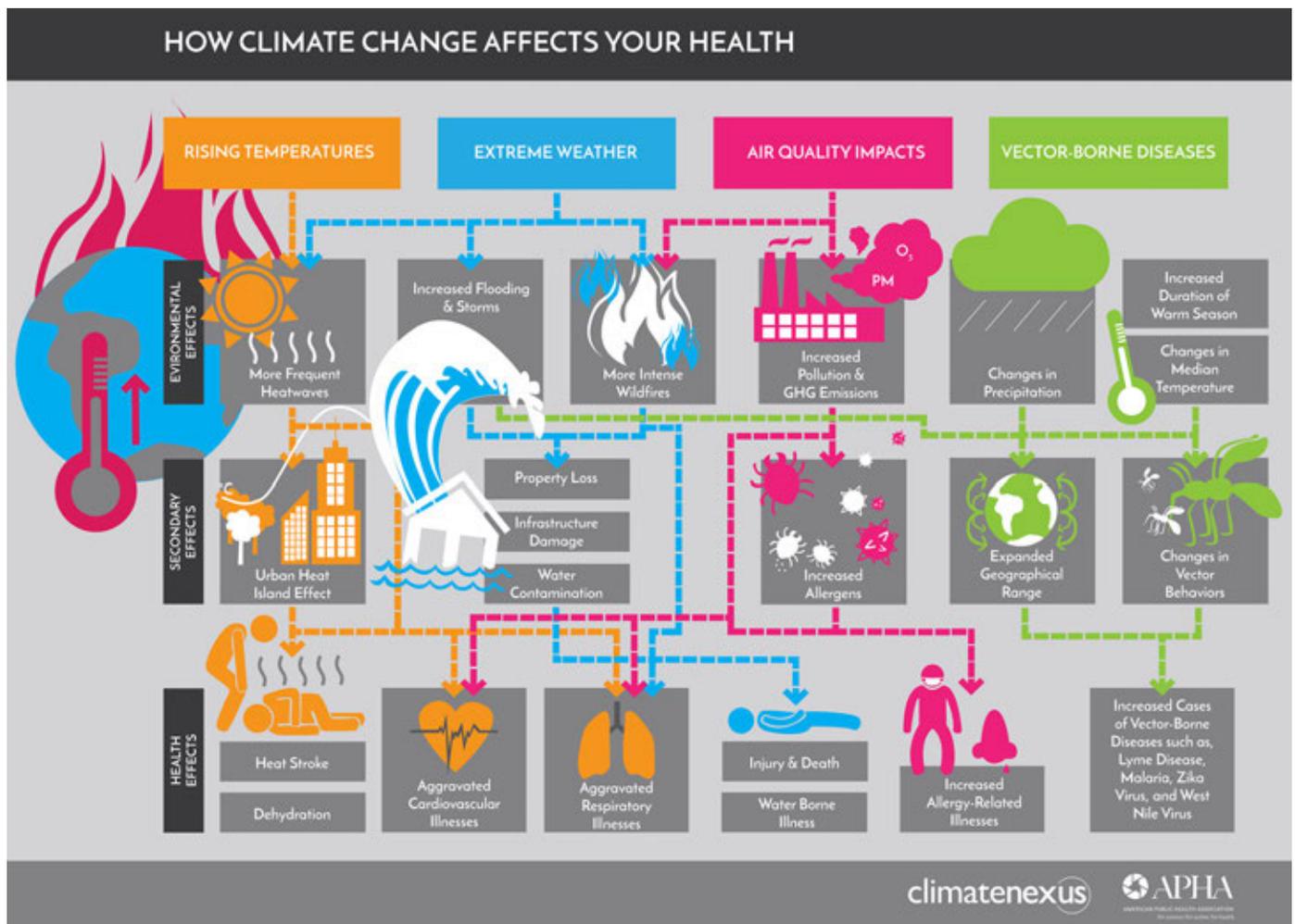




# Health Impacts of Climate Change

Climate change threatens the fundamentals that sustain life and health—fresh water, food, clean air, shelter, and security—and thus threatens the health and possibly the very survival of the communities that local health departments serve. Climate change is a global phenomenon, but it is people and communities at the local level that experience its consequences. Climate change exacerbates local and global health inequities because some people and communities bear an unfair burden of these health harms, including low-income communities, communities of color, native and tribal communities, the very young and very old, and those with chronic illnesses. This Section provides an overview of the health impacts of climate change.



APHA, Climate Nexus 2016

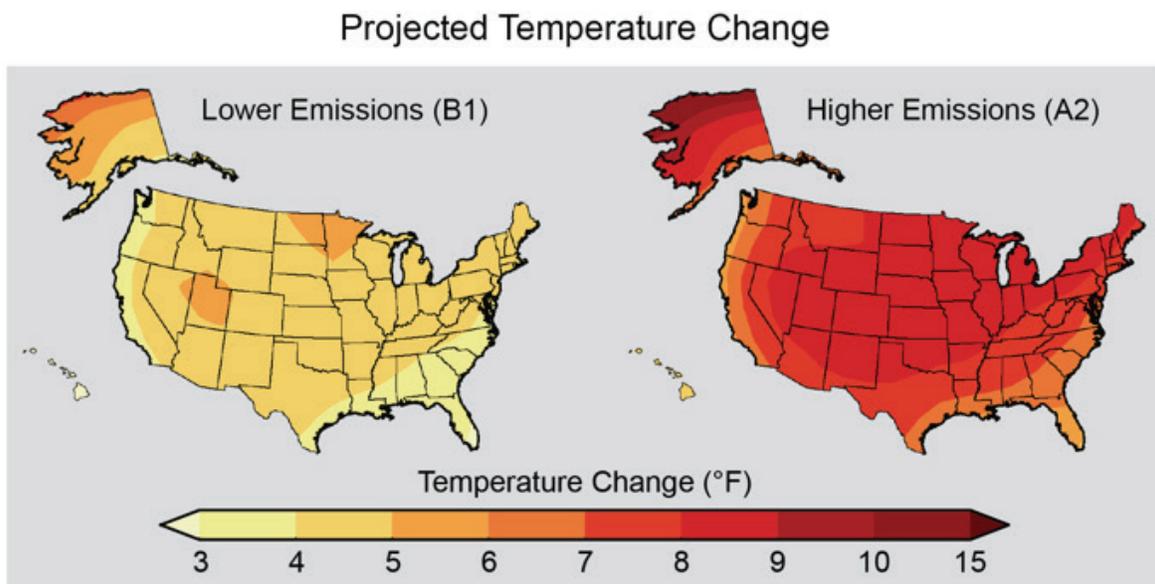
## 4.1 Extreme Heat

The CDC defines extreme heat as “summertime temperatures that are substantially hotter and/or more humid than average for that location at that time of year.”<sup>1</sup> *Climate change increases extreme heat exposure.*

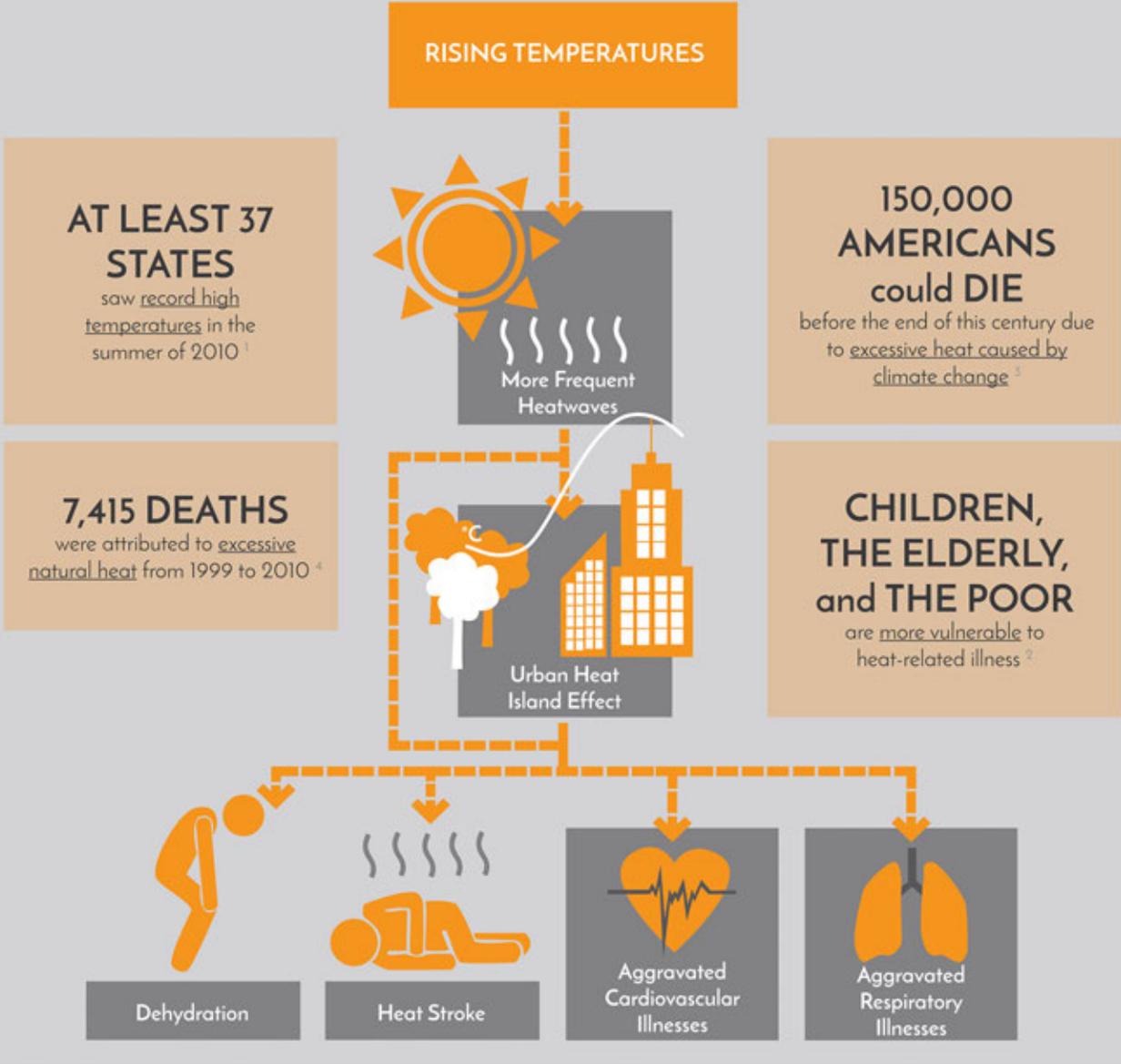
### Climate Change Worsens Extreme Heat

- Seventeen of the country’s eighteen warmest years on record have occurred since 2001.<sup>2</sup>
- In 2017, periods of extreme heat broke state records throughout the summer and fall. Every state had an annual average temperature that was warmer than usual.<sup>3</sup> Arizona, Georgia, New Mexico, North Carolina, and South Carolina had the warmest year on record.<sup>4</sup> There has been a dramatic increase in hot nighttime temperatures in the U.S., reducing critical hours of relief during heat waves.<sup>5</sup>
- Different regions of the U.S. are expected to see varying levels of temperature increase due to climate change; average temperature is projected to increase by 3–5°F by the mid-2030s and 2.8–10.8°F by the end of the century.<sup>6</sup> See Figure 4.1.1.

**Figure 4.1.1:** Projected change in average surface air temperature from 2071 to 2099 relative to 1970–1999 temperatures under a scenario that assumes substantial reductions in GHGE (B1) and a higher emissions scenario that assumes continued increases in global GHGE (A2)<sup>7</sup>



# HOW CLIMATE CHANGE AFFECTS YOUR HEALTH



<sup>1</sup> <http://www.mdc.org/health/clinics/heat.asp>  
<sup>2</sup> <http://www1.eppc.gov/ClimateChange/Impacts/Health.html>  
<sup>3</sup> <http://www.mdc.org/globalwarming/urban-heat/>  
<sup>4</sup> <http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5226a1.htm>



APHA, Climate Nexus 2016

## Health Impacts of Extreme Heat

Heat already causes more deaths than any other natural disaster.<sup>8</sup>

- From 1999–2010, 7,415 people died from heat-related illness in the U.S., an average of 618 per year.<sup>9</sup> Extreme heat results in excess death and illness through heat stroke, heat exhaustion, and exacerbation of chronic illness. In addition, heat exposure triggers multiple physiological mechanisms that cause damage to the brain, heart, intestines, kidneys, liver, lungs, and pancreas.<sup>10</sup>
- Increased ozone levels from extreme heat exacerbate asthma, respiratory disease, and cardiovascular disease.<sup>11</sup>
- Heat stress and associated dehydration can exacerbate renal disease and may be linked to new epidemics of chronic kidney disease.<sup>12</sup>
- Exposure to extreme heat impacts mental health through increased incidence of disease, death, violence, aggression, suicide and higher rates of admission for those with a psychiatric condition. Persons with mental illness may have triple the risk of death during a heat wave.<sup>13</sup> In the U.S., there is an association between periods of extreme heat and increased rates of violent crimes in cities.<sup>14</sup>
- Some medications are sensitive to heat and may lose effectiveness or cause harmful side effects when exposed to heat.<sup>15</sup> Other medications alter individual tolerance to extreme heat, increasing the risk of heat illness.<sup>16</sup>
- Heat waves contribute to crop and livestock loss, resulting in rising food prices and increased food insecurity.<sup>17,18</sup>

## Extreme Heat and Health Equity

- **Urban heat islands:** Low income and communities of color are more likely to be located in “urban heat islands”—dense urban areas with fewer trees, less green space, more buildings, higher energy use, and more impervious asphalt and concrete. These characteristics create urban heat islands where nighttime temperatures may be as much as 22°F higher than surrounding areas. These vulnerabilities often map onto areas of historical residential segregation.<sup>19</sup>
- **Race and ethnicity:** As of 2013, African Americans were 52% more likely, Asian Americans 32% more likely, and Hispanics 21% more likely to live in heat vulnerable areas of the U.S. compared with non-Hispanic Whites.<sup>20</sup>
- **Rural communities:** The risk of heat-related mortality may be about 3% higher in rural areas when compared to urban areas, potentially linked with less access to health care services, greater proportions of elderly people, many outdoor occupations, fewer media to share heat information, and less access to air conditioning and transportation.<sup>21</sup>
- **Working conditions:** Outdoor farmworkers are at greater risk of exposure to extreme heat, and from 1992–2006, heat-related deaths were 20 times higher among crop workers than the general U.S. population.<sup>22</sup> Occupational heat stress and chronic dehydration may lead to chronic kidney disease in outdoor workers.<sup>23</sup>

## LHD Spotlight:

### Cooling Centers in Maricopa County, Arizona

In 2005, 35 individuals died over a 9-day period of extreme heat in Maricopa County.<sup>29</sup> MCDPH partnered with the Arizona Department of Health Services and Arizona State University to evaluate community access to and perceptions of cooling centers by surveying facility visitors and managers and observing use during an extreme heat event.

There are 58 private and public cooling centers in Maricopa County—locations that are air-conditioned or cooled and have been designated as a site individuals can go to during heat events.<sup>30</sup> The evaluation found that many cooling centers were open only on weekdays, primarily in community centers, senior centers, and religious institutions without clear or visible signs notifying the public of the availability of a cooling center.<sup>31</sup> Eighty-four percent of visitors were unemployed, 33% had no permanent residence, and 11% of those who indicated a permanent residence had no air conditioning at their place of living.<sup>32</sup>

Maricopa County subsequently developed a Heat Relief Regional Network—a partnership of municipalities, nonprofit organizations, and faith-based organizations—to mitigate heat health risks. The Network maintains a list of cooling centers and services on available maps and hosts trainings on heat illness prevention for facility managers.<sup>33</sup>

- **Social isolation:** Social, cultural, and linguistic isolation are all risk factors for heat illness.<sup>24</sup> In the European heat wave of 2003, elders living alone had the highest mortality rates.<sup>25</sup>
- **Physical or cognitive impairments:** Limited mobility increases the risk of isolation, and the ability to move to a cooler location. Cognitive impairment may limit the ability to recognize risk or seek assistance during an extreme heat event.
- **Age:** The very young and the elderly are less able to sense and adapt to changes in temperature, due to limitations in body temperature regulation.
- **Chronic Illness:** Those with conditions such as obesity, diabetes or renal, cardiovascular and respiratory diseases are at higher risk of heat illness, including exacerbation of complications related to their underlying illness.<sup>26</sup>
- **Air Conditioning Access:** A 2005 study found that African American households had 5.3% higher heat-related mortality rate than White households, and had half the access to central AC.<sup>27</sup>
- **Evolving Extreme Heat Geography:** People living in some regions of the U.S., such as coastal communities, may be especially vulnerable to extreme heat because they are not currently acclimatized to increased temperatures but will experience increased high heat days.<sup>28</sup>

## World Health Organization's Core Elements of Heat–Health Action Plans<sup>43</sup>

1. Agreement on a lead body to coordinate a multi-purpose collaborative mechanism between bodies and institutions and to direct the response if an emergency occurs.
2. Accurate and timely alert systems.
3. A heat-related health information plan (what is communicated, to whom and when).
4. A reduction in indoor heat exposure, including medium- and short-term strategies and advice on how to keep indoor temperatures low during heat episodes.
5. Particular care for vulnerable population groups.
6. Preparedness of the health- and social-care systems (staff training and planning, appropriate health care and the physical environment).
7. Long-term urban planning to address building design and energy and transport policies that will ultimately reduce heat exposure.
8. Real-time surveillance and evaluation.

### What Local Health Departments Can Do

See Sections [6—Programs](#) and [7—Functions](#)

#### Assessment and Surveillance

- Conduct a heat vulnerability assessment for your jurisdiction:
  - Use available data to identify and map vulnerable populations, neighborhoods with characteristics that increase temperatures, and the location and availability of cooling centers.
  - Share this information with partners including health care providers and institutions, community based organizations, schools, emergency management agencies, and social services agencies.
  - Share this information with residents and community-based organizations to foster awareness of heat illness prevention and to elicit suggestions for steps the community and local agencies might take to address heat vulnerability.
  - Use the heat vulnerability assessment to demonstrate the need for preferential greening in tree and park poor neighborhoods, urban heat islands, and areas with high numbers of people with individual or household risk factors for heat illness.
- Initiate heat illness syndromic surveillance and partner with local health care facilities to implement reporting on heat-related illness (See the Section [7.1—Surveillance](#)).

## Intersectoral Collaboration

Collaborate with parks, public works, sustainability offices, and community groups to support and fund the expansion of green space and green infrastructure that reduces ambient temperatures and provides access to cooler spaces, including tree canopy, parks, water features, and urban streams.

- Ensure preferential planting of less allergenic trees and plants.<sup>34</sup>
- Implement cool and green roofs programs and support related rebates for homes and businesses.<sup>35</sup>

Following are example recommendations for intragency initiatives to combat heat:

- Provide shading for transit stops, bike lanes, and sidewalks; provide access to cooling buses by working with transit agencies and public works.<sup>36</sup>
- Collaborate with law enforcement and emergency services to train police and first responders to recognize heat-related illness in vulnerable populations and ensure that heat response plan includes strategies to reach homebound individuals.
- Ensure that local codes require facilities such as assisted-living establishments monitor and automate air-cooling systems to remain within comfortable temperatures in all living and communal areas.<sup>37</sup>
- Establish relationships with local OSHA officials and employers to ensure that outdoor workers and others vulnerable to heat are informed, and that employers are aware of their responsibilities to prevent occupational heat-related illness, especially providing plenty of drinking water, shaded cool areas, and extended breaks for workers.<sup>38</sup> Adjust work schedules to reduce physical demands during the hottest times of day.<sup>39</sup>
- Use home visits to assess housing conditions and vulnerability of household members, provide heat health information, and make referrals to social service agencies and programs that provide financial support (rebates, bill-paying subsidies) for services that could prevent heat-related illness (air conditioning, tree planting, weatherization).
  - Work with utilities and other agencies to inform residents about and ensure enforcement of “disconnection rules” that prohibit electricity cut-offs.<sup>40</sup>
  - Connect clients and communities to resources for financial support in coping with heat, such as Low-Income Home Energy Assistance Program (LIHEAP).<sup>41</sup>
- Work with housing and social service agencies to integrate extreme heat assessments and education into home visiting programs.

## Prepare for Extreme Heat Events

Implement early warning systems for extreme heat events by collaborating with local weather forecasters to use a standard terminology for heat health and agree on the threshold used. In addition, consider the following:

- Broadcast extreme heat conditions with information on preventing heat illness, checking on neighbors and family members, and access to cooling centers.
- Set up a phone line and webpage in multiple languages with information on cooling centers and heat illness prevention. Ask the media to publicize these outlets.



*Extreme Heat Warning in Death Valley*  
Graeme Maclean, 2014



*Outdoor Farmworkers*  
Andrew Reding, 2012

- Contact local facilities that serve vulnerable populations (e.g. nursing homes, senior centers, schools and child care providers, homeless services) to ensure protocols for extreme heat are in place and facilities are prepared for activation.
- Establish and evaluate cooling centers to assess the availability of cooling centers and cool sites in your jurisdiction. Ensure there is adequate outreach to communities and vulnerable populations informing them of facilities and cooling sites open during extreme heat events.
  - Work with public agencies and local businesses to make more air conditioned spaces available for extended hours during extreme heat events and make sure that cooling site facilities have adequate power to continue air conditioning.
  - Survey visitors and facility managers of cooling centers to evaluate services, utilization, capacity, and accessibility, including via public transit.<sup>42</sup>

### Community Engagement and Education

Integrate climate change in materials and media messages for the public to increase awareness that climate change is a health issue. Here is an advisory from a webpage warning of extreme heat and health issues:

#### Extreme Heat

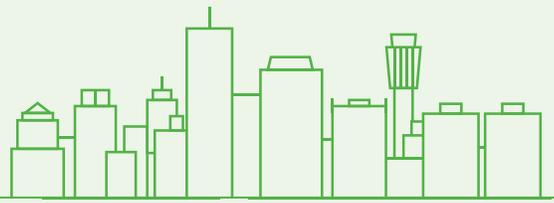
**Original:** Hot and humid summer weather can cause heat illness and even death. More Americans die from heat waves than all other natural disasters combined.<sup>44</sup>

**Modified:** Hot and humid summer weather can cause heat illness and even death. *As climate change causes increasing temperatures around the world, our area can expect to experience more heat events like this.* More Americans die from heat waves than all other natural disasters combined.

- Conduct public awareness campaigns in multiple languages and via various media to educate communities about strategies to reduce neighborhood heat and prevention of heat illness. See the CDC's [Tips for Preventing Heat Illness](#) for more information.<sup>45</sup>
- Inform clients to check with their doctor about medications that increase the risk of heat illness (e.g. psychotropic medications, diuretics, tranquilizers, some medications for Parkinson's disease) and whether prescribed medications (e.g. insulin) may lose effectiveness if exposed to high temperatures. See Polk County, Iowa's [medications and heat handout](#) for an example.<sup>46</sup>
- Educate local clinicians on the health impacts of heat and how they can protect patients and community health during extreme heat, and provide materials for patient waiting rooms. See [A Physician's Guide on Climate Change, Health and Equity](#).

## For More Information

- [CDC Extreme Heat Preparedness:](#)
  - [English site and materials](#)
  - [Spanish site and materials](#)
- [US EPA Heat Island Effect Website](#)
- [US Climate and Health Assessment, Chapter 2: Temperature-Related Death and Illness](#)
- [APHA and CDC's Extreme Heat Can Impact Our Health in Many Ways](#)



# From Surveillance to Engagement: Maricopa County Department of Public Health

Maricopa County Department of Public Health (MCDPH) engaged with diverse partners to host a series of workshops, Bridging Climate Change and Public Health, elevating the health and equity impacts of climate change for numerous partners.

Maricopa County might be considered “heat central” in the U.S. Phoenix, the largest city in the county, has an average of 110 days with temperatures over 100°F and 19 days over 110°F. Average daily temperatures in the Southwest are projected to rise 2.5–8°F by 2100. Maricopa County Department of Public Health (MCDPH) conducts surveillance of heat illness, including syndromic surveillance. From 2006 to 2014, Maricopa County experienced 691 heat-associated deaths. A 2015 rapid epidemiologic assessment of households revealed that although 95% of residents have central air conditioning, high electricity and maintenance costs prevent many from using it.

MCDPH maintains public cooling centers and hydration stations throughout heat season, and partners with community organizations to promote their use and warn the public about heat risks. Although the 2015 [Maricopa County Multi-Jurisdictional Hazard Mitigation Plan](#) identified the likelihood of increased intensity and duration of extreme heat days due to climate change, MCDPH did not refer to climate change in its public communications on heat.

MCDPH recognized that the homebound population is exceptionally vulnerable to extreme heat, and in early 2016 launched a project to assess their needs. In partnership with the Area Agency on Aging, the City of Phoenix Home Delivered Meals program, Arizona State University (ASU), and Maricopa County Human Services Department, MCDPH created a survey that was distributed to homebound individuals by meal delivery staff. Of the 1300 surveys distributed, 472 people responded. The survey identified the need to increase awareness of heat-related services, simplify the process for obtaining services, and make transportation to cooling centers more accessible for homebound individuals.

## From Surveillance to Community Engagement

In November 2016, MCDPH convened a wide array of stakeholders for the first “Bridging Climate Change and Public Health” summit. MCDPH presented the results of the homebound survey and information on impacts of climate change on extreme heat and health. With 45 participating organizations, it set the stage for further discussion about collaborative efforts to address the challenges of climate change. Staff found a very high level of receptivity to the discussion. *“Most importantly, we no longer hesitate to use the term climate change—it has proven to be much more acceptable in our community than we had anticipated.”*

Following a second summit in May 2017, MCDPH convened stakeholders to develop a formal [Bridging Climate Change and Public Health Strategic Plan](#) for Maricopa County. In a series of three meetings, community partners identified five strategic directions, including:

- Celebrate incremental success and climate and health champions.
- Promote community awareness and public education about climate and health.
- Foster environmental and climate action for a healthier community.
- Coordinate research and collaborative efforts to catalyze change.
- Develop a strategic and targeted communication plan.

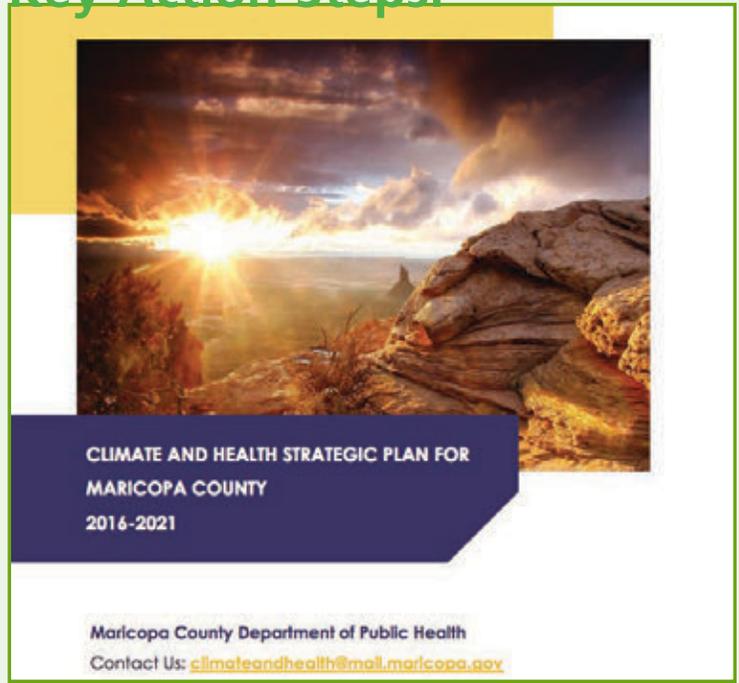
### Future Work

MCPDH has received funding from the Arizona Department of Health Services Building Resilience Against Climate Effects (BRACE) program that will be used to implement the first Strategic Plan action step. Celebrating Success and Champions, will recognize Climate and Health Champions—local youth, citizens, schools, organizations, or businesses that are implementing sustainable solutions and/or ecofriendly practices or policies that promote health in the face of climate change. MCDPH sees the recognition of positive action as one more way to spread awareness about climate and health in Maricopa County.

### Learn More

- [Bridging Climate Change and Public Health Strategic Plan](#)
- [Bridging Climate Change and Public Health](#)
- [Maricopa County Heat Surveillance](#)

## Key Action Steps:



- Conduct surveillance on climate-related health impacts.
- Identify a vulnerable population of focus and work with diverse partners to more effectively reach that population, including assessing climate-related health needs.
- Utilize surveillance results to engage the public on climate and health.
- Host a summit or workshop to talk about climate, health, and equity connections; provide a structure for community and stakeholder input to identify actions to protect health.
- Develop a Climate and Health Strategic Plan with other local agencies and stakeholders.

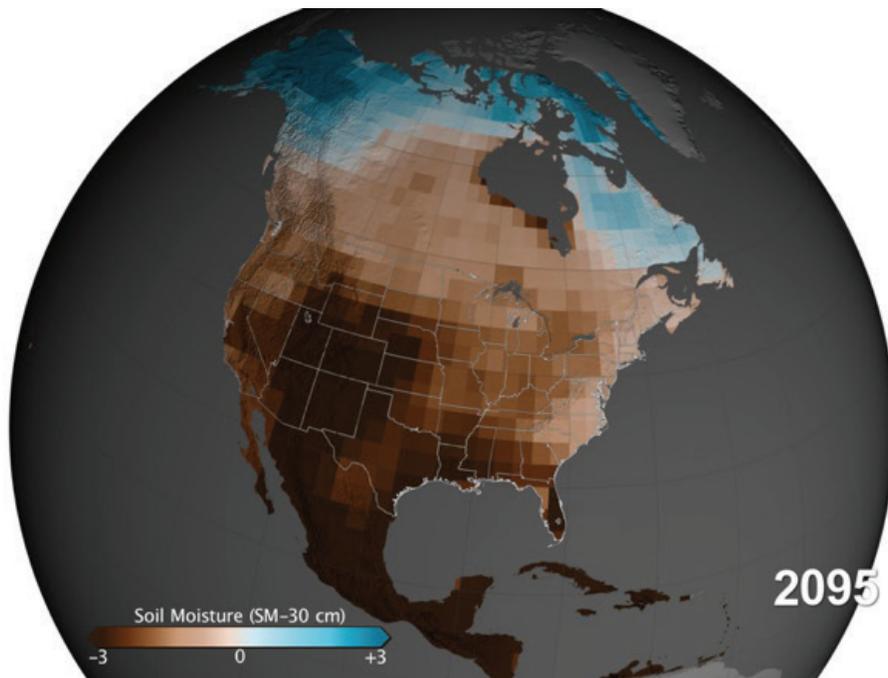
## 4.2 Drought

### Climate Change Increases Drought Frequency and Intensity

Drought is a deficiency of rainfall over a period of time, resulting in a water shortage for some activity, group, or environmental sector.<sup>1</sup> Climate change is increasing the frequency, severity, and duration of droughts: A NASA analysis found that, with current greenhouse gas emission trends, the Southwest and Central Plains of the U.S. have an 80% likelihood of megadroughts that could last decades between the years 2050 and 2099 (Figure 4.2.1).<sup>2</sup>

- With emissions cuts, the chance of megadroughts in these regions decreases to 60%.<sup>3</sup>
- While the U.S. Dust Bowl in the 1930s lasted a decade, NASA analyses have found that future droughts throughout the U.S. may last at least 30 to 35 years, resulting in the driest periods of these regions in the last 1,000 years.<sup>4,5</sup>
- Water consumption and withdrawal of water from surface and underground water aquifers is increasing, and leading to greater pressure on limited water resources.<sup>6</sup>

**Figure 4.2.1:** Soil moisture 30 cm below ground projected through 2095 for high emissions scenario RCP 8.<sup>7</sup>





2013 Drought in Texas  
Bob Nichols, USDA, 2013



Extensive Tree Die-Off in Sierra National Forest Wildland Urban Interface  
U.S. Forest Service, Pacific Southwest Region 5, 2016

## Health Impacts of Drought

People need water to drink, cook, grow food, and for sanitation and hygiene. Severe drought may reduce water access (including through strict conservation measures) so that water for these purposes is limited. Drought can cause these health risks:

- Lower crop yields and increased crop loss contribute to rising food prices and amplify food insecurity, associated with increased risk of chronic diseases.<sup>8</sup>
- The affects of drought on physical health, food security, economic livelihood, social stability, and forced migration can have serious mental health impacts.<sup>9</sup>
- Drought can increase the concentration of industrial chemicals, heavy metals, and agriculture runoff contaminants in groundwater, increasing the risk of toxic exposure if communities increase reliance on groundwater sources as surface water diminishes.
- As communities draw on groundwater, land sinking puts infrastructure like roads, aqueducts and levees at risk of permanent damage.<sup>10</sup>
- Drought increases over-pumping of groundwater that contributes to seawater intrusion and increased groundwater salinity<sup>11</sup> (See Section [4.6—Sea Level Rise](#)).
- Dry vegetation and increased heat from drought are associated with more frequent wildfires, which have widespread health impacts (See Section [4.3—Wildfires](#)).<sup>12</sup>
- Drought increases the risk of infectious and vector-borne disease. The risk of Valley Fever increases as soil dries out and dust is dispersed in the air.<sup>13</sup> Due to increased household water collection during drought, increased pools of stagnant water in storm water and sewer pipes can bring mosquitoes closer to human populations and increase vector-borne disease transmission.<sup>14</sup> As animals seek water, they and the insects they host may move closer to where people live, increasing the likelihood of human exposures (See Section [6.2—Infectious Disease](#)).<sup>15</sup>
- Due to crop loss and lower yields, drought can cause displacement and mass migration for agriculture workers. By 1940, the Dust Bowl had forced 2.5 million people out of the Plains states.<sup>16</sup>

## Drought and Health Equity

- **Poverty:** Those with limited financial resources are vulnerable to food and water insecurity from rising food and water prices associated with drought and crop loss.<sup>17</sup>
- **Agricultural Workers:** Farmers and communities are more vulnerable to the adverse economic impacts of drought, and to the mental health impacts.<sup>18</sup>
- **Rural Communities:** Poor rural communities are disproportionately reliant on small water systems or private drinking water wells, and thus at increased risk of water shortages or exposure to contaminated well water.<sup>19</sup>
- **Tribal Communities:** Native communities are already facing impacts of long-term drought on their agriculture and livestock, springs, medicinal and culturally important plants, and drinking water supplies.<sup>20</sup> Native communities are more likely to lack access to clean, potable drinking water than other groups in the U.S.<sup>21</sup>
- **Chronic Illness:** Lack of safe drinking water can exacerbate pre-existing renal disease.<sup>22</sup> Food insecurity is associated with higher risks of chronic illness such as diabetes and hypertension (See Section [4.8—Food Security](#)).
- **Race and Ethnicity:** African American and Filipino populations are at increased risk of contracting dust-related Coccidioidomycosis (Valley fever).<sup>23</sup> Eighty percent of U.S. farmworkers identify as Hispanic, and this group is more vulnerable to economic impacts of extended periods of drought.<sup>24</sup>

## What Local Health Departments Can Do

See Sections [6—Programs](#) and [7—Functions](#)

### Assessment and Surveillance

- Work with water utilities and other agencies to conduct a drought vulnerability assessment.<sup>33</sup>
  - Assess climate impacts on likelihood of drought, the projected impact on agriculture/farming, inventory of well owners, community water sources, water pricing, and water insecurity.
  - Identify vulnerable populations and community assets.
  - Monitor water price increases and assess impacts on low-income residents.
  - Scale mosquito monitoring to correspond to changes in precipitation and identify where nesting sites may proliferate due to drought.
  - Increase groundwater and surface water quality monitoring during drought for increased concentration of contaminants and increased salinity in areas at risk of saltwater incursion.
- Survey households using the Community Assessment for Public Health Emergency Response (CASPER) methodology to understand the drought’s impact on household water use, water access, conservation behaviors, hygiene, work, budgets, and health to plan programming and response to needs of your jurisdiction (See Section [7.1—Surveillance](#)).<sup>34</sup>
- Enhance monitoring of water quality and contamination during drought.<sup>35</sup>

## LHD Spotlight: Understanding the Impacts of Drought in Tulare County, CA<sup>25</sup>

Tulare County, California is a rural agricultural community in California's San Joaquin Valley and may be a harbinger of what increased drought looks like. As the worst California drought in recorded history lingered on, private wells in Tulare County started to run dry. By November 2015, 1,308 wells had run dry, affecting over 6,000 residents.<sup>26</sup>

- Thousands of agricultural workers lost their jobs as thousands of acres of farmland were fallowed.
- Local food banks and other services were overwhelmed.
- Local emergency rooms reported a 25% increase in respiratory disease visits.<sup>27</sup>
- The community saw a rise in illnesses such as West Nile Virus and Valley Fever and twice the statewide rate of diarrheal disease in 2013.<sup>28,29</sup>
- Throughout the county, there were rising levels of stress, anxiety, depression, and other mental health concerns.<sup>30</sup>

To better understand how the drought was impacting communities within its jurisdiction, the Tulare County Health and Human Services (TCHHS) Agency partnered with the California Department of Public Health's Division of Environmental and Occupational Disease Control to survey residents using the Community Assessment for Public Health Emergency Response (CASPER) methodology. TCHHS representatives went door-to-door within clustered regions of the county to gather responses to a survey assessing 1) household demographics, 2) drought knowledge and practices, 3) water access and use, 4) conservation practices, 5) related employment and health impacts, and 6) emergency communication preferences.<sup>31</sup> This informed TCHHS about vulnerable communities in their jurisdiction and how to improve drought-related communications.

Many of the residents surveyed were undocumented and were thus afraid to report that their taps had run dry, providing TCHHS with vital information on vulnerability within the community to improve their outreach efforts. In some communities, a third of the households requested Spanish for emergency communications. These [surveys](#) highlighted potential entry points for programmatic action, such as improving conservation behaviors or ensuring better hygiene practices.<sup>32</sup>

### Intersectoral Collaboration

- Work with local water agencies/suppliers to develop protocols to ensure that water price increases do not lead to water shutoffs that impact health and well-being.
- Work with local water agencies and suppliers to prepare community drinking water delivery plans to supplement drinking and hygiene supplies in vulnerable areas.<sup>36</sup> Provide alternate water supplies, including hauled water and bottled water.
- Collaborate with parks and recreation, public works, and community groups to support rain water catchment and grey water reuse.

- Educate community members about safe and healthy water conservation.
- Ensure water from community rain barrels is clearly marked for non-potable uses and ensure individuals installing home rainwater systems are informed about safe usage.
- Promote the use of screens and other mosquito deterrents for water storage vesicles to prevent the spread of mosquito-borne illness.
- Work with local water agencies to assess permit requests for new wells or requests to dig existing wells deeper to prevent additional draws on local water resources in drought prone areas.<sup>37</sup>
- Support improvement of existing water systems to ensure adequacy of access to safe and clean drinking water, such as: establishing connections to adjacent public water system, replacing or rehabilitating wells, increasing access to temporary treatment systems.

### Prepare for Droughts

- Prepare for an influx of public health service requests with prolonged drought.<sup>38</sup> Anticipate extra resources for vector control.
- Collaborate across agencies and community groups to build support for initiatives that protect ever more precious water from contamination (e.g. nitrate contamination policies, reducing pesticide use) to reduce the likelihood of enhanced contamination.<sup>39</sup>

### Community Engagement and Education

- Integrate mentions of climate change in materials and media messages for the public, to increase public awareness that climate change is a health issue. Opportunities include public health alerts, health advisory announcements, and educational materials and campaigns related to drought. For example:

#### Drought

**Original:** Drought can cause significant mental health impacts on residents, especially in rural communities that depend upon farming and ranching as a basis of economic support. Risk of stress, depression, suicide, and substance abuse may increase during a drought.<sup>40</sup>

**Modified:** Drought can cause significant mental health impacts on residents, especially in rural communities that depend upon farming and ranching as a basis of economic support. Risk of stress, depression, suicide, and substance abuse may increase during a drought. California *is likely to experience extended periods of drought in coming decades due to climate change.*

- Conduct public awareness campaigns—in multiple languages and via various media—and educate clients and communities on the rising risks of drought due to climate change, health risks associated drought, and how to prevent them, including:
  - Use language-appropriate outreach to inform residents of available drought assistance, including behavioral health, public health, and food assistance services.<sup>41</sup>

- Disseminate information on water conservation during routine facilities inspections and home visits.<sup>42</sup>
- Communicate the importance of hand hygiene and educate clients on alternatives that can be used when water is limited.<sup>43</sup>
- Discuss how prolonged drought may increase West Nile Virus incidence and how to avoid transmission: use of insect repellent, clothing, window screens, destruction of breeding habitat, avoiding outdoors during peak hours.
- Educate communities on Valley Fever and how to avoid transmission: avoiding areas and activities with high dust exposure (construction or dusty fields, gardening, etc.), staying indoors with windows closed on windy and dusty days, and ensuring good indoor air filtration.
- Educate communities about how to access and wear respirators, such as an N95 mask if activities in areas with poor air quality cannot be avoided.
- Discuss the social and psychological impacts of drought and refer clients to mental health services.
- Provide well owners with information on testing wells more frequently during drought when there is less water to dilute contaminants.<sup>44,45</sup>
- Educate local clinicians on the health impacts of drought and how they can best protect patient and community health during droughts. For more information see [\*A Physician's Guide on Climate Change, Health and Equity\*](#).

## For More Information

- [\*Preparing for the Health Effects of Drought: A Resource Guide for Public Health Professionals\*](#)
- [\*CDC Drought and Health site\*](#)
- [\*When Every Drop Counts: Protecting Public Health During Drought Conditions, A Guide for Public Health Professionals\*](#)
- [\*Health effects of drought: A systematic review of the evidence\*](#)
- [\*NACCHO's How Local Health Departments can Assist in Response to the California Drought\*](#)
- [\*US Climate and Health Assessment, Chapter 4: Extreme Events\*](#)
- [\*APHA and CDC factsheet on extreme rainfall, drought, climate change, and health\*](#)



*N-95 Mask Fit Testing by Alamosa County Public Health*  
Alamosa County Public Health, 2010



*Firefighters During Idaho Wildfire*  
U.S. Department of Agriculture, 2012

## 4.3 Wildfires

### Climate Change Increases Wildfire Risk

Climate change causes higher temperatures, earlier snowmelt, and drier conditions that increase the frequency, intensity and duration of wildfires, as well as the length of wildfire seasons in the U.S.<sup>1</sup>

- Wildfire seasons are expected to be longer and stronger across the U.S. by 2050.<sup>2</sup> High fire years are likely to occur 2–4 times per decade by 2050, instead of once per decade, as was the average before 2010.<sup>3</sup>
- Increasing development at the wildland-urban interface places more homes and people at risk. In 2015, a USDA study assessed vulnerability in “wildland/urban interface” and found almost one-third of the U.S. population lived in the most vulnerable areas to wildfires.<sup>4</sup>
- Warmer temperatures and precipitation changes associated with climate changes are contributing to growth in bark beetle populations, leading to millions of dead trees across Western forests.<sup>5</sup> Unhealthy forests may contribute to more intense wildfires.<sup>6</sup>

### Wildfires Worsen Climate Change

Wildfires contribute to global warming by releasing massive amounts of carbon into the atmosphere and reducing the amount of forest available to sequester carbon.<sup>7</sup> Up to 3% of annual U.S. greenhouse gas emissions come from wildfires.<sup>8</sup> Western forests are important carbon sinks, capturing 20–40% of U.S. carbon emissions.<sup>9</sup> The EPA estimates that U.S. wildfires emitted around 164.1 million metric tons of carbon dioxide in 2015, growing substantially from previous years, and accounting for 2% of the country’s annual CO<sub>2</sub> emissions.<sup>10</sup>

### Health Impacts of Wildfires

- Wildfires are a major source of particulate matter (PM).<sup>18,19</sup> PM exposure increases the risk of cardiovascular disease and respiratory illnesses, and wildfires increase the risk of premature death, exacerbated asthma, bronchitis, chest pain, and negative birth outcomes from PM exposure.<sup>20</sup>

- Wildfire smoke can travel long distances and affect the health of people far downwind of the fire. Smoke from the 2002 wildfires in Quebec caused a 30-fold increase in PM2.5 in Baltimore, MD, which is nearly 1,000 miles downwind,<sup>21</sup> and pollutants from a 2004 Alaska wildfire were found in Europe.<sup>22</sup> Air quality in surrounding regions can also remain poor for weeks.<sup>23</sup>
- Wildfires also increase exposure to carbon monoxide, ground level ozone and toxic chemicals released from burning building materials or used to fight the fire.<sup>24</sup>
- Indoor air quality is impacted as smoke penetrates into homes, which is where the majority of exposure to wildfire particulate matter occurs for individuals sheltering in place.<sup>25</sup>
- Wildfires cause immediate harm through burns, traumatic injury, smoke inhalation, and heat stress; wildland firefighters are at particularly high risk.<sup>26,27</sup>
- Soil erosion and runoff from wildfires can contaminate water supplies far downstream from the fire site, negatively impacting the quality, quantity, and availability of safe freshwater supplies.<sup>28</sup>
- Wildfires can leave soils damaged and vulnerable to extreme erosion, which can lead to dangerous flooding and mudslides if heavy rains impact the area after the fire.<sup>29</sup>
- Wildfires burn everything in their path, including dangerous chemicals (e.g. in pesticides, propane, gasoline, plastic, and paint) that can burn down to ash with very high concentrations of any toxic components.<sup>30</sup> Clean-up workers may be at highest risk of exposure.
- Wildfires stress health care and public health systems, including skilled nursing facilities, with evacuations, increased medical visits, and the need for emergency response resources.
- The stress, displacement, and loss of home and community associated with wildfires can cause significant mental health problems, including anxiety, depression, and PTSD.<sup>31</sup>

## Western Wildfires in 2017

- Wildfires burned 9,781,062 acres across the U.S., the 3rd largest acreage burned in a year in U.S. records, killing 54 people and costing over \$18 billion in damage.<sup>11,12</sup>
- In Montana, a total of 2,420 fires burned 1.4 million acres, surpassing the previous record set in 2012 for the most area burned in the state for over 100 years.<sup>13</sup>
- In the fall, dozens of wildfires across the Pacific Northwest blanketed the region in thick smoke, creating states of emergencies in many areas.<sup>14</sup>
- There were 7,117 fires in California that burned 505,956 acres, more than double the previous five-year average (202,786 acres).<sup>15</sup>
- Five of the twenty most destructive wildfires in California history occurred in 2017.<sup>16</sup>
- Fires across Southern California in December burnt away vegetation, leaving soils vulnerable to flooding and erosion. In January 2018, heavy rains in these areas led to dangerous flooding and mudslides that killed more than 20 people.<sup>17</sup>

## Wildfires and Health Equity

- **Age:** The very young and the very old are more sensitive to the air quality impacts of wildfires. For children, their developing respiratory systems make them vulnerable to long-term impacts of wildfire smoke, particulates, and ground level ozone.
- **Place:** Communities and households at the wildland-urban interface where human-built environments are adjacent to areas of wildland vegetation are at greater risk of wildfires.<sup>32</sup>
- **Socioeconomic Status:** Low-income households are less likely to have disaster insurance and have fewer resources to cope with or rebound from home and property loss or temporary displacement.
- **Race and Ethnicity:** African Americans have higher rates of asthma and cardiovascular disease that increase sensitivity to the health effects of smoke.
- **Tribal Communities:** Native American and Alaska Native populations living near forested regions are at increased risk of displacement, smoke-exposure, injury, and property loss, especially if more populated areas are prioritized for fire management response.<sup>33</sup>
- **Legal Status:** Undocumented families are not eligible for FEMA assistance and even those who are eligible may fear applying. Immigrants may also have concerns about accessing evacuation shelters and other relief services due to inadequate cultural and linguistic competency of service providers, and undocumented immigrants may fear legal repercussions of seeking services.<sup>34</sup>
- **Emergency Responders:** Firefighters, health care personnel and emergency responders are at increased risk for injury, death, and respiratory impacts of wildfires, as well as mental health affects due to trauma. Wildfire fire fighters are exposed to safety hazards, including burns, electrocution, ash, slips, trips and falls, falling trees, rocks, and vehicle accidents.<sup>35,36</sup>
- **Outdoor Workers:** Other outdoor workers (farmworkers, utility workers) are at risk for respiratory effects of smoke and pollution.<sup>37</sup>
- **Underlying Health Conditions and Status:** Individuals with pre-existing cardiac or respiratory disease are at risk of disease exacerbations due to wildfire smoke. The emergency conditions created by wildfires disrupt individuals' ability to adequately manage their health conditions.
  - People with disabilities (mobility, sensory, cognitive) may be at greater risk of injury or death during evacuations from wildfires.

## What Local Health Departments Can Do

See Sections [6—Programs](#) and [7—Functions](#)

### Assessment and Surveillance

Assess which neighborhoods and what critical infrastructure are vulnerable to wildfires. Wildfires can cause health problems in communities well downwind of a fire and air quality can remain poor for weeks.<sup>38</sup>

The EPA Community Health Vulnerability Index for wildfires includes: asthma prevalence in children and adults, chronic obstructive pulmonary disease, hypertension, diabetes, obesity, percent of population 65 years of age and older, and indicators of socioeconomic status.<sup>39</sup> Researchers recently mapped social vulnerability and biophysical

vulnerability to identify communities at risk in the coterminous U.S., areas with high wildfire potential had, on average, *lower* social vulnerability to wildfires.

- Collaborate with local fire departments and forest services to identify areas vulnerable to wildfire.
- Work with local air quality control agencies to ensure that plans are in place for adequate monitoring of wildfire smoke, both at fixed stations and through low cost, portable monitors for rapid and localized monitoring as fires and winds shift.
- The data from these indices can be used alongside modeled air quality forecast data generated to develop maps of communities with vulnerable populations.
- Partner with local health care partners and facilities to develop systems for syndromic surveillance of smoke-related illness, and implement at the onset of a wildfire in your region or if smoke from afar is creating poor air quality (See Section [7.1—Surveillance](#)).
- After a wildfire, survey households using the Community Assessment for Public Health Emergency Response (CASPER) methodology<sup>40</sup> (See Section [7.1—Surveillance](#)).

### **Intersectoral Collaboration**

Collaborate with community-based organizations to inform vulnerable communities about climate impact projections for wildfire, and engage community residents in preparedness efforts. In addition, work with:

- Zoning departments to support land use policies that reduce development at the urban-wild land interface.<sup>41</sup>
- Building and code enforcement for strengthening building codes to ensure flame resistance for buildings in wildfire-prone areas.<sup>42</sup>
- Local forest service to support smart forestry management, e.g. controlled burns and thinning to manage overcrowded forests, which are more susceptible to wildfires.<sup>43</sup>
- Fire and air quality agencies to deploy air monitors that send information from the ground to satellites, which transmit real time data to web tools so people can remain informed about smoke levels and air quality during a wildfire.<sup>44</sup>
- Social services and health providers to provide HEPA filters to individuals at high risk for smoke-related illness, as smoke can penetrate homes during wildfires.<sup>45</sup>
- Local tribes to ensure Native communities know where shelters are located and how to access services following a wildfire.

### **Prepare for Wildfire Emergencies**

Preparation for wildfire emergencies requires attention to what should happen before, during and after a wildfire event:

- Work with emergency management agencies to engage residents in neighborhood trainings including instructions on how to respond if a fire encroaches their property.
- Prepare evacuation and displacement plans. Include plans for shelters that are equipped to provide clean air, especially for vulnerable populations.

- Establish and exercise plans to ensure that all community members receive information about evacuation orders and the location of shelters
- Plan for provision of fitted respirators and masks (P100 or N95)—and how to use them—for those in smoke-laden areas.
- When deciding on potential closures, consider pollutant levels inside schools and businesses and how they are likely to compare to those in homes—in some cases, schools may be safer for children.<sup>46</sup>
- Consider strategies to provide home air filtration (e.g. HEPA filters) for high risk individuals.<sup>47</sup>
- Coordinate with pharmacies to allow prescription refills for critical medications without renewed contact with physicians during emergencies.<sup>48</sup>

Be ready to provide information and support after a wildfire:

- Connect clients and communities with evacuation and relief centers and financial resources to help cope after wildfires. Vulnerable communities and undocumented individuals and others may be hesitant to access services. For an example of assistance for undocumented families after a wildfire, see the [Undocufund site](#).<sup>49</sup>
- Work with social services and mental health agencies to assure access to mental health services, including for children.
- Provide guidelines for safely inspecting and reentering properties<sup>50</sup>, and make this information readily available in emergency shelters, online, through media, in multiple languages, etc. Include information on health hazards associated with fire retardants and toxic ash, and about the potential for food contamination.<sup>51</sup>

### Community Engagement and Education

Find opportunities to integrate mentions of climate change in materials and media messages for the public whenever relevant, to increase public awareness that climate change is a health issue. Opportunities include public health alerts, health advisory announcements, and educational materials and campaigns related to wildfires.

#### Wildfires

**Original:** Droughts and dry conditions throughout various times of the year increase the risk for wildfires. Careless use of fire in highly wooded areas can also dramatically increase the chance of a wildfire, which can then quickly spread across trees and dry brush and threaten homes and businesses that are in vicinity.<sup>52</sup>

**Modified:** Droughts and dry conditions throughout various times of the year increase the risk for wildfires. *Wildfires are increasing in intensity in our area due to climate change.* Careless use of fire in highly wooded areas can also dramatically increase the chance of a wildfire, which can then quickly spread across trees and dry brush and threaten homes and businesses that are in vicinity.

- Provide guidelines, in multiple languages and via various media, on how to reduce smoke exposure including the following example recommendations:<sup>53</sup>
  - Close up homes and buildings by shutting windows and doors
  - Set air conditioners to “re-circulate” settings to prevent smoky outside air from being drawn into the building
  - Use air cleaners and HEPA filters
  - Avoid vacuuming or other activities that can disperse dust
  - Reduce physical activity and drink plenty of fluids
  - Check the AirNow website ([www.airnow.gov](http://www.airnow.gov)) for updated air quality information throughout the day as smoke patterns change due to wind and other conditions
  - Wear appropriate respirators and masks (P100 or N95) properly when outside or in smoke-laden areas and contact local emergency relief services for fitted respirators if needed.
- For clients and community groups in areas at greater risk of wildfire (e.g. in the WUI)
  - Educate clients about maintaining a “defensible” space clear of brush and trees.
  - Advise clients to create a personal and family emergency plan in case of evacuation from wildfire.
  - Create informational materials for parents and guardians of young children on the additional risks children face during and after a wildfire with information to protect them against smoke inhalation, chemical exposures, and other hazards.<sup>54</sup>
  - Provide air quality notifications after a wildfire and urge communities to limit outdoor exposure in times of heavy smoke pollution.

Educate local clinicians on the health impacts of wildfires and how they can best protect patient and community health during wildfires. For more information see [A Physician’s Guide on Climate Change, Health and Equity](#).

## For More Information

- [Oregon Health Authority Wildfires and Smoke Page](#) (includes patient care guides)
- [Washington Department of Health Wildfire Smoke page](#)
- [Centers for Disease Control Wildfire Emergency Response page](#)
- [EPA’s Air Monitoring Toolbox](#)

## 4.4 Air Quality

“The risks from air pollution are now far greater than previously thought or understood, particularly for heart disease and strokes... evidence signals the need for concerted action to clean up the air we all breathe.”

*Dr. Maria Neira, Director, WHO Department for Public Health,  
Environmental and Social Determinants of Health<sup>1</sup>*

### Climate Change Worsens Air Quality

- Climate change makes it difficult to attain national air quality standards for ground-level ozone, a major component of smog, because climate change is causing higher temperatures, which increase ozone formation, and increasing the frequency of stagnation events that create the worst ozone episodes.
  - Increased ozone levels due to climate change could result in thousands of additional illnesses and deaths per year in coming decades.<sup>2</sup>
- Climate change is increasing the frequency and intensity of wildfires, which can spread pollution and particulate matter over large distances, increasing the risk of premature deaths and respiratory and cardiovascular disease risks (See Section [4.3—Wildfires](#)).<sup>3</sup>
- As droughts increase in frequency and severity due to climate change, increased dust levels from dried soil worsens air quality.
- Climate change also impacts indoor air quality, as intensified storms and flooding lead to excess moisture and mold production.
- Air conditioner use increases with higher temperatures and more extreme heat days, causing increases in air pollution from fossil fuel based electricity production.

### Air Pollution and Health

There are 133.9 million people in the U.S. exposed to unhealthy levels of air pollution, and 41% of people in the U.S. live in counties with unhealthy levels of ozone or particulate matter.<sup>4</sup>

- Poor air quality exacerbates existing respiratory illness including asthma.<sup>5</sup>
- Increased ozone levels due to climate change could result in thousands of additional illnesses and deaths per year in coming decades.<sup>6</sup>
- Air pollution exposure is associated with higher risks of cardiovascular disease and lung cancer, and may be related to both low birth weight and preterm birth.<sup>7,8</sup>
- Poor air quality limits physical activity, which is important for cardiovascular and bone health, obesity prevention, and mental health.
- Mold exposure from flooding and excess indoor moisture is associated with upper respiratory tract symptoms, cough, and wheeze, and can exacerbate asthma.<sup>9</sup>



## Air Quality and Health Equity

- **Poverty:** Low-income households and communities of color are more likely to have neighborhood characteristics that increase exposure to climate change-related air pollution, such as proximity to roadways and polluting industries, lack of green space, and urban heat islands.
  - Those living in areas with a median household income of \$20,000 or less experience rates of emergency room visits and hospitalizations for asthma that are four times higher than those in areas with a median income greater than \$100,000.<sup>10</sup>
  - Low-income households, people of color, and non-English speaking and foreign-born persons are more likely to live near busy roadways, and therefore face worse air quality.
  - Lack of adequate coverage and health care can result in poorly managed disease for those with respiratory or cardiovascular illness.
- **Race and Ethnicity:** In the U.S., 11.2% of African Americans are currently diagnosed with asthma, (compared to 7.7% of Whites) and have an ED visit rate for asthma three times higher than Whites.<sup>11</sup> Nearly 1 in 2 Latinos live in counties frequently violating clean air and ozone standards, exacerbating air quality issues, and Latino children are twice as likely to die from asthma as non-Latino Whites.<sup>12,13</sup>
- **Age:** Children are particularly sensitive as their respiratory systems are developing and air pollution can cause permanent damage.
- **Chronic Illness:** Individuals with pre-existing chronic conditions, such as asthma, other respiratory disease, and cardiovascular disease, are at greater risk of disease exacerbation due to air pollution.
- **Health Insurance:** Lack of adequate coverage and health care can result in poorly managed disease for those with respiratory or cardiovascular illness.
- **Outdoor Work:** Outdoor workers—particularly those engaged in strenuous physical activity—may face higher risks due to air pollution.<sup>14,15</sup>

## What Local Health Departments Can Do

See Sections [6—Programs](#) and [7—Functions](#)

### Assessment and Surveillance

Identify and collect data to map air quality and identify key sources of air pollution. Collaborate with community based organizations and “community scientists” to use portable air quality monitors to learn about air quality in the community and enhance air quality monitoring. See the [EPA Air Sensor Toolbox](#) (See Section [7.1—Surveillance](#)).<sup>16</sup>

### Intersectoral Collaboration

Work with local and regional air quality agencies:

- Support strong air quality plans that tackle both air pollution and greenhouse gas emissions, for example through providing health data and communications support.<sup>17</sup>

- Develop an emergency and early warning system for communities at highest risk for increasing episodes of poor air quality with climate change:
  - Collaborate with environmental justice and other community groups to plan the warning system.
  - Prepare text and social media alerts in multiple languages to warn vulnerable individuals that air pollution levels are high so they can reduce their exposure and ensure they have needed medication.<sup>18</sup>
- Work with the air district and local community-based organizations to deploy inexpensive real-time air monitors that will provide online data on regional air pollution levels and more detailed information about air pollution “hot spots.”
- Support and encourage city and county efforts to increase energy efficiency and renewable energy. Advocate for programs to allow lower-income homeowners and renters to benefit from rooftop solar and energy efficiency programs.
- Work with local and regional transportation and planning agencies to reduce transportation-related pollution, including from goods movement (See Section [5.1—Transportation](#)).
  - Promotion of energy efficiency in both new and existing buildings.
  - Promotion of the switch from natural gas to electricity for space and water heating in buildings.
  - Expansion of urban heat island reduction and air quality improvement strategies such as tree planting and other urban greening, cool roofs, and cool pavements.
- Collaborate with parks, public works, and community-based organizations to increase the number and diversity of less allergenic trees planted in your jurisdiction and improve other urban heat island reduction strategies, to reduce local air pollution and heat-related ozone increases (See Section [5.4—Urban Greening](#)).
- Work with local schools and school districts to reduce traffic-related air pollution exposure near schools:<sup>19</sup>
  - Adopt anti-idling policies for school buses, passenger vehicles and delivery trucks.
  - Site new schools away from traffic and in locations that enhance opportunities for biking, walking, and taking public transit to school
  - Plant trees to reduce air pollution and provide shaded places for students to be active and socialize, and consider use of trees and vegetation as barriers between schools and busy roadways.
  - Upgrade filtration systems used in classrooms.
  - Locate air intakes away from pollution sources
- Implement policies in your department (and encourage your jurisdiction to do the same across agencies) that reduce vehicle-miles-travelled for field staff and reduce automobile commuting for all staff (See Section [5.1—Transportation](#)).

### Prepare for the Air Quality Impacts of Climate Change

- Develop an emergency and early warning system for communities at highest risk for increasing episodes of poor air quality with climate change:
  - Collaborate with environmental justice and other community groups to plan the warning system.
  - Prepare text and social media alerts in multiple languages to warn vulnerable individuals that air pollution levels are high so they can reduce their exposure and ensure they have needed medication.<sup>20</sup>
  - Messages should include clear instructions to reduce exposure (i.e. stay indoors and limit physical activity).
  - Collaborate with local media sources to broadcast information on where the public can go for air quality-related information; broadcast air quality conditions, information to reduce impacts and related illness exacerbation, and encouragement to check on vulnerable neighbors and family members.
- Prepare plans for clean air shelters and disseminate information about clean air shelters to individuals who are at high risk of serious health complications from extended periods of poor air quality.

### Community Engagement and Education

Look for opportunities to integrate mentions of climate change in materials and media messages for the public whenever relevant, to increase public awareness that climate change is a health issue. Opportunities include public health alerts, health advisory announcements, and educational materials and campaigns related to air quality. For example:

#### Air Quality

**Original:** Air pollution comes from a variety sources, including industrial sources, transportation, farming practices and even natural sources. Air quality on any given day is also impacted by a complex set of factors involving the weather and how pollutants interact with each other in the atmosphere.<sup>21</sup>

**Modified:** Air pollution comes from a variety sources, including industrial sources, transportation, farming practices and even natural sources. Air quality on any given day is also impacted by a complex set of factors involving the weather and how pollutants interact with each other in the atmosphere, ***and by climate change that is causing more pollen and more very hot days that increase air pollution.***

- Conduct public awareness campaigns in multiple languages and via various media and educate clients on the rising risks of poor air quality due to climate change.
- Encourage walking and biking on less busy roadways—even a block away from busiest roadways has less pollution.<sup>22</sup>
- Advise clients with asthma or other respiratory illness to check the [Air Quality Index](#) every day for unsafe ozone and particulate levels. Talk to clients about adjusting their activities and recreation when air quality is bad. For clients who smoke, encourage them to quit and provide resource support.
- Educate local clinicians on the health impacts of climate change and air quality and how they can best protect patient and community health during bad air days. For more information see [A Physician's Guide on Climate Change, Health and Equity](#). Encourage clinicians to have [posters](#) in their facilities regarding climate change and asthma in children and adults.

## For More Information

- [American Lung Association State of the Air Report](#)
- [EPA Clean Power Plan site and Factsheet](#)
- [Sneezing and Wheezing—NRDC report on climate change, allergies, asthma and air quality](#)
- [US Climate and Health Assessment, Chapter 3: Air Quality Impacts](#)
- [APHA and CDC fact sheet on air quality and climate change](#)

# Interagency Collaboration: Multnomah County Health Department

Multnomah County Health Department (MCHD) in Oregon has a long-term focus on equity and a history of working with community-based organizations on place-based health initiatives, and with the regional land use and transportation planning organization and other agencies on climate adaptation. Many of MCHD's community partners work in environmental justice communities that are disproportionately vulnerable to climate health impacts.

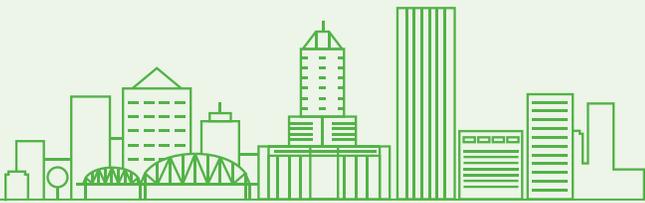
In early 2016, MCHD built on an existing partnership with the Coalition of Communities of Color (CCC) to launch the Healthy Environments Data Indicator Project (HEDIP), in collaboration with Portland State University Planning Department. The project grew out of a request to improve community capacity to work with MCHD in designing health and environmental data collection, analysis, and tools of greater use to the community.

HEDIP created a climate and health tool that uses an interactive story board to display a series of brief narratives that accompany county maps of 20 indicators in four vulnerability domains: 1) demographics, 2) socioeconomic status, 3) existing health burden, and 4) air pollution from point sources. The indicators were also combined into a single score that was used to rank and map climate and health vulnerability for each of the 171 Multnomah County census tracts. CCC provided input into indicator selection and display. In a facilitated training with four CCC climate and environmental justice member organizations, MCHD reviewed the HEDIP findings and discussed the use of data to support policy and systems change.

## Key Action Steps:



- Seek input from community partners on indicators, and share data and information to build CBO capacity to understand and use data to engage in local planning and policy advocacy.
- Translate climate and health vulnerability assessments into accessible, understandable formats.
- Use data to inform local and state policymakers about health vulnerabilities relevant to policy.
- Establish partnerships with local CBOs that represent communities that bear a disproportionate burden of climate and/or environmental impacts. (See [Section 7.2—Engagement](#))



CCC developed and piloted two community-led climate and health workshops that covered climate, health, and justice concepts, and used the HEDIP tool to educate policy makers about the importance of addressing the needs of disadvantaged communities in state climate policy. These conversations informed the discussion of a proposed “Healthy Climate Bill” (SB1574) that would create a carbon trading market linked with GHGE reduction goals, and direct a portion of carbon auction revenues to projects that benefit disadvantaged communities. HEDIP served to illustrate a potential mechanism to identify disadvantaged communities.

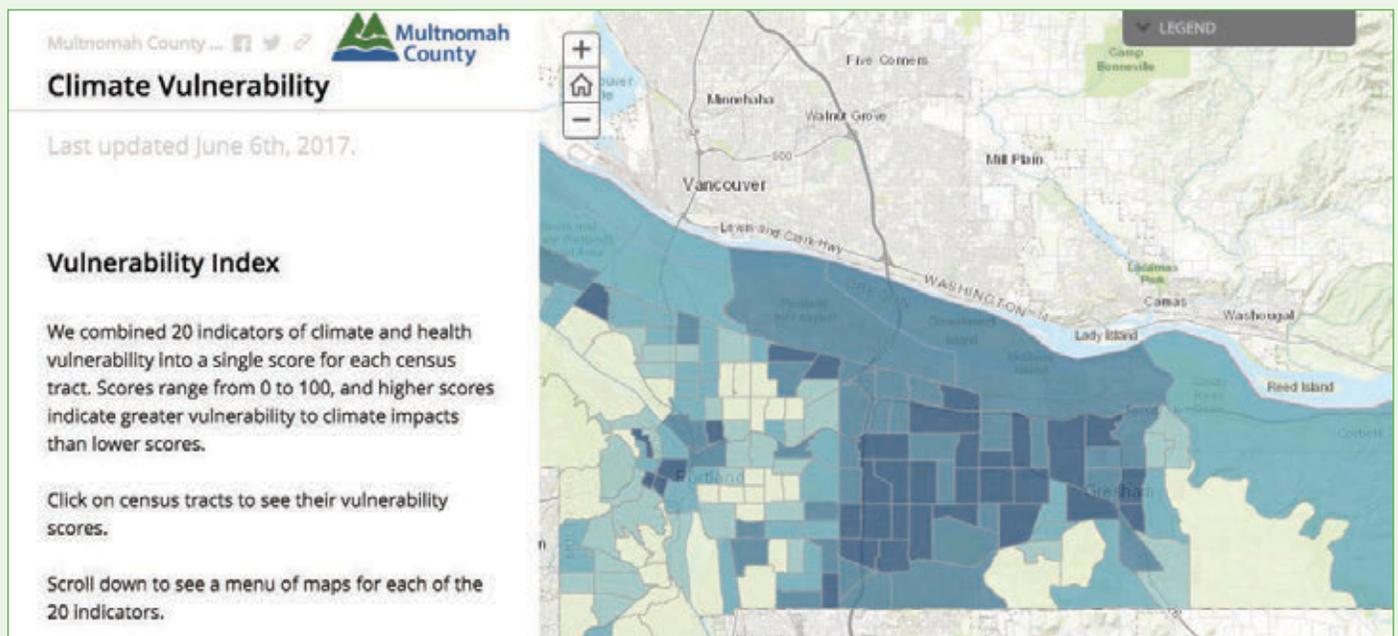
During this time, MCDH, CCC, and other stakeholders identified air pollution as a key priority. Further analysis by MCDH determined that transportation-related pollution and residential wood smoke burning contributed more pollution than point sources in Multnomah County. These analyses—with other HEDIP data—informed development of neighborhood climate and health profiles and policy briefs, and were used by MCDH to provide input into Multnomah County’s analyses of 30 state legislative bills.

## Future Work and Lessons Learned

MCHD continues to translate data into action, using the Integrated Transport and Health Impact Modeling Tool (ITHIM) to inform the Regional Transportation Plan (See Section [7.1—Surveillance](#)). MCHD is now an active participant in an interdepartmental workgroup convened by the County Office of Sustainability to update and implement the county’s climate action plan, and is providing technical assistance on the use of HEDIP climate vulnerability maps. For example, Transportation and Emergency Management are using the maps to inform planning efforts.

## Learn More

- [Multnomah County Climate Vulnerability Maps](#)



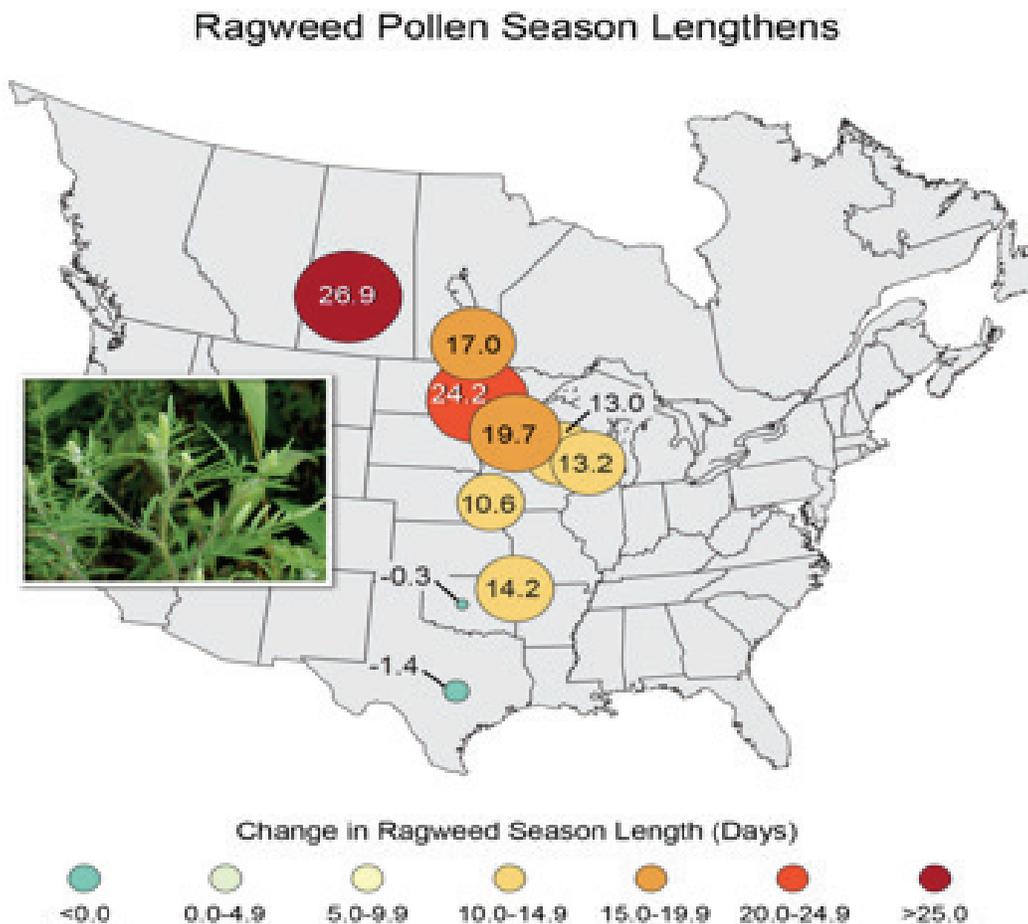
## 4.5 Allergens

Climate change affects the start, duration, and intensity of global pollen seasons, and causes increases in other air pollutants and respiratory illnesses that exacerbate asthma<sup>1</sup>

### Climate Change Increases Allergen Exposures

- Increasing temperatures lead to earlier and longer pollen and allergy seasons, due to more frost-free days and earlier and longer flowering seasons. Since 1995, the season for ragweed pollen—one of the most common outdoor allergens—has lengthened by over 20 days in some parts of the U.S. (See Figure 4.5.1)<sup>2</sup>

**Figure 4.5.1:** Change in Ragweed Pollen Season, 1995–2015<sup>3</sup>



- Higher carbon dioxide levels and more winter precipitation cause greater plant growth, resulting in increased pollen production and potency.<sup>4</sup> This will increase the allergenicity of trees commonly found across the U.S.
  - Annual birch pollen production and peak values are expected to be 1.3–2.3 times higher from 2020–2100.<sup>5</sup>

- Exposure to allergy-inducing molds—the allergenicity of which can also increase with higher CO<sub>2</sub> levels—may increase as more frequent and severe extreme storms lead to more flooding.<sup>6</sup>
- Higher temperatures increase production of ozone, which sensitizes the respiratory tract to allergens.<sup>7</sup>
- Carbon dioxide enhances production of the chemical (urushiol) in poison ivy and poison oak that causes contact dermatitis; carbon dioxide also increases the spread in growth of these allergenic plants.

## Health Impacts of Allergens

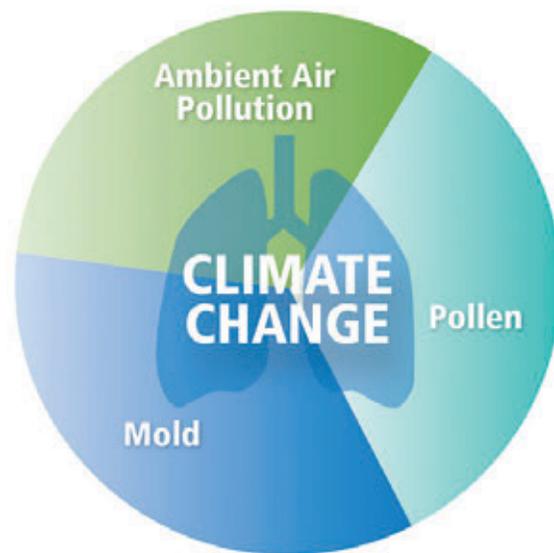
Hay fever, asthma, and eczema are the three major allergic diseases associated with exposure to pollens from trees, weeds, grasses, molds, and other indoor allergens.<sup>8</sup> Nearly 40% of urban populations and close to 25% of rural populations in the U.S. are sensitive to outdoor allergens.<sup>9</sup> The prevalence of hay fever in the U.S. rose from 10% in 1970 to 30% in 2000.<sup>10</sup> Allergies are a significant contributor to work and school absence and the 6th most costly chronic disease in the U.S., with healthcare expenditures of about \$21 billion annually.<sup>11</sup>

## Allergens and Health Equity

- **Housing:** Poor housing construction and maintenance can increase exposure to pollen or mold.<sup>12</sup>
- **Poverty:** People living in poverty may lack health insurance coverage for allergy management. Low-income communities and households have fewer resources for home rehabilitation to prevent mold growth following flooding.<sup>13</sup>

# Climate Change Impacts on Asthma and Allergies

Three main exposures affect asthma and allergies: pollution, pollen, and mold.



### Ambient Air Pollution

Climate change increases the amount of airborne pollutants in the environment. Ambient pollutants include particulate matter, carbon monoxide, oxides of nitrogen, and volatile organic compounds. When sunlight combines with oxides of nitrogen and volatile organic compounds, increased ozone levels result. People with asthma are more susceptible to the effects of ozone and also have increased responses to allergens after ozone exposure. In addition to asthma, it is important to note that these exposures are associated with adverse cardiovascular effects.

### Pollen

Longer warm seasons result in longer pollen seasons and, therefore, longer allergy seasons. Higher temperatures, changes in precipitation, increased carbon dioxide levels, and changes in plant growth patterns all contribute to a longer and more intense allergy season. For example, higher carbon dioxide levels increase pollen levels and pollen potency. Longer and more intense pollen seasons have negative effects on the respiratory system, especially among those with allergies or asthma. This is particularly true of ragweed season.

### Mold

Mold growth is related to increased storms, precipitation, flooding, temperatures, and humidity. Mold is a hazard that can harm our health by decreasing the air quality in home, school, and work environments. Mold can cause respiratory irritation and is a common trigger for asthma and allergies. Reactions to mold exposures are an especially troublesome problem for people with asthma or weakened immune systems.

This document is made possible by memorandum of understanding between the American Public Health Association and ecoAmerica.

- **Race and Ethnicity:** African Americans tend to have higher rates of allergic sensitization compared to Whites.<sup>14</sup>
- **Working Conditions:** Outdoor workers face increased exposure to pollen and to allergenic plants. Low-wage workers without paid sick leave face job and economic loss if required to miss work due to allergies or asthma.<sup>15</sup>
- **Asthma or other Chronic Respiratory Illness:** Exposure to aeroallergens can trigger asthma symptoms.<sup>16</sup>
- **Air Pollution:** Ozone causes airway sensitization, so people living in areas with high ozone levels may be at higher risk.<sup>17</sup>

## What Local Health Departments Can Do

See Sections [6—Programs](#) and [7—Functions](#)

### Assessment and Surveillance

- Collaborate with other agencies and organizations to improve pollen monitoring in your jurisdiction.<sup>18</sup>
- Prepare an online forum for community scientists in your jurisdiction to report the timing of pollen production in their neighborhood. This data can then be cross-referenced with data on tree cover and air quality to identify vulnerable areas.<sup>19</sup>

### Intersectoral Collaboration

Collaborate with public works, parks and recreation, urban forestry, planning, and community based organizations—including local botanic gardens, arboretums, and horticultural societies—to establish policies for preferential planting of less allergenic trees and plants, and for planting a variety of trees so that people are at less risk of an allergic response to a particular pollen.<sup>20</sup> Consult with allergy specialists and work with public works and local tree-planting groups to ensure that allergenicity is a tree-selection consideration.

- Many cities favor planting of male trees to avoid tree-litter on sidewalks, but it is male trees that produce pollen.<sup>21</sup>
- Consider a pollen control ordinance (as in Las Vegas, Albuquerque, Tucson) to prohibit planting or sale of highly allergenic plants.<sup>22</sup>
- Support policies that reduce air pollution, which exacerbates respiratory illnesses and the impacts of allergens. Ozone, the key pollutant associated with climate change, may be the major driver of pollutant/pollen interactions.<sup>23</sup>

### Community Engagement and Education

Look for opportunities to integrate mentions of climate change in materials and media messages for the public whenever relevant, to increase public awareness that climate change is a health issue. Opportunities include public health alerts, health advisory announcements, and educational materials and campaigns related to allergens. For example:

## Pollen

**Original:** Ragweed pollen is dominant in the fall and blooms from Mid-July to September.<sup>24</sup>

**Modified:** Ragweed pollen is dominant in the fall and blooms from Mid-July to September. *Rising temperatures associated with climate change can lead to longer and more severe ragweed seasons.*

- Educate clients and communities—in multiple languages and via various media—on the rising risks of allergens, and how to minimize exposures, reduce allergy symptoms, and manage asthma.
  - Check pollen levels frequently—individuals can sign up for free alerts at [National Allergy BureauTM](#).
  - For clients with asthma, [check ozone levels](#).
  - For individuals with allergies: The best times to be outdoors are when pollen levels are lower, typically on rainy, cloudy, and windless days. Keep windows closed during allergy season to prevent pollen from drifting inside; drive with car windows closed. Shower after time outdoors, to remove pollen that can collect on your skin, clothes, and hair.
- Provide opportunities for community scientists to participate in pollen and asthma monitoring. For example, Louisville’s Asthmapolis project tracks asthma attacks using a mobile network of smart inhalers; city staff are mapping attacks to see correlations with tree cover, air quality, and heat islands.<sup>25</sup>
- Use home visits to educate clients about allergens, mold prevention, and climate change, and to assess housing conditions. Provide referrals to low-income weatherization services (e.g. better sealing of windows).
- Educate local clinicians about climate change and allergies and how they can best protect patient and community health. See [A Physician’s Guide on Climate Change, Health and Equity](#). Encourage local clinicians to put up [posters](#) in their facilities regarding the impact of climate change on allergies.

## For More Information

- [American Academy of Allergy, Asthma and Immunology](#)
- [EPA report on climate change and allergens](#)
- [US Climate and Health Assessment, Chapter 3: Air Quality Impacts](#)
- [Sneezing and Wheezing—NRDC report on climate change, allergies, asthma and air quality](#)
- [APHA and ecoAmerica’s fact sheet on climate change, allergies, and health](#)

## 4.6 Sea Level Rise

### Climate Change Increases the Risk of Sea Level Rise and Related Flooding

- Globally, under moderate emissions scenarios, sea levels are expected to rise 0.3–0.6 feet by 2030, 0.5–1.2ft by 2050, and 1.0–4.3ft by 2100.<sup>1</sup> The rate of sea level rise is now greater than in at least the last 2,800 years.
- Sea level rise in the U.S. will vary along the country’s coastlines:<sup>2</sup> Under all scenarios, the Northeast and Gulf of Mexico coastlines are expected to see greater sea level rise than the global averages, while the Pacific Northwest and Alaska are expected to see less under low and moderate sea level rise scenarios.
- Rising sea levels in the U.S. will increase the frequency and extent of coastal flooding with hurricanes, Nor’easters, and other coastal storms.

### Health Impacts of Sea Level Rise

Health risks associated with rising sea levels include:

- Increased risk of waterborne illness, vector born disease, and indoor mold growth<sup>3,4</sup> (See Section [4.7— Storms and Flooding](#)).
- Displacement of communities living in coastal areas, increasing their risk of related mental health problems.
- Increased salinity of groundwater basins and well water:
  - Higher salinity in drinking water has been associated with increased blood pressure and kidney disease, and higher risk of preeclampsia.<sup>5,6,7</sup>
  - Reduced crop yields in agricultural areas, impacting food security.<sup>8</sup>
  - Changes in the growth of microorganisms and vectors that use water as breeding grounds, with potential impacts on waterborne and vector borne illness.<sup>9</sup>
- Impacts on hazardous material sites, with risk of community exposure to toxic materials.<sup>10</sup>
- Inundation of coastal wastewater and water treatment facilities in the event of storms and storm surge.<sup>11</sup>
- Ground, surface and drinking water contamination from inundation of septic systems, especially in rural areas.<sup>12</sup>
- Impacts on coastal tourism through damage to beachfront property and beaches, with significant economic and job losses.<sup>13</sup>

### Sea Level Rise and Health Equity

- **Geography:** Populations that reside in coastal areas are most impacted by sea level rise.
- **Poverty:** Low-income households are less likely to have disaster insurance, less able to recover from flooding and property loss associated with sea level rise, and have fewer resources to relocate.<sup>14</sup>
  - Residents of areas with failing public waste and water infrastructure, lack of protective barriers (e.g. seawalls), and poor public transit are more vulnerable to flooding and may face evacuation challenges.

- Low-income communities and households lack funds for adaptation responses, such as elevating roads or costly remodels to elevate homes, which could lessen the risk of displacement and its associated health impacts.<sup>15</sup>
- Communities with poor housing quality and building ventilation are at increased risk of indoor air pollution from excess moisture and vector borne disease due to lack of window screens.
- Low-income communities are disproportionately impacted by food and water price increases due to sea level rise impacts on drinking water and crop yield.
- **Gentrification and displacement:** As flooding from sea level rise becomes more common, wealthier homeowners are moving to higher ground, displacing lower income communities that have historically been redlined from beachfront neighborhoods.<sup>16</sup>
- **Tribal Communities:** Indigenous communities that practice subsistence farming and fishing are particularly vulnerable to the impacts of sea level rise—including saline intrusion—on crops and freshwater ecosystems, and of fisheries collapse.<sup>17</sup> Coastal inundation also threatens important indigenous cultural and archaeological resources.<sup>18</sup>
  - 98% of Isle de Jean Charles—the home of a Biloxi-Chitimacha-Choctaw community off the coast of Louisiana—has been lost to sea level rise. Tribal leaders are working with local organizations to create community-based resettlement strategies that emphasize community cohesion and traditions, youth engagement, and sharing experience with other coastal communities facing similar challenges.<sup>19</sup>
- **Chronic Illness:** Individuals with illnesses such as asthma or other respiratory conditions are more vulnerable to indoor air pollution and mold illness from excess moisture or flooding.<sup>20</sup>
- **Individuals with Disabilities:** Cognitive, hearing, physical, and mobility impairments may impede safe evacuation during flooding events.<sup>21</sup>

## What Local Health Departments Can Do

See Sections [6—Programs](#) and [7—Functions](#)

### Assessment and Surveillance

Collaborate with other agencies to understand projections for sea level rise, saltwater intrusion, and flooding due to groundwater inundation and storm surges. Work with local emergency management, public works, water agencies and coastal conservation agencies and organizations to develop maps of flood-prone coastal areas and at-risk critical infrastructure in your jurisdiction. Visit these websites:

- [NOAA's Sea Level Rise Viewer](#)<sup>22</sup>
- [FEMA flood maps](#) (Note that many of FEMA's maps underestimate flood risk as they are based on historical flooding and do not incorporate sea level rise projections)<sup>23,24</sup>

Identify at-risk populations: Social vulnerability indicators for sea level rise include poverty, gender, race and ethnicity, age, disabilities, housing, and transit/transportation access.<sup>25</sup> See the sea level rise vulnerability assessment conducted by the Florida Health Innovation Institute.

### Intersectoral Collaboration

- Coordinate with other agencies to fully understand and be ready to implement the flood emergency response plan.
- Parks, Public Works, Emergency Management, and community groups to implement a green infrastructure plan to reduce storm water runoff and flooding risks and to protect waterways and sewage lines from debris and pollutants (See Section [5.4—Urban Greening](#))
- community based organizations and planning agencies in most vulnerable neighborhoods to develop long-range planning for sea level rise
- Planning and Public Works to assess road infrastructure and ascertain the need for planning to reroute or elevate critical roads (e.g. those providing access to a hospital, power plant, etc.)
- vector control agencies to plan for enhanced mosquito monitoring following flooding and with rising ground water and sea level rise
- local tribes to ensure Native American communities access shelter and services following flooding and in light of sea level rise, including “managed retreat” and anti-displacement measures to protect people now living on higher ground
- local water agencies to monitor permit requests for new or deeper wells and limit excessive draws on local groundwater basins that increase vulnerability to salt water intrusion<sup>26</sup>
- local emergency management, public works, planning, fish and wildlife, and coastal conservation agencies, and community based organizations to protect reefs, sand, coastal wetlands restoration, and other natural barriers that reduce erosion and protect coastal areas from storm surges.



Flood damage on December 22, 2010 in downtown Laguna Beach, California. Rodenberg Photography / Shutterstock.com



Water coming over the streets in Kemah during Hurricane Harvey  
Cire notrevo / Shutterstock.com

### Prepare for Storm Surge and Flooding Related to Sea Level Rise

See Section [4.7—Storms and Flooding](#) and Section [6.5—Preparedness](#)

- Prepare and exercise a coastal flooding, storm surge, and sea level rise contingency plan in coordination with agencies that manage critical waste and water infrastructure and with health care facilities at risk of flooding.
- Ensure evacuation and shelter plans address the needs of vulnerable populations.

## Community Engagement and Education

Look for opportunities to integrate climate change in materials and media messages for the public to increase public awareness that climate change is a health issue. Opportunities include public health alerts and advisories and educational materials related to sea level rise. For example:

### Seawater

**Original:** Some coastal wells in Washington are now unusable because of seawater intrusion. This is particularly true in coastal areas where high population growth has placed increased demands on groundwater supplies.<sup>27</sup>

**Modified:** Some coastal wells in Washington are now unusable because of seawater intrusion, *which is associated with sea level rise due to climate change*. This is particularly true in coastal areas where high population growth has placed increased demands on groundwater supplies.

- Develop and implement a plan for community engagement and participation in sea level rise vulnerability assessments and planning.<sup>28</sup> Folly Beach, South Carolina included community input from vulnerable neighborhoods in preparing the city’s Sea Level Rise Adaptation Report.<sup>2</sup>
- Conduct public awareness campaigns—in multiple languages and via various media—and educate clients and communities on risks related to rising sea levels, and how to stay safe and healthy during and after extreme flooding events.
- Engage residents in community science initiatives such as the [Urban Tides Community Science Initiative](#).
- Develop resources to explain how to properly address in-home dampness and flooding, tenant and landlord responsibilities, and how to select a professional contractor. See the Extreme Storms and Flooding section for more details.<sup>30</sup>
- Advise community members to create a personal and family emergency plan in case of evacuation from flooding and connect them with resources to cope with displacement.
- Educate local clinicians on the health impacts of sea level and how they can best protect patient and community health in the face of sea level rise and coastal flooding. For more information see [A Physician’s Guide on Climate Change, Health and Equity](#).

## For More Information

- [NOAA’s Sea Level Rise Viewer](#)
- [APHA and CDC factsheet on flooding, climate change, and health](#)

# A Framework for Action: San Francisco Department of Public Health

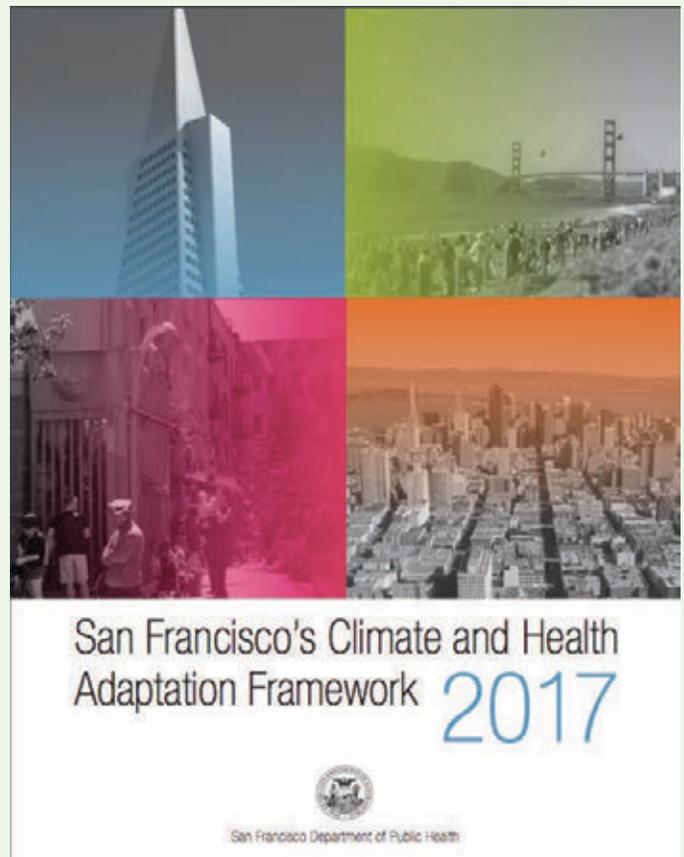
The San Francisco Department of Public Health (SFDPH) launched its [Climate & Health Program](#) in 2010 with funding from the [CDC's Climate Ready States and Cities Initiative](#). The first step in the [BRACE framework](#) is to anticipate climate impacts and assess vulnerability. SFDPH completed assessments for extreme heat events (2013) and [flooding and extreme storms](#) (2016), a [climate and health profile](#) exploring the major health impacts of climate change, preparedness plans for extreme heat and storm/flooding emergencies, and a health co-benefits analysis of the county's climate action plan.

To assess public health preparedness, Climate and Health program (CHP) staff surveyed SFDPH leadership to better understand perceptions of climate impacts and capacity to implement adaptations, reviewed SFDPH strategic planning documents to identify opportunities for departmental action, and assessed climate vulnerability of SFDPH facilities.

## From Assessment to Action

In 2017, CHP shifted from assessment to action with the release of its [Climate and Health Adaptation Framework](#). The Framework provides “a starting point to engage San Francisco’s diverse City and community stakeholders in designing solutions that reduce health disparities and climate health impacts... a tool to begin conversations about how best to adapt to the health impacts of climate change.” It includes the prior vulnerability assessments, indicators of climate risk, an overview of SFDPHs capacity to address climate and health, and proposed strategies and activities to reduce risk and promote health equity in the era of climate change.

The Framework outlines over 70 interventions, including working with other city departments to develop an in-building leak audit program for low-income homes, and evaluating the effectiveness of public information services in extreme weather events. Equity is a guiding principle in the work of SFDPH, and the Framework explicitly addresses the disproportionate burden of climate and health impacts on low-income communities and communities of color.





## Future Work and Lessons Learned

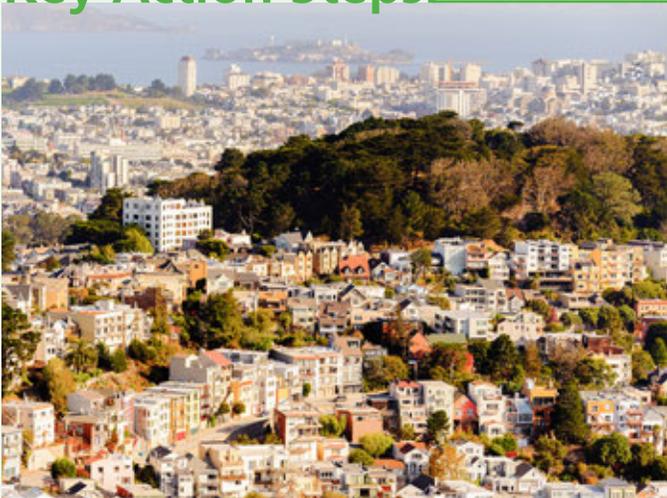
SFDPH is developing a Climate and Health Outreach Plan to increase engagement with residents and community based organizations to prioritize adaptation strategies that respond to the concerns of vulnerable communities. Climate and health champions have been identified across SFDPH programs, and SFDPH is bringing their expertise into efforts to improve collaboration with twelve City departments. One proposal is the development of a unified climate and health message for use across multiple City climate initiatives.

Former climate and health program director, Cyndy Comerford shared, “the most successful partnerships have been with organizations and city departments that share our view that climate change is a systems issue, connected to transportation, food, energy, health care systems, and beyond.”

## Learn More

- [San Francisco’s Climate and Health Adaptation Framework: 2017](#)
- [San Francisco Climate Change & Health Program](#)
- [San Francisco Department of Public Health](#)
- [San Francisco County CalBRACE Climate and Health Profile](#)

## Key Action Steps:



- Conduct a climate and health vulnerability assessment that can form the foundation for a climate and health profile, preparedness plans, community engagement strategies, and recommendations for action.
- Work with LHD program and agency partners to establish a strategic plan to address climate change, health, and equity.
- Use the plan to advance community engagement in prioritizing action on climate, health, and equity.

## 4.7 Storms and Flooding

### Climate Change Increases the Risk of Extreme Storms and Flooding

Extreme precipitation events occur when the air is almost completely saturated, which can occur more quickly at higher temperatures, so extreme events are likely to increase in intensity by about 6% to 7% for each degree Celsius of temperature increase.<sup>1</sup>

- As the U.S. has many geographic regions, future changes in seasonal average precipitation will be variable depending on season and geography. Overall, high-latitude regions are projected to become wetter, subtropical areas drier, but there is significant uncertainty regarding the U.S. middle latitudes.<sup>2</sup>
- The number of extreme precipitation events is expected to increase by two to three times historical averages in every U.S. region by 2100, with the highest increases expected in the Northeast.<sup>3</sup>
- Due to climate change, global precipitation patterns are likely to become more variable into the future, with extremes becoming more extreme, which can lead to additional vulnerability.<sup>4</sup>

### Health Impacts of Extreme Precipitation

- Extreme storms directly cause injury and death due to trauma and drowning.
  - Although the official count due to Hurricane Maria is 64 fatalities in Puerto Rico, some analysts place the actual number at over 4,000.<sup>5</sup>
- Extreme storms and flooding can disrupt medical care, particularly for those with chronic illness. Three days after Hurricane Maria, only 3 hospitals on Puerto Rico were functioning, and 40% were still running on generator power two months after the storm.<sup>6</sup> Two major hospitals were evacuated during Super Storm Sandy, and several were not yet fully operational a year after the storm.
  - A third of deaths after Hurricane Maria were attributed to delayed or interrupted health care, and many residents reported inability to access medications and lack of electricity for respiratory equipment.<sup>7</sup>
- Extreme storms can disrupt critical infrastructure, including electricity, sanitation, water treatment, food refrigeration, communications systems, and transportation.<sup>8</sup> Months after Hurricane Maria, close to 50% of homes on Puerto Rico were still without power, nearly 50% of the island's sewage treatment plants did not have electricity to operate, and over 300,000 Puerto Ricans still lacked access to clean water.<sup>9,10,11,12</sup>
- Mold exposure and related mold illness post-flooding may increase due to excess indoor moisture and is associated with upper respiratory tract symptoms, cough, and wheeze, and can exacerbate asthma.<sup>13</sup>
- Water-borne illness risks increase due to exposure to sewage or water treatment systems overflow, or skin wounds and fungal infections from exposure to flood waters.<sup>14</sup>
- Heavy rainfall is frequently followed by a proliferation of mosquitos, increasing the risk of vector-borne illnesses particularly in warmer climates.<sup>15</sup>
- Flooding from storms can contaminate ground and surface water resources with runoff from hazardous and superfund sites.<sup>16</sup>

- Use of diesel generators during power outages can impact air quality. Improper use of generators in enclosed spaces caused 15 deaths due to carbon monoxide poisoning after Hurricane Sandy.<sup>17</sup>
- Extreme precipitation can lead to erosion and dangerous mudslides, increasing risk of injury and death, as seen in Montecito, CA when heavy precipitation caused destructive mudslides and over 20 fatalities in January 2018, following the largest wildfire in California history that charred much of the area's soil in December 2017.<sup>18</sup>
- Extreme precipitation and flooding cause displacement—which poses risks associated with injury, exposure to contaminated floodwaters, and loss of medications—and property loss.<sup>19</sup> An estimated 1.5 million fled their homes after Hurricane Katrina, and some estimate that hundreds of thousands were never able to return.<sup>20</sup> Damage to the Oroville Dam following severe rains caused the evacuation of over 100,000 people for two days.<sup>21</sup>

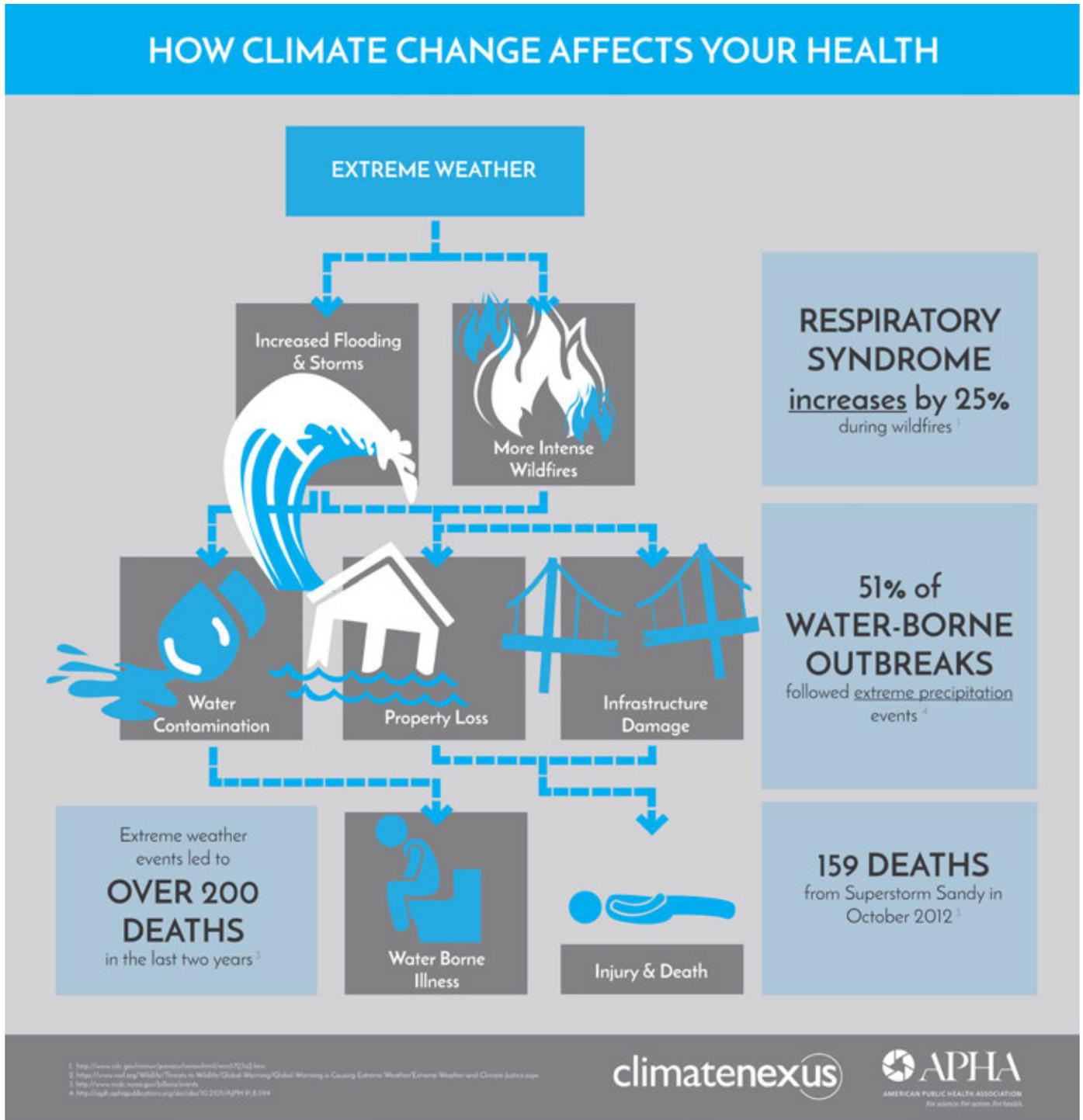
## Extreme Precipitation and Health Equity

- **Failing and Aging Public Infrastructure:** Lack of investment in secure transportation or protective barriers leaves residents vulnerable to flooding and poses barriers for evacuation. Inadequate or failing water treatment and sewage systems—especially combined sewer overflow systems— increase the risk of contamination after floods and storms.
- **Poverty:** Low-income communities are disproportionately underinsured for extreme weather events and often lack access to emergency credit to recuperate from property loss. As climate change increases the frequency and severity of extreme weather

## Extreme Storms and Mental Health: Hurricane Katrina

Exposure to extreme weather events, such as floods, hurricanes and wildfires, is associated with a range of mental health impacts, including post-traumatic stress disorder (PTSD), depression, anxiety and suicide, increased rates of substance abuse, and interpersonal violence.<sup>22</sup> Mental health impacts persisted long after Hurricane Katrina and its immediate aftermath were over.

- In some impacted areas, prevalence of PTSD rose from 15% a few months after the hurricane to 21% a year later. During the same timeframe, the proportion of people with suicidal thoughts more than doubled: from 2.8% to 6.4%.<sup>23</sup>
- Veterans with preexisting mental illness were 6.8 times more likely to develop additional mental illness after the disaster, as compared to those without a preexisting mental condition.<sup>24</sup>
- Hope abounds: One study found that two-thirds of those who experienced increased rates of PTSD and psychosis one year after the storm no longer displayed symptoms of psychological distress three years afterwards, while some others even reported “post-traumatic growth,” or the feeling that surviving the hurricane made them stronger. These findings suggest the importance of long-term support for survivors of climate change-related disasters.<sup>25</sup>



APHA, Climate Nexus 2016

events, insurance prices will rise and continue to move further out of reach for low-income individuals and communities.<sup>26</sup> Four out of 5 homes damaged by Hurricane Harvey lacked flood insurance.<sup>27</sup>

- **Homelessness:** Homeless people often occupy areas near creeks or rivers, making them more vulnerable to storms and floods.<sup>28</sup>
- **Substandard Housing:** Poor housing quality and ventilation increase the risk of indoor air pollution and most from excess moisture.
- **Legal Status:** Undocumented families are not eligible for FEMA assistance and even those who are eligible may fear applying. Immigrants may also have concerns about accessing evacuation shelters and other relief services due to inadequate cultural and linguistic competency of service providers, and undocumented immigrants may fear legal repercussions of seeking services.<sup>29</sup>
- **Chronic illness:** Extreme storms can interrupt treatment for chronic illnesses due to displacement, power outages, stressed health systems, and high-demand for medical supplies.<sup>30,31</sup>
- **Individuals with Disabilities:** People with disabilities have high rates of illness, injuries, or death during extreme events, as cognitive, hearing, physical, and mobility impairments may impede safe evacuation.
  - Emergency information and instructions are not always accessible for those with disabilities that affect communication, and individuals with disabilities can have challenges communicating their needs in an emergency or evacuation situation.<sup>32,33</sup>
  - Power outages can impair electrically powered medical equipment and elevators, preventing some from evacuating or leaving them without necessary treatments.<sup>34</sup>

“When patients with cardiac health issues face evacuation due to flooding, fire or other natural disasters, a spike in stress and anxiety levels may be only the beginning. For sudden, jarring, life-changing events—like that of Hurricane Harvey in Texas and Louisiana this past week—can markedly disrupt months or years of steady treatment and control of heart disease and other conditions.”

*American Heart Association<sup>35</sup>*

- **Race and Ethnicity:** African Americans households faced slower recovery from Hurricane Katrina compared to comparable white households, and recent studies have revealed higher rates of mental illness among Hurricane Katrina survivors who were African American, low-income, and between the ages of 18 and 34, especially single mothers.<sup>36,37</sup>
- **Age:** Almost half of the deaths resulting from Hurricane Katrina were people over the age of 75, and over 10% of total deaths occurred in nursing homes.<sup>38</sup>
- **Women and Children:** Extreme storms, flooding, and related stress can negatively impact pregnancies and disrupt related care, while children are susceptible to severe mental health impacts<sup>39</sup> Globally, women are injured and die more often from extreme events.<sup>40</sup>

## LHD Spotlight: San Francisco Department of Public Health<sup>44</sup>

The San Francisco Department of Public Health (SFDPH) conducted a flood health vulnerability assessment in order to focus resources on and design interventions for vulnerable populations. SFDPH included indicators on socioeconomic and demographic, exposure to flooding, pre-existing health conditions, and housing quality (see the table below). To obtain data, the department used results from the American Community Survey and from other local agencies, such as the San Francisco Public Utilities Commission, California Office of Statewide Health Planning and Development, the 2015 San Francisco Homeless Count, the San Francisco Police Department, and the San Francisco Fire Department.

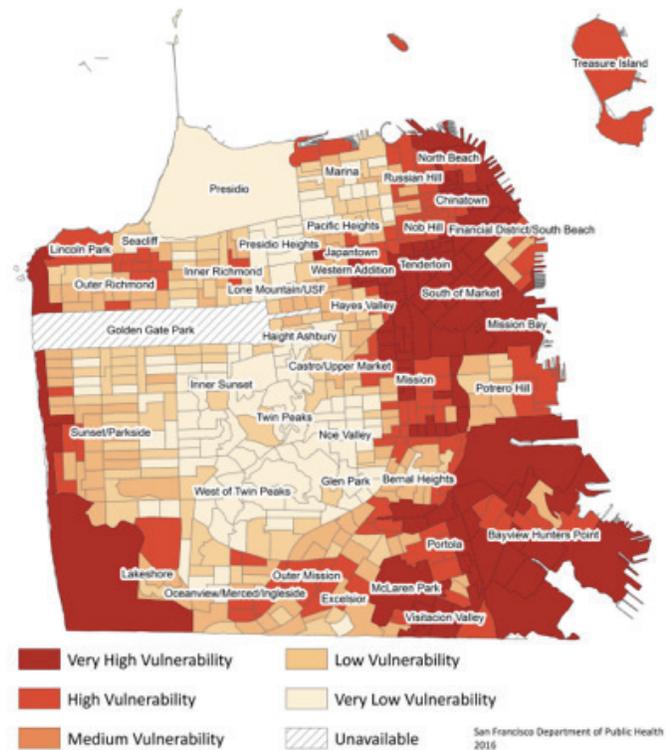
Vulnerability	Indicators <sup>45</sup>
<b>Social and Demographic</b>	Age: Percent of residents who identify as under 18 and over 65
	Percent of residents who do not identify as white
	Percent of residents below 200% of the federal poverty rate
	Percent of residents over 25 with at least a high school degree
	Percent of households with adults who do not speak English
<b>Exposure</b>	Percent of land in 100-year flood plain with 36in of sea level rise
	Percent of land projected to have over 6in of precipitation during a 100-year storm
	Minimum Elevation
<b>Health</b>	Adult hospitalization rate due to diabetes
	Adult hospitalization rate due to asthma
	Adult hospitalization rate due to schizophrenia and other psychotic disorders
	Percent of residents who report a physical disability
<b>Housing</b>	Homeless population, per 1000 residents
	Annual housing violations, per 1000 residents
	Percent of residents who report living alone

*continued on next page*

## LHD Spotlight continued

SFDPH was able to overlay available data creating vulnerability indexes for each indicator set and a combined flood health vulnerability score by block group and neighborhood. The resulting maps defined areas that are most likely to experience flooding and areas that are most likely to experience the health impacts of this flooding.

Figure 22. Final Flood Health Vulnerability Index



## What Local Health Departments Can Do

See Sections [6—Programs](#) and [7—Functions](#)

### Assessment and Surveillance

- Collaborate with local emergency management, public works, and other agencies to collect and share data to conduct a flood vulnerability assessment:
  - identify flood-prone areas and areas in need of updated infrastructure to reduce flood risk.
  - identify critical infrastructure vulnerable to floods and storm surges.
  - identify neighborhoods with social vulnerability to floods. Social vulnerability indicators used in one index created specifically for hurricanes included poverty, gender, race and ethnicity, age, and disabilities.<sup>41</sup>
- FEMA offers [flood maps searchable by specific addresses](#), though flooding from Hurricane Harvey demonstrates that many of these maps are out of date.<sup>42,43</sup>

### Intersectoral Collaboration

- Collaborate with other agencies to ensure that your jurisdictions' hazard mitigation and response plans incorporate climate impact projections for storm surge and precipitation and adequately address flooding from extreme storms and/or storm surge.<sup>46</sup> Coordinate with other agencies to fully understand and be ready to implement the flood emergency response plan.
- Collaborate with Parks, Public Works, Emergency Management, and community groups to develop and implement a green infrastructure plan to reduce storm water runoff and flooding risks and to protect waterways and sewage lines from debris and pollutants (See Section [7.5—Greening](#)).
- Collaborate with community-based organizations to inform vulnerable communities about climate impact projections for storm surge, precipitation and flooding, and engage community residents in flood resilience and preparedness.
- Work with local organizations and health care institutions to implement a voluntary registry for those with physical, mental, and sensory disabilities to preauthorize emergency response personnel to enter their homes during search-and-rescue operations.<sup>47</sup>
- Collaborate with vector control agencies to assure availability of increased mosquito monitoring following extreme precipitation and flood events.
- Work with local tribes to ensure Native communities know where shelters are located and how to access services following flooding and extreme storms.



*Flooding in Minot, North Dakota*  
DVIDS, 2011

### Prepare for Extreme Storms and Flooding

- Develop a flood warning alert system for areas at risk:
  - Prepare boil water orders and other alerts in multiple languages so they are ready to issue to various media outlets and through text alerts and/or social media.
  - If landslides or debris flows have occurred previously in your jurisdiction, prepare messaging and resources for communities to prepare for a potential future event.<sup>48</sup>
  - Evaluate use and effectiveness of public information services during and after extreme weather events.<sup>49</sup>

- Prepare plans for shelters with backup power sources and ensure the needs of vulnerable populations are taken into consideration; disseminate shelter information to at risk groups including older adults, pregnant women, those with chronic illness who require medications, and low income communities.<sup>50</sup>
  - Ensure all shelters and emergency centers are accessible to and comfortable for individuals with physical and mental disabilities.
  - Connect individuals with local shelters that provide safe spaces, especially for LGBTQ individuals who are at higher risk of harassment and assault.
  - Prepare [information sheets](#) for families in shelters on the potential for health outcomes from flooding and mental health impacts from stress and displacement, including how to find services.
  - Ensure local wastewater treatment facilities that may be vulnerable to flooding have prepared response plans.
  - Work with social services and mental health agencies to assure access to mental health services.
- Collaborate with health care facilities and systems to increase flood resilience and plan for extreme storm and flooding events.
  - Develop a plan for how medical care will continue if flooding impacts health care facilities. For example, coordinate with pharmacies to allow refill prescriptions for people with chronic illness, even if unable to contact the prescribing physician, during emergencies.<sup>51</sup>
  - Advocate for integration of design features in new health facilities that foster resiliency to flooding, for example:<sup>52</sup>
    - Elevation of first floor above projected flood elevation and placement of critical patient care functions above first floor
    - Placement of all critical mechanical/electrical infrastructure on the roof and/or above flood elevations
    - Use of green roofs to reduce storm water discharge
- Assure that chronically ill patients, their communities, and their providers have contingency plans during and after disasters.<sup>53</sup>
- Make sure evacuation strategies address the needs of all members of the community, including those without access to automobiles, non-English speakers, and people with disabilities.

### **Community Engagement and Education**

Look for opportunities to integrate mentions of climate change in materials and media messages for the public whenever relevant, to increase public awareness that climate change is a health issue. Opportunities include public health alerts, health advisory announcements, and educational materials and campaigns related to storms and flooding. For example:

## Flood Advisory

**Original:** Heavy rain causes floodwaters to rise and pool on streets and throughout neighborhoods. In these situations, be aware of the following...<sup>54</sup>

**Modified:** Heavy rain causes floodwaters to rise and pool on streets and throughout neighborhoods. *As climate change increases the potential for more intense storms and related flooding, we need to be even more prepared.* In these situations, be aware of the following...

- Conduct public awareness campaigns—in multiple languages and via various media—and educate clients and communities on the rising risks of extreme weather due to climate change, health risks, and how to stay safe and healthy during and after extreme events.
- Advise clients to create a personal and family emergency plan in case of evacuation from an extreme storm or flooding. Educate clients about the potential for flooding following wildfires and discuss the potential need for flood insurance.<sup>55</sup>
- Develop resources to explain how to properly address in-home dampness and flooding, tenant and landlord responsibilities, and how to select a professional contractor.<sup>56</sup> Use home visits to provide guidelines for reentering homes after flooding:<sup>57</sup>
  - Remind individuals to NEVER turn power on or off or use an electric tool or appliance while standing in water.
  - Provide information about the risks of sewage contamination and mold for individuals whose homes are flooded,
  - Educate individuals on indoor air quality concerns following flooding. Provide information on mold prevention and treatment options, including preventing mold by washing surfaces with water and detergent and wearing an N95 mask while treating mold.<sup>58</sup>
  - Provide safety guidelines for drying out and cleaning flooded homes
- Educate local clinicians on the health impacts of extreme storm events and how they can best protect patient and community health during storms and flooding. For more information see [A Physician's Guide on Climate Change, Health and Equity](#).



Seawater Inundation Following Hurricane Ike on the Bolivar Peninsula, Texas  
NOAA, 2008

## For More Information

- [EPA's Flood Resilience Checklist](#)
- [CDC Flood information](#)
  - [Cleanup, Mold, Landslides and Mudslides](#)
- FDA Food and Water Safety during floods ([English](#), [Spanish](#))
- [EPA Green Infrastructure and Managing Flood Risk information](#)
- [US Climate and Health Assessment, Chapter 4: Extreme Events](#)
- [APHA and CDC factsheet on flooding, climate change, and health](#)
- [APHA, American Psychological Association, and ecoAmerica factsheet on climate change and mental health](#)

## 4.8 Nutrition and Food Security

Food security is “access by all people at all times to enough food for an active, healthy life.”<sup>1</sup> It requires that a stable, nutritious food supply is available and accessible to all communities to nourish themselves.

### Climate Change Threatens Food Security<sup>2,3</sup>

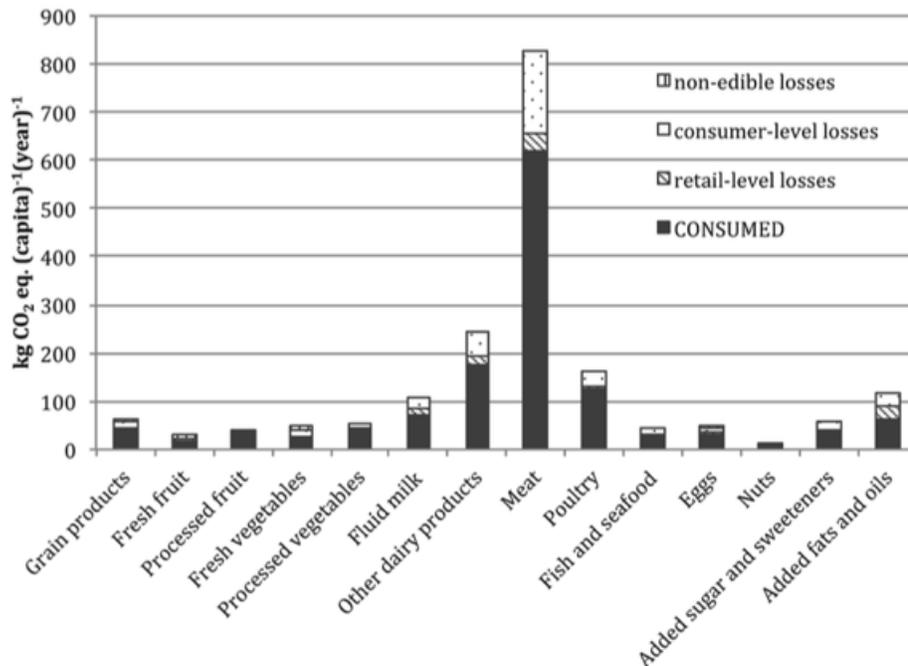
- Crop yields are reduced by extreme heat, drought, and extreme weather events, all of which are increasing in frequency and severity due to climate change.<sup>4</sup> Warmer temperatures also cause higher ground-level ozone concentrations that cause millions of tons of crop losses each year.<sup>5</sup> Warmer temperatures are leading to fewer “chill hours”, required for production of avocados, nuts, and tree fruits.<sup>6</sup>
- Higher temperatures and drought associated with climate change can cause heat stress and illness in livestock, reducing milk and egg production.<sup>7</sup>
- Declining fish yields due to overfishing and ocean dead zones are further impacted by ocean acidification from with rising carbon dioxide levels.
- Warmer temperatures increase the growth of *Salmonella*, *Camphylobacter*, *Rotavirus*, and various *Vibrio*, and harmful algal blooms, increasing the risk of food contamination.<sup>8</sup>
- Increased atmospheric CO<sub>2</sub> reduces the nutritional value of crops such as barley, sorghum, soy, wheat and rice by reducing their protein and micronutrients content.<sup>9</sup>
- Extreme weather events can disrupt transportation of food products, disrupting food supply chains and increasing loss due to spoilage.<sup>10</sup>
- The Intergovernmental Panel on Climate Change (IPCC) estimates that global food production will decrease by 2% per decade, while global food demand increases by 14% per decade.<sup>11</sup> Climate change has increased the number of malnourished children by 7–20% globally.<sup>12</sup>

### Agricultural Systems Drive Climate Change

See Section [5.3—Agriculture](#)

- In 2016, agriculture contributed about 9% of the country’s total greenhouse gas emissions<sup>13</sup> (See Figure 4.8.1).
- When fertilizer use, refrigeration, transportation, and land use changes are taken into account, our food and agriculture systems account for about a third of all global GHGE.<sup>14</sup> The typical American meal includes ingredients from at least five other countries, contributing to transportation GHGE, especially if food is shipped by air.<sup>15</sup>
- Expansion of agricultural lands can lead to deforestation and soil degradation, removing important carbon sinks.<sup>16</sup>

**Figure 4.8.1:** Annual Greenhouse Gas Emissions Per Capita Associated with U.S. Food Production in 2010 (kg CO<sub>2</sub>-eqs kilograms of carbon dioxide equivalents)<sup>17</sup>



## Health Impacts of Food Insecurity<sup>22</sup>

Food insecurity includes under-consumption (of nutrients, fruits, vegetables, and protein in developing nations) and overconsumption of low-cost, high-calorie, low-nutrient foods. Under-consumption negatively impacts development and diminishes physical capacity.<sup>23</sup> Over-consumption is a major contributor to development of chronic diseases such as obesity, cardiovascular disease, and diabetes.

- In 2014, 37.9% of adults and 20.6% of adolescents in the U.S. were obese.<sup>24</sup>
- About 1 in every 4 deaths in the U.S. is the result of heart disease (approximately 610,000 people annually).<sup>25</sup>
- 9.4 percent of the U.S. population (30.3 million people) has diabetes, and 84.1 million have prediabetes.<sup>26</sup>
- Overconsumption of red and processed meat is associated with increased risk of heart disease, stroke, Type 2 diabetes, certain cancers, and premature death.<sup>27</sup>
- Good nutrition is essential to healthy pregnancy, nursing and newborn outcomes.

## Food Waste<sup>18</sup>

Forty percent of food produced in the United States goes uneaten. That's 62.5 million tons of food. Households generate 43% of all food waste. Meanwhile, there were 42.2 million people, including 13.1 million children, who did not have enough food in 2015.<sup>19</sup> In landfills, these organic materials are broken down by bacteria to produce methane, a potent greenhouse gas (GHG).<sup>20</sup> Diversion of food waste from the landfill to better uses, including safe food donation, addresses two critical health issues—food insecurity and climate change.<sup>21</sup>



*Pigs in a Concentrated Animal Feeding Operation (CAFO)*  
USGS, 2005



*Organic Farm in California*  
Public Domain

## Food Security and Health Equity

- **Poverty:** Low-income people have less ability to absorb rising food prices and may be forced to choose between food and other necessities. Food insecurity is associated with higher risks for diabetes and hypertension.<sup>28</sup>
- **Food Deserts:** According to 2000 data, 13.5 million people in the U.S. have low access to a supermarket, 82 % of whom live in urban areas.<sup>29</sup> In these areas, the impacts of climate change on food security and health are further exacerbated by lack of access to healthy foods.
- **Race and Ethnicity:** Food insecurity is more common in people of color and those living in poverty. According to the USDA, 12.3 % of U.S. households were food insecure in 2016: 22.5 % of African American households, 18.5 % of Hispanic households, 10.7 % of other, non-Hispanic households, while only 9.3 % of White households.<sup>30</sup> As of the 2014 National Agricultural Workers Survey, 80 % of U.S. farmworkers identify as Hispanic and only 53 % had work authorization, leaving many members of this community vulnerable to economic impacts of climate change on U.S. agriculture.<sup>31</sup>
- **Tribal Communities:** Many indigenous communities practice hunting, subsistence farming and fishing, and are thus vulnerable to climate change impacts on local game, farming and aquatic habitats. Rising sea levels will also threaten freshwater and saltwater fishing habitats for many indigenous coastal communities.<sup>32</sup>
- **Occupation:** Agricultural workers are often undocumented and poorly paid, and at risk of climate-related illness. Declines in crop yields result in job and economic losses for agricultural workers and farming communities. Warmer temperatures are expanding the territory of certain crop pests, leading to higher use of toxic herbicides and pesticides and associated risks of pesticide-related illness.<sup>33</sup> Farmworkers engage in heavy labor even during extreme heat. Repeated dehydration may be the cause of epidemic chronic kidney disease of unknown etiology in agricultural communities around the world.<sup>34</sup>
- **Pregnant Women:** Nutrition is essential to healthy pregnancy, nursing and newborn outcomes; poor nutrition is associated low birth weight and other adverse outcomes.<sup>35</sup>

## What Local Health Departments Can Do

See Sections [6—Programs](#) and [7—Functions](#)

### Intersectoral Collaboration

- Collaborate with agencies, schools, and local institutions (e.g. hospitals) to support adoption of food procurement policies that healthy food systems.
- Work with planning, public works, agricultural agencies, regional farmers and land trusts, and community organizations:
  - Promote urban and peri-urban agriculture and agricultural land conservation.
  - Establish farmers markets, including allowance of SNAP EBT, and support other farm-to-fork programs
- Collaborate with planning agencies to ensure the local General Plan includes food access considerations, and promote zoning that supports farmers markets, healthy food retail outlets, and community gardens.<sup>36</sup>
- Partner with schools and school districts:
  - Develop programs to reduce meat served in school meals—e.g. “Meatless Mondays”
  - Support and encourage prevention of food waste and composting of food waste in school cafeterias
  - Establish school gardens
  - Work with local farmers, agricultural commissioners, and community organizations to establish and expand farm to school programs
  - Integrate climate change into lessons about nutrition
- Collaborate with academic agricultural researchers and local agricultural organizations to educate growers and agricultural operations about agriculture-climate change-health connections.
- Provide health data and considerations to support advocacy for subsidies for fruits and vegetable farming and for reduced federal subsidies for commodity crops.
- Collaborate across public health and environmental health programs to reduce food waste and improve safe surplus food donation.
  - Train environmental health specialists on climate change, food waste, and food insecurity using, for example, the Safe Surplus Food Donation Best Management Practices.<sup>37</sup>
  - Disseminate information on food waste reduction—for example the Safe Surplus Food Donation Toolkit—during routine food facilities inspections.<sup>38</sup>
  - Integrate education about date labels and food waste into WIC and NEOP materials and outreach/education programs. See the Save the Food Campaign.<sup>39</sup>
  - Work with local food policy councils, businesses, and Environmental Health to reduce food waste and increase surplus food donation to local nonprofit hunger relief organizations.

## Community Engagement and Education

Look for opportunities to integrate climate change in materials and media messages for the public whenever relevant, to increase public awareness that climate change is a health issue. Opportunities include public health alerts and advisories and educational materials related to food and nutrition.

### Community Health Needs Assessment

**Original:** While most report little or no difficulty, 17.4% of Metro Area adults report that it is “very” or “somewhat” difficult for them to access affordable, fresh fruits and vegetables.<sup>40</sup>

**Modified:** While most report little or no difficulty, 17.4% of Metro Area adults report that it is “very” or “somewhat” difficult for them to access affordable, fresh fruits and vegetables. *This is a growing concern as climate change impacts local agriculture and may increase food insecurity.*

- Educate communities, stakeholders, and policy makers about the impact of climate change on food security and nutrition and actions with climate and health benefits.
  - Educate communities on the food-climate change connection, and on the climate and health benefits of reduced meat consumption and sustainable local food systems (urban farms, farmers markets, community gardens, organic food)
  - Encourage clients and community residents to reduce meat consumption and increase consumption of fruits and vegetables; buy locally and sustainably produced food and develop backyard and community gardens, and reduce food waste at home and when eating out.
- Educate food handlers about climate change-related increased risk of food contamination and how to maintain hygiene in food preparation under conditions of extreme heat and water shortages.
- Educate health care providers on the health impacts of climate change and food systems and how to protect patient and community health. See [A Physician’s Guide on Climate Change, Health and Equity](#).

## For More Information

- [Re-Fed: Reducing Food Waste](#)
- [USDA’s Creative Solutions to Ending School Food Waste](#)
- [Feeding America’s Map the Meal Gap resource](#)
- [NRDC’s Save the Food Campaign](#)
- [Equitable Development Toolkit: Local Food Procurement](#)
- [Sample Policy: Los Angeles Good Food Purchasing Policy](#)
- [US Climate and Health Assessment, Chapter 7: Food Safety, Nutrition, and Distribution](#)
- [Aligning Food System Policies to Advance Public Health](#)