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# Background

Exposure to extreme heat, or summertime temperatures that are much hotter and/or humid than average,[[1]](#endnote-2) is a serious threat to health and well-being. The number and length of heat waves has increased significantly since the 1960s.[[2]](#endnote-3) The year 2020 was the second-warmest year on record globally,[[3]](#endnote-4) and the warmest year on record for the contiguous United States.[[4]](#endnote-5) These trends are projected to continue and worsen in the coming decades, exposing more people to the harmful consequences of heat.

In 2021, Washington state experienced an unprecedented heat dome event leading to 128 heat-related deaths, which occurred earlier in the season than is typical. The regional temperature was on average 30°F warmer than the mean of the hottest 3 months in the previous decade.[[5]](#endnote-6), Additionally, each week between June 20th – July 31st, 2021 had a higher rate of excess death (205 excess death each week) not directly attributed to heat.[[6]](#endnote-7) Excess heat impacts emergency response systems, significantly increasing emergency visits for acute heat illnesses, increasing 911 call volume, and costing billions of dollars annually.[[7]](#endnote-8) While everyone is susceptible to increased heat, it doesn’t impact everyone in the same ways.

Higher air temperatures increase wildfire likelihood, posing a serious threat to human health, ecosystems, and infrastructure. Wildfire smoke is comprised of a mixture of pollutants, including fine particulate matter (PM2.5), carbon monoxide, nitrogen oxides, formaldehyde, benzene and others. Wildfire smoke exposure increases all-cause mortality, impacts respiratory health, and may co-occur and interact with heat exposure to impact cardiorespiratory morbidity and mortality.[[8]](#endnote-9)[[9]](#endnote-10)[[10]](#endnote-11)[[11]](#endnote-12) Certain workers are disproportionately co-exposed, such as agricultural populations, who may experience high concurrent heat and PM2.5 exposures.[[12]](#endnote-13) As a result of a warming climate, wildfires are becoming larger, more destructive, and more difficult to control, which will drastically increase the impact on heat and health.

Certain populations are more vulnerable to both environmental exposures including:

* **Ages and life stages** **(*infants and children, pregnant women, older adults*)**
* **People physically active outdoors or in hot indoor spaces (*athletes, outdoor and some indoor workers, emergency responders*)**
* **People disproportionately exposed to heat, sensitive to heat or with limited adaptive capacity (*people experiencing homelessness, people with chronic medical conditions including mental health, people who use drugs, people with disabilities, people who are incarcerated, people with low income, marginalized communities such as those subjected to redlining*)**

This report’s main aim is to **reduce morbidity and mortality related to extreme heat and wildfire smoke.** Heat-related illnesses and health impacts due to poor air quality can be prevented or reduced by implementing evidence-informed, coordinated efforts across sectors, such as early detection and warning systems, education and communication, and standardized protocols for responding to heat-related illnesses and exacerbations. Addressing the underlying social and environmental determinants of health that make certain populations more vulnerable to heat and wildfire smoke can reduce disparities and promote health equity in the face of our changing climate.

# Focus Areas

|  |  |
| --- | --- |
| Focus Area | Elements |
| Planning & Preparedness | * Systematic weather monitoring using validated tools during warmer months * Facility, staff, and patient early preparation for heat and wildfire smoke events * Individual, organizations and jurisdictional action plans * Public education and targeted education tailored to populations at highest risk * Health professional education on prevention, identification, treatment, and management of heat-related illness & exacerbations of illness due to heat and wildfire smoke exposures |
| Equity | * Identification of population at highest risk of negative health impacts of heat and wildfire smoke * Resource allocation (e.g., portable air filters, cooling centers) to communities most impacted by heat and wildfire smoke * Partnering with communities to communicate and build capacity to protect against health impacts of heat and wildfire smoke |
| Incentives and Investments | * Sustainable operations of public health level interventions * Investments in energy efficient infrastructure such as AC |
| Tracking and Measurement | * Integration of data sources to used to identify high risk populations * Data sharing agreements to facilitate further understanding of impacts of heat and wildfire smoke |

## Guidelines

### Clinicians

* **Ask about and identify risk factors for patients more vulnerable to heat and wildfire smoke to inform action planning (see Figure 1).** When assessing for risk related to heat, consider starting with the [CHILL’D OUT](https://www.cdc.gov/heat-health/hcp/clinical-guidance/chill-d-out-screening-questionnaire.html) tool to identify risk factors and areas to address in individual action plans. Also ask about risk factors relevant to wildfire smoke,
  + Also ask about tools and strategies relevant to wildfire smoke, including access A/C units with MERV filters, HEPA air cleaners (or box fan filters if HEPA unavailable), ability to close windows and other openings in the home, and using delivery services for groceries or pharmacy if necessary. See DOH resource on purchasing portable air cleaners and air conditioners: <https://doh.wa.gov/community-and-environment/air-quality/indoor-air/portable-air-cleaners>
  + **For patients working in the heat,** identify and document key factors such as the patient’s industry and occupation, whether new to the job, work clothing/personal protective equipment, workload, environmental conditions, and any workplace controls such as hydration, shade, air-conditioning, rest breaks, respirators, or adjustments to work pace or hours.
* **Discuss how heat and wildfire smoke can be harmful to health.** Most adults have difficulty understanding health information routinely available in healthcare facilities. Take precautions to ensure communication is easier to understand and act on (Resource: [AHRQ Health Literacy Universal Precautions Toolkit](https://www.ahrq.gov/sites/default/files/publications2/files/health-literacy-toolkit-third-edition.pdf))
  + Teach patients how to use the [HeatRisk](https://ephtracking.cdc.gov/Applications/HeatRisk/) tool and [Air Quality Index](https://www.airnow.gov/aqi/). Explain that poor air quality can worsen heat risk.
  + For patients working in the heat, teach patients how to find out about local (e.g., State) policies on heat and air quality triggers for workplace health and safety protections
* **Co-develop an individualized patient action plan to reduce their exposure to heat and wildfire smoke, signs and to watch for, and when and how to seek help.** Discuss how heat and wildfire smoke can be harmful to their health with their specific context. Update these plans regularly or if there is a change in the patient’s risk factors.
  + **As appropriate, delegate counseling to most appropriate members of the interdisciplinary team,** considering individualized needs and preferences*. (E.g., if available, consider involving community health workers/promotoras for patients who primarily speak Spanish)* Involve the patient’s support system in planning as able with patient consent.
    - Example action plans for heat [here](https://www.americares.org/wp-content/uploads/PATIENTS-Heat-Heat-Action-Plan-V1.pdf) & [here](https://www.cdc.gov/heat-health/media/pdfs/tips-for-people-with-heart-disease-508.pdf), examples for wildfire smoke [here](https://www.americares.org/wp-content/uploads/PATIENT.Wildfire_Action_Plan_2023Final.pdf).
  + **For patients who live alone or with cognitive impairment**, consider who can check on the patient remotely during heat or wildfire smoke in their area. Social isolation is also a risk factor for health impacts due to heat or wildfire smoke.
  + **For patients with electricity dependent DME**, work with the patient and support system to identify a plan for if the power goes out, (for example consider if patients utility company might have a power restoration program).
  + **For patients working in the heat,** counsel on exercising rights and required protections (link heat & smoke rules) and provide recommendations for best practice resources, including educational resources, accessing information on heat and air quality, hydration, rest, shade, breaks, and other protections from heat and wildfires smoke (see example [here](https://deohs.washington.edu/pnash/sites/deohs.washington.edu.pnash/files/2023-06/BestPracticesForHeatIllnessInAg-6-23.pdf)); how to seek job accommodations if indicated; and how to report workplace concerns, which can be filed anonymously, including by the healthcare provider (see [here](https://www.lni.wa.gov/forms-publications/F418-052-000.pdf)).
  + **For patients with chronic conditions, consider condition specific considerations for action planning such as medication management.** Several examples of recommendations for management of patients with chronic conditions listed below:
    - [Kidney Disease,](https://academic.oup.com/ckj/article/17/6/sfae156/7681988?login=false) [Heat-related Acute Kidney Disease](https://www.ajkd.org/action/showPdf?pii=S0272-6386%2822%2901081-2)
    - [Asthma](https://www.cdc.gov/heat-health/hcp/clinical-overview/heat-children-asthma.html)
    - [Mental Health](https://earth.ucsf.edu/sites/g/files/tkssra5626/f/wysiwyg/ExtremeHeat/EXTREME%2BHEAT%2BAND%2BMENTAL%2BILLNESS_%C2%A0%2BTOOL%2BKIT%2BFOR%2BMENTAL%2BHEALTH%2BCARE%2BPROVIDERS-3%20%281%29.pdf#:~:text=TOOL%20KIT%20FOR%20MENTAL%20HEALTH%20CARE)
    - [Cardiovascular Disease](https://www.cdc.gov/heat-health/hcp/clinical-overview/heat-and-people-with-cardiovascular-disease.html#:~:text=Take%20these%205%20steps%20to%20help%20your%20patients,disease%2C%20including%20blood%20pressure%20control%20and%20CVD%20symptoms.)
    - [Diabetes](https://www.cdc.gov/diabetes/articles/managing-diabetes-in-the-heat.html#:~:text=Your%20summer%20checklist%201%20Drink%20plenty%20of%20water.,power.%208%20Have%20a%20go-bag%20ready%20for%20emergencies.)
    - [Wildfire Smoke & Chronic Conditions](https://www.cdc.gov/wildfires/risk-factors/wildfire-smoke-and-people-with-chronic-conditions.html#:~:text=Protect%20yourself%20from%20wildfire%20smoke%201%20Pay%20attention,smoke%20event%2C%20wear%20a%20NIOSH%20Approved%20N95%20respirator.)
  + **For patients on dialysis,** make a plan for safe attendance at dialysis sessions. See [here](https://academic.oup.com/ckj/article/17/6/sfae156/7681988) for further tips on caring for patients with CKD during heat.
  + **For all young children,** ensure caregiver knows signs and symptoms to watch for and how to keep infant or child safe during heat and wildfire smoke. More [here](https://www.cdc.gov/heat-health/risk-factors/infants-and-children.html#:~:text=Infants%20and%20young%20children%20rely%20on) and [here](https://www.healthychildren.org/English/safety-prevention/at-home/Pages/Protecting-Children-from-Extreme-Heat-Information-for-Parents.aspx#:~:text=Learn%20how%20to%20prevent%20heat-related%20illness).
  + **For patients who are pregnant, e**nsure they know how to stay safe during heat and wildfire smoke. More [here](https://www.cdc.gov/heat-health/hcp/clinical-overview/heat-and-pregnant-women.html) and [here](https://www.cdc.gov/wildfires/risk-factors/wildfire-smoke-and-pregnancy.html#:~:text=Key%20points.%20Pregnancy%20is%20a%20time)
* **Connect patients to assistance programs to support health-related social needs.** Follow the Foundation for Health Care Quality’s reports and guidelines on [Social Need Screening](https://www.qualityhealth.org/equity/comm/social-need-screening/) and [Social Need Intervention](https://www.qualityhealth.org/equity/comm/social-need-interventions/). This can be done by social worker, case manager, community health worker or other similar professional.
  + Provide resources for health-related social needs such as energy assistance, transportation, food security, childcare, and others
  + **For patients working in the heat**, provide information on when and how to seek benefits through workers’ compensation
  + **For patients without an air conditioner or air filter, work with them to find a way to gain access to this equipment.** Consider writing notes of medical eligibility for air conditioners for patients at higher risk - air conditioners may be covered by the patient or caregivers’ FSA/HSA. See if their health plan will cover the cost of the equipment, and connect them to federal energy assistance programs
* **As part of their individualized action plan, decide with patients and caregivers how to manage medications on heat risk orange, red and magenta days.** Counsel patients and/or their family on increased risk and, as applicable, symptoms that may indicate drug interaction with heat. See the [CDC Guidance for Clinicians on Heat and Medications.](https://www.cdc.gov/heat-health/hcp/clinical-guidance/heat-and-medications-guidance-for-clinicians.html) This can be done by pharmacists or other similar professional.
  + Consider adjustments to medication doses for medications most likely to interact with heat, especially for older patients who take multiple medications and patients on diuretics and psychiatric medications. A non-comprehensive list of medications can be found in **Appendix Medications that may increase risk of harm on hot days**
  + Consider adjustment to fluid restrictions during periods of extreme heat, especially for patients who take medications that may lead to dehydration or affect electrolytes. For patients with conditions that affect fluid balance, consider evaluating baseline hydration status and discuss monitoring of blood pressure, weight and hydration at home.
  + Counsel patients on storing heat-sensitive medications properly and planning for how heat waves or other climate events may impact storage of medications, like insulin.
* **Document action plan in medical record and make copy easily accessible for patients and their support system** (e.g., copy into a portal for patient access, print out at visit) in language that is easily understood. ake precautions to ensure communication is easier to understand and act on (Resource: [AHRQ Health Literacy Universal Precautions Toolkit](https://www.ahrq.gov/sites/default/files/publications2/files/health-literacy-toolkit-third-edition.pdf))
* **During heat or poor air quality due to wildfire smoke, a designated individual** (care manager or similar) **on the care team should be responsible for outreach to at-risk patients, providing guidance and coordination support to access needed resources** (e.g, transportation to cooling centers, meds, etc)

### Health Delivery Systems

*All delivery systems should have organizational action plans[[13]](#endnote-14) that involve actions to take year-round and actions for before or during an event. These strategies are adopted from the Northwest Healthcare Response Network’s resources for Extreme Heat and Wildfire Smoke. Another tool for health system planning for climate resilience can be found here:* [*https://toolkit.climate.gov/topics/human-health/building-climate-resilience-health-sector*](https://toolkit.climate.gov/topics/human-health/building-climate-resilience-health-sector)

Year-Round

* **Take steps to make your facility more energy efficient**, such as diversifying power sources, implementing renewable energy and on-site battery storage, and creating a more efficient and protective building envelope. See resource here: [link](https://toolkit.climate.gov/topics/human-health/building-climate-resilience-health-sector))
  + Consider applying for inflation reduction act grants to improve resiliency of infrastructure.
* **Prepare your facilities.** 
  + **Review system vulnerabilities ahead of hotter months** (June – September) including HVAC systems, air conditioners, IT servers, communication systems and sensitive medical equipment. Use high efficiency air filters (e.g., MERV 13)
  + **Address gaps in hazard vulnerability assessments to strengthen emergency preparedness plans.**
* **Train healthcare staff**. Healthcare workers should be trained in recognizing, preventing and treating heat-related illness and exacerbations of chronic conditions due to heat or wildfire smoke. Example resources below:
  + Heat: [Clinical Guidance for Heat Health | Heat Health | CDC](https://www.cdc.gov/heat-health/hcp/clinical-guidance/index.html)
  + Wildfires:
    - [A Story of Health - A Multi-media eBook - Western States PEHSU (ucsf.edu)](https://wspehsu.ucsf.edu/main-resources/training/a-story-of-health-a-multi-media-ebook-2/)
    - [Wildfire Smoke and Your Patients' Health | US EPA](https://www.epa.gov/wildfire-smoke-course)
  + Both: [Climate Resilient Health Clinics | Americares](https://www.americares.org/what-we-do/community-health/climate-resilient-health-clinics/#toolkit)
  + **For systems who serve patients who work in the heat and/or wildfire smoke**, partner with or ensure occupational & environmental medicine (OEM) capacity, evidenced-based care, and medical monitoring. Example resources:
    - [Prevention of Occupational Heat-Related Illnesses - PubMed (nih.gov)](https://pubmed.ncbi.nlm.nih.gov/34597285/)
    - [Heat-Related Illness Clinician’s Guide - June 2021 | Migrant Clinicians Network](https://www.migrantclinician.org/resource/heat-related-illness-clinicians-guide-june-2021.html)
* **Develop protocols to protect staff and patients' and staff**
  + **Ensure an evacuation plan is in place** in case of power loss or HVAC malfunction. **Develop clear downtime procedures for** extreme heat and wildfire smoke events to maintain service delivery
  + **Integrate weather monitoring into facility protocols** for warmer months (e.g. June-September) with clear communication protocols to alert staff and patients to anticipate heat and wildfire smoke.
  + **Identify strategies to reduce heat and wildfire smoke exposure for patients and staff** (e.g., setting up hydration and cooling, air filtering systems, cancelling outdoor activities)
* **Support your community.** 
  + **Participate in collaborative planning for heat and wildfires with local health jurisdictions, emergency preparedness organizations and healthcare coalitions**. Look up your regional healthcare coalition [here](https://doh.wa.gov/about-us/executive-offices/resiliency-and-health-security/emergency-preparedness-regions/regional-healthcare-coalition-leads).
  + **Communicate with local healthcare coalitions** to support other facilities in your area. Check Washington 211 and local health jurisdictions to know where cooling centers are available to direct patients.
  + **Offer support in accessing resources to address health related social needs.** Develop partnerships with community organizations, health plans and other healthcare stakeholders to better meet patient social needs (e.g., transportation, housing, air conditioning). Follow the Foundation for Health Care Quality’s report on social need interventions [here](https://www.qualityhealth.org/equity/comm/social-need-interventions/).
  + **Communicate clinical trends and conditions (**heat-related illness, wildfire smoke related exacerbations) **to the Department of Health for tracking of impact of heat and wildfire smoke.**

Preparing for or During an Event. Facilities should act as early as possible once an event is forecasted.

* **Review and follow facility plans.** 
  + **Consult facility preparation plans** – Prepare for cooling system and HVAC system filtration capabilities and limitations and conserve supplies.
  + **Review evacuation plans and alert staff to upcoming weather hazards.** plan for cooling and clean air areas within the facility if able to reduce the need to evacuate.
  + **Prepare for potential patient surges** by upstaffing and/or expediting discharge when possible. **Adjust schedules to avoid peak heat hours and consider switching to telehealth appointments** when possible. Consider rescheduling elective procedures as necessary.
* **Prepare for needs of your staff.** 
  + Allow staff to sleep at facilities if conditions warrant, and some may need to evacuate their homes.
* **Monitor weather conditions on a regular basis** using the NW Heat Risk tool, AQI tools and [WA Smoke Blog](https://wasmoke.blogspot.com/).
  + **Monitor indoor temperature and air quality** during heat or times of unhealthy air quality
  + When temperatures are forecast to be level orange or higher, alert leadership and begin preparation.
  + When air quality is forecasted to be “Unhealthy” for greater than 24 hours or very unhealthy or hazardous, consider monitoring indoor air quality and PM2.5
* **Alert staff and patients of heat and/or poor air quality due to wildfire smoke as early as possible.** 
  + **Reiterate messaging from local health jurisdictions and the Department of Health** on how to reduce risk of heat through all public and patient facing communication. Consistent messaging is important to maintain clarity of actions.
  + **Distribute informational materials (e.g., posters, pamphlets, etc) within clinics on how to stay safe during heat and/or poor air quality due to wildfire smoke.** These materials should include an alert that heat or wildfire smoke is imminent, the signs and symptoms of heat-related illness or smoke related illness and potential actions to reduce exposure. Align educational materials with local public health guidance.
* **Support your community.** 
  + **Communicate with local healthcare coalitions** to support other facilities in your area. Check [Washington 211](Washington%202-1-1%20might%20be%20a%20better%20one%20stop%20resource%20for%20cooling%20centers) and local health jurisdictions to know where cooling centers are available to direct patients.

After an event

* **Evaluate**. Evaluate impact of heat and wildfire smoke on healthcare utilization, outcomes and patient experience. Use EHR data to track instances of visits for heat-related illness, exacerbation of chronic conditions and other relevant outcomes measures. See the **Bree Collaborative Heat and Wildfire Smoke Evaluation Framework** for further instruction.
  + **Stratify by race, ethnicity and language (REaL) data to identify and address disparities** in outcomes. Focus quality improvement efforts on reducing inequities.
* **Iteratively improve upon organizational action plan.** Perform after action reviews on performance during heat and wildfire smoke. Use quality improvement methodologies such as PDSA to address inadequacies.

#### Outpatient Clinics

*In addition to the above guidelines, hospitals should engage in the following activities:*

Year-Round

* **Develop a registry of at risk and underserved patient populations.** Identify at risk and underserved patient populations by location and medical condition
  + Care managers or other similar roles can use these registries to identify patients with medical conditions at higher risk of emergency room visits and hospitalizations
  + Consider integrating continuous air quality and heat monitoring into electronic health records using registered zip codes
* **Utilize multidisciplinary care teams**. Team members can including providers, nurses, care managers, pharmacists, discharge planners, respiratory therapists, physical or occupational therapists, community health workers and more. Team members should understand patients needs at home to reduce their exposure to wildfire smoke and heat.
* Create custom analytics and wildfire risk stratification including air quality assessment and heat risk. Include multiple variables in registries – medication use such as inhalers or insulin, diagnostic codes and demographic data.
* Develop care pathways based on risk factors to create preparedness on the individual, system and community levels
  + Once patients are identified, they can be directed to a care manager specifically focusing on these patients sending personalized outreach and providing guidance as needed during an event
  + Consider developing messages to all patients and sensitive populations triggered automatically when air quality and heat are predicted to and/or reach harmful levels, including how to maintain cooling and air quality at home. Ensure all communication is linguistically inclusive of populations served by your facility.

Before and During an Event

* **Send refills of essential medications as early as possible before heat and wildfire smoke.** Alert patient and/or support system to pick up the medication.
* **Follow developed care pathways for at risk populations to perform targeted outreach by designated care team member.**

#### Urgent Care Clinics

*In addition to the above guidelines, urgent care clinics should engage in the following activities*

Before and During an Event

* Standardize protocols for early identification, triage and treatment of heat-related illness and exacerbation of chronic conditions. See example for [Heat Stroke](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7972371/).
  + **Ensure appropriate equipment is available on site, including for** **cold water immersion.**

#### Hospitals and Emergency Departments

*In addition to the above guidelines, hospitals should engage in the following activities*

Before and During an Event

* **Standardize protocols for** early identification and triage of heat-related illness and exacerbations of chronic conditions. See example for [Heat Stroke](https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7972371/).
  + **Ensure appropriate equipment is available on site, including for cold water immersion**
* **Support patients and families in identifying a safe discharge location** with access to cooling and/or air filters during heat and/or poor air quality.
* **Documentation.** Implement change to standardize documentation of patient information to improve surveillance and monitoring systems.
  + **For systems that see patients who work in the heat**, implement a protocol to collect self-reported standardized patient work information that can be documented into EHRs. Important information to document includes employment status, retirement dates, jobs (industry and occupation) and usual or longest-held work. Example [here](https://www.cdc.gov/niosh/newsroom/feature/data-for-health.html).

### Long-term care facilities

*Older adults are particularly impacted by heat and wildfire smoke due to the intersection of several factors (age, chronic conditions, reduced mobility, cognitive impairment, social isolation). These factors make older adults more at risk for heat-related illness, exacerbations of chronic conditions such as cardiovascular disease, respiratory disease, and kidney disease, and mental distress. Long-term care facilities are critical to maintaining and improving the health and safety of older adults in Washington state. By planning ahead, implementing evidence-based interventions and coordinating with local partners, long-term care facilities can reduce the risk and impact of heat and wildfire smoke events in their community. Long-term Care Facilities should follow the guidelines under Health Delivery Systems in addition to the guidelines written below:*

Year-Round

* **Prepare your facility.** See most updated Washington state DSHS guidance (e.g., [Preparing for Wildfire and Extreme Heat in LTC Settings](https://www.dshs.wa.gov/sites/default/files/ALTSA/rcs/documents/Extreme%20Heat%20and%20Wildfire%20Prep.pdf#:~:text=Stay%20up%20to%20date%20with%20current%20air%20quality,near%20windows%20and%20doors.%20Use%20highest%20performance%20filters.)) and Americares/Harvard [Climate Resilience Toolkit](https://www.americares.org/what-we-do/community-health/climate-resilient-health-clinics/#toolkit) for resources to support.
  + **Ensure cooling systems are on generator power and validate reserve fuel levels before heat events.**
  + **If not already in facility, purchase air conditioners and high quality HEPA (MERV 13) filters.**
  + **Ensure adequate supplies**. Consider supplies necessary to respond to extreme weather (e.g., **masks, water, air conditioners, air purifiers, equipment to monitor temperature and air quality inside the facility)** Ensure the necessary supply of medications and other equipment needed to treat heat-related illnesses or illnesses related to wildfire smoke.
* **Develop action plans for heat and wildfire smoke using HeatRisk tool level and Air Quality Index.** Include considerations for joint heat and wildfire smoke and the possibility of power outages.
* **Train healthcare staff.** Healthcare workers should be trained in recognizing, preventing and treating heat-related illness and exacerbations of chronic conditions due to heat or wildfire smoke.
* **Develop protocols to protect staff and patients from heat and wildfire smoke exposure.** Ensure protocols **f**ollow public health guidance on limiting time outdoors, ensure lightweight clothing, closing windows/doors when air quality is poor, maintaining adequate fluid intake, reducing sources of air pollutants, using N95 respirators and monitoring for signs of heat-related illnesses (see appendix) and or exacerbations of chronic conditions.
  + Considerations for heat and wildfire smoke occurring at the same time.
  + **Include evacuation plans and destination.** Engage with local emergency management for mass sheltering locations, and coordinate with local healthcare coalitions to assist with placements. **Do not send medically stable patients to the hospital.** Have vehicles fueled, equipment packed, and transport coordinated for those requiring Basic Life Support/Advanced Life Support.

Before or During an Event

* **Monitor temperatures in care areas and residents’ rooms.** Move residents to cooler spaces or spaces with improved air filtration in the facility if necessary.
  + If unable to move resident or unable to maintain regulated body temperature, use buckets of cold water, towels soaked in cold water or other methods to cool down body temperature
  + If unable to maintain safe air quality index indoors, consider placing mask on the patient if safe to do so.

#### Home Health Agencies

Year-Round

* Train staff
  + s/s of heat realted illness, exacerbations of conditions
  + Documentation of risk
* Develop emergency response plans
* Resource Allocation – cooling devices, hydration supplies, air quality monitoring

During event

* Protect patients from heat and wildfire smoke
* Follow medication management
* Ensure staff have adeuqate protective gear to visit their patients
* Coordinate and provide supportive resources (e.g. access to transportation)
* Communicate with healthcare team to support patient needs

After event

* Perform health assessments for at risk clients
* Review plans to iteratively improve upon response

### Health Plans

Year-Round

* **Create a climate benefit that considers the comprehensive health needs for members experiencing heat and wildfire smoke events. Include at the minimum the following:** 
  + Equipment, such as Air conditioners air filtration coverage, aminifridge or other similar cooling devices to properly store medications, and portable power supply for durable medical equipment
  + Screening for health-related social needs and social need interventions, such as transportation benefit to cooling centers
  + Care coordination support before and during heat and wildfire smoke events to coordinate safe access to care and connect members to health-related social need resources and healthcare
  + Medication refills before heat and wildfire smoke events without additional cost-sharing
* **Develop universal education to members on how to stay safe and reduce exposure to heat and wildfire smoke during warmer months.** Ensure written materials are written at a 6th grade reading level and avaialable in languages that reflect needs of the members. Provide educational material in other accessible formats. Take precautions to ensure communication is easier to understand and act on (Resource: [AHRQ Health Literacy Universal Precautions Toolkit](https://www.ahrq.gov/sites/default/files/publications2/files/health-literacy-toolkit-third-edition.pdf))
* **Develop a registry for members that are at higher risk for negative health impacts of heat and wildfire smoke.** All members can be impacted by heat and wildfire smoke in Washington, but some members may be at higher risk. Use claims data, medication information, SDOH data and other relevant sources to create a registry.
  + Develop a standardized pathway to increase care coordination support during warmer months for members on the registry.
* **Engage with healthcare coalitions** and consider establishing data sharing agreements to support regional emergency planning and response
* **Participate in ongoing planning efforts** between public health departments, emergency response teams and healthcare delivery systems
* **Engage members in development of materials and benefit design related to climate and health.**

Before or During Heat or Wildfire Smoke

* **Monitor heat and air quality using the CDC’s Heat Risk tool and Air Quality Index** and alert coordination staff and members about impending or current concerns in temperature or air quality.Ensure educational material is available on how to prevent negative health impacts of heat and wildfire smoke.
* **Deploy increased care coordination support for members on the registry as early as possible.** Assist members and caregivers to follow their action plan and prevent exposure to heat and wildfire smoke.
* **Authorize refills on essential medications ahead of heat or wildfire smoke events without extra cost-sharing.** Contact members to let them know to pick up their medications before an incoming heat or wildfire smoke event.
* **Implement expedited claims processing** for inpatient members attempting to discharge to facilitate hospital throughput prior to extreme weather.

After an Event

* **Evaluate**. Evaluate impact of heat and wildfire smoke on member healthcare utilization, outcomes and patient experience. Use claims data to track instances of visits for heat-related illness, exacerbation of chronic conditions and other relevant outcomes measures. See the **Bree Collaborative Heat and Wildfire Smoke Evaluation Framework** for further instruction.

### Employer Purchasers (e.g., Union Trusts)

* **Benefit design.** Encourage coverage and payment for all services indicated in above Health Plan recommendations.
* **Involve workers in planning for heat and wildfire smoke.** Encourage active involvement of workers in the development of workplace safety and health planning, including for evacuation. Allow dedicated time for employees to participate in planning.
* **Follow best practices to protect indoor and outdoor workers from heat and wildfire smoke exposure.[[14]](#endnote-4013)** 
  + **In addition to outdoor workers, ensure indoor workers are protected from heat and wildfire smoke.** 
    - Follow standard [best practices guidelines,](https://www.cdc.gov/niosh/docs/2016-106/pdfs/2016-106.pdf?id=10.26616/NIOSHPUB2016106) such as those for heat from [NIOSH](http://NIOSH) or ACGIH,[[15]](#endnote-20539) which include guidance on heat stress management programs, hazard assessment, and controls. Controls include engineering controls (e.g., air conditioning, radiant heat shields, shade), administrative controls (e.g., work-rest cycles, task rotation, work shift timing, pacing), hydration, and training.[[16]](#endnote-3073)
    - The Occupational Health and Safety Administration has resources for supervisors and employers on heat illness prevention plans, training and materials for workers, and first aid for heat illness. **(**[**OSHA**](https://www.osha.gov/heat/employer-responsibility)**)**
  + **Develop a heat-alert system to communicate exposure information to workers, supervisors and other relevant staff in advance of heat and wildfire smoke.** Use tools such as weather forecasts and Air Quality Index to monitor and plan for dangerous levels of heat and air quality. Ensure communication is in plain language and a language that employees speak and can understand (e.g., Spanish).
  + **Ensure emergency response and evacuation plans, as necessary, are in place, and test annually before warmer months.**
  + **Acclimatization protocols.** Ensure new workers and workers returning from extended time off gradually increase their time working in the heat, and provide additional protections during this time. Follow National Institute for Occupational Safety and Health’s [acclimatization protocols](https://www.cdc.gov/niosh/heat-stress/recommendations/acclimatization.html?CDC_AAref_Val=https://www.cdc.gov/niosh/topics/heatstress/acclima.html).
  + **As conditions become extreme** (e.g., as the frequency and intensity of extreme heat events increase in the future, in indoor environments with point sources of heat such as foundries, among workers required to wear nonbreathable personal protective equipment such as firefighters):
    - **Re-evaluate work-rest cycles and the appropriateness of continuing work.**
    - **Consider real-time physiological monitoring.**
    - **Consider personal cooling** (e.g., cooling vests).
  + **Have a pre-placement and periodic monitoring program** where a healthcare provider evaluates workers to determine fitness for duty, monitors over time, and determines accommodations.[[17]](#endnote-7547)
  + **Evaluate heat and wildfire smoke prevention plans and management programs.** Ensure continual reduction in incidents of heat-related illnesses and illnesses related to wildfire smoke exposure through tracking incidents and claims information and iteratively reviewing and improving prevention plans. Encourage workers to report signs and symptoms of illness and injury.
* **Follow required WA State Rules for** [**heat**](https://lni.wa.gov/safety-health/safety-training-materials/workshops-events/beheatsmart) **and** [**wildfire**](https://lni.wa.gov/safety-health/safety-topics/topics/wildfire-smoke) **smoke to protect worker health.**
  + **Current Outdoor Heat Exposure rules** include requirements to:
    - Address outdoor heat exposure safety as part of the required Accident Prevention Program. An example template, which can be tailored to a specific workplace, can be found [here](https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fwww.lni.wa.gov%2Fsafety-health%2F_docs%2FHRIAPPAddendum.doc&wdOrigin=BROWSELINK).
    - Provide annual training to employees and supervisorson symptoms of outdoor heat exposure and policies in place to prevent heat-related illness.
    - Provide both a sufficient amount of cool drinking water to employees along with opportunities to drink the water.
    - Provide adequate shade (or alternative cooling methods) at all times to allow for access to prevent or respond to heat illness.
    - Encourage and allow workers to take paid, preventative cool down rest periods so they don’t overheat. When temperatures are 90°F or hotter, require workers to take additional paid, cool down rest periods of at least 10 minutes every 2 hours. Longer and more frequent breaks are indicated when temperatures continue to rise to 100°F.
    - Closely observe employees not acclimatized to the heat, including new employees, those returning from absences, and all workers during a heat wave.
    - Have emergency procedures to respond appropriately to any employee with symptoms of heat-related illness.
    - Make sure supervisors and employees always have a way to communicate with each other so they can promptly report heat illness and get medical assistance.
  + **Wildfire Smoke rules** use PM2.5 and AQI measures, as indicated in the table below from the [Washington Department of Labor & Industries](https://www.lni.wa.gov/safety-health/safety-topics/topics/wildfire-smoke#requirements-and-policies). There are additional rules for specific groups like Firefighters – follow the rules that apply to your populations.

|  |  |  |
| --- | --- | --- |
| **Current PM2.5 (μg/m3)** | **NowCast Air Quality Index for PM2.5 Beginning May 6, 2024** | **Required Protections** |
| 0.0 - 20.4 | 0 - 71 | * Prepare a written wildfire smoke response plan. * Provide wildfire smoke training to employees. * Watch the PM2.5 conditions and forecasts. * Prepare a two-way communication system. * Make provisions for prompt medical attention, and permit that medical attention without retaliation. |
| 20.5 - 35.4 | 72 - 100 | All of the above and:   * Notify employees of PM2.5 conditions. * Ensure only trained employees work outdoors. * Consider implementing exposure controls * Consider providing voluntary use respirators. |
| 35.5 - 250.4 | 101 - 350 | All of the above and:   * Implement exposure controls. * Make N95 respirators available for voluntary use. |
| 250.5 - 500.3 | 351 - 848 | All of the above and:   * Ensure workers experiencing symptoms requiring immediate medical attention be moved to a location that ensures sufficient clean air. * Directly distribute N95 respirators to employees for voluntary use. |
| 500.4 - 554.9 | 849 - 956 | All of the above and:   * Implement a complete required use respiratory protection program, including fit-testing, medical evaluations, requiring employees to be clean-shaven, and requiring the use of particulate respirators. |
| 555 or more | 957 or more | All of the above and:   * Require respirators with an assigned protection factor (APF) of 25 or more. |

### Washington Health Care Authority

* Using Medicaid data, **develop addition to emPOWER map** for state and regional emergency planning that includes all data elements of emPOWER dataset. Consider pathways to allow this information to be available to local emergency responders before an emergency.
* **Utilizing MTP 2.0 1115 waiver authority, develop air conditioner and filter program to distribute air conditioner and high quality air filters** for at highest risk of morbidity and/or mortality from heat and wildfire smoke (e.g., adults living alone, older adults, those with chronic conditions and those living with disabilities) and living in areas most impacted by heat and [wildfire smoke](https://ecology.wa.gov/air-climate/climate-commitment-act/overburdened-communities). See Oregon’s Air Conditioner and Air Filter Deployment Program [here](https://www.oregon.gov/oha/HSD/OHP/Tools/AC-Air-Filtration-FAQ.pdf).
  + Consider using Washington census tracts with highest PM2.5 burden through the DOH’s [Washington Tracking Network](https://fortress.wa.gov/doh/wtn/WTNPortal/#!q0=8909)
* In partnership with the Department of Health, analyze claims data to identify populations and geographic areas in Washington state that are more vulnerable to morbidity and mortality from heat and wildfire smoke. Share this information with relevant entities to inform allocation of resources and to help regional and local entities response to climate events.
  + Consider investigation into heat and wildfire smoke related health outcomes associated with medications that may place individuals at higher risk of heat-related illness or exacerbations of chronic conditions. Share findings with health delivery systems and clinicians to better inform clinical decision making around medication management.

### Local Public Health Jurisdictions)

* **Develop heat and wildfire smoke response plans that are integrated with other emergency response plans**. Follow guidance provided from Washington Department of Health and please see King County’s example for [heat](https://cdn.kingcounty.gov/-/media/king-county/depts/executive/climate-office/documents/finalheatstrategy071724optimized.pdf?rev=3fb7d49bf4d04bebaf2c65f184b01a5d&hash=1AE0DB5F333D790356B78D723F96CEC6) and [wildfire smoke](https://kingcounty.gov/en/-/media/king-county/depts/dph/documents/health-safety/environmental-health/healthy-water-air-soil/wildfire-smoke/wildfire-smoke-response-plan.pdf?rev=e29df5fde79941bd8b4ba531b68984f9&hash=91B9631D55E5EF47FB18E6E0830FCB22) to develop a plan that meets the unique needs and context of your community. Consider that community members may not want to abandon livestock or pets.
* **Use predictive tools to identify threshold for action**, such as NWS HeatRisk and the Air Quality Index (AQI) or more updated tools as they become available.
* **Identify organizations in your area that provide services to vulnerable groups and include them in response planning and activation.** These include long-term care facilities, local shelters, schools, outdoor camps, libraries, community-based and faith-based organizations, local public transportation, etc.
  + Work with partners to embed guidance for extreme heat and wildfire smoke into processes for human services organizations active in your region.
  + Include messaging to health care facilities when heat wave or poor air quality to alert of increased risk. Messaging should include signs and symptoms to watch out for, anticipatory guidance to provide patients, and contact information for relevant local public health authorities and healthcare coalitions.
* **Partner with communities to communicate and build capacity to protect against health impacts of heat and wildfire smoke.** Engage representatives from various communities in response planning and implementation.
  + **Develop public education for heat and wildfire smoke that is tailored to the community’s needs.** (e.g., 6th grade reading level, multiple languages reflecting communities they serve, other communication strategies beyond written communications)
  + **Consider coordinating outreach teams to check on neighbors and deliver water to individuals most at risk** (e.g., those living alone, people experiencing homelessness, etc)
* **When setting up cooling centers, consider Washington State DOH, local health department, and emergency management agencies if available.** Ensure the building is able to stay cool, there are areas to rest, and it’s a space near transit with accessibility for differently abled individuals.
  + **Consider planning for emergent mental health needs in the community in collaboration**. Plan to train on mental health first aid.

### Washington Department of Health

* **Consider pursuing a data sharing agreement with the Health Care Authority** to use all payors claims database to identify associations between specific medications and emergency room visits, hospitalizations and/or mortality related to heat and/or wildfire smoke.
* **Education and messaging.** Promote public awareness and education on signs, symptoms and appropriate response for heat-related illnesses and smoke exposure. Support community-based organizations and local leaders to disseminate culturally and linguistically appropriate messages and materials. Coordinate with the Department of Labor and Industries on amplifying messaging, communication, and resources for at-risk workers.
* **Develop state-level heat and wildfire smoke action plans to support LHJs when they activate an IMT response.**
* **Surveillance and Monitoring.** Consider disseminating ED utilization trends to healthcare coalitions to monitor activity in different regions in the state~~.~~
* **Training.** Consider developing training for healthcare organizations on improving documentation

### Washington Department of Social and Human Services

* **Develop or adopt heat and wildfire smoke educational materials or training for home care aides.** The training should include how to identify populations most vulnerable to heat and wildfire smoke, understand the way medicines interact differently during heat, how to prevent heat or wildfire smoke-related illnesses and death, and how to connect clients to social services that can reduce their exposure to heat and smoke, such as electricity assistance programs. See New York City’s [example](https://www.nyc.gov/assets/orr/pdf/Cool_Neighborhoods_NYC_Report.pdf).

**Given the reach of higher temperatures and wildfire smoke’s impact across the state and many populations, the workgroup felt it necessary to provide guidelines for other audiences in the state**

### Emergency Medical Services (EMS) Pre-hospital Healthcare

* **Establish and train relevant staff on protocols for heat-related illness that include recognition, rapid cooling and supportive care.[[18]](#endnote-17)[[19]](#endnote-18)**
  + Ensure the protocol emphasizes cold water immersion as first line therapy if available, do not stop cold water immersion to transport the patient; **cool first, transport second.**
* **Monitor and protect EMS personnel and patients from exposure to heat and wildfire smoke and poor air quality,** using appropriate personal protective equipment (PPE) such as N95 respirators. **Employers are required to follow State Rules for** [**heat**](https://lni.wa.gov/safety-health/safety-training-materials/workshops-events/beheatsmart) **and** [**wildfire**](https://lni.wa.gov/safety-health/safety-topics/topics/wildfire-smoke) **(smoke to protect worker health** **but should also follow additional best practices to protect workers’ health.Capture impressions of heat-related and/or wildfire smoke exposure related illness and report any cases of heat-related or wildfire smoke-related illness to local health authorities.** Improve documentation of whether cases are work-related.
  + Work with EMS personnel to improve documentation of work-relatedness variable in WEMSIS.

### Washington State Legislature

* Fund Washington HCA to purchase air conditioners and air filters
* Consider regulation and funding requiring family homes to acquire and use air conditioners and high-quality air filers and requiring adult family homes Examples [here](https://www.portland.gov/phb/documents/appendix-f-phb-air-conditioning-requirements-1/download) and [here](https://dallascityhall.com/departments/codecompliance/DCH%20documents/docs/Chapter%2027%20Reference%20Manual%20(2)%20(003).pdf).
* Consider including additional funding to subsidize higher electricity costs from using air conditioners and purifiers in geographies most impacted by heat and wildfire smoke.

# Evidence Review

## Appendix A. Tools for Heat and Air Quality Monitoring

The workgroup generally endorses use of a standardized tools to indicate thresholds for action for heat and wildfire smoke. [The National Weather Service’s HeatRisk Tool](https://www.weather.gov/media/safety/NWS-HeatRisk-X3-2024.pdf) is a color-numeric-based index that provides a forecast risk of heat-related impacts to occur over a 24-hour period. HeatRisk takes into consideration not just the flat temperature at a given time, but how unusual the heat is for the time of year, the duration of the heat in both daytime and nighttime temperatures and if those temperatures pose an elevated risk of heat-related impacts based on Centers for Disease Control (CDC) data. The HeatRisk tool has not been validated specifically in worker populations. The figure below shows the different levels and risk of heat-related impacts by threshold:

A chart with text on it

Description automatically generated

The Air Quality Index (AQI) provides information on levels of air pollutants and health effects. The AQI was developed by the Environmental Protection Agency (EPA) and is based on national air quality standards for six criteria pollutants: ground-level ozone, particulate matter, carbon monoxide, sulfur dioxide, nitrogen dioxide, and lead. The AQI assigns a color and a number from 0 to 500 to each pollutant, with higher numbers indicating higher levels of pollution and greater health risks. The AQI can be used to plan outdoor activities, reduce exposure to unhealthy air, and protect sensitive groups such as people with asthma, heart disease, or lung disease. Air quality can be monitored via [AirNow.gov](https://www.airnow.gov/?city=Seattle&state=WA&country=USA), with detailed information down to zip code about air quality. The figure below describes the health impacts by air quality threshold. A chart of different colors

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## Populations Most Impacted by Heat and Wildfire Smoke

Heat has a greater impact on some populations. This is in part determined by a person’s exposure, which varies depending living in an urban vs rural area, housing quality, access to cooling, air pollution; sensitivity to heat stress, which depends on age, medical conditions, medication use, hydration; and a person’s adaptive capacity, a person’s ability of people to cope with and recover from heat stress influenced by social drivers of health such as social support, income, education, housing, transportation and access to health care. For workers and athletes, heat stress is a combination of environmental exposure, non-breathable clothing or personal protective equipment that inhibits heat loss, and metabolic heat generation from physical activity. More vulnerable population categories include:

* **Ages and life stages** **(*infants and children, pregnant women, older adults*):** These groups have higher physiological sensitivity to *heat and wildfire smoke* and may have limited ability to regulate body temperature, seek shelter, or access health care. Infants and children are more likely to experience dehydration, fever, and electrolyte imbalance due to heat, or respiratory symptoms like coughing, wheezing, decreased lung function or pneumonia. Pregnant women are at increased risk of severe maternal morbidity (SMM), preterm birth, and low birth weight due to heat, and wildfire smoke may increase the risk of low birth weight or preterm birth. Older adults are more likely to have chronic medical conditions, reduced mobility, cognitive impairment, or social isolation that can exacerbate the effects of heat and wildfire in addition to a reduced ability to regulate their body temperature.
* **People physically active outdoors or in hot indoor spaces (*athletes, outdoor and some indoor workers, emergency responders*):** These groups have higher exposure to heat and may exert themselves physically, which can increase the risk of heat exhaustion, heat stroke, dehydration, and cardiovascular events. These groups are at particular risk if they are unacclimatized, which can occur if new to the job, returning from a prolonged absence, or during sudden increases in heat stress. Higher exposure to wildfire smoke for outdoor workers can increase risks of negative impacts especially without adequate protection. Workers in occupations such as agriculture, construction, public administration (e.g., firefighters), and utilities may face additional hazards such as musculoskeletal hazards from heavy equipment, pesticides, or electric shocks that can compound the effects of heat. Emergency responders may encounter situations where they must wear protective gear, work in confined spaces, or assist people in distress, which can increase their heat stress. Workers in precarious work arrangements may have less protections from heat and wildfire smoke, and those paid by the piece (amount of work accomplished) may have a financial incentive not to take breaks to cool down.
* **People disproportionately exposed to heat, sensitive to heat or with limited adaptive capacity (*people experiencing homelessness, people with chronic medical conditions, people with disabilities, people who are incarcerated, people with low income, marginalized communities*):** These groups may face multiple barriers to accessing cooling, hydration, health care, or social support during heat events. People experiencing homelessness may lack shelter, clothing, or personal belongings that can protect them from heat. People with chronic medical conditions such as diabetes, heart disease, kidney disease, or mental illness may have impaired thermoregulation, increased fluid loss, or may have adverse reactions to medications due to heat.[[20]](#endnote-19) For example, cardiovascular disease is a primary cause of increased risk of death during heatwaves, and respiratory disease (particularly COPD) predisposes individuals to experience death by respiratory disease, and a secondary cause of death during higher temperatures. Wildfire smoke exposure increases ischemic events, as well as worsens heart failure and arrythmias. Cerebrovascular disease is the tertiary cause of death during heatwaves mostly caused by heat-related reductions in cerebral blood flow and damage to the blood-brain barrier. Heat can cause dehydration, which can lead to or facilitate kidney fibrosis and potential failure. Chronic kidney disease can predispose individuals to cardiovascular events during heat, and wildfire smoke increases excess same-day mortality for dialysis patients, decreases renal function and hastens progression to end-stage renal disease. Diabetes reduces skin blood flow and sweating during heat waves. Mental health conditions can increase risk of contracting heat-related illness due to physiological thermoregulatory inhibitions from medications or behavioral changes which influence adapted capacity. Patients with asthma, chronic obstructive pulmonary disease and other chronic respiratory conditions are particularly vulnerable to smoke, and can experience increased respiratory symptoms, emergency room visits or hospitalization. Besides chronic conditions, other factors influence adaptive capacity; people with disabilities may have reduced mobility, communication, or self-care abilities that can limit their adaptive capacity to heat. People who are incarcerated may be confined in overcrowded, poorly ventilated, or uncooled facilities that can increase their heat exposure and stress.

### Drivers of Inequitable Impact

While anyone can be impacted by heat and wildfire smoke, certain groups of people experience a higher level of impact. According to the Washington Department of Health, 61% of heat-related deaths from June 26-August 30, 2021 were male, and 47% were between the ages of 65-79. Another 25% were between 45-64 and 20% were 80+ in age. 77% of those who experienced heat-related deaths were Non-Hispanic White, followed by 6% Hispanic and 6% Non-Hispanic Black. The preliminary death counts by county show 21% of deaths occurring in King County, 18% in Pierce, 12% in Spokane and 10% in Snohomish.[[21]](#endnote-20)

Our communities do not experience heat and wildfire smoke in the same way. Social drivers of health compound the impact of climate change for specific groups of people. For example, lack of access to adequate and affordable housing; people who have lower incomes are more likely to live in older, substandard, and overcrowded housing units that lack insulation, ventilation, air conditioning, and other cooling devices. These housing conditions can create indoor heat islands that exacerbate the effects of outdoor heat waves and increase the risk of heat-related illness and death. Redlining, or the discriminatory practice of denying or limiting services to specific neighborhoods based on their racial or ethnic background, pushed marginalized groups to live in neighborhoods with less green space, fewer buildings that could provide cooling centers, and areas with worse housing quality. Studies have shown that redlined neighborhoods experience higher levels of heat stress, heat-related hospitalizations, and mortality than non-redlined areas, as well as greater exposure to PM 2.5 and other air pollutants. Redlining also affects access to health care, social services, transportation, and education, creating multiple barriers for residents to cope with and recover from climate-related health impacts.

People belonging to marginalized racial and ethnic groups are also disproportionately exposed to occupational heat stress. People from BIPOC communities and immigrants are overrepresented in outdoor and indoor occupations that involve high levels of physical exertion, such as agriculture, construction, landscaping, manufacturing, and warehousing. These workers often lack adequate protection, training, and access to water, shade, and rest breaks, increasing their risk of heat exhaustion, heat stroke, and other heat-related illnesses. Furthermore, these workers may face economic and social pressures to continue working despite the heat, such as fear of losing income, job security, or immigration status. Occupational heat stress can also affect the health and well-being of workers' families and communities, as workers may suffer from chronic conditions or experience increased mental distress during heat and wildfire smoke. Outdoor workers are at a heightened risk of developing chronic conditions due to prolonged exposure to heat; the combined environmental exposure, non-breathable clothing, and physical exertion can exacerbate underlying health conditions and facilitate the onset of new chronic conditions. Also, workers already with chronic conditions can experience exacerbation or worsening of those conditions if proper precautions of accommodations are not provided.

## Tracking and Measurement

**ICD-10 Coding**

There are notable challenges in utilizing ICD-10 coding for conditions related to heat and wildfire smoke. At the clinician level, many clinicians may feel uncomfortable attributing a patient’s presentation to a particular hazard. The majority of ICD-10 codes for climate-related hazards are categorized as external cause codes, and the current iteration does not capture the full spectrum of harms related to climate hazards. Improved specificity would allow for greater attribution and allocation of resources. Since clinicians are not used to using climate hazard-related ICD-10 coding, any implementation of this coding would need to come with robust recommendations for educating staff on their use and reimbursement attached to incentivize use. Also, expanding beyond the clinician in coding for social determinants or environmental hazards can improve uptake.

Below are a list of ICD-10 codes related to heat and wildfire smoke exposure and heat-related illness.

|  |  |
| --- | --- |
| Heat or Wildfire Smoke Related Concern | ICD-10 Code |
| Heat-related illness | T67.0- Heatstroke and sunstroke |
| T67.1-, heat syncope |
| T67.2-, heat cramp |
| T67.3-, heat exhaustion, anhidrotic |
| T67.4-, heat exhaustion due to salt depletion |
| T67.5-, heat exhaustion, unspecified |
| T67.6-, heat fatigue, transient |
| T67.7-, heat edema |
| T67.8-, other effects of heat and light |
| T67.9-, effect of heat and light, unspecified |
| Exposure to Heat | X30 Exposure to natural excessive heat |
| Exposure to Fire/Smoke | X010XX, A Exposure to flames in uncontrolled fire, not in building or structure, initial encounter |
| X011XX, A Exposure to smoke in uncontrolled fire, not in building or structure, initial encounter |
| X018XX, A Other exposure to uncontrolled fire, not in building or structure, initial encounter |
| Dehydration | E860 Dehydration |
| P741 Dehydration of a newborn |
| Natural | X398XX, A Other exposure to forces of nature, initial encounter |
| Smoke and Poor Air Quality | Z77.110 Contact with and (suspected) exposure to air pollution |
| X08.8 Exposure to other specified smoke, fire |
| Disaster | Z655 – Exposure to disaster, war, and other hostilities |
| Occupation | Z5739, Occupational exposure to other air contaminants |
| Z576, Occupational exposure to extreme temperature |

Below is a non-exhaustive list of ICD-10 codes that if documented may indicate an increased risk of negative impacts of heat and wildfire smoke. These codes can be used to build registries in delivery systems and health plans to target interventions and track outcomes for vulnerable patient populations.

|  |  |
| --- | --- |
| **Condition** | **ICD-10 Code** |
| Chronic Conditions | N18.XX - Chronic Kidney Disease |
| I20-25 - Ischemic Heart Disease |
| I30-52 – Other forms of heart disease |
| E08-E13 Diabetes mellitus |
| J45 – Asthma, J46 Status asthmaticus |
| J44 – COPD; J40-47 chronic lower respiratory diseases; J60-70 lung diseases due to external agents; |
| Diseases of the Respiratory System | J30-39 Other diseases of upper respiratory tract |
| J**7**0.5 Respiratory conditions due to smoke inhalation |
| J80-84 Other respiratory diseases principally affecting the interstitium |
| Pregnancy | O09: Supervision of high-risk pregnancy |
| O10-O16: Edema, proteinuria, and hypertensive disorders in pregnancy, childbirth, and the puerperium |
| O80-O82: Encounter for delivery |
| Social Determinants of Health | Z55: Problems related to education and literacy |
| Z56: Problems related to employment and unemployment |
| Z57: Occupational exposure to risk factors |
| Z59: Problems related to housing and economic circumstances |
| Z60: Problems related to social environment |
| Z62: Problems related to upbringing |
| Z63: Other problems related to primary support group, including family circumstances |
| Z64: Problems related to certain psychosocial circumstances |
| Z65: Problems related to other psychosocial circumstances |
| Behavioral health | Z65: Problems related to other psychosocial circumstances |
| F10-F19: Mental and behavioral disorders due to psychoactive substance use |
| F20-F29: Schizophrenia, schizotypal, delusional, and other non-mood psychotic disorders |
| F30-F39: Mood [affective] disorders |
| F40-F48: Anxiety, dissociative, stress-related, somatoform, and other nonpsychotic mental disorders |
| F50-F59: Behavioral syndromes associated with physiological disturbances and physical factors |
| F60-F69: Disorders of adult personality and behavior |
| F70-F79: Intellectual disabilities |
| F80-F89: Pervasive and specific developmental disorders |
| F90-F98: Behavioral and emotional disorders with onset usually occurring in childhood and adolescence |
| F99: Unspecified mental disorder |

The ICD-10 coding system must be adaptable to emerging health issues, especially those linked to climate change. As the frequency and intensity of extreme heat and wildfires increase, the health impacts are likely to evolve. The current coding system does not fully account for new or emerging conditions, leading to gaps in data and hindering effective public health responses. Regular updates and revisions to the ICD-10 codes are essential to address these evolving challenges adequately. Furthermore, standardized coding is vital for billing and reimbursement processes, helping to avoid discrepancies and ensuring that healthcare providers are adequately compensated for their services. In the context of climate-related health impacts, such as heat-related illnesses or respiratory conditions exacerbated by wildfire smoke, standardized ICD-10 coding allows for the effective monitoring and analysis of trends, enabling timely interventions and policy-making to mitigate these impacts.

**Registries**

Registries are used internally for delivery sites and health plans for managing patients with particular diseases or populations. Registries tracking chronic conditions over time, such as for patients with diabetes or depression, have been shown to improve quality of care for learning-oriented health systems and individual outcomes. Using a registry to identify patients that are more susceptible to the impacts of heat and wildfire smoke can support delivery systems and health plans with quality improvement processes and make the case for future investments. Registries are helpful when tracking intervenable characteristics of defined and reachable population, and while healthcare teams may not be able to directly address the underlying source of higher risk (e.g., zip code) there are tangible, practical strategies that individuals and their families can take to reduce the risk of experiencing negative health outcomes from heat and wildfire smoke. Washington state maintains statewide dashboards on disparities that draw from community-level and individual level data sources, and many community-based organizations are using referral management platforms that may collect information on referrals for social service needs that are relevant to increased risk for heat and wildfires. Washington state agencies should consider developing a registry that combines sources to provide a comprehensive picture of increased risk for heat and wildfire smoke to be shared for quality improvement projects.

**Social Determinants of Health (SDOH) Data Collection, Workflows and Interoperability**

The Foundation for Health Care Quality published a report and [Social Determinants of Health and Health Equity](https://www.qualityhealth.org/bree/wp-content/uploads/sites/8/2021/05/FHCQ-Bree-SDoH-Equity-Final.pdf) in 2021, including guidelines for collecting and tracking SDOH data. Populations with identified health related social needs can be more at risk for heat-related illnesses and exacerbations of chronic conditions due to heat and wildfire smoke. Collection of SDOH data is important for understanding risk for heat and wildfire smoke, but SDOH data is sensitive information for which patients and member may be rightly concerned about the privacy practices employed to keep their information safe and receiving biased healthcare. These concerns must be met with clear and communicated best practices for data privacy, patient perceived stigma, and information autonomy. This includes the importance of soliciting dynamic consent and providing transparent communication throughout the process.

SDOH data collection can be integrated into the EHR which can increase visibility of this information for the care team and facilitate conversations about risk and development of action plans to avoid heat and wildfire smoke. Several vendors have integrated SDOH screening tools such as PRAPARE to collect information in a standardized fashion which facilitates interoperable exchange of information between systems.

## Appendix I Patient-Directed Guidelines

### Patients and Families

* **Know your heat and wildfire smoke risk.** Many people are at increased risk of negative health impacts related to heat and wildfire smoke, including older adults, children, people with chronic conditions like cardiovascular disease, kidney disease, heart failure, asthma, people who are pregnant, and people with certain occupations like agriculture or construction
* Know the signs of heat-related illness and smoke exposure– See [**Appendix X Heat-Related Illness Signs and Symptoms**](#_Appendix_X_Heat-Related) **and** [Wildfire smoke and your health - Canada.ca](https://www.canada.ca/en/health-canada/services/publications/healthy-living/wildfire-smoke-health.html)
* When a period of high temperatures (e.g., heat wave) or wildfire smoke is expected, make a plan with your household members to reduce exposure to heat and smoke. Examples [here](https://www.americares.org/wp-content/uploads/PATIENTS-Heat-Heat-Action-Plan-V1.pdf) and here.
* During high temperatures, heat waves or when the air quality is poor:[[22]](#endnote-21)
  + **Stay out of the heat and indoors to avoid exposure to wildfire smoke**. Avoid going outside or doing strenuous activity. Stay in the shade, spend 2-3 hours during the day in a cool place.
  + **Keep your home or building cool**. When air quality is good, use the night air to cool down your home by opening your windows after dark. During the day, close windows and cover them with blinds or shutters to block direct sunlight. Turn off electrical devices if possible and safe. Postpone vacuuming until air quality improves. Use electric fans **when temperatures are below 104F/40C**. If using air conditioning, set the thermostat to 81F and turn on an electric fan.
    - **Smoke and heat can make each other worse**.
  + **Keep your body cool and hydrated**. Use light, loose-fitting clothing and bed linens, take cool showers or baths. Wet your skin using a damp cloth, spray or wet light clothing. Drink water regularly.
  + **Regularly check in with neighbors and vulnerable people in your circle** – especially those over 65, those with heart, lung or kidney conditions, mobility concerns or those who live alone.
  + Protect infants and children. **Never leave children or animals in a parked vehicle for any amount of time.** Avoid direct exposure to the sun during peak hours, seeking shade or staying indoors instead. Never cover an infant stroller or pram with dry fabric – this makes it hotter inside the carriage; instead use a thin wet cloth and rewet as necessary to lower the temperature. Dress children in lightweight loose-fitting clothing that covers the skin, and use wide-brimmed hats, sunglasses and sunscreen to protect them.
* **If you work outside, your employer should protect you from heat and wildfire smoke.** 
  + Review Washington Labor & Industries [Be Heat Smart](https://lni.wa.gov/safety-health/safety-training-materials/workshops-events/beheatsmart) website and [educational pamphlet](https://lni.wa.gov/forms-publications/F417-218-909.pdf) and [Wildfire Smoke](https://lni.wa.gov/safety-health/safety-topics/topics/wildfire-smoke#overview) website and resources

## Appendix II Heat-Related Illness Signs and Symptoms

|  |  |  |
| --- | --- | --- |
| **Illness** | **Signs/Symptoms** | **What to Do** |
| **Heat Stroke** | High body temperature (103F or higher)  Hot, red, dry or damp skin  Fast, strong pulse  Headache  Dizziness  Nausea  Confusion  Losing consciousness (passing out) | **Call 911 right away,** heat stroke is a medical emergency  Move the person to a cooler place  Help lower body temperature with cool cloths or a cool bath  Do not give them anything to drink |
| **Heat exhaustion** | Heavy sweating  Cold, pale, clammy skin  Fast, weak pulse  Nausea or Vomiting  Muscle cramps  Tiredness or weakeness  Dizziness  Headache  Fainting (passing out) | Move to a cool place  Loosen clothes  Put cool wet cloths on body or take a cool bath  Sip water  **Get medical help right away if:** vomiting, symptoms get worse or last longer than 1 hour |
| **Heat Cramps** | Heavy sweating during intense exercise  Muscle pains or spasms | Stop physical activity and move to a cool place  Drink water or sports drinks  Wait for cramps to go away before doing any more physical activity  **Get medical help right away if:** cramps last longer than 1 hour, you’re on a low sodium diet or you have heart problems |
| **Heat Syncope** | Dizziness, lightheadedness, and fainting, particularly after prolonged standing or sudden rising from a lying or sitting position. The skin may appear pale and feel cool and moist to the touch. | Lie down in a cool place  Elevate legs to improve blood flow to the brain  Drink water or sports drinks to rehydrate  **Seek medical attention if symptoms persist or worsen** |
| **Heat Rash** | Red clusters of pimples or small blisters on the skin, often in areas where clothing causes friction, such as the neck, chest, groin, and elbow creases. It typically occurs in hot, humid conditions and can be itchy or cause a prickling sensation | Move to a cooler, less humid environment  Keep the affected area dry and avoid further sweating  Wear loose, light clothing to prevent irritation  Apply cold compresses or take cool baths to soothe the skin  Use calamine lotion or hydrocortisone cream to relieve itching and discomfort  **Seek medical attention if symptoms persist or worsen** |
| **Rhabdomyolysis** | Muscle pain, weakness, and swelling, often accompanied by dark, tea-colored urine. Other symptoms may include nausea, vomiting, confusion, and irregular heartbeat | **Seek medical attention immediately, as this can lead to kidney injury**  Stop any activity that may have caused the condition.  Stay hydrated by drinking plenty of water  Avoid taking nonsteroidal anti-inflammatory drugs (NSAIDs) like ibuprofen, as they can further harm the kidneys.  At home, monitor urine color and volume, and report any changes to a healthcare professional. |

## Appendix III. Medications that may increase risk of harm on hot days

See also the CDC’s [Heat and Medications](https://www.cdc.gov/heat-health/hcp/clinical-guidance/heat-and-medications-guidance-for-clinicians.html) resource

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | | Medications that may increase risk of harm on hot days | | | | |
| **Medication Type** | | | **Drug Class** | **Probability of Risk** | **Examples** | **Mechanisms** |
| **Cardiovascular medications** | **Antihypertensives** | | Diuretics | High | Furosemide Hydrochlorothiazide Acetazolamide | Electrolyte imbalance  Volume depletion, dehydration and increased risk of fainting and falls  Reduced thirst sensation.  *Notes: Causes increased urine output; may lead to significant fluid and electrolyte loss.* |
| Beta blockers |  | Atenolol  Metoprolol  Propranolol | Reduced superficial vasodilation  Decreased sweating  Reduced blood pressure, increased risk of fainting and falls |
|  | Calcium channel blocker |  | Amlodipine  Felodipine  Nifedipine | Decreased blood pressure, increased risk of fainting and falls  Electrolyte imbalance |
| Angiotensin Converting Enzyme Inhibitor **(ACEi) and**Angiotensin II Receptor blockers **(ARBs)** |  | **ACEi**:  Enalapril  Lisinopril  Ramipril  **ARB:**  Valsartan  Losartan | Decreased blood pressure, increased risk of fainting and falls  Reduced thirst sensation |
| Angiotensin Receptor-Neprilysin Inhibitors (**ARNIs),**  combination drug including ARB |  | Sacubitril/Valsartan | See ARBs |
|  | **Anti-platelet medications** | |  |  | Clopidogrel | Reduced superficial vasodilation |
|  | Aspirin |
|  | **Antianginals** | | Nitrates |  | Glyceryl Trinitrate, Isosorbide Mononitrate | Worsened hypotension |
| **Psychiatric medications** |  | | Mood stabilizer | Medium-high | Lithium | Diabetes insipidus induced water loss and risk for fainting, falls  Electrolyte imbalance  Risk for toxicity in setting of dehydration because of narrow therapeutic index;  *Notes: affect fluid balance* |
| Antipsychotics | Medium-high | Haloperidol, Olanzapine, Quetiapine, Risperidone | Impaired sweating  Impaired temperature:  *Notes: interfere with heat regulation.* |
| Selective Serotonin Reuptake Inhibitors **(SSRI)**and Serotonin and Norepinephrine Reuptake Inhibitors **(SNRI)** |  | **SSRI:**  Fluoxetine, Sertraline  **SNRI:**  Duloxatine  Venlafaxine | Increased sweating |
| Tricyclic antidepressants **(TCAs)** |  | Amitriptyline, Clomipramine | Decreased sweating |
| **Antiseizure medications** |  | |  |  | Topiramate | Decreased sweating |
|  | Oxcarbazepine | Increased sweating  Increased urination |
|  | Carbamazepine | Dizziness and weakness, especially after increased dose |
| **Antihistamines with anticholinergic properties** |  | |  | Medium-high | Promethazine, Doxylamine, Diphenhydramine | Decreased sweating  Impaired thermoregulation;  *Notes: Reduces sweat production, potentially impairing heat dissipation.* |
| **Analgesics** |  | | Nonsteroidal anti-inflammatory drugs (NSAIDS) | Medium |  | Kidney injury with dehydration;  *Notes: May affect fluid balance and increase the risk of dehydration* |
| Aspirin |  |  | Increased heat production with overdose  Kidney injury with dehydration |
| Acetaminophen |  |  | Heat related liver injury increase risk for acetaminophen hepatoxicity |
| **Antibiotics** |  | |  |  | Sulfonamides | Kidney injury risk with dehydration |
| **Antiretrovirals** |  | |  |  | Indinavir | Kidney injury risk with dehydration |
| **Thyroid replacement** |  | |  |  | Levothyroxine | Excessive sweating |
| **Stimulants** |  | |  |  | Cocaine | Reduced sweating  Reduced dilation of skin blood vessels  Impaired heat perception |
|  | Amphetamine, Methylphenidate | Increased body temperature |
| **Hallucinogens** |  | |  |  | Methyl​enedioxy​-methamphetamine (**MDMA**) (and alternatives) | Reduced sweating  Reduced skin blood vessel dilation  Impaired heat perception |
| **Alcohol** |  | |  |  |  | Increased sweating  Increased urination  Impaired heat perception |
| **Opioids** |  | |  |  |  | Increased sweating,  Decreased blood pressure  Impaired heat perception |
| **Insulin** |  | |  |  |  | Heat can damage insulin making it less effective [[23]](#endnote-22) |

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| --- | --- | --- |
| Citation | Abstract | Findings |
| Population Specific | | |
| Hopp, S., Dominici, F., & Bobb, J. F. (2018). Medical diagnoses of heat wave-related hospital admissions in older adults. Preventive medicine, 110, 81–85. https://doi.org/10.1016/j.ypmed.2018.02.001 | Heat waves have been associated with adverse human health effects, including higher rates of all cause and cardiovascular mortality, and these health effects may be exacerbated under continued climate change. However, specific causes of hospitalizations associated with heat waves have not been characterized on a national scale. We systematically estimated the risks of cause-specific hospitalizations during heat waves in a national cohort of 23.7 million Medicare enrollees residing in 1,943 U.S. counties during 1999–2010. Heat waves were defined as ≥2 consecutive days exceeding the county’s 99th percentile of daily temperatures, and were matched to non-heat wave periods by county and week. We considered 50 outcomes from broad disease groups previously associated with heat wave-related hospitalizations, and estimated cause-specific relative risks (RRs) of hospital admissions on heat wave days. We identified 11 diagnoses with a higher admission risk on heat wave days, with heat stroke and sunstroke having the highest risk (RR=22.5, [95% CI 14.9–34.2]). Other diseases with elevated risks included fluid and electrolyte disorders [(Hyperosmolality RR=1.4, [95% CI 1.1–1.3]; Hypoosmolaltiy RR=1.2, [95% CI 1.1 1.3])] and acute kidney failure (RR=1.1, [95% CI 1.1–1.2]). These risks tended to be higher under more severe heat wave events. In addition, risks were higher among adults in the oldest (≥85) category (reference: 65–74) for volume depletion and heat exhaustion. Several causes of hospitalization identified are preventable, and public health interventions, including early warning systems and plans targeting risk factors for these illnesses, could reduce adverse effects of heat in the present and under climate change. | heat waves (2+ consecutive days exceeding country's 99th percentile of daily temperatures) 11 diagnoses with higher admission rates on heat wave days (3 HRI, 4 fluid and electrolyte imbalance, 2 septicemia, acute kidney failure, UTI) highest risk of heat stroke admission during heat waves, oldest adults 85+ were at highest risk. |
| Bunker A, Wildenhain J, Vandenbergh A, Henschke N, Rocklöv J, Hajat S, Sauerborn R. Effects of Air Temperature on Climate-Sensitive Mortality and Morbidity Outcomes in the Elderly; a Systematic Review and Meta-analysis of Epidemiological Evidence. EBioMedicine. 2016 Apr;6:258-268. doi: 10.1016/j.ebiom.2016.02.034. Epub 2016 Feb 23. PMID: 27211569; PMCID: PMC4856745. | Introduction: Climate change and rapid population ageing are significant public health challenges. Understanding which health problems are affected by temperature is important for preventing heat and cold-related deaths and illnesses, particularly in the elderly. Here we present a systematic review and meta-analysis on the effects of ambient hot and cold temperature (excluding heat/cold wave only studies) on elderly (65+ years) mortality and morbidity. Methods: Time-series or case-crossover studies comprising cause-specific cases of elderly mortality (n=3,933,398) or morbidity (n=12,157,782) were pooled to obtain a percent change (%) in risk for temperature exposure on cause-specific disease outcomes using a random-effects meta-analysis. Results: A 1°C temperature rise increased cardiovascular (3.44%, 95% CI 3.10-3.78), respiratory (3.60%, 3.18-4.02), and cerebrovascular (1.40%, 0.06-2.75) mortality. A 1°C temperature reduction increased respiratory (2.90%, 1.84-3.97) and cardiovascular (1.66%, 1.19-2.14) mortality. The greatest risk was associated with cold-induced pneumonia (6.89%, 20-12.99) and respiratory morbidity (4.93% 1.54-8.44). A 1°C temperature rise increased cardiovascular, respiratory, diabetes mellitus, genitourinary, infectious disease and heat-related morbidity. Discussion: Elevated risks for the elderly were prominent for temperature-induced cerebrovascular, cardiovascular, diabetes, genitourinary, infectious disease, heat-related, and respiratory outcomes. These risks will likely increase with climate change and global ageing. | 1C increase in temperature - increased cardiovascular mortality (3.44%, CI 3.1-3.78); respiratory mortality (3.60%, CI 3.18-4.02), and cerebrovascular mortality (1.4%, CI 0.06-2.75); heat exposure increased RD morbidity (2.76%, CI 1.51-4.03), heat-induced diabetes mellitus (1.02% CI (0.43 - 1.63) and heat-related overall genitourinary morbidity (2.12%, CI 1.65-2.59) |
| Singh, N., Areal, A. T., Breitner, S., Zhang, S., Agewall, S., Schikowski, T., & Schneider, A. (2024). Heat and Cardiovascular Mortality: An Epidemiological Perspective. Circulation research, 134(9), 1098–1112. https://doi.org/10.1161/CIRCRESAHA.123.323615 | As global temperatures rise, extreme heat events are projected to become more frequent and intense. Extreme heat causes a wide range of health effects, including an overall increase in morbidity and mortality. It is important to note that while there is sufficient epidemiological evidence for heat-related increases in all-cause mortality, evidence on the association between heat and cause-specific deaths such as cardiovascular disease (CVD) mortality (and its more specific causes) is limited, with inconsistent findings. Existing systematic reviews and meta-analyses of epidemiological studies on heat and CVD mortality have summarized the available evidence. However, the target audience of such reviews is mainly limited to the specific field of environmental epidemiology. This overarching perspective aims to provide health professionals with a comprehensive overview of recent epidemiological evidence of how extreme heat is associated with CVD mortality. The rationale behind this broad perspective is that a better understanding of the effect of extreme heat on CVD mortality will help CVD health professionals optimize their plans to adapt to the changes brought about by climate change and heat events. To policymakers, this perspective would help formulate targeted mitigation, strengthen early warning systems, and develop better adaptation strategies. Despite the heterogeneity in evidence worldwide, due in part to different climatic conditions and population dynamics, there is a clear link between heat and CVD mortality. The risk has often been found to be higher in vulnerable subgroups, including older people, people with preexisting conditions, and the socioeconomically deprived. This perspective also highlights the lack of evidence from low- and middle-income countries and focuses on cause-specific CVD deaths. In addition, the perspective highlights the temporal changes in heat-related CVD deaths as well as the interactive effect of heat with other environmental factors and the potential biological pathways. Importantly, these various aspects of epidemiological studies have never been fully investigated and, therefore, the true extent of the impact of heat on CVD deaths remains largely unknown. Furthermore, this perspective also highlights the research gaps in epidemiological studies and the potential solutions to generate more robust evidence on the future consequences of heat on CVD deaths. | GBD study shows heat leading to ~93,000 CVD deaths worldwide 2019 alone; from recent meta-analysis, 2.1% increase in CVD-related mortality for every 1C rise in temperature and increas of 11.7% in CVD mortality during a heat wave. High temperature/heat waves can affect CVD deaths on same day and several subsequent days after exposure - lag effect. recent meta-analysis shows 0.8% higher RR in people 65+ than in people 0-64 per 1C increase in temperature. three studies examining effect of high temperature moderated by air pollution - increasing levels of PM2.5 increased risk of CVD mortality; proposed impact on cardiovascular disease is through dehydration and increased metabolic demand; several research gaps, including on impact of policy interventions like heat action plans and disproportionate impact on vulnerable groups. |
| Desai Y, Khraishah H, Alahmad B. Heat and the Heart. Yale J Biol Med. 2023 Jun 30;96(2):197-203. doi: 10.59249/HGAL4894. PMID: 37396980; PMCID: PMC10303253. | Globally, more people die from cardiovascular disease than any other cause. Extreme heat can have serious implications for heart health, especially in people with pre-existing cardiovascular conditions. In this review, we examined the relationship between heat and the leading causes of cardiovascular diseases as well as the proposed physiological mechanisms for the deleterious effect of heat on the heart. The body’s response to high temperatures, including dehydration, increased metabolic demand, hypercoagulability, electrolyte imbalances, and systemic inflammatory response, can place a significant strain on the heart. Epidemiological studies showed that heat can result in ischemic heart disease, stroke, heart failure, and arrhythmia. However, targeted research is needed to understand the underlying mechanisms of hot temperatures on these main causes of cardiovascular disease. Meanwhile, the absence of clinical guidance on how to manage heart diseases during heat events highlights the need for cardiologists and other health professionals to lead the charge in addressing the critical relationship between a warming climate and health. | Ischemic heart disease: extreme heat associated with 7% increase in ischemic heart disease mortality, meta-analysis showing 2.8% increase in ischemic heart disease mortality with 1C increase in temperature; Stroke: risk of stroke increases 1.13% for every 1C increase in temperature and more pronounced in 65+ - increase in 1.5% stroke mortality for every 1C increase in temperature; another study reported additional 1.6 deaths for every 1,000 stroke deaths attributed to heat days; conflicting data when comparing between differnet types of strokes; heart failure: excess 2.6 deaths for every 1,000 HF deaths due to extreme temperature, extreme heat led to 12% increase in heart failure related death; arrythmias: conflicting evidence on arrythmia risk from extreme heat; |
| Alahmad, B., Khraishah, H., Royé, D., Vicedo-Cabrera, A. M., Guo, Y., Papatheodorou, S. I., Achilleos, S., Acquaotta, F., Armstrong, B., Bell, M. L., Pan, S. C., de Sousa Zanotti Stagliorio Coelho, M., Colistro, V., Dang, T. N., Van Dung, D., De' Donato, F. K., Entezari, A., Guo, Y. L., Hashizume, M., Honda, Y., … Koutrakis, P. (2023). Associations Between Extreme Temperatures and Cardiovascular Cause-Specific Mortality: Results From 27 Countries. Circulation, 147(1), 35–46. https://doi.org/10.1161/CIRCULATIONAHA.122.061832 | Background: Cardiovascular disease is the leading cause of death worldwide. Existing studies on the association between temperatures and cardiovascular deaths have been limited in geographic zones and have generally considered associations with total cardiovascular deaths rather than cause-specific cardiovascular deaths.  Methods: We used unified data collection protocols within the Multi-Country Multi-City Collaborative Network to assemble a database of daily counts of specific cardiovascular causes of death from 567 cities in 27 countries across 5 continents in overlapping periods ranging from 1979 to 2019. City-specific daily ambient temperatures were obtained from weather stations and climate reanalysis models. To investigate cardiovascular mortality associations with extreme hot and cold temperatures, we fit case-crossover models in each city and then used a mixed-effects meta-analytic framework to pool individual city estimates. Extreme temperature percentiles were compared with the minimum mortality temperature in each location. Excess deaths were calculated for a range of extreme temperature days.  Results: The analyses included deaths from any cardiovascular cause (32 154  935), ischemic heart disease (11 745 880), stroke (9 351 312), heart failure (3 673 723), and arrhythmia (670 859). At extreme temperature percentiles, heat (99th percentile) and cold (1st percentile) were associated with higher risk of dying from any cardiovascular cause, ischemic heart disease, stroke, and heart failure as compared to the minimum mortality temperature, which is the temperature associated with least mortality. Across a range of extreme temperatures, hot days (above 97.5th percentile) and cold days (below 2.5th percentile) accounted for 2.2 (95% empirical CI [eCI], 2.1–2.3) and 9.1 (95% eCI, 8.9–9.2) excess deaths for every 1000 cardiovascular deaths, respectively. Heart failure was associated with the highest excess deaths proportion from extreme hot and cold days with 2.6 (95% eCI, 2.4–2.8) and 12.8 (95% eCI, 12.2–13.1) for every 1000 heart failure deaths, respectively.  Conclusions: Across a large, multinational sample, exposure to extreme hot and cold temperatures was associated with a greater risk of mortality from multiple common cardiovascular conditions. The intersections between extreme temperatures and cardiovascular health need to be thoroughly characterized in the present day—and especially under a changing climate. | 2.6 excess deaths rom 1000 heart failure deaths from extreme hot temperatures; ischemic heart disease is most common cause of death, and about 1% of all ischemic heart disease deaths are attributed to extreme temperatures; stroke: every 1.6-9 excess deaths attributable to extreme heat or cold days; |
| Liu, J., Varghese, B. M., Hansen, A., Zhang, Y., Driscoll, T., Morgan, G., Dear, K., Gourley, M., Capon, A., & Bi, P. (2022). Heat exposure and cardiovascular health outcomes: a systematic review and meta-analysis. The Lancet. Planetary health, 6(6), e484–e495. https://doi.org/10.1016/S2542-5196(22)00117-6 | Background Heat exposure is an important but underappreciated risk factor contributing to cardiovascular disease. Warming temperatures might therefore pose substantial challenges to population health, especially in a rapidly aging population. To address a potential increase in the burden of cardiovascular disease, a better understanding of the effects of ambient heat on different types of cardiovascular disease and factors contributing to vulnerability is required, especially in the context of climate change. This study reviews the current epidemiological evidence linking heat exposures (both high temperatures and heatwaves) with cardiovascular disease outcomes, including mortality and morbidity. Methods In this systematic review and meta-analysis, we searched PubMed, Embase, and Scopus for literature published between Jan 1, 1990, and March 10, 2022, and evaluated the quality of the evidence following the Navigation Guide Criteria. We included original research on independent study populations in which the exposure metric was high temperatures or heatwaves, and observational studies using ecological time series, case crossover, or case series study designs comparing risks over different exposures or time periods. Reviews, commentaries, grey literature, and studies that examined only seasonal effects without explicitly considering temperature were excluded. The risk estimates were derived from included articles and if insufficient data were available we contacted the authors to provide clarification. We did a random-effects meta-analysis to pool the relative risk (RR) of the association between high temperatures and heatwaves and cardiovascular disease outcomes. The study protocol was registered with PROSPERO (CRD42021232601). Findings In total, 7360 results were returned from our search of which we included 282 articles in the systematic review, and of which 266 were eligible for the meta-analysis. There was substantial heterogeneity for both mortality (high temperatures: I2=93·6%, p<0·0001; heatwaves: I2=98·9%, p<0·0001) and morbidity (high temperatures: I2=98·8%, p<0·0001; heatwaves: I2=83·5%, p<0·0001). Despite the heterogeneity in environmental conditions and population dynamics among the reviewed studies, results showed that a 1°C increase in temperature was positively associated with cardiovascular disease-related mortality across all considered diagnoses. The overall risk of cardiovascular disease-related mortality increased by 2·1% (RR 1·021 [95%CI 1·020–1·023]), with the highest specific disease risk being for stroke and coronary heart disease. A 1°C temperature rise was also associated with a significant increase in morbidity due to arrhythmias and cardiac arrest and coronary heart disease. Our findings suggest heat exposure leads to elevated risk of morbidity and mortality for women, people 65 years and older, individuals living in tropical climates, and those in countries of lower-middle income. Heatwaves were also significantly associated with a 11·7% increase in risk of mortality (RR 1·117 [95% CI 1·093–1·141]), and increasing heatwave intensity with an increasing risk (RR 1·067 [95% CI 1·056–1·078] for low intensity, 1·088 [1·058–1·119] for middle intensity, and 1·189 [1·109–1·269] for high intensity settings). Interpretation This review strengthens the evidence on the increase in cardiovascular disease risk due to ambient heat exposures in different climate zones. The widespread prevalence of exposure to hot temperatures, in conjunction with an increase in the proportion of older people in the population, might result in a rise in poor cardiovascular disease health outcomes associated with a warming climate. Evidence-based prevention measures are needed to attenuate peaks in cardiovascular events during hot spells, thereby lowering the worldwide total heat-related burden of cardiovascular disease-related morbidity and death. Funding | increase in temperature 1C = 2.1% cardiovascular disease related mortality; heat waves associated with increased risk mortality in age groups 0-64 (1.057) and 65+ (1.147), mortality increased with heatwave intensity in people 65+ (low intensity RR 1.094 CI 1.047-1.141, moderate 1.106 CI 1.035-1.177, high RR 1.233 CI 1.071-1.394) morbidity increased in 65+ as heatwave intensity increased (low RR -.975 CI 0.920-1.03, middle RR 1.029 CI 0.98-1.078, high RR 1.26 CI 0.997-1.255); stronger risk with stroke (3.8% increased risk) and coronary heart diseases (2.8% increased risk) - for morbidity, increased risks related to arrhthmias and cardiac arrest (1.6%) and out of hospital arrest (2.1%); during heat waves, cardiovascular disease related mortality signfiicantly increased by 11.7% |
| Milet M, Samuel M, Hoshiko S, Radhakrishna R, Aragón T. (July 2023). Excess mortality during the September 2022 heat wave in California. Sacramento, CA: California Department of Public Health, Office of Health Equity | Episodes of extreme heat are increasing with climate change. • Heat can lead to death directly, or indirectly by affecting other conditions such as cardiovascular or respiratory conditions. • During the September 2022 record-breaking 10-day heat wave in California, there was a 5% increase in deaths – 395 more deaths than would be expected. • The highest increases in deaths were seen among people aged 25-64, Hispanic Californians, and of the South Coast region. • Deaths due to extreme heat can be prevented or reduced through actions to decrease exposure and improve resilience. • California has invested $404 million towards addressing extreme heat impacts, guided by the state’s Extreme Heat Action Plan, and many initiatives have been carried out or are already underway | Increased rate ratio of deaths in 25-64 (1.11) Hispanic Californians (1.10) South Coast (1.09); |
| Kuehn L, McCormick S. Heat Exposure and Maternal Health in the Face of Climate Change. Int J Environ Res Public Health. 2017 Jul 29;14(8):853. doi: 10.3390/ijerph14080853. PMID: 28758917; PMCID: PMC5580557. | Climate change will increasingly affect the health of vulnerable populations, including maternal and fetal health. This systematic review aims to identify recent literature that investigates increasing heat and extreme temperatures on pregnancy outcomes globally. We identify common research findings in order to create a comprehensive understanding of how immediate effects will be sustained in the next generation. Following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guide, we systematically reviewed articles from PubMed and Cochrane Reviews. We included articles that identify climate change-related exposures and adverse health effects for pregnant women. There is evidence that temperature extremes adversely impact birth outcomes, including, but not limited to: changes in length of gestation, birth weight, stillbirth, and neonatal stress in unusually hot temperature exposures. The studies included in this review indicate that not only is there a need for further research on the ways that climate change, and heat in particular, may affect maternal health and neonatal outcomes, but that uniform standards for assessing the effects of heat on maternal fetal health also need to be established. | Heat correlated with increased risk or rate of preterm burth in 15/17 studies; extreme heat exposure correlated with increased risk of early term birth in 5/6 studies; extreme heat correlated with low birth weight at time of delivery 3/5 studies; heat waves increase stress in neonates through either neonatal intensive care unite admissions or heat-related infant death (2 studies); no established critical period of maternal sensitivity to hot temperatures, |
| Bekkar B, Pacheco S, Basu R, DeNicola N. Association of Air Pollution and Heat Exposure With Preterm Birth, Low Birth Weight, and Stillbirth in the US: A Systematic Review. JAMA Netw Open. 2020 Jun 1;3(6):e208243. doi: 10.1001/jamanetworkopen.2020.8243. Erratum in: JAMA Netw Open. 2020 Jul 1;3(7):e2014510. PMID: 32556259; PMCID: PMC7303808. | Importance: Knowledge of whether serious adverse pregnancy outcomes are associated with increasingly widespread effects of climate change in the US would be crucial for the obstetrical medical community and for women and families across the country.  Objective: To investigate prenatal exposure to fine particulate matter (PM2.5), ozone, and heat, and the association of these factors with preterm birth, low birth weight, and stillbirth.  Evidence review: This systematic review involved a comprehensive search for primary literature in Cochrane Library, Cochrane Collaboration Registry of Controlled Trials, PubMed, ClinicalTrials.gov website, and MEDLINE. Qualifying primary research studies included human participants in US populations that were published in English between January 1, 2007, and April 30, 2019. Included articles analyzed the associations between air pollutants or heat and obstetrical outcomes. Comparative observational cohort studies and cross-sectional studies with comparators were included, without minimum sample size. Additional articles found through reference review were also considered. Articles analyzing other obstetrical outcomes, non-US populations, and reviews were excluded. Two reviewers independently determined study eligibility. The Arskey and O'Malley scoping review framework was used. Data extraction was performed according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) reporting guideline.  Findings: Of the 1851 articles identified, 68 met the inclusion criteria. Overall, 32 798 152 births were analyzed, with a mean (SD) of 565 485 (783 278) births per study. A total of 57 studies (48 of 58 [84%] on air pollutants; 9 of 10 [90%] on heat) showed a significant association of air pollutant and heat exposure with birth outcomes. Positive associations were found across all US geographic regions. Exposure to PM2.5 or ozone was associated with increased risk of preterm birth in 19 of 24 studies (79%) and low birth weight in 25 of 29 studies (86%). The subpopulations at highest risk were persons with asthma and minority groups, especially black mothers. Accurate comparisons of risk were limited by differences in study design, exposure measurement, population demographics, and seasonality.  Conclusions and relevance: This review suggests that increasingly common environmental exposures exacerbated by climate change are significantly associated with serious adverse pregnancy outcomes across the US. | 11 studies analyzing PM2.5 whole-pregnancy exposure - risk of preterm birth/low birth weight increased median of 11.5% (range 2-19%); 4 studies analyzing ozone whole pregnancy exposure, 2 found increased risk from 3-9.6% in preterm birth; 10 studies reported racial/ethnic disparities with increased risk of preterm brith among mothers in minority groups - 8 noted higher risk for black mothers, higher risk preterm birth among patients with asthma; 5 studiess showed no exposure between pM2.5 and preterm birth; 8 studies examining whole pregnancy exposure to PM2.5 found 2-36% increased risk low birthweight; 3 found whole pregnancy exposure to ozone associated with significant increase in risk of low birthweight (6-13%); 13 reported association of racial ethnic disparities with increased risk of low birth weight among mothers in minority groups - most frequently black mothers (77% of studies) then Asian (31%) then Hispanic (23%). 1 study noted increases risk of stillbirth associated wtih high exposure of ozone during third trimester; Mothers with asthma found to be especially susceptible to stillbirth if exposed to PM2.5 during whole-pregnancy; 5 studies explored maternal exposure to heat and preterm birth, 4/5 found increased risk - range of increased risk preterm birth 8.6-21%; 3 studies looked at association of maternal heat exposure and low birth weight specifically in third trimester; 2 studies examining heat and stilbirth - increased risk of 10.4% per 5.6 mean ambient temp, and second study reported 6% increase per 1C in week before delivery during warm season; women with asthma may be particularly susceptible to adverse outcomes such as preterm birth, stillbirth, in association with PM2.5 exposure during gestation, Black mothers are at greatest risk of preterm birth and low birth weight; ongoing research may be enahnced by improved geographic information systems that can be mapped onto existing US publci health databanks; |
| Amjad, S., Chojecki, D., Osornio-Vargas, A., & Ospina, M. B. (2021). Wildfire exposure during pregnancy and the risk of adverse birth outcomes: A systematic review. *Environment international*, *156*, 106644. https://doi.org/10.1016/j.envint.2021.106644 | Background: Maternal wildfire exposure (e.g., smoke, stress) has been associated with poor birth outcomes with effects potentially mediated through air pollution and psychosocial stress. Despite the recent hike in the intensity and frequency of wildfires in some regions of the world, a critical appraisal of the evidence on the association between maternal wildfire exposure and adverse birth outcomes has not yet been undertaken. We conducted a systematic review that evaluated the scientific evidence on the association between wildfire exposure during pregnancy and the risk of adverse birth outcomes.  Methods: Comprehensive searches in nine bibliographic databases were conducted from database inception up to June 2020. Observational epidemiological studies that evaluated associations between exposure to wildfire during pregnancy and adverse birth outcomes were eligible for inclusion. Studies were assessed using the National Toxicology Program's Office of Health Assessment and Translation (NTP OHAT) risk of bias tool and certainty of evidence was assessed using the Grading of Recommendations, Assessment, Development and Evaluation (GRADE) framework. Screening of retrieved articles, data extraction, and risk of bias assessment were performed by two independent reviewers. Study results were synthesized descriptively.  Results: Eight epidemiological studies conducted in four countries and involving 1,702,252 births were included in the review. The exposure to wildfire during pregnancy was assessed in individual studies by measurement of PM2.5 (n = 2), PM10 (n = 1), Total Ozone Mapping Spectrometer (TOMS)aerosol index (n = 1), heat spots (n = 1), and by proximity of maternal residence to wildfire-affected areas (n = 3). There is some evidence indicating that maternal wildfire exposure associates with birth weight reduction (n = 7) and preterm birth (n = 4), particularly when exposure to wildfire smoke occurred in late pregnancy. The association between wildfire exposure and small for gestational age (n = 2) and infant mortality (n = 1) was inconclusive.  Conclusion: Current evidence suggests that maternal exposure to wildfire during late pregnancy is linked to reduced birth weight and preterm birth. Well-designed comprehensive studies are needed to better understand the perinatal effects of wildfires. | low and very low certainty of evidence with confounding variables; 6/7 studies found association of wildfire exposure during pregnancy and mean reduction in birth weight - the studies that examined it found second and third trimester exposure had strongest negative effect on birth weight. infant mortality investifated in single study in Indonesia - confounding bias was strong; Heterogeneity of design and measurement meant pooled assessment of evidence could not be conducted. |
| Fatima SH, Rothmore P, Giles LC, Varghese BM, Bi P. Extreme heat and occupational injuries in different climate zones: A systematic review and meta-analysis of epidemiological evidence. Environ Int. 2021 Mar;148:106384. doi: 10.1016/j.envint.2021.106384. Epub 2021 Jan 17. PMID: 33472088. | Background: The link between heat exposure and adverse health outcomes in workers is well documented and a growing body of epidemiological evidence from various countries suggests that extreme heat may also contribute to increased risk of occupational injuries (OI). Previously, there have been no comparative reviews assessing the risk of OI due to extreme heat within a wide range of global climate zones. The present review therefore aims to summarise the existing epidemiological evidence on the impact of extreme heat (hot temperatures and heatwaves (HW)) on OI in different climate zones and to assess the individual risk factors associated with workers and workplace that contribute to heat-associated OI risks.  Methods: A systematic review of published peer-reviewed articles that assessed the effects of extreme heat on OI among non-military workers was undertaken using three databases (PubMed, Embase and Scopus) without temporal or geographical limits from database inception until July 2020. Extreme heat exposure was assessed in terms of hot temperatures and HW periods. For hot temperatures, the effect estimates were converted to relative risks (RR) associated with 1 °C increase in temperature above reference values, while for HW, effect estimates were RR comparing heatwave with non-heatwave periods. The patterns of heat associated OI risk were investigated in different climate zones (according to Köppen Geiger classification) based on the study locations and were estimated using random-effects meta-analysis models. Subgroup analyses according to workers' characteristics (e.g. gender, age group, experience), nature of work (e.g. physical demands, location of work i.e. indoor/outdoor) and workplace characteristics (e.g. industries, business size) were also conducted.  Results: A total of 24 studies published between 2005 and 2020 were included in the review. Among these, 22 studies met the eligibility criteria, representing almost 22 million OI across six countries (Australia, Canada, China, Italy, Spain, and USA) and were included in the meta-analysis. The pooled results suggested that the overall risk of OI increased by 1% (RR 1.010, 95% CI: 1.009-1.011) for 1 °C increase in temperature above reference values and 17.4% (RR 1.174, 95% CI: 1.057-1.291) during HW. Among different climate zones, the highest risk of OI during hot temperatures was identified in Humid Subtropical Climates (RR 1.017, 95% CI: 1.014-1.020) followed by Oceanic (RR 1.010, 95% CI: 1.008-1.012) and Hot Mediterranean Climates (RR 1.009, 95% CI: 1.008-1.011). Similarly, Oceanic (RR 1.218, 95% CI: 1.093-1.343) and Humid Subtropical Climates (RR 1.213, 95% CI: 0.995-1.431) had the highest risk of OI during HW periods. No studies assessing the risk of OI in Tropical regions were found. The effects of hot temperatures on the risk of OI were acute with a lag effect of 1-2 days in all climate zones. Young workers (age < 35 years), male workers and workers in agriculture, forestry or fishing, construction and manufacturing industries were at high risk of OI during hot temperatures. Further young workers (age < 35 years), male workers and those working in electricity, gas and water and manufacturing industries were found to be at high risk of OI during HW.  Conclusions: This review strengthens the evidence on the risk of heat-associated OI in different climate zones. The risk of OI associated with extreme heat is not evenly distributed and is dependent on underlying climatic conditions, workers' attributes, the nature of work and workplace characteristics. The differences in the risk of OI across different climate zones and worker subgroups warrant further investigation along with the development of climate and work-specific intervention strategies. | pooled results suggest overall risk of occupational injury increased by 1% for 1 degree celcius increase in temp above reference value, 17.4% during heat waves; effect of hot temperatures on increased risk of OI were acute with lag effect of 1-2 days in all climate zones; Workers <35 years, male workers, and agriculture/forestry/fishing/construction/manufacturing were high risk of OI during hot temperatures; Workers <35, male workers, and electricity/gas/water/manufacturing industries found to be high risk during heat wave; impacts of hot temperatures on OI were estimated to be acute with lag effect of 1-2 days; For subgroups of hot temperature studies - RR of OI was 1.018 for males, 1.009 for <35 years old, 1.006 for > 35 years old, 1.008 new workers, 1.007 expereinced workers, specific workers 1.032, outdoor worker 1.009, indoor 1.005, agriculture 1.010, construction 1.009, manufacturing 1.007; for heat wave subgroups - RR of OI was 1.27 for males, 1.16 for females, 1.26 for < 35, 1.22 for > 35, 1.45 for new workers, 1.31 for experienced workers, 1.060 for oudoor work, 1.24 indoor work, 1.41 for manufacturing, 1.38 for agriculture, 1.300 construction, 1.27 transport, 1.5 electricity/gas/water |
| Wen J, Zou L, Jiang Z, Li Y, Tao J, Liu Y, Fu W, Bai X, Mao J. Association between ambient temperature and risk of stroke morbidity and mortality: A systematic review and meta-analysis. Brain Behav. 2023 Jul;13(7):e3078. doi: 10.1002/brb3.3078. Epub 2023 Jun 2. PMID: 37269140; PMCID: PMC10338745. | Background Previous studies have suggested that ambient temperature is associated with the morbidity and mortality of stroke although results among these investigations remained unclear. Therefore, the purpose of present meta‐analysis was to summarize the evidence of the relationship between ambient temperature and stroke morbidity and mortality.  Methods A systematic search of the PubMed, Embase, and Web of Science databases was from inception to April 13, 2022. The pooled estimates for heat ambient temperature and cold ambient temperature, which were defined as comparison between extreme hot or cold conditions and the reference or threshold temperature, were calculated utilizing a random‐effects model. A total of 20 studies were included in the meta‐analysis.  Results The pooled estimated show that the heat ambient temperature was significant associated with 10% (relative risk [RR], 1.10; 95% confidence interval [95%CI]: 1.02–1.18) and 9% (RR, 1.09; 95%CI: 1.02–1.17) increase in the risk of stroke morbidity and mortality, respectively. In addition, the pooled estimated show that the cold ambient temperature was significant associated with 33% (RR, 1.33; 95%CI: 1.17–1.51) and 18% (RR, 1.18; 95%CI: 1.06–1.31) increase in the risk of stroke morbidity and mortality, respectively.  Conclusion Integrated epidemiological evidence supports the hypothesis that both heat and cold ambient temperature have positive association with the risk of stroke morbidity and mortality. Targeted measures should be promoted in public health to reduce this risk. | heat ambient temperature associated with 10% increase stroke morbidity, 9% increase smoke mortality. Global Burden of Disease Study - 9% stroke disability adjusted life years and 8.5% of stroke deaths could be attributable to PM2.5 exposure. |
| Vaidyanathan A, Malilay J, Schramm P, Saha S. Heat-Related Deaths - United States, 2004-2018. MMWR Morb Mortal Wkly Rep. 2020 Jun 19;69(24):729-734. doi: 10.15585/mmwr.mm6924a1. PMID: 32555133; PMCID: PMC7302478. | Deaths attributable to natural heat exposure, although generally considered preventable (1), represent a continuing public health concern in the United States. During 2004–2018, an average of 702 heat-related deaths occurred in the United States annually. To study patterns in heat-related deaths by age group, sex, race/ethnicity, and level of urbanization, and to explore comorbid conditions associated with deaths resulting from heat exposure, CDC analyzed nationally comprehensive mortality data from the National Vital Statistics System (NVSS).\* The rate of heat-related mortality tended to be higher among males, persons aged ≥65 years, non-Hispanic American Indian/Alaska Natives, and persons living in noncore nonmetropolitan and large central metropolitan counties. Natural heat exposure was a contributing cause of deaths attributed to certain chronic medical conditions and other external causes. Preparedness and response initiatives directed toward extreme heat events, currently underway at local, state, and national levels, can contribute to reducing morbidity and mortality associated with natural heat exposure. Successful public health interventions† to mitigate heat-related deaths include conducting outreach to vulnerable communities to increase awareness of heat-related symptoms and provide guidance for staying cool and hydrated, particularly for susceptible groups at risk such as young athletes and persons who are older or socially isolated (2). Improved coordination across various health care sectors could inform local activities to protect health during periods of high heat. For instance, jurisdictions can monitor weather conditions and syndromic surveillance data to guide timing of risk communication and other measures (e.g., developing and implementing heat response plans, facilitating communication and education activities) to prevent heat-related mortality in the United States. CDC also recommends that federal, state, local, and tribal jurisdictions open cooling centers or provide access to public locations with air conditioning for persons in need of a safe, cool, environment during hot weather conditions. In light of the coronavirus disease 2019 (COVID-19) pandemic, CDC updated its guidance on the use of cooling centers to provide best practices (e.g., potential changes to staffing procedures, separate areas for persons with symptoms of COVID-19, and physical distancing) to reduce the risk for introducing and transmitting SARS COV-2, the virus that causes COVID-19, into cooling centers.§ | 39% heat-related deaths were 65+ years old; among racial/ethnic groups, Non-Hispanic AIAN had highest rate of heat-related deaths (0.6 per 100,000) and Non-Hispanic Black individuals had second highest number of heat-related deaths (0.3 per 100,000); across urbanization, highest heat-related mortality rates observed among persons living in noncore nonmetropolitan (0.3 per 100,000) and large central metropolitan counties (0.3 per 100,000); natural heat explosure were recorded as cause of death in 59%, and remaining (41%) heat was a contributing cause; when heat was a contributing factor, major cardio disease (49%) or external causes (36%) were most often listed, accounting for 85% of such deaths; more specifically, 34% ischemic heat deaths, 10% hypertension, 18% alchohol poisoning or drug overdoses; |
| Gould, C. F., Heft-Neal, S., Johnson, M., Aguilera, J., Burke, M., & Nadeau, K. (2024). Health Effects of Wildfire Smoke Exposure. *Annual review of medicine*, *75*, 277–292. https://doi.org/10.1146/annurev-med-052422-020909 | We review current knowledge on the trends and drivers of global wildfire activity, advances in the measurement of wildfire smoke exposure, and evidence on the health effects of this exposure. We describe methodological issues in estimating the causal effects of wildfire smoke exposures on health and quantify their importance, emphasizing the role of nonlinear and lagged effects. We conduct a systematic review and meta-analysis of the health effects of wildfire smoke exposure, finding positive impacts on all-cause mortality and respiratory hospitalizations but less consistent evidence on cardiovascular morbidity. We conclude by highlighting priority areas for future research, including leveraging recently developed spatially and temporally resolved wildfire-specific ambient air pollution data to improve estimates of the health effects of wildfire smoke exposure. | same day all-cause mortality increased by 0.15% per 1 ugm increase in wildfire specific PM2.5; respiratory hospitalizations increased by 0.25% (CI 0.09-0.52%) and respiratory ED visits by 0.36% (CI 0.19-0.53); per additional 1ugm increased in ambient wildfire smoke PM2.5; evidence of heterogeneity in effects across studies for non respiratory and cardiovascular events; |
| Liu Y, Austin E, Xiang J, Gould T, Larson T, Seto E. Health Impact Assessment of the 2020 Washington State Wildfire Smoke Episode: Excess Health Burden Attributable to Increased PM2.5 Exposures and Potential Exposure Reductions. Geohealth. 2021 May 1;5(5):e2020GH000359. doi: 10.1029/2020GH000359. PMID: 33977180; PMCID: PMC8101535. | Major wildfires starting in the summer of 2020 along the west coast of the United States made PM2.5 concentrations in this region rank among the highest in the world. Washington was impacted both by active wildfires in the state and aged wood smoke transported from fires in Oregon and California. This study aims to estimate the magnitude and disproportionate spatial impacts of increased PM2.5 concentrations attributable to these wildfires on population health. Daily PM2.5 concentrations for each county before and during the 2020 Washington wildfire episode (September 7–19) were obtained from regulatory air monitors. Utilizing previously established concentration‐response function (CRF) of PM2.5 (CRF of total PM2.5) and odds ratio (OR) of wildfire smoke days (OR of wildfire smoke days) for mortality, we estimated excess mortality attributable to the increased PM2.5 concentrations in Washington. On average, daily PM2.5 concentrations increased 97.1 μg/m3 during the wildfire smoke episode. With CRF of total PM2.5, the 13‐day exposure to wildfire smoke was estimated to lead to 92.2 (95% CI: 0.0, 178.7) more all‐cause mortality cases; with OR of wildfire smoke days, 38.4 (95% CI: 0.0, 93.3) increased all‐cause mortality cases and 15.1 (95% CI: 0.0, 27.9) increased respiratory mortality cases were attributable to the wildfire smoke episode. The potential impact of avoiding elevated PM2.5 exposures during wildfire events significantly reduced the mortality burden. Because wildfire smoke episodes are likely to impact the Pacific Northwest in future years, continued preparedness and mitigations to reduce exposures to wildfire smoke are necessary to avoid excess health burden. | 13-day exposure to wildfire smoke estimated to lead to 92.2 more all-cause mortality cases; with odds ratio of wildfire smoke days, 38.4 increased all cause mortality and 15.1 increased respiratory mortality cases attributable to wildfire smoke episode. |
| Association between wildfire smoke exposure and Seattle, Washington Pediatric Hospital services, 2006–2020 | Pacific Northwest wildfire smoke events have been increasing in prevalence and severity over the past three decades, resulting in documented negative health outcomes in adults. However, there is less evidence demonstrating the effect of wildfire smoke in pediatric populations. To evaluate the association between wildfire smoke exposure and healthcare utilization in a pediatric tertiary medical center in Seattle, WA. We utilized a case–crossover study to determine the odds of pediatric emergency department (ED) visit/ hospital admission at Seattle Children's Hospital on wildfire smoke days versus non-wildfire smoke days during wildfire season (June to September), 2006–2020. The health outcomes dataset reports hospital encounters in two categories: ED visits or admissions that are for inpatient or observational purposes. The health outcomes dataset reports hospital encounters in two categories: ED visits or admissions that are for inpatient or observational purposes. The reported encounter types are mutually exclusive. We stratified analyses by individual-level characteristics and examined associations for lagged exposures 0–7 d prior to admission. In adjusted analyses, smoke exposure was associated with a 7.0% (95% CI: 3.0%–12.0%) increase in odds of all-cause hospital admissions and a 0.0% (95% CI: −3.0%, 3.0%) change in odds of all-cause ED visits. We also observed increases in the odds of all-cause hospital admissions ranging from 4.0% to 8.0%, for lagged exposure on days 1–7. When stratified by health outcomes, we found a 9.0% (95% CI: 1.0%–17.0%) and an 11.0% (95% CI:1.0%–21.0%) increase in the odds of ED visits for respiratory and respiratory infection-related concerns, respectively. Our results demonstrate associations between wildfire smoke and negative health effects in children. Similar to other studies, we found that wildfire smoke exposure was associated with an increase in respiratory-related ED visits and all-cause hospital admissions in a pediatric population. These results will help inform patient education and motivate interventions to reduce pediatric morbidity during wildfire season. | smoke exposure was associated with a 7.0% (95% CI: 3.0%–12.0%) increase in odds of all-cause hospital admissions and a 0.0% (95% CI: −3.0%, 3.0%) change in odds of all-cause ED visits; odds of all-cause hospital admissions ranging from 4.0% to 8.0%, for lagged exposure on days 1–7. When stratified by health outcomes: we found a 9.0% (95% CI: 1.0%–17.0%) and an 11.0% (95% CI:1.0%–21.0%) increase in the odds of ED visits for respiratory and respiratory infection-related concerns, respectively |
| Comparison of wildfire smoke estimation methods and associations with cardiopulmonary-related hospital admission | Climate forecasts predict an increase in frequency and intensity of wildfires. Associations between health outcomes and population exposure to smoke from Washington 2012 wildfires were compared using surface monitors, chemical-weather models, and a novel method blending three exposure information sources. The association between smoke particulate matter ≤2.5 μm in diameter (PM2.5) and cardiopulmonary hospital admissions occurring in Washington from 1 July to 31 October 2012 was evaluated using a time-stratified case-crossover design. Hospital admissions aggregated by ZIP code were linked with population-weighted daily average concentrations of smoke PM2.5 estimated using three distinct methods: a simulation with the Weather Research and Forecasting with Chemistry (WRF-Chem) model, a kriged interpolation of PM2.5 measurements from surface monitors, and a geographically weighted ridge regression (GWR) that blended inputs from WRF-Chem, satellite observations of aerosol optical depth, and kriged PM2.5. A 10 μg/m3 increase in GWR smoke PM2.5 was associated with an 8% increased risk in asthma-related hospital admissions (odds ratio (OR): 1.076, 95% confidence interval (CI): 1.019–1.136); other smoke estimation methods yielded similar results. However, point estimates for chronic obstructive pulmonary disease (COPD) differed by smoke PM2.5 exposure method: a 10 μg/m3 increase using GWR was significantly associated with increased risk of COPD (OR: 1.084, 95%CI: 1.026–1.145) and not significant using WRF-Chem (OR: 0.986, 95%CI: 0.931–1.045). The magnitude (OR) and uncertainty (95%CI) of associations between smoke PM2.5 and hospital admissions were dependent on estimation method used and outcome evaluated. Choice of smoke exposure estimation method used can impact the overall conclusion of the study | 10ugm increase in PM2.5 associated with 8% increased risk in ashtma-related hospital admissions, other smoke estimation methods yielded similar results. However, point estimates for COPD differed by smoke PM2.5 exposure methods (10ugm incrase ising GWR was significantly associated with increased risk of COPD, magnitude (OR) and uncertainty of associations between smoke PM2.5 and hospital admissions were dependent on estimation method use and outcome evaluated. |
| Doubleday, A., Schulte, J., Sheppard, L., Kadlec, M., Dhammapala, R., Fox, J., & Busch Isaksen, T. (2020). Mortality associated with wildfire smoke exposure in Washington state, 2006-2017: a case-crossover study. *Environmental health : a global access science source*, *19*(1), 4. https://doi.org/10.1186/s12940-020-0559-2 | Background: Wildfire events are increasing in prevalence in the western United States. Research has found mixed results on the degree to which exposure to wildfire smoke is associated with an increased risk of mortality.  Methods: We tested for an association between exposure to wildfire smoke and non-traumatic mortality in Washington State, USA. We characterized wildfire smoke days as binary for grid cells based on daily average PM2.5 concentrations, from June 1 through September 30, 2006-2017. Wildfire smoke days were defined as all days with assigned monitor concentration above a PM2.5 value of 20.4 μg/m3, with an additional set of criteria applied to days between 9 and 20.4 μg/m3. We employed a case-crossover study design using conditional logistic regression and time-stratified referent sampling, controlling for humidex.  Results: The odds of all-ages non-traumatic mortality with same-day exposure was 1.0% (95% CI: - 1.0 - 4.0%) greater on wildfire smoke days compared to non-wildfire smoke days, and the previous day's exposure was associated with a 2.0% (95% CI: 0.0-5.0%) increase. When stratified by cause of mortality, odds of same-day respiratory mortality increased by 9.0% (95% CI: 0.0-18.0%), while the odds of same-day COPD mortality increased by 14.0% (95% CI: 2.0-26.0%). In subgroup analyses, we observed a 35.0% (95% CI: 9.0-67.0%) increase in the odds of same-day respiratory mortality for adults ages 45-64.  Conclusions: This study suggests increased odds of mortality in the first few days following wildfire smoke exposure. It is the first to examine this relationship in Washington State and will help inform local and state risk communication efforts and decision-making during future wildfire smoke events | odds of all ages nontraumatic mortality was 1% higher on wildfire smoke days; previous days exposure associated with 2% increase; odds of same-day respiratory mortality increased by 9% while odds of same-day COPD mortality increased by 14%; |
| Neumann, J. E., Amend, M., Anenberg, S., Kinney, P. L., Sarofim, M., Martinich, J., Lukens, J., Xu, J. W., & Roman, H. (2021). Estimating PM2.5-related premature mortality and morbidity associated with future wildfire emissions in the western US. *Environmental research letters : ERL [Web site]*, *16*(3), 10.1088/1748-9326/abe82b. https://doi.org/10.1088/1748-9326/abe82b | Wildfire activity in the western United States (US) has been increasing, a trend that has been correlated with changing patterns of temperature and precipitation associated with climate change. Health effects associated with exposure to wildfire smoke and fine particulate matter (PM2.5) include short- and long-term premature mortality, hospital admissions, emergency department visits, and other respiratory and cardiovascular incidents. We estimate PM2.5 exposure and health impacts for the entire continental US from current and future western US wildfire activity projected for a range of future climate scenarios through the 21st century. We use a simulation approach to estimate wildfire activity, area burned, fine particulate emissions, air quality concentrations, health effects, and economic valuation of health effects, using established and novel methodologies. We find that climatic factors increase wildfire pollutant emissions by an average of 0.40% per year over the 2006-2100 period under Representative Concentration Pathway (RCP) 4.5 (lower emissions scenarios) and 0.71% per year for RCP8.5. As a consequence, spatially weighted wildfire PM2.5 concentrations more than double for some climate model projections by the end of the 21st century. PM2.5 exposure changes, combined with population projections, result in a wildfire PM2.5-related premature mortality excess burden in the 2090 RCP8.5 scenario that is roughly 3.5 times larger than in the baseline period. The combined effect of increased wildfire activity, population growth, and increase in the valuation of avoided risk of premature mortality over time results in a large increase in total economic impact of wildfire-related PM2.5 mortality and morbidity in the continental US, from roughly $7 billion per year in the baseline period to roughly $36 billion per year in 2090 for RCP4.5, and $43 billion per year in RCP8.5. The climate effect alone accounts for a roughly 60% increase in wildfire PM2.5-related premature mortality in the RCP8.5 scenario, relative to baseline conditions. | increase in billions per year of economic impact of wildfire events |
| Berberian AG, Gonzalez DJX, Cushing LJ. Racial Disparities in Climate Change-Related Health Effects in the United States. Curr Environ Health Rep. 2022 Sep;9(3):451-464. doi: 10.1007/s40572-022-00360-w. Epub 2022 May 28. PMID: 35633370; PMCID: PMC9363288. | Purpose of Review Climate change is causing warming over most parts of the USA and more extreme weather events. The health impacts of these changes are not experienced equally. We synthesize the recent evidence that climatic changes linked to global warming are having a disparate impact on the health of people of color, including children.  Recent Findings Multiple studies of heat, extreme cold, hurricanes, flooding, and wildfires find evidence that people of color, including Black, Latinx, Native American, Pacific Islander, and Asian communities are at higher risk of climate-related health impacts than Whites, although this is not always the case. Studies of adults have found evidence of racial disparities related to climatic changes with respect to mortality, respiratory and cardiovascular disease, mental health, and heat-related illness. Children are particularly vulnerable to the health impacts of climate change, and infants and children of color have experienced adverse perinatal outcomes, occupational heat stress, and increases in emergency department visits associated with extreme weather.  Summary The evidence strongly suggests climate change is an environmental injustice that is likely to exacerbate existing racial disparities across a broad range of health outcomes. | national study 1999-2017 found accross all ages among Black, Latinx, AIAN individuals compared to white had higher risk of dysing with increased temperatures; another national stidu found higher proportion of heat-realted deaths among non-Us citizaens than US citizens (more than 85% of nonUS citizens who died of excessive heat exopsure were Hispanic, 95% of all heat-related non-US citizen deaths took place in CA, AR and TX; HIgher risk of cardiovascular, renal and respiratory disease associated with heat and heatwave events exceeding that of Whites; two national studies of patients hospitalized for heat troke observed that African Americans had highest likelihood for acute kidney injury and rhabdomyolosis compared to whites and Hispanics. |
| Andersen ZJ, Vicedo-Cabrera AM, Hoffmann B, et al. Climate change and respiratory disease: clinical guidance for healthcare professionals. Breathe 2023; 19: 220222 [DOI:10.1183/20734735.0222-2022]. | Climate change is one of the major public health emergencies with already unprecedented impacts on our planet, environment and health. Climate change has already resulted in substantial increases in temperature globally and more frequent and extreme weather in terms of heat waves, droughts, dust storms, wildfires, rainstorms and flooding ,with prolonged and altered allergen and microbial exposureaswell as the introduction of new allergens to certain areas. All these exposures may have a major burden on patients with respiratory conditions, which will pose increasing challenges for respiratory clinicians and other healthcareproviders. In addition, complex interactions between these different factors, along with other major environmental risk factors (e.g. air pollution), will exacerbate adverse health effects on the lung. For example, an increase in heat and sunlight in urban areas will lead to increases in ozone exposure among urban populations; effects of very high exposure to smoke and pollution from wildfires will be exacerbated by the accompanying heat and drought; and extreme precipitation events and flooding will increase exposure to humidity and mould indoors. This review aims to bring respiratory healthcare providers up to date with the newest research on the impacts of climate change on respiratory health. Respiratory clinicians and other healthcare providers need to be continually educated about the challenges of this emerging and growing public health problem and be equipped to be the key players in solutions to mitigate the impacts of climate change on patients with respiratory conditions. | critical element is "co-benefits" which is how climate change mitigation activities can help advance other policy goals and improve health at the same time. Co-benefits arise from balance in form of health benefits larger than the cost of actions - co-benefits arise from the reductions in air pollution levels, increase in exposure to nature and green spaces and promotion of active travel, physcial activity and sustainable diets which ahve been seen to translate into immediate improvements in health, including reducing risk of cardiorespiratory diseases and other comorbidities; some co-benefit actions proposed by WHO: transition to more sustainable food sources such as diets with reduced use of meat, especially beef, vegetarian or purely plant based diets; active transport instead od driving, connect with nature, sustainable drug prescribing to reduce emissions of greenhouse gases --> clinicians have a role in advocating for interentions to address climate change, educating patients on risk, monitoring for high risk timepoints and new risks that emerge as a result of climate change, "cool places" or "cooling devices" for heatwave conditions, prescribing differently to reduce greenhouse gas emissions when possible, etc |
| Henry, S., Ospina, M. B., Dennett, L., & Hicks, A. (2021). Assessing the Risk of Respiratory-Related Healthcare Visits Associated with Wildfire Smoke Exposure in Children 0-18 Years Old: A Systematic Review. International journal of environmental research and public health, 18(16), 8799. <https://doi.org/10.3390/ijerph18168799> | Wildfires are increasing in frequency, size, and intensity, and increasingly affect highly populated areas. Wildfire smoke impacts cardiorespiratory health; children are at increased risk due to smaller airways, a higher metabolic rate and ongoing development. The objective of this systematic review was to describe the risk of pediatric respiratory symptoms and healthcare visits following exposure to wildfire smoke. Medical and scientific databases and the grey literature were searched from inception until December 2020. Included studies evaluated pediatric respiratory-related healthcare visits or symptoms associated with wildfire smoke exposure. Prescribed burns, non-respiratory symptoms and non-pediatric studies were excluded. Risk of bias was evaluated using the National Toxicology Program's Office of Health Assessment and Translation Risk of Bias Rating Tool. Data are presented narratively due to study heterogeneity. Of 2138 results, 1167 titles and abstracts were screened after duplicate removal; 65 full text screens identified 5 pre-post and 11 cross-sectional studies of rural, urban and mixed sites from the USA, Australia, Canada and Spain. There is a significant increase in respiratory emergency department visits and asthma hospitalizations within the first 3 days of exposure to wildfire smoke, particularly in children < 5 years old. | Within the first 3 days of wildfire smoke exposure, there is an increase in emergency department visits and asthma hospitalizations. |
| Gao, Y., Huang, W., Yu, P., Xu, R., Yang, Z., Gasevic, D., Ye, T., Guo, Y., & Li, S. (2023). Long-term impacts of non-occupational wildfire exposure on human health: A systematic review. Environmental pollution (Barking, Essex : 1987), 320, 121041. <https://doi.org/10.1016/j.envpol.2023.121041> | The intensity and frequency of wildfires is increasing globally. The systematic review of the current evidence on long-term impacts of non-occupational wildfire exposure on human health has not been performed yet. To provide a systematic review and identify potential knowledge gaps in the current evidence of long-term impacts of non-occupational exposure to wildfire smoke and/or wildfire impacts on human health. We conducted a systematic search of the literature via MEDLINE, Embase and Scopus from the database inception to July 05, 2022. References from the included studies and relevant reviews were also considered. The Newcastle-Ottawa Scale (NOS) and a validated quality assessment framework were used to evaluate the quality of observational studies. Study results were synthesized descriptively. A total of 36 studies were included in our systematic review. Most studies were from developed countries (11 in Australia, 9 in Canada, 7 in the United States). Studies predominantly focused on mental health (21 studies, 58.33%), while evidence on long-term impacts of wildfire exposure on health outcomes other than mental health is limited. Current evidence indicated that long-term impacts of non-occupational wildfire exposure were associated with mortality (COVID-19 mortality, cardiovascular disease mortality and acute myocardial disease mortality), morbidity (mainly respiratory diseases), mental health disorders (mainly posttraumatic stress disorder), shorter height of children, reduced lung function and poorer general health status. However, no significant associations were observed for long-term impacts of wildfire exposure on child mortality and respiratory hospitalizations. The population-based high-quality evidence with quantitative analysis on this topic is still limited. Future well-designed studies considering extensive wildfire smoke air pollutants (e.g., particulate matter, ozone, nitrogen oxides) and estimating risk coefficient values for extensive health outcomes (e.g., mortality, morbidity) are warranted to fill current knowledge gaps | Evidence is limited for long-term health impacts of nonoccupational exposure to wildfire smoke but some studies showed an increase in mortality, mental health disorders, reduced lung function and poorer general health status. Further studies are needed but evidence suggests several long-term negative health impacts of wildfire smoke exposure. |
| Foo, D., Stewart, R., Heo, S., Dhamrait, G., Choi, H. M., Song, Y., & Bell, M. L. (2024). Wildfire smoke exposure during pregnancy and perinatal, obstetric, and early childhood health outcomes: A systematic review and meta-analysis. Environmental research, 241, 117527. https://doi.org/10.1016/j.envres.2023.117527 | "Abstract  Background: Maternal exposure to air pollution during pregnancy is associated with adverse birth outcomes, although less is known for wildfire smoke. This systematic review evaluated the association between maternal exposure to wildfire smoke during pregnancy and the risk of perinatal, obstetric, and early childhood health outcomes.  Methods: We searched CINAHL Complete, Ovid/EMBASE, Ovid/MEDLINE, ProQuest, PubMed, Scopus, Web of Science, and Google Scholar to identify relevant epidemiological observational studies indexed through September 2023. The screening of titles, abstracts, and full-texts, data extraction, and risk of bias assessment was performed by pairs of independent reviewers.  Results: Our systematic search yielded 28,549 records. After duplicate removal, we screened 14,009 studies, identifying 31 for inclusion in the present review. Data extraction highlighted high methodological heterogeneity between studies, including a lack of geographic variation. Approximately 56.5% and 16% originated in the United States and Brazil, respectively, and fewer in other countries. Among the studies, wildfire smoke exposure during pregnancy was assessed using distance of residence from wildfire-affected areas (n = 15), measurement of air pollutant concentration during wildfires (n = 11), number of wildfire records (n = 3), aerosol index (n = 1), and geographic hot spots (n = 1). Pooled meta-analysis for birthweight and low birthweight were inconclusive, likely due to low number of methodologically homogenous studies. However, the reviewed studies provided suggestive evidence for an increased risk of birthweight reduction, low birthweight, preterm birth, and other adverse health outcomes.  Conclusions: This review identified 31 studies evaluating the impacts of maternal wildfire smoke exposure on maternal, infant, and child health. Although we found suggestive evidence of harm from exposure to wildfire smoke during pregnancy, more methodologically homogenous studies are required to enable future meta-analysis with greater statistical power to more accurately evaluate the association between maternal wildfire smoke and adverse birth outcomes and other health outcomes." | Inconclusive evidence due to low number of methodological homogenous studies, but individual studies provide suggested evidence for increased risk of birthweight reduction, low birthweight, preterm birth and other adverse health outcomes |
| Long-term Care | | |
| Montrose, L., Walker, E. S., Toevs, S., & Noonan, C. W. (2022). Outdoor and indoor fine particulate matter at skilled nursing facilities in the western United States during wildfire and non-wildfire seasons. Indoor air, 32(6), e13060. <https://doi.org/10.1111/ina.13060> | Wildfire activity is increasing in parts of the world where extreme drought and warming temperatures contribute to fireprone conditions, including the western United States. The elderly are among the most vulnerable, and those in long-term care with preexisting conditions have added risk for adverse health outcomes from wildfire smoke exposure. In this study, we report continuous co-located indoor and outdoor fine particulate matter (PM2.5 ) measurements at four skilled nursing facilities in the western United States. Throughout the year 2020, over 8000 h of data were collected, which amounted to approximately 300 days of indoor and outdoor sampling at each facility. The highest indoor 24 h average PM2.5 recorded at each facility was 43.6 µg/m3 , 103.2 µg/m3 , 35.4 µg/m3 , and 202.5 µg/m3 , and these peaks occurred during the wildfire season. The indoor-to-outdoor PM2.5 ratio and calculated infiltration efficiencies indicated high variation in the impact of wildfire events on Indoor Air Quality between the four facilities. Notably, infiltration efficiency ranged from 0.22 to 0.76 across the four facilities. We propose that this variability is evidence that PM2.5 infiltration may be impacted by modifiable building characteristics and human behavioral factors, and this should be addressed in future studies. | This study was done in the Western United States. Air quality monitoring in long-term care facilities are not monitored well, and for facilities that do monitor air quality it is variable. Modifiable building characteristics and human behavioral factors could be addressed to improve air quality. |
| Costs | | |
| Wondmagegn, B. Y., Xiang, J., Williams, S., Pisaniello, D., & Bi, P. (2019). What do we know about the healthcare costs of extreme heat exposure? A comprehensive literature review. The Science of the total environment, 657, 608–618. <https://doi.org/10.1016/j.scitotenv.2018.11.479> | Exposure to extreme heat can lead to a range of heat-related illnesses, exacerbate pre-existing health conditions and cause increased demand on the healthcare system. A projected increase in temperature may lead to greater healthcare expenditure, however, at present the costs of heat-related healthcare utilization is under-researched. This study aims to review the literature on heat-related costs for the healthcare system with a focus on ED visits, hospitalization, and ambulance call-outs. PubMed, Scopus, and Embase were used to search relevant literature from database inception to December 2017 and limited to human studies and English language. After screening, a total of ten papers were identified for final inclusion. In general, the healthcare costs of heat extremes have been poorly investigated in developed countries and not reported in developing countries where the largest heat vulnerable populations reside. Studies showed that exposure to extreme heat was causing a substantial economic burden on healthcare systems. Females, the elderly, low-income families, and ethnic minorities had the highest healthcare costs on a range of health services utilization. Although a few studies have estimated heat healthcare costs, none of them quantified the temperature-healthcare cost relationship. There is a need to systematically examine heat-attributable costs for the healthcare system in the context of climate change to better inform heat-related policy making, target interventions and resource allocation | heat-driven health costs are both direct (health interventions) and indirect (productivity costs); this study looked at direct healthcare costs; four of the 10 studies found provided projected direct costs; the studies used different heat exposure indicators, no established standard for calculating excessive cost but apparent temperature (AT) has been reported as better in some locations; to verify heat-associated illnesses, it's recommended to triangulate clinical diagnosis data and temperature measures; |
| Limaye, V. S., Max, W., Constible, J., & Knowlton, K. (2019). Estimating the Health-Related Costs of 10 Climate-Sensitive U.S. Events During 2012. GeoHealth, 3(9), 245–265. <https://doi.org/10.1029/2019GH000202> | "Climate change threatens human health, but there remains a lack of evidence on the economic toll of climate‐sensitive public health impacts. We characterize human mortality and morbidity costs associated with 10 climate‐sensitive case study events spanning 11 US states in 2012: wildfires in Colorado  and Washington, ozone air pollution in Nevada, extreme heat in Wisconsin, infectious disease outbreaks of tick‐borne Lyme disease in Michigan and mosquito‐borne West Nile virus in Texas, extreme weather in Ohio, impacts of Hurricane Sandy in New Jersey and New York, allergenic oak pollen in North Carolina,  and harmful algal blooms on the Florida coast. Applying a consistent economic valuation approach to published studies and state estimates, we estimate total health‐related costs from 917 deaths, 20,568 hospitalizations, and 17,857 emergency department visits of $10.0 billion in 2018 dollars, with a sensitivity range of $2.7–24.6 billion. Our estimates indicate that the financial burden of deaths, hospitalizations, emergency department visits, and associated medical care is a key dimension of the overall economic impact of climate‐sensitive events. We found that mortality costs (i.e., the value of a statistical life) of $8.4 billion exceeded morbidity costs and lost wages ($1.6 billion combined). By better characterizing health damages in economic terms, this work helps to shed light on the burden climate‐sensitive events already place on U.S.  public health each year. In doing so, we provide a conceptual framework for broader estimation of climate‐sensitive health‐related costs. The high health‐related costs associated with climate‐sensitive events highlight the importance of actions to mitigate climate change and adapt to its unavoidable impacts." | total cost for wildfire case study was $2.3 billion, mostly in mortality cost. Most morbidity cost in Washington wildfires came from ED visits and hospital admissions. Most cost went to Medicare (26.8) then private insurance (16.4) then Medicaid (7.8) and expected payer total was 54.6. Conditions more likely to burden older adults such as hurricanes and wildfires have a high burden to Medicare - health of older adults significantly impacted by climate-sensitive events and further signals need for targeted health efforts for vulnerable groups. |
| Health System Resilience | | |
| Gibson, L., & McGuire, C. (2021). Health systems and the pandemic: Key lessons for the future. NEJM Catalyst. <https://catalyst.nejm.org/doi/full/10.1056/CAT.21.0454#sec-2> | Earth’s warming climate is causing heat waves to become more frequent, longer lasting, and hotter, while occurring in locations unaccustomed to such weather events. Extreme heat events (EHEs), such as those in the western United States, India, Pakistan, Central Europe, and other locations in recent years, are one of the deadliest consequences of climate change. EHEs cause excess morbidity and mortality directly from heat illness, aggravation of comorbid conditions, and exacerbation of the damaging health effects of social factors as well as indirectly from corollary events such as wildfires and air pollution. Climate change–related EHEs are projected to worsen for at least the next 3 decades, necessitating that health systems be prepared to meet a growing burden of heat-related illnesses and become more heat resilient, as well as to reduce health care–related climate impacts. In this article, the authors discuss the health effects of EHEs and provide illustrative examples of what health systems can do to promote climate readiness and heat resiliency. | Health systems have to consider the role they play in preparing for extreme heat. Mapping vulnerable populations, ensuring that these populations receive appropriate counseling and warning, and forming close partnerships and communication with organizations that can assist vulnerable populations during heat waves is perhaps one of the most essential undertakings of a health care system. As the recent Pacific Northwest experience with heat waves demonstrates, hospital preparedness for the influx of patients that result from an EHE is important, but health systems also have to invest in building community resilience to keep community members out of the hospital as much as possible. |
| Miller, H., & Smith, J. (2023). Title of the article. American Journal of Public Health. <https://doi.org/10.2105/AJPH.2023.307260> | Extreme heat is a public health threat that extends beyond juris-dictions and institutions and has urgent short-term emergency and long-term mitigation components. Managing this issue can be problematic. Heat action plans (HAPs) are one policy tool used by public health and emergency management agencies to address the public health impacts of an increasingly warming environment. The article by Randazza et al. in this issue of AJPH(p. 559) examines the common content of HAPs and identiﬁes gaps in heat preparedness | Recommendations included shifting governance structure to public health focus would help build climate resilience, gaps need to be closed between identifying vulnerable populations and targeted interventions, and surveillance data needs to be included into the review process of heat action plans. |
| Community Based Interventions | | |
| Hasan F, Marsia S, Patel K, Agrawal P, Razzak JA. Effective Community-Based Interventions for the Prevention and Management of Heat-Related Illnesses: A Scoping Review. Int J Environ Res Public Health. 2021 Aug 7;18(16):8362. doi: 10.3390/ijerph18168362. PMID: 34444112; PMCID: PMC8394078. | Background: Extreme temperatures have negative consequences on the environment, ecosystem, and human health. With recent increases in global temperatures, there has been a rise in the burden of heat-related illnesses, with a disproportionate impact on low- and middle-income countries. Effective population-level interventions are critical to a successful public health response. Objective: This scoping review aims to summarize the evidence on the effectiveness of population-level heat-related interventions and serve as a potential guide to the implementation of these interventions. Methods: Studies that evaluated the effectiveness of community-based interventions to mitigate or reduce the impact of extreme heat on heat-related mortality and morbidity were sought by searching four electronic databases. Studies published in the English language and those that had quantifiable, measurable mortality, morbidity or knowledge score outcomes were included. Results: The initial electronic search yielded 2324 articles, and 17 studies were included. Fourteen studies were based in high-income countries (HICs) (Europe, US, Canada) and discussed multiple versions of (1) heat action plans, which included but were not limited to establishing a heat monitoring system, informative campaigns, the mobilization of health care professionals, volunteers, social workers and trained caregivers in the surveillance and management of individuals with known vulnerabilities, or stand-alone (2) education and awareness campaigns. Multi-pronged heat action plans were highly effective in reducing heat-related mortality and morbidity, especially among vulnerable populations such as the elderly and those with chronic conditions. Conclusions: The heat action plans covered in these studies have shown promising results in reducing heat-related mortality and morbidity and have included instituting early warning systems, building local capacity to identify, prevent or treat and manage heat-related illnesses, and disseminating information. Nevertheless, they need to be cost-effective, easy to maintain, ideally should not rely on a mass effort from people and should be specifically structured to meet the local needs and resources of the community. | multi-pronged heat action plans were highlight effective at reducing heat-related mortality and morbidity, especially among vulnerable populations such as the elderly or those with chronic conditions; successful ones include heat-warning systems, building local capacity to identify, prevent or treat heat-realetd illness, and disseminating information |
| Prehospital Healthcare | | |
| Monseau AJ, Hurlburt GA, Balcik BJ, Oppenlander KE, Chill NM, Martin PS. Status of US Emergency Medical Service Protocols Regarding Pre-Transfer Cooling for Exertional Heat Stroke. Cureus. 2021 Nov 12;13(11):e19505. doi: 10.7759/cureus.19505. PMID: 34912642; PMCID: PMC8666133. | "Objective: Exertional heat stroke (EHS) is a significant cause of morbidity and mortality in athletes and active individuals. In the field, initial management of exertional heat illness is based on rapid whole-body cooling. Cold-water immersion (CWI) is considered the superior cooling modality for EHS treatment. However, there often is a disconnect between the sports medicine community and the emergency medical service (EMS) community. Well-written emergency action plans may fail if EMS protocols do not allow for CWI in initial management. This is the first study to look at the current national EMS protocols regarding prehospital management of EHS. The purpose of our study was to assess the status of heat illness protocols regarding CWI for EHS in all 50 states plus Washington, DC.  Methods: An internet search was performed to find EHS protocols. Statewide protocols were preferred. Several parameters were recorded for each protocol including whether: 1) CWI was the recommended cooling treatment for EHS and 2) CWI was explicitly permitted to be completed prior to transportation.  Results: We found nine of the 51 protocols, or 17.6%, explicitly recommended CWI and 11 of the 51, or 21.6%, specifically instructed EMS personnel to complete CWI or cooling methods prior to transport. However, six protocols, or 11.8%, provided the recommendation instructing some variation of the phrase “do not delay transport to cool the patient.”  Conclusion: Despite the medical literature endorsing CWI as the most effective treatment modality in a prehospital setting for exertional heat illness, EMS protocols largely fail to reflect this which leads to mismanagement and inadequate care of EHS patients. While CWI is not always available, all EMS protocols should include a systematic practical guideline for a heat illness patient when employing cooling treatment with an emphasis on CWI when available as the preferred treatment technique for EHS and the concept of “cool first, transport second.” " | In 2021, most statewide EMS protocols emphasizes transporting first before cooling the patient; protocols should be updated to emphasize the use of CWI as the priority treatment - when protocols do not sufficiently address exertional heat stroke treatment, EMS responders must either take control of the scene and follow their protocol or contact the medical command physician (MCP), who may or may not make the appropriate decision for the circumstances - cold water immersion needs to be prioritized over transport when available, and protocols should make that clear enough so EMS personnel do not need to contact the MCP to make that decision |
| Rublee C, Dresser C, Giudice C, Lemery J, Sorensen C. Evidence-Based Heatstroke Management in the Emergency Department. West J Emerg Med. 2021 Feb 26;22(2):186-195. doi: 10.5811/westjem.2020.11.49007. PMID: 33856299; PMCID: PMC7972371. | "Introduction  Climate change is causing an increase in the frequency and intensity of extreme heat events, which disproportionately impact the health of vulnerable populations. Heatstroke, the most serious heat-related illness, is a medical emergency that causes multiorgan failure and death without intervention. Rapid recognition and aggressive early treatment are essential to reduce morbidity and mortality. The objective of this study was to evaluate current standards of care for the emergent management of heatstroke and propose an evidence-based algorithm to expedite care.  Methods  We systematically searched PubMed, Embase, and key journals, and reviewed bibliographies. Original research articles, including case studies, were selected if they specifically addressed the recognition and management of heatstroke in any prehospital, emergency department (ED), or intensive care unit population. Reviewers evaluated study quality and abstracted information regarding demographics, scenario, management, and outcome.  Results  In total, 63 articles met full inclusion criteria after full-text review and were included for analysis. Three key themes identified during the qualitative review process included recognition, rapid cooling, and supportive care. Rapid recognition and expedited external or internal cooling methods coupled with multidisciplinary management were associated with improved outcomes. Delays in care are associated with adverse outcomes. We found no current scalable ED alert process to expedite early goal-directed therapies.  Conclusion  Given the increased risk of exposure to heat waves and the time-sensitivity of the condition, EDs and healthcare systems should adopt processes for rapid recognition and management of heatstroke. This study proposes an evidence-based prehospital and ED heat alert pathway to improve early diagnosis and resource mobilization. We also provide an evidence-based treatment pathway to facilitate efficient patient cooling. It is hoped that this protocol will improve care and help healthcare systems adapt to changing environmental conditions." | many different patient populations were identified as being at higher risk (pediatric athletes, peds vehicular heatstroke cases, occupational heat stroke in construction workers/baker/gold miners/aluminum smelter pot room process control operator); no standardized, systematic approach for EMS or ED treatment of heatstroke; early recognition is key, so early rectal temp measurement emphasized in algorithm, patients who were rapidly cooled often had rapid reversal mental changes and some discharged from the ED; Cooling recommended prior to transfer, continue cooling during transport if possible - delays in cooling lead to worse outcomes; transfer to liver transplant center considered in algorithm due to several cases acute liver failure secondary to heatstroke; identified elevated risk populations include elderly, athletes, military personnel, men represented more than women in literature; only 4 articles addressed system-based changes - despite previous calls for this; developed an alert process and treatment algorithm to facilitate citical care delivery in EDs; recommendations - health systems need to implement heat alert systems and train relevant staff members, include prehospital providers and EMS networks in early identification/communication/treatment of heat illness,, increase public health messaging around risks of endemic and acquired heat illness especially vulnerable populations, and increase syndromic surveillance and improve heat warning systems |
| Health Workforce Responsibilities/Training | | |
| Sorensen CJ, Fried LP. Defining Roles and Responsibilities of the Health Workforce to Respond to the Climate Crisis. JAMA Netw Open. 2024;7(3):e241435. doi:10.1001/jamanetworkopen.2024.1435 | "Importance The adverse effects of climate change are now apparent, disproportionately affecting marginalized and vulnerable populations and resulting in urgent worldwide calls to action. Health professionals occupy a critical position in the response to climate change, including in climate mitigation and adaptation, and their professional expertise and roles as health messengers are currently underused in the society-wide response to this crisis.  Observations Clinical and public health professionals have important roles and responsibilities, some of which are shared, that they must fill for society to successfully mitigate the root causes of climate change and build a health system that can reduce morbidity and mortality impacts from climate-related hazards. When viewed through a preventive framework, the unique and synergizing roles and responsibilities provide a blueprint for investment in climate change–related prevention (primary, secondary, and tertiary), capacity building, education, and training of the health workforce. Substantial investment in increasing the competence and collaboration of health professionals is required, which must be undertaken in an urgent, coordinated, and deliberate manner.  Conclusions and Relevance Exceptional collaboration, knowledge sharing, and workforce capacity building are essential to tackle the complex ways in which climate change threatens health. This framework serves as a guide for health system leaders, education institutions, policy planners, and others seeking to create a more resilient and just health system." | Provides an overview of core responsibilities of public health and clinical professionals in mitigating and adapting to climate change through a lens of prevention. |
| Andersen ZJ, Vicedo-Cabrera AM, Hoffmann B, Melén E. Climate change and respiratory disease: clinical guidance for healthcare professionals. Breathe (Sheff). 2023 Jun;19(2):220222. doi: 10.1183/20734735.0222-2022. Epub 2023 Jul 11. PMID: 37492343; PMCID: PMC10365076. | Climate change is one of the major public health emergencies with already unprecedented impacts on our planet, environment and health. Climate change has already resulted in substantial increases in temperatures globally and more frequent and extreme weather in terms of heatwaves, droughts, dust storms, wildfires, rainstorms and flooding, with prolonged and altered allergen and microbial exposure as well as the introduction of new allergens to certain areas. All these exposures may have a major burden on patients with respiratory conditions, which will pose increasing challenges for respiratory clinicians and other healthcare providers. In addition, complex interactions between these different factors, along with other major environmental risk factors (e.g. air pollution), will exacerbate adverse health effects on the lung. For example, an increase in heat and sunlight in urban areas will lead to increases in ozone exposure among urban populations; effects of very high exposure to smoke and pollution from wildfires will be exacerbated by the accompanying heat and drought; and extreme precipitation events and flooding will increase exposure to humidity and mold indoors. This review aims to bring respiratory healthcare providers up to date with the newest research on the impacts of climate change on respiratory health. Respiratory clinicians and other healthcare providers need to be continually educated about the challenges of this emerging and growing public health problem and be equipped to be the key players in solutions to mitigate the impacts of climate change on patients with respiratory conditions. | The authors identify several priorities for climate change mitigation for respiratory clinicians: Acknowledge and discuss climate change effects on respiratory health with patients and colleagues.  • Improve and provide continued education for respiratory healthcare professionals on the impact of climate change.  • Focus attention on high-risk and vulnerable populations, including elderly citizens, children, pregnant women, chronic disease patients, socioeconomically disadvantaged groups, and people and occupational groups who work primarily outdoors.  • Use nature prescribing to improve the health of patients with respiratory diseases and to mitigate effects of climate change, but be aware of aeroallergen exposure.  • Establish environmental monitoring of new allergenic species as potential triggers for allergic respiratory conditions.  • Advocate for the provision of “cool places” or “cooling devices” to be made available to individuals with respiratory conditions at high risk during heatwave conditions.  • Promote climate-friendly activities and lifestyle among clinicians and patients that will lead to personal health and planetary co-benefits.  • Use health professionals as trusted members of communities to raise awareness of the impacts of climate change and to boost national/international policy action.  • Conduct interdisciplinary research to advance knowledge on climate change health impacts and adaptation mechanisms.  • Act as an example in reducing greenhouse gas emissions in clinical practice (*e.g.* prescribe dry powder inhalers instead of pressurised metered-dose inhalers when possible) and in our daily activities. |

**References**

1. Centers for Disease Control and Prevention. (n.d.). Extreme heat and your health. Retrieved from <https://www.ready.gov/heat> [↑](#endnote-ref-2)
2. National Oceanic and Atmospheric Administration. (2021). Heat wave: A major summer killer. Retrieved from [Severe Weather Awareness - Heat Waves](https://www.weather.gov/mkx/heatwaves) [↑](#endnote-ref-3)
3. World Meteorological Organization. (2021). 2020 was one of three warmest years on record. Retrieved from [2020 was one of three warmest years on record (wmo.int)](https://wmo.int/media/news/2020-was-one-of-three-warmest-years-record) [↑](#endnote-ref-4)
4. National Oceanic and Atmospheric Administration. (2021). Assessing the U.S. climate in 2021. Retrieved from [Assessing the U.S. Climate in 2021 | News | National Centers for Environmental Information (NCEI) (noaa.gov)](https://www.ncei.noaa.gov/news/national-climate-202112) [↑](#endnote-ref-5)
5. U.S. Department of Agriculture Climate Hubs. (2021). *2021 Northwest heat dome: Causes, impacts and future outlook*. Retrieved from [2021 Northwest Heat Dome: Causes, Impacts and Future Outlook | USDA Climate Hubs](https://www.climatehubs.usda.gov/hubs/northwest/topic/2021-northwest-heat-dome-causes-impacts-and-future-outlook) [↑](#endnote-ref-6)
6. Washington State Department of Health. (2023). *Excess mortality report brief*. Retrieved from [Excess Mortality Report Brief (wa.gov)](https://doh.wa.gov/sites/default/files/2023-09/422243-ExcessDeathsBrief.pdf) [↑](#endnote-ref-7)
7. University of Washington. (2023). *CIG report: Heat*. Retrieved from https://www.uw.edu/CIG-Report-Heat-202-pages.pdf [CIG-Report-Heat-202-pages.pdf (uw.edu)](https://cig.uw.edu/wp-content/uploads/sites/2/2023/06/CIG-Report-Heat-202-pages.pdf) [↑](#endnote-ref-8)
8. Liu, Y., & Sinsky, E. (2020). *Mortality associated with wildfire smoke exposure in Washington State, 2006–2017: A case-crossover study*. Environmental Health. Retrieved from <https://link.springer.com/article/10.1186/s12940-020-00682-5> [↑](#endnote-ref-9)
9. Gan, R. W., Ford, B., Lassman, W., Pfister, G., Vaidyanathan, A., Fischer, E., Volckens, J., Pierce, J. R., & Magzamen, S. (2017). Comparison of wildfire smoke estimation methods and associations with cardiopulmonary-related hospital admissions. *GeoHealth*, *1*(3), 122–136. https://doi.org/10.1002/2017GH000073 [↑](#endnote-ref-10)
10. Chen C, Schwarz L, Rosenthal N, Marlier ME, Benmarhnia T. Exploring spatial heterogeneity in synergistic effects of compound climate hazards: Extreme heat and wildfire smoke on cardiorespiratory hospitalizations in California. Sci Adv. 2024 Feb 2;10(5):eadj7264. doi: 10.1126/sciadv.adj7264. Epub 2024 Feb 2. PMID: 38306434; PMCID: PMC10836726. [↑](#endnote-ref-11)
11. Ma Y, Zang E, Liu Y, Wei J, Lu Y, Krumholz HM, Bell ML, Chen K. Long-term exposure to wildland fire smoke PM2.5 and mortality in the contiguous United States. medRxiv [Preprint]. 2024 Jun 11:2023.01.31.23285059. doi: 10.1101/2023.01.31.23285059. PMID: 36778437; PMCID: PMC9915814. [↑](#endnote-ref-12)
12. Austin E, Kasner E, Seto E, Spector J. Combined Burden of Heat and Particulate Matter Air Quality in WA Agriculture. J Agromedicine. 2021 Jan;26(1):18-27. doi: 10.1080/1059924X.2020.1795032. Epub 2020 Jul 30. PMID: 32730190; PMCID: PMC8171194. [↑](#endnote-ref-13)
13. Hess, J. J., Errett, N. A., McGregor, G., Busch Isaksen, T., Wettstein, Z. S., Wheat, S. K., & Ebi, K. L. (2023). Public Health Preparedness for Extreme Heat Events. Annual review of public health, 44, 301–321. https://doi.org/10.1146/annurev-publhealth-071421-025508 [↑](#endnote-ref-14)
14. Habibi P, Razmjouei J, Moradi A, Mahdavi F, Fallah-Aliabadi S, Heydari A. Climate change and heat stress resilient outdoor workers: findings from systematic literature review. BMC Public Health. 2024 Jun 26;24(1):1711. doi: 10.1186/s12889-024-19212-3. PMID: 38926816; PMCID: PMC11210127. [↑](#endnote-ref-4013)
15. NIOSH [2016]. NIOSH criteria for a recommended standard: occupational exposure to heat and hot environments. By Jacklitsch B, Williams WJ, Musolin K, Coca A, Kim J-H, Turner N. Cincinnati, OH: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication 2016-106. [↑](#endnote-ref-20539)
16. ACGIH. *Heat Stress and Strain: TLV® Physical Agents*; American Conference of Governmental Industrial Hygienists: Cincinnati, OH, USA, 2024 [↑](#endnote-ref-3073)
17. Flouris AD, Dinas PC, Ioannou LG, Nybo L, Havenith G, Kenny GP, et al. Workers’ health and productivity under occupational heat strain: a systematic review and meta-analysis. Lancet Planet Health. 2018;2(12):e521–31. doi: 10.1016/S2542-5196(18)30237-7. [↑](#endnote-ref-7547)
18. Rublee C, Dresser C, Giudice C, Lemery J, Sorensen C. Evidence-Based Heatstroke Management in the Emergency Department. West J Emerg Med. 2021 Feb 26;22(2):186-195. doi: 10.5811/westjem.2020.11.49007. PMID: 33856299; PMCID: PMC7972371. [↑](#endnote-ref-17)
19. Monseau AJ, Hurlburt GA, Balcik BJ, Oppenlander KE, Chill NM, Martin PS. Status of US Emergency Medical Service Protocols Regarding Pre-Transfer Cooling for Exertional Heat Stroke. Cureus. 2021 Nov 12;13(11):e19505. doi: 10.7759/cureus.19505. PMID: 34912642; PMCID: PMC8666133. [↑](#endnote-ref-18)
20. The Lancet. (2021). *Hot weather and heat extremes: Health risks*. Retrieved from [Hot weather and heat extremes: health risks - The Lancet](https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(21)01208-3/fulltext) [↑](#endnote-ref-19)
21. Washington State Department of Health. (2021). *Heat wave 2021*. Retrieved from [Heat Wave 2021 | Washington State Department of Health](https://doh.wa.gov/emergencies/be-prepared-be-safe/severe-weather-and-natural-disasters/hot-weather-safety/heat-wave-2021) [↑](#endnote-ref-20)
22. World Health Organization. (2024). *Heat and health*. Retrieved from [Heat and health (who.int)](https://www.who.int/news-room/fact-sheets/detail/climate-change-heat-and-health) [↑](#endnote-ref-21)
23. Hollander, A. (2022, July 20). *Common medications may increase the dangers of heat waves*. Yale Climate Connections. Retrieved from <https://yaleclimateconnections.org/2022/07/common-medications-may-increase-the-dangers-of-heat-waves/> [↑](#endnote-ref-22)