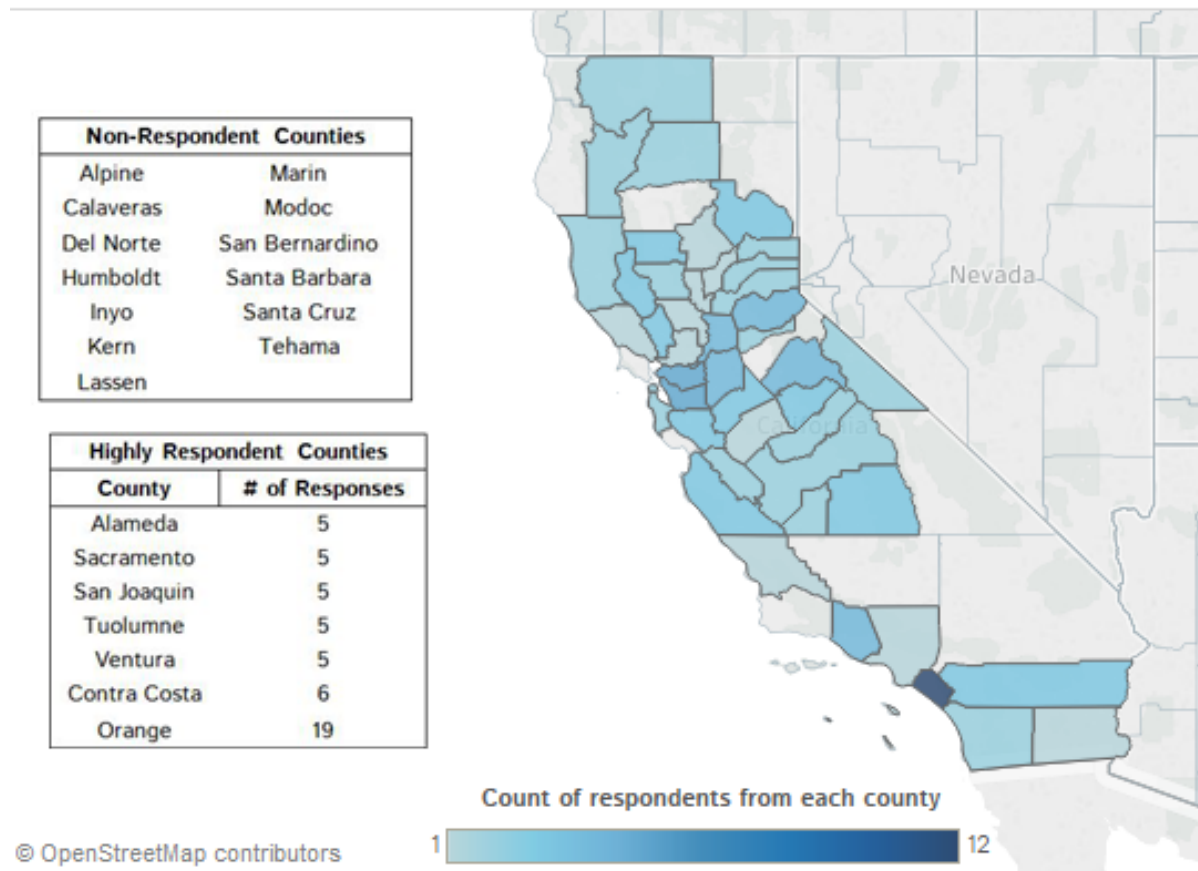
¹⁴ Planning processes include climate action plans, climate adaptation and preparedness plans, extreme heat plans, hazard mitigation plans and general plans, among others

- Supports all of California’s regions and captures local climate variability at thresholds tailored to place and population;
- Includes contextual layers of social and heat vulnerability and highlights key equity issues across geographies;
- Presents projections for climate and weather data out to mid-century and provides contextual layers at the census tract level whenever feasible;
- Is user-friendly and provides valuable information that can be easily interpreted and analyzed.

By designing a tool that is focused on informing long-term planning to mitigate the public health impacts of extreme heat, we hope to enable better integration of climate projections and potential heat vulnerability risks and outcomes into local planning processes. Our tool will cover the entire state of California and therefore will also provide state officials with the opportunity to better understand which regions are at highest risk of poor health outcomes to prioritize future research and funding efforts. The ability to compare risks and potential outcomes across counties will also position local practitioners to leverage scarce resources by sharing information and best practices across agencies and geographies. Given the multi-faceted nature of heat vulnerability, we also hope that this tool will empower local practitioners to better communicate the urgency of this issue to build much needed support for improved planning and new solutions.

APPENDIX A: User Needs Assessment Methodology

Four Twenty Seven conducted a User Needs Assessment (UNA) in the summer of 2016 to inform the development of an online decision support tool for the California Heat & Health Project. The UNA consisted of approximately 30 phone interviews and an online survey of over 100 public health and emergency preparedness stakeholders and practitioners representing 43 California counties. The following graphs show both non- and highly respondent counties as well as the count of respondents from each county.

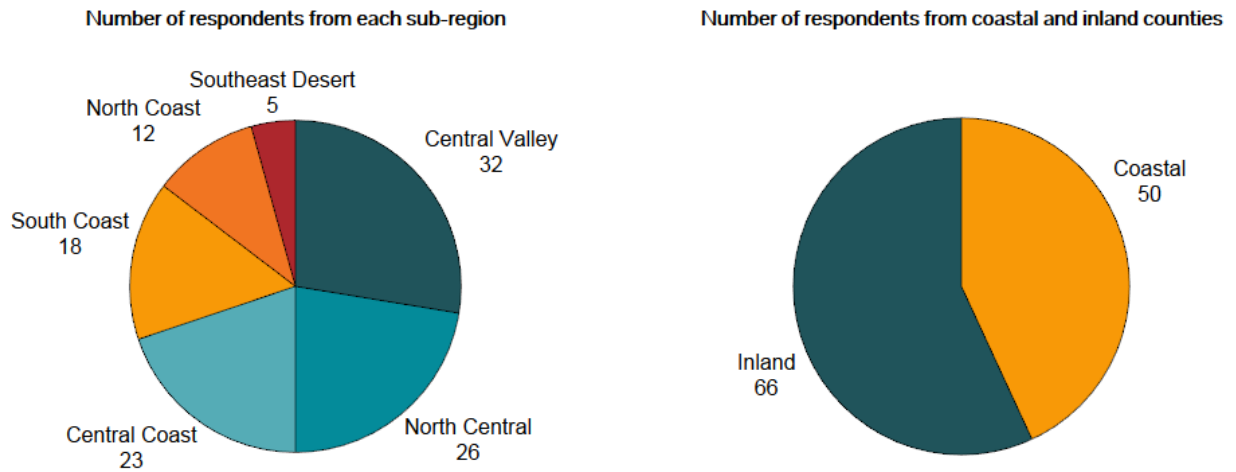


The Four Twenty Seven team reached out to various public health associations and agencies as well as Cal OES to promote and distribute the online survey and conduct interviews. These groups included:

- The California Conference of Health Officers (CCLHO)
- The California Directors of Public Health Nursing
- The County Health Executives Association of California
- The San Joaquin Valley Public Health Consortium
- The Climate Readiness Institute’s Bay Area Climate and Health Working Group
- The Public Health Alliance of Southern California

Our outreach efforts resulted in diverse regional distribution of survey respondents. Regional distribution of survey respondents is illustrated in the following graphs.

Respondent Breakdown



Four Twenty Seven coordinated with and gathered input from our project Technical Leads at the California Department of Public Health’s Office of Health Equity through monthly calls and interviews. We also interviewed key stakeholders at the California Governor’s Office of Planning and Research. Detailed survey results are tabulated in an interactive dashboard and available to review upon request.

The survey included twelve questions designed to help us understand the following:

- Various roles and responsibilities across public health and emergency management agencies in responding to extreme heat events
- How information on heat events and the health impacts of extreme heat is distributed and communicated across the state
- Key information gaps that our online decision support tool could address to improve health outcomes during and following an extreme heat event

APPENDIX B: Online Survey Questions

1. How are you alerted when an Excessive Heat Warning is issued in your county/jurisdiction? (click all that apply)
 - g. I am notified by the local National Weather Service (NWS)
 - h. I am notified by my California Health Alert Network (CA HAN) Coordinator
 - i. I am notified by my county/jurisdiction's Public Health Information Officer
 - j. I am notified by my county/jurisdiction's Public Health Emergency Preparedness Coordinator
 - k. I am notified by someone in my county/jurisdiction's Office of Emergency Services/Preparedness
 - l. I am notified by a colleague or supervisor that receives the alert directly
 - m. I am not notified

2. Which response best represents your primary responsibility after an Excessive Heat Warning is issued by the National Weather Service (NWS) in your county/jurisdiction? (click all that apply)
 - a. Outreach to public services (hospital, ambulatory, and other emergency services)
 - b. Outreach to community residents and/or vulnerable individuals
 - c. Coordinate with the State Office of Emergency Services or other State Agency
 - d. County-wide coordination with other departments/agencies
 - e. Oversee implementation of your county/jurisdiction's Extreme Heat/Heat Contingency plan procedures
 - f. Implement a portion of your county/jurisdiction's Extreme Heat/Heat Contingency Plan procedures (e.g. conducting outreach on heat safety to vulnerable populations)
 - g. Other (please specify)

3. Indicate the importance of each of the following categories of socio-demographic indicators used to identify vulnerable populations in your county/jurisdiction when planning for and/or responding to an extreme heat event.

	Not Important	Somewhat Important	Moderately Important	Important	Very Important
Medical conditions					
Occupational hazards					
Demographics					
Social Factors					

Environmental quality					
Income security					
Built environment					
Educational attainment					

4. What information do you not currently have access to that would be helpful in planning and preparing for extreme heat events? (click all that apply)
 - a. Long-term projection (in years or decades) of extreme heat events in your county/jurisdiction
 - b. Short-term projection (in weeks) of extreme heat events in your county/jurisdiction
 - c. Probability of the severity of an extreme heat event in your county/jurisdiction
 - d. Local information on vulnerable populations in your county/jurisdiction (zip code or census tract level data as opposed to county level data)
 - e. I don't need any additional information
 - f. I don't know

5. When preparing for and responding to an extreme heat event, would it be helpful to have access to the locations of any of the following categories of community assets in your county/jurisdiction? (click all that apply)
 - a. Schools
 - b. Public venues with air conditioning (i.e. libraries)
 - c. Private venues with air conditioning (i.e. theaters, shopping malls)
 - d. Swimming pools
 - e. I don't know
 - f. No. I already have access to information on community assets of interest

6. Please comment on any other priority information and data gaps that currently impede your or your county/jurisdiction's ability to adequately prepare for and mitigate public health risks from extreme heat events.

7. Which of the following tools or resources have you used to identify populations and/or individuals in your county/jurisdiction that are particularly vulnerable to the public health impacts of extreme heat? (click all that apply)
 - a. Maps of Social Vulnerability to Climate Change by the Pacific Institute
 - b. Cal EPA Urban Heat Island interactive maps
 - c. Cal Enviro Screen 2.0

- d. My Hazards Tool by Cal OES Healthy Communities Data and Indicators Project (HCI) by CDPH
 - e. Internal mapping or point location database containing local data on vulnerable populations or individuals
 - f. I don't use any tools or resources
8. Based on you answer to question 9 above, which of these tools are the most useful and why?
9. Does your agency/department coordinate with any other agencies/departments within your county/jurisdiction to plan for and/or implement interventions (e.g. installing green or cool roofs, providing energy rebates or subsidies for air conditioning for low income residents, increasing urban tree canopy, replacing concrete or asphalt with cool, porous pavement, etc.) that help to mitigate the public health impacts of extreme heat? (click all that apply)
- a. Public or district hospital(s)
 - b. County social/human services agency
 - c. County or city public works department(s)
 - d. County or city planning department(s)
 - e. County or city sustainability department(s)
 - f. County or city transportation department(s)
 - g. County or city general services department(s)
 - h. I don't know
 - i. No, my agency/department does not coordinate with other agencies/departments to plan for or mitigate the public health impacts of extreme heat
10. Does your agency/department coordinate with any other organizations to plan for and/or implement interventions (e.g. conducting home vulnerability assessments, heat-focused health education and outreach, etc.) that help to mitigate the public health impacts of extreme heat? (click all that apply)
- a. Private hospitals
 - b. Utilities
 - c. Non-profit/community organizations
 - d. No, my agency/department does not coordinate with other agencies/departments to plan for or mitigate the public health impacts of extreme heat
 - e. I don't know
 - f. Other organizations:
11. In your opinion, what are the top three most effective local interventions/actions to mitigate the public health impacts of extreme heat for your county/jurisdiction (i.e. installing green or cool roofs, providing energy rebates or subsidies for air conditioning for low income residents, increasing urban tree canopy, replacing concrete or asphalt with cool, porous pavement, etc.)?

12. Share any other thoughts that could help us to better design the Heat and Health Decision Support Tool and make it more useful for your county/jurisdiction.

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