ClimaWATCH

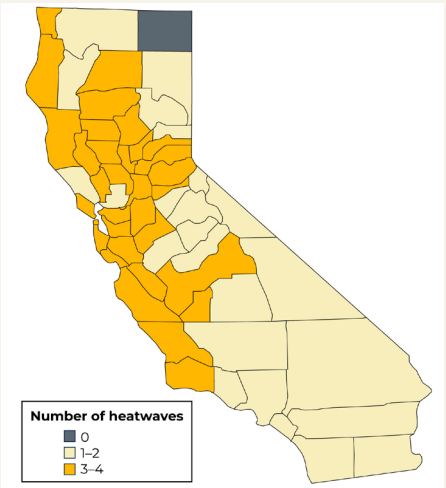
Mathematica

Heat Vulnerability Assessments in California

Californians feeling the heat

Californians consistently see some of the highest temperatures in the country, with three in four residents regularly exposed to heat waves.[1] Prolonged heat exposure can trigger wide-reaching harm—including droughts, wildfires, overloaded power grids, and infrastructure damage—costing the United States billions of dollars.

- In 2020, **57 of the state's 58 California counties** faced heat waves during which the daily average temperature was in the top 5 percent of all temperatures recorded since 1981; in 16 of these counties, daily average temperatures exceeded 90°F, and reached as high as 104°F.
- In 1981, heat waves lasted an average of 2.5 days; by 2020, the average duration increased to 3.7 days.



Heat waves are responsible for more deaths than any other weather-related hazard and cause or worsen a range of physical and mental health problems. They can trigger acute health issues such as heat stroke and lead to life-threatening events such as heart attacks and kidney failure. Heat waves thereby result in surges in health care visits and costs, straining health system resources, overloading staff already burdened by California's health workforce shortages, and threatening continuity of care.

Mathematica's ClimaWATCH tool facilitates heat vulnerability assessments by identifying communities that have been hit hardest by extreme heat, pinpointing the root causes of vulnerability, and quantifying heat-related health effects. In 2020[2], California counties with one or more heat waves:

- Saw **seven times more hospital visits for heat stress than the national average**, but substantial dips in utilization for other acute conditions, pointing to delays in care.
- Faced excess Medi-Cal costs that amounted to **11 to 12 times higher than the national average** to treat heat stress, electrolyte imbalance, acute myocardial infarction, and acute renal failure.[3]

About this brief

Using findings from ClimaWATCH (*Climate and Weather Analytics, Trends, and Community Health*), an interactive tool for heat vulnerability assessment, this brief clarifies how heat waves have affected the health of the 38 percent of Californians covered by Medi-Cal. The brief also covers how heat-related illnesses vary over time and across California counties with different sources of vulnerability.

Diversity of heat experiences in the Golden State

In California, the highly variable topography—ranging from mountains and valleys to deserts and long coastlines—creates varied microclimates that influence local exposure to extreme heat. Furthermore, the state is home to diverse communities with varied sources of social, environmental, and infrastructural vulnerability. These differences can lead to highly variable heat-related health effects from one county to another.

For example, California counties with heat waves have higher vulnerability measures than counties without heat waves, including vulnerability due to the following factors:

- **Socioeconomic status** (86 percent versus 41 percent vulnerability)
- Households occupied by **seniors, children, and people with disabilities** (65 percent versus 29 percent)
- **Language barriers** (96 percent versus 81 percent vulnerability)
- Inadequate **tree canopy cover** (Tree Inequity Score of 31 versus 22, on a scale of 0 to 56)

Mathematica's ClimaWATCH tool also quantifies the magnitude of historical surges in health care costs, providing information that can support health system preparedness and response. To illustrate this, we looked at ClimaWATCH insights for three California counties that differ geographically and demographically. Each has distinct social vulnerabilities and environmental risk factors that magnify the effects of heat waves on the health of its residents. We assessed how these counties fared in terms of excess health service use and Medi-Cal spending attributable to heat waves, and how such effects varied by demographics and care setting. Exhibit 1 summarizes our findings, which we describe in greater detail throughout this brief.

Exhibit 1. Key insights from ClimaWATCH for three diverse California counties

County	Heat wave exposure in 2020	Notable excesses in average treatment costs per patient around heat waves	Greatest sources of vulnerability
Riverside	2 heat waves 13 extreme heat days 92°F average temperature	**Blind or with disabilities:** $11,100 to treat electrolyte imbalance (vs. $2,800 countywide) **Seniors:** $29,300 to treat acute myocardial infarction (vs. $1,200 countywide) **Pregnant:** $9,400 to treat acute renal failure (vs. $3,500 countywide)	Language barriers Natural disaster risk Impervious surfaces
Tulare	2 heat waves 8 extreme heat days 92°F average temperature	**Children:** $53,000 to treat electrolyte imbalance and $56,000 to treat acute renal failure (vs. $1,600 and $6,400 countywide, respectively) **In-patient setting:** $21,700 to treat heat stress (vs. $122 countywide)	Language barriers Socioeconomic status Tree canopy cover
Santa Barbara	3 heat waves 15 extreme heat days 76°F average temperature	**Children:** $125,000 to treat electrolyte imbalance (vs. $1,100 countywide) **Seniors**: $7,500 to treat acute renal failure (vs. $2,300 countywide)	Language barriers Housing/ transportation Natural disaster risk

Note: Santa Barbara did not see any heat waves during which average daily temperatures were above 90°F. However, ClimaWATCH highlights that heat-related health issues can accumulate even at lower temperatures.

Riverside County

Riverside County is the fourth most populous county in California. Its climate regions vary from hot and dry desert areas (including in Joshua Tree National Park) to cooler mountains areas with a milder Mediterranean climate.

Heat wave exposure

- Riverside County saw at most three heat waves per year in recent years (2016 to 2021).
- The county faced two heat waves in 2020, averaging 4.5 days each, with temperatures averaging 93°F.

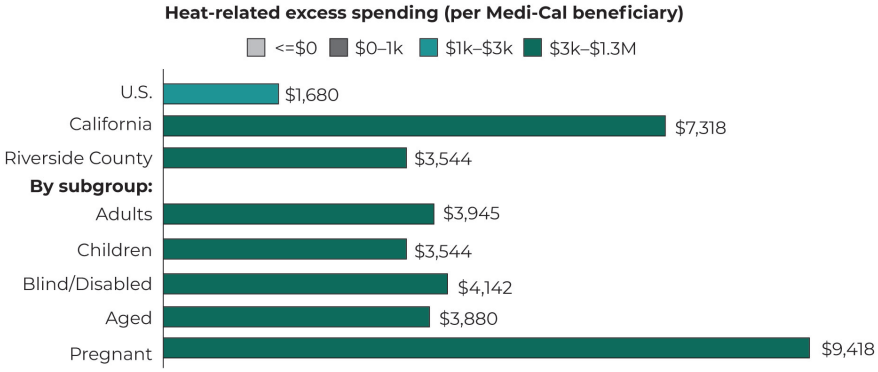
Socioenvironmental vulnerabilities and implications for planning

- As a largely urban area, Riverside County has high levels of impervious surface cover relative to other counties. These surfaces can retain heat, increase water runoff (which can carry pollutants), divert water from existing vegetation, and contribute to flash flooding.
- The county has a low level of canopy tree cover, so it lacks sufficient shade to help bring temperatures down. These two factors make it more difficult for the county to combat the urban heat islands, which can be as much as 20°F hotter than surrounding areas.

Heat-related health burden based on Medi-Cal data (covering 39 percent of county residents)

- Excess costs to treat heat stress were higher countywide than statewide (averaging $1,900 versus $742 per beneficiary, respectively).
- **Beneficiaries who are blind or with disabilities** had fewer excess visits for electrolyte imbalance than Medi-Cal beneficiaries countywide, but much higher treatment costs ($11,100 versus $2,800 per beneficiary).
- Despite a dip in Medi-Cal utilization for acute myocardial infarction, the county saw increases in treatment costs, particularly among **seniors** ($29,300 versus $1,200 per beneficiary countywide).
- Despite a dip in Medi-Cal utilization for acute renal failure, the county saw increases in treatment costs across all demographic groups (Exhibit 2), with particularly pronounced impacts for **pregnant beneficiaries** ($9,400 versus $3,500 per beneficiary countywide).

Exhibit 2. Excess spending on acute renal failure in Riverside County, by demographic group



Note: The heat-related excess spending measures reflect average increases in 2020 costs per Medi-Cal beneficiary at the national, state, and county levels, and among different demographic subgroups.

Tulare County

Tulare County is a rural county with the dry summers and wet winters typical of a Mediterranean climate. In Tulare County, outdoor workers comprise 38 percent of the workforce.

Heat wave exposure

- Tulare County saw up to four heat waves per year in recent years (2016 to 2021).
- The county faced two heat waves in 2020, averaging three days each, with temperatures averaging 93°F.

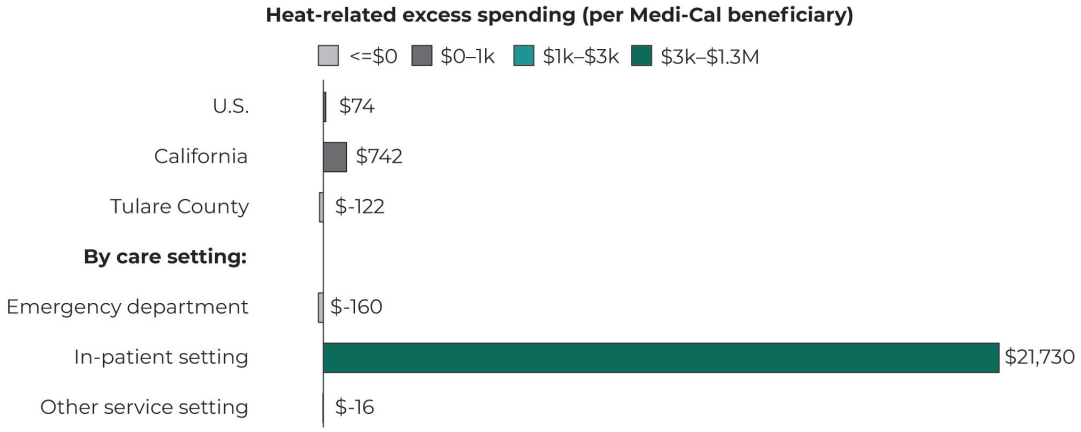
Socioenvironmental vulnerabilities and implications for planning

- Tulare County has one of the highest poverty rates of any county in California. It also falls into the highest category of vulnerability across multiple social and environmental factors, including housing and transportation, minority composition, and disability, all of which increase the disparate effects of extreme heat.
- In this agricultural county, outdoor workers get little respite from the heat during heat waves. Heat-related crop damage, drought, and invasive species can cause further hardship to residents.

Heat-related health burden based on Medi-Cal data (covering 58 percent of county residents)

- Although the county saw only a small increase in the number of health care visits for heat stress, there was a large increase in spending to treat heat stress in **inpatient settings** (Exhibit 3), amounting to more than $21,700 per beneficiary (versus no excess countywide, and $742 statewide).
- Excess utilization for acute heat-related conditions was 75 percent higher in **children** than Medi-Cal beneficiaries countywide, but treatment costs increased by considerably more. This was particularly true for electrolyte imbalance ($53,000 versus $1,600 per beneficiary) and acute renal failure ($56,000 versus $6,300 per beneficiary).

Exhibit 3. Excess spending on heat stress in Tulare County, by care setting



Note: The heat-related excess spending measures shown reflect average increases in 2020 costs per Medi-Cal beneficiary at the national, state, and county levels, and among beneficiaries treated in different care settings.

Santa Barbara County

Santa Barbara County's diverse topography leaves it climate vulnerable on many dimensions. In the mountains, heavy rainfall causes mudslides and temperatures can dip below freezing in the winter. In the valleys, extreme heat and little rain create high wildfire risk and drought conditions.

Heat wave exposure

- Santa Barbara County saw at most three heat waves per year in recent years (2016 to 2021).
- The county faced three milder heat waves in 2020, averaging five days each, with temperatures averaging 76°F.

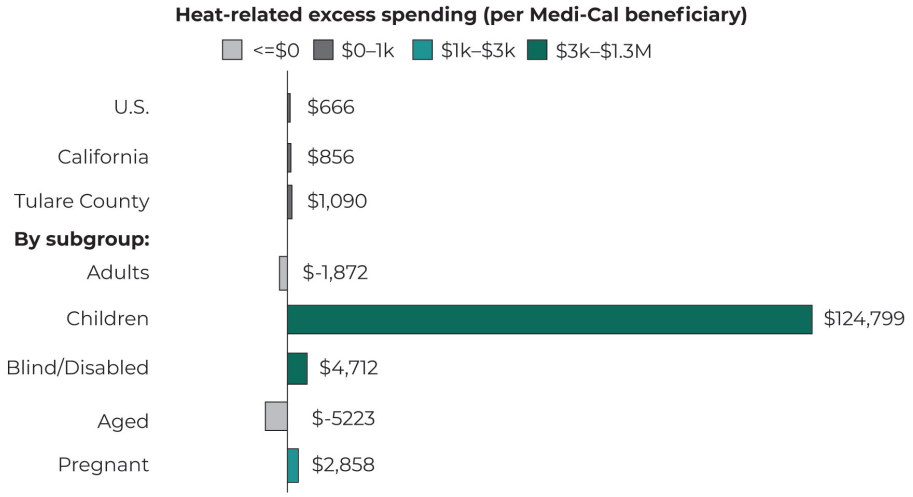
Socioenvironmental vulnerabilities and implications for planning

- Santa Barbara County is predominantly urban and suburban, and its high levels of impervious surface cover create urban heat islands that increase ambient temperature for long periods.
- The county also has high levels of housing vulnerability due to its large stock of old, crowded, or multiunit housing, so many residents might lack access to air conditioning, making it more difficult to stay cool indoors during heat waves. Furthermore, public cooling centers might not have room for Santa Barbara County's larger than average unsheltered population.

Heat-related health burden based on Medi-Cal data (covering 38 percent of county residents)

- Despite a decrease in visits for acute renal failure around heat waves, the county saw increases in treatment costs, which averaged $7,500 among **seniors** (versus $2,300 countywide).
- Despite a decrease in visits for electrolyte imbalance around heat waves, the county saw increases in treatment costs (Exhibit 4), which were substantially higher among **children** (averaging almost $125,000 versus $1,100 per child countywide).

Exhibit 4. Excess spending on electrolyte imbalance in Santa Barbara County, by demographic group



Note: The heat-related excess spending measures shown reflect average increases in 2020 costs per Medi-Cal beneficiary at the national, state, and county levels, and among different demographic subgroups.

Catalyzing momentum for heat resilience and health equity

In April 2022, the governor of California launched the state's Extreme Heat Action Plan, marking meaningful state-level movement toward a more heat-resilient California. The plan highlights actions the state has already taken to address the health and social impacts of extreme heat and recommends future actions. For example, the state is supporting efforts to identify and intervene in heat-related illness earlier, and the Department of Public Health has begun efforts to ensure continuity of health care for patients during heat-related emergencies.

While these actions have largely taken shape at the state level, a main goal of California's Extreme Heat Action Plan is to support local heat action planning and response. To date, many California counties have created broader climate action plans, but do not yet have plans dedicated to addressing extreme heat. The localized and integrated data available through ClimaWATCH can clarify how extreme heat exposure, susceptibility, and health impacts vary from county to county across California. With this information, local officials can start developing effective, tailored, and equitable heat action plans to help make communities more climate resilient.

ClimaWATCH can also complement other vulnerability assessment tools currently in use in California, such as the California Natural Resources Agency's California Heat Assessment Tool (CHAT) and the Department of Public Health's Climate Change and Health Vulnerability Indicators for California visualization platform (CCHViz). CHAT examines dimensions of heat vulnerability along census tracts and offers forward-looking projections of how heat events might affect health, with the ability to focus on specific health conditions. CCHViz uses data visualizations to explore the health impact of extreme heat days at the county level across an array of exposure, sensitivity, and adaptive capacity indicators, as well as some demographic subgroups. ClimaWATCH adds the ability to benchmark excess heat-related health issues with rates measured in other counties, statewide, and nationally. Critically, it also provides a cost accounting of such issues, to facilitate strategic planning, cost-benefit analyses, and program evaluations.

Preparing for a hotter future

With heat waves predicted to become more frequent, intense, and widespread, California state and local officials and health systems have roles to play to mitigate impact and prepare for increases in the demand and costs for health services. By highlighting how communities can be vulnerable to heat waves, ClimaWATCH can help officials decide where to direct their attention and resources. Examples of adaptation strategies include the following:

Patient screening and education. During regular patient check-ups, health care providers can screen for social risk factors, such as high housing vulnerability, which can magnify the impacts of heat on health. Providers can also provide educational pamphlets on how to safely take and store medications, such as insulin, to prevent spoilage during heat waves. Using ClimaWATCH, health systems can also develop tailored heat safety campaigns to educate patients and clinicians on how heat affects health, who is most affected, and how to recognize and address heat-related illnesses. Tailored emergency heat protocols could help prevent heat stress and other acute conditions from becoming life-threatening or fatal.

Accessible heat risk messaging. In counties with high levels of vulnerability due to language barriers, officials can translate heat alerts and education materials into multiple languages, as has been done at the state level. They can distribute these materials in partnership with community-based organizations that serve minority groups to ensure the materials reach residents who are linguistically isolated. For those who are blind or visually impaired, officials can ensure that color-coded maps and graphics have accompanying text descriptions, so that the information can be accessed using adaptive technologies such as screen readers or screen magnification.

Surge capacity. Health systems can use ClimaWATCH measures of heat-related excess Medi-Cal visits to create tailored surge staffing plans that account for heat-related increases in demand and ensure continuity of care during heat waves.

Transportation. In counties with high transportation vulnerability, officials might work with community partners that have access to large-capacity vehicles, such as schools and churches. Together, they can arrange free transportation to cooling centers, hydration stations, and health care facilities with air conditioning and reliable power during heat waves.

Nature-based solutions. Counties with high levels of impervious surfaces and low tree canopy cover can implement some of the nature-based solutions included in the state's heat action plan—such as planting more shade trees to reduce direct sun exposure, increase the absorption of precipitation into the ground, and keep buildings cooler—thereby reducing demand for air conditioning.

Endnotes

[1] Though there is currently no consensus definition, a heat wave is typically defined as two or more consecutive days when temperatures exceed a physiologically based absolute threshold (for example, 90°F) or a location-based relative threshold (for example, the 95th percentile of historical values).

[2] Throughout the brief, we highlight data from 2020, the latest year for which Medi-Cal data are available in ClimaWATCH.

[3] Health care cost data are based on the roughly 20 percent of Californians covered by a Medi-Cal fee-for-service plan.

How we developed our findings

The findings in this brief are based on Mathematica's ClimaWATCH tool for climate vulnerability assessments, which helps officials see where heat waves concentrate, which communities are most at risk, how various types of health effects accumulate in localities, and the financial toll of heat-related illnesses on those localities. To develop ClimaWATCH, Mathematica statisticians, data scientists, and health policy researchers used national Medicaid claims, localized metrics on temperature and humidity; and county-level indices on vulnerability resulting from demographic, social, geographic, environmental, and infrastructural features. ClimaWATCH is publicly available at climawatch.climate.mathematica.org and is also a featured heat health tool on the National Integrated Heat Health Information System's heat.gov.

To learn more about Mathematica's Climate and Health Analytics initiative and how you could adapt the ClimaWATCH tool to your needs, visit https://www.mathematica.org/sp/climate-change/climate-action or email Aparna Keshaviah at akeshaviah@mathematica-mpr.com.