

9.1 Excessive Heat Events

- Excessive heat can be a hidden killer. In August 2003, excessive heat killed more than 15,000 people in France. In Cook County, Illinois in 1995, more than 700 deaths were attributed to heat. Because heat does no physical damage and deaths tend to occur in private dwellings, the extent of a heat disaster is often not visible to the public.
- Since the mid-1970s, an average of three or four heat-related fatalities has occurred each summer in Seattle. During excessively warm summers, such as the summer of 1992, up to 50 to 60 deaths have occurred.
- The season, humidity, duration and availability of cooling systems all strongly influence the impact of excessive heat events.
- Seattle's typically mild summers result in a population that is less acclimatized to extreme heat compared with that of many other cities in the United States. Health effects associated with heat begin in Seattle at lower temperatures than many other places. The relative temperature, compared to normal seasonal temperatures, is often more important than the actual temperature. Seattle is among the cities with the highest heat sensitivity in the country
- Many Seattle homes and businesses lack cooling systems, increasing our vulnerability.
- The most vulnerable people in heat events are the elderly, infants, the homeless, the poor and people who are socially isolated.
- Heat cramps, heat exhaustion, and heat stroke are examples of negative health effects associated with both average warmer summer temperatures and temperature extremes.
- In Seattle, most fatalities are indirectly caused by heat, e.g., heart attacks, strokes, and respiratory illness.
- Climate research shows that extreme heat events have become more severe in the Pacific Northwest in recent decades. Experts project that temperatures on the hottest days in the Puget Sound area will increase by 6.5°F on average by 2050.⁴⁹⁵ Nighttime low temperatures are also increasing, limiting nighttime heat relief.
- Heat can be costly. The costs of one extreme heat wave in California in 2006 were estimated at over \$200 million.

91.1 Context

On July 29, 2009, the temperature reached 103° at SeaTac airport, an all-time record. Two people in Western Washington died. The most brutal temperatures lasted three days. If the extreme weather had lasted a few days more, the number of fatalities would probably have climbed dramatically. Seattle has a famously mild climate that makes it difficult for the community to acclimate to extreme heat when it occurs.

An excessive heat event (EHE), or heat wave, is a weather pattern that is substantially hotter and/or more humid than average for a location at that time of year. EHE's can cause dehydration, heat cramps, heat exhaustion, heat stroke, and even death. Seattle's proximity to the Pacific Ocean generally results in mild summers with low humidity. Onshore air flows off the cool Pacific Ocean act as a natural air conditioner for the region. However, when dry air from the Northwest interior sinks along the western slopes of the Cascade Mountains it gets compressed and heats up. In the summer, when the sun is the strongest, Seattle experiences EHEs when the onshore flows of the Pacific decrease and there is an occurrence of downslope flow on the western slopes of the Cascade mountains. EHEs in Seattle usually



do not last very long because the pressure difference that builds with the warming air eventually grows to the point where marine air will surge in and cool the area once again.⁴⁹⁶

In an average year, about 134 Americans succumb to the effects of summer heat.⁴⁹⁷ During the summer of 2006, 253 people in the United States died as a direct result of heat.⁴⁹⁸ Heat waves in August 2003 that affected all of Western Europe resulted in more than 15,000 deaths in France alone. In July 1995, "excessive heat" conditions were blamed for more than 700 deaths in Cook County, Illinois. In July 1993, similar temperature extremes led to roughly 120 deaths in Philadelphia, Pennsylvania.

Human bodies dissipate heat by varying the rate and depth of blood circulation, by losing water through the skin and sweat glands, and by panting when the body's core is heated above 98.6°F. The skin handles about 90% of the body's heat dissipating function. Sweating, by itself, does nothing to cool the body unless the water is removed by evaporation. High relative humidity delays evaporation. Heat disorders generally have to do with a reduction or collapse of the body's ability to shed heat by circulatory changes and sweating, or a chemical imbalance of salt caused by too much sweating. When heat gain exceeds the level the body can remove, or when the body cannot compensate for fluids and salt lost through perspiration, the temperature of the body's inner core begins to rise and can cause damage to the brain and other vital organs. Heat-related illness may develop.

Once the air temperature exceeds skin temperature, convective cooling from the skin is no longer possible. The effects of ventilation/wind reverse, adding heat to the body. This is a dangerous scenario that causes individuals sitting in hot rooms with fans on to accelerate deterioration under hot conditions. Some decedents in the Chicago heat wave were found in indoor spaces with the fan on and are believed to have died as a result of this mechanism.

Statistical analysis of King County mortality data by David Hondula found that adverse health effects for heat begin to rise at 25.9° C (78.6° F). This is several degrees lower that other cities in the United States. The research studied day to day baseline conditions and not extreme events.⁴⁹⁹ Understanding our increased vulnerability to high temperatures, researchers have recently examined whether excessive heat days increase the risk of Emergency Medical Service (EMS) demand, hospitalizations, and mortality in King County. Calkins and colleagues found that on excessive heat days, there was an 8% increase in Basic Life Support (BLS) calls and a 14% increase in Advanced life Support (ALS) calls (over a 6-year study period). The risk of these EMS calls increases with each unit increase of the humidity index.⁵⁰⁰ Isaksen and colleagues analyzed hospital admissions and mortality associated with EHE in King County over a 30-year period. They report a 2% increases.⁵⁰¹ Both researchers identified the elderly as an especially vulnerable population. More surprisingly, however, their studies revealed an increased risk on EHE days for EMS calls, diabetes-related mortality, kidney disorders, acute renal failure, natural heat exposure, and asthma hospitalizations for young and middle-aged adults, a population generally thought to be more resilient to heat.⁵⁰²

The Washington Climate Impacts Group (CIG) projects that EHEs in the northwest will become more severe in the future. They project that the hottest days in the Puget Sound area will increase by 6.5°F, on average, by the 2050s.⁵⁰³ Based on current models, EHEs are not expected to increase in frequency due to climate change.

91.2 History

While good meteorological records exist for Seattle, heat waves are more complex that just high temperatures. Other factors like time of year, humidity, duration, extent of nighttime cooling, and the availability of cooling systems all strongly influence the effect. Because of these factors and the recognition of EHEs as a type of disaster only recently, records are marginal.

1981. A heat wave lasted several days in the upper 90s.



1992. A record 15 heat warnings were issued by the National Weather Service for the Seattle area. An estimated 50 – 60 people died because of the heat⁵⁰⁴.

1994. A city-wide heat extreme is set, recorded at 100 degrees.

2009. A new all-time record set when the maximum temperature reached 103 degrees. Humidity was unusually high.⁵⁰⁵ Two deaths in Western Washington are directly attributable to the heat.

2015. Seattle's hottest summer on record. The average high temperature was 80.2 degrees Fahrenheit. July had 10 days with high temperatures in the 90s.⁵⁰⁶

91.3 Likelihood of Future Occurrences

The Washington Climate Change Impacts Assessment looked at the likelihood of future extreme heat events. It used three different scenarios of summer warming—low, moderate and high—and developed estimates for the number heat events. In every scenario, they predict a rise. In the worst-case scenario, Seattle could have an average of ten heat events per year with a maximum duration of 57 days by 2085 (Table 47).

Climate data for the Puget Sound area from 1901 to 2009 reveals a trend towards daily low temperatures increasing at a higher rate than daily high temperatures.⁵⁰⁷ In other words, night time temperatures are rising, meaning there could be less of a cooling effect at night during future EHE's.

	1980 - 2006	2025	2045	2085
1980 - 2006				
Mean annual heat events	1.7			
Mean (max) event duration in days	2.2(6)			
Low				
Mean annual heat events		2.6	3.1	3.8
Mean (max) event duration in days		2.2(6)	2.3(7)	2.3(8)
Medium				
Mean annual heat events		3.6	4.7	7.2
Mean (max) event duration in days		2.3(7)	2.6(14)	2.9(18)
High				
Mean annual heat events		5.8	8.8	10.1
Mean (max) event duration in days		2.7(18)	3.2(18)	6.1(57)

Table 9-1. Projected Heat Events

Source: Washington State Climate Change Impact Assessment, 2009.

91.4 Vulnerability

Demographic vulnerability to EHEs is similar to other hazards. Factors that increase vulnerability include: age (65+), ethnicity, preexisting health conditions, education, income. Many residents lack efficient cooling systems in their homes or businesses and remain unaware how to protect themselves. 2015 American Housing Survey data shows that only 33.7% of Seattle area homes have air conditioning. For those aged 65 and older, the percentage only jumps slightly, to 37%.⁵⁰⁸ However, building trends



suggest there could be a future increase. About a quarter of new apartment buildings constructed in Seattle in the past decade have air conditioning.⁵⁰⁹

The difference between the normal temperature and the current temperature dictates the real impact that heat has on the individual. Since we normally have fairly mild temperatures, our population can feel more stressed at lower temperatures than many other places, especially if the rise happens suddenly.

Warmer average summer temperatures experienced in cities across the United States and elsewhere have led to premature death among certain populations, including those who are elderly, very young, poor, cognitively or physically impaired and already burdened with chronic disease, such as hypertension and diabetes. The most vulnerable people in Seattle tend to be the elderly.

Urban areas can also have reduced air flow because of tall buildings and increased amounts of waste heat generated from vehicles, factories, and air conditioners. When vegetation in urban areas is replaced with buildings, especially those with dark roofs, and dark paving materials, the heat absorbed during the day increases and cooling from shade and evaporation of water from soil and leaves is lost. These factors can contribute to the development of an urban heat island with higher daytime maximum temperatures and less nighttime cooling than surrounding rural areas.

A 2009 study of heat vulnerability on a national scale found that Seattle is on par with Chicago, site of a 1995 EHE that killed over 700 people. The study uses a Heat Vulnerability Index, driven by four factors: social isolation, lack of air conditioning, the proportion the population with chronic medical conditions, and social vulnerability (race, poverty, age, and housing conditions). The authors suggested that local and regional factors also play a role and suggested research of these as a next step in defining local hazard exposure.⁵¹⁰

Figure 9-1. Comparative Heat Vulnerability Nationally





A separate study in 2015 showed that the risk of mortality from EHEs can vary even within cities. For Seattle specifically, postal code areas that have higher percentages of elderly (65+) residents and Pacific Islander residents are associated with a higher risk of heat-related death during EHEs.⁵¹¹

91.5 Consequences

Looking at Seattle area weather and mortality statistics back to the mid-1970s, an average of three or four fatalities have occurred each summer.⁵¹² During excessively warm summers, such as the summer of 1992, up to 50 to 60 deaths have occurred. According to the state health department, hospitalizations for heat-related illness in Washington state range from 25-113 people each year.⁵¹³ In Seattle, most fatalities are indirectly caused by heat, such as heart attacks, strokes and respiratory illness.





Source: Colleen Reid, personal communication. 2009.

Hotter temperatures may also make people with certain heath conditions such as diabetes and obesity less likely to pursue physical activity critical to management and improvement of their health conditions. These factors, along with research suggesting increases in the demand of healthcare services during EHEs, means that Seattle's EMS and healthcare institutions could be overwhelmed during a severe EHE.

Warmer temperatures are typically associated with precursors of air pollutants that are in turn linked to respiratory disease and reduced lung function. In addition to causing climate change, high carbon dioxide concentrations in the atmosphere are associated with production of allergens such as ragweed



pollen that can, in turn, contribute to asthma cases by combining with fossil fuel pollutants, especially diesel exhaust.

There are also non-health consequences of heat. EHEs can increase the risk of brush fires as vegetation dries. In July 2018, fire fighters in King County responded to 20 brush fires in one weekend alone.⁵¹⁴ Brush fires can threaten adjacent property and cause traffic delays on major roads. High heat can also cause steel to expand, threatening the function of certain infrastructure like draw bridges. In 2018 firefighters in Chicago had to hose down a steel bridge that would not open to boat traffic due to heat expansion.⁵¹⁵ Seattle has 7 bridges that must open to marine traffic.⁵¹⁶

EHEs have the ability to lead to power outages if energy demand spikes as more people use cooling units. The majority of Seattle residents still do not have air conditioning units. Despite the growth of air conditioning in new apartment complexes, the technology being used is very energy efficient, so demand is not increasing locally.⁵¹⁷ If Seattle were to increase its air conditioning consumption to national levels, around 75%, it could overload the system to the point where outages could occur.⁵¹⁸ In 2018, Los Angeles experienced unprecedented energy demand levels during a heat wave, causing over 25,000 residents to lose power, some for as long as three days.⁵¹⁹ About 73% of households have air conditioning in Los Angeles.⁵²⁰ EHEs that coincide with a drought or low snow-pack year for Seattle's watersheds could result in a water shortage. If Seattle's water reserves are already low, high demand during hot days could lead the City to impose water usage curtailments.

Climate research suggests an increase in EHE severity, which is discussed further in the chapter on climate change.

91.6 Conclusions

Meteorologists can accurately forecast EHE development and the severity of the associated conditions with several days of lead time. The National Weather Service (NWS) has developed a Heat Health Watch/Warning System that tailors excessive heat guidance to specific regions in the country. The Seattle area implemented this new system in 2005, becoming the 15th urban region of at least 500,000 in population to do so. Excessive heat events may be becoming more severe in the Northwest. This may increase the exposure of vulnerable populations.