

Heat Waves in the United States

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1. Heat Waves

The association between ambient temperature and mortality has been demonstrated in many parts of the world. It is usually U-shaped with increased risks for cold and hot temperatures, which when they last for a number of days, there may be additional risks because of the extra pressures on the body's cooling and heating systems and other non-physiological related factors such as the inability of health services to respond when a large number of individuals fall ill. Sustained extremes of temperature over a number of consecutive days can be generally described as heat or cold waves (Barnett et al., 2012). Such extreme events which are associated with particularly hot sustained temperatures have been known to have a considerable impact on human mortality and regional economies, as well as ecosystems and wildlife. Two notorious and well documented examples of heat waves are the 1995 Chicago heat wave and the 2003 Paris heat wave, where in each case, extremely high temperatures increased human mortality and caused inconvenience, discomfort and had widespread economic impacts. A possible definition of a heat wave refers to the "worst annual heat event" which is characterized by lack of relief from very warm nighttime temperatures for three consecutive days. A second and more precise definition uses temperature thresholds and a heat wave is defined as the longest period of consecutive days satisfying the following three conditions: (i) the daily maximum temperature must be above the 97.5th percentile of the distribution of maximum temperatures in the observations (T1) for at least 3 days, (ii) the average daily maximum temperature must be above T1 for the entire period and (iii) the daily maximum temperature must be above the 81st percentile (T2) for every day of the entire period (Meehl et al., 2004).

2. A Silent Killer

Heat waves are characterized as silent killers, natural disasters that do not leave a trail of destruction in their wake (Luber et al., 2008). Prolonged exposure to high temperatures during heat waves can cause heat-related illnesses, including heat cramps, heat syncope, heat exhaustion, heat stroke and death. Usually, heat exhaustion is the most common heat-related illness characterized by several signs and symptoms including intense thirst, heavy sweating, weakness, paleness, discomfort, anxiety, dizziness, fatigue, fainting, nausea or vomiting and

headache. Internally, body temperature can be normal, slightly above or below while externally the skin can be cool and moist. In case heat exhaustion remains unrecognized and untreated, such mild symptoms may progress to a heat stroke. This is a severe illness clinically defined as core body temperature ≥ 40.6 °C, accompanied by hot, dry skin and central nervous system abnormalities such as delirium, convulsions and/or coma (Luber et al., 2008). In general, most of the excess mortality from heat waves is related to cardiovascular, cerebrovascular and respiratory causes, concentrating mostly on more susceptible groups such as elders and poor people without access to air conditioning or any other cooling systems (Kovats et al., 2006). For example in the 2003 heat wave that struck Paris, strong correlations were observed between urban living conditions, poverty, isolation, and ill health, confirming the heat wave as the silent killer of mute victims, unveiling social inequalities in the face of risks (Poumadere et al., 2005). It is also known that people with chronic mental disorders or pre-existing medical conditions (e.g., cardiovascular disease, obesity, neurologic or psychiatric disease), and those receiving medications that interfere with salt and water balance (e.g., diuretics, anticholinergic agents, and tranquilizers that impair sweating), are at greater risk for heat-related illness and death. Drinking alcoholic beverages, ingesting narcotics (e.g., cocaine or amphetamines), and participating in strenuous outdoor physical activities (e.g., sports or manual labor) in hot weather also are risk behaviors associated with heat-related illnesses (Luber et al., 2008).

3. The Association with Global Climate Change

There is increasing evidence that the earth's climate is changing at an alarming rate. This has led the UN Intergovernmental Panel on Climate Change (IPCC) to conclude that "warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising of global average sea level" (IPCC, 2007). Also, climate model simulations project that year-round temperatures across North America are likely to warm approximately 1° - 3°C. Especially the impact of climate change on U.S. heat waves may have already begun as it is observed that there is an upward trend in the occurrence frequency of heat waves from 1949 to 1995 by 20% (Luber et al., 2008). IPCC also projects with high confidence that extreme heat events will intensify in both magnitude and duration over portions of the U.S. where they already occur (Poumadere et

al., 2005). Further analyses of the U.S. climate change scenarios through General Circulation Models (GCMs) project that, for the period 2080 to 2099, Chicago will experience a 25% increase in the number of heat waves and the number of annual heat wave days in Los Angeles for the 2070 to 2099 time period will increase from 12 to 44-95. In another study that also used GCMs, it was estimated that by 2020, under the current emission rates, excess annual summer deaths will increase from 1840 to 1981-4100 (Luber et al., 2008). Moreover, it was also estimated that human activities since 1851 have more than doubled the risk of a heat wave occurring in present days (Poumadere et al., 2005).

4. Heat waves in the United States.

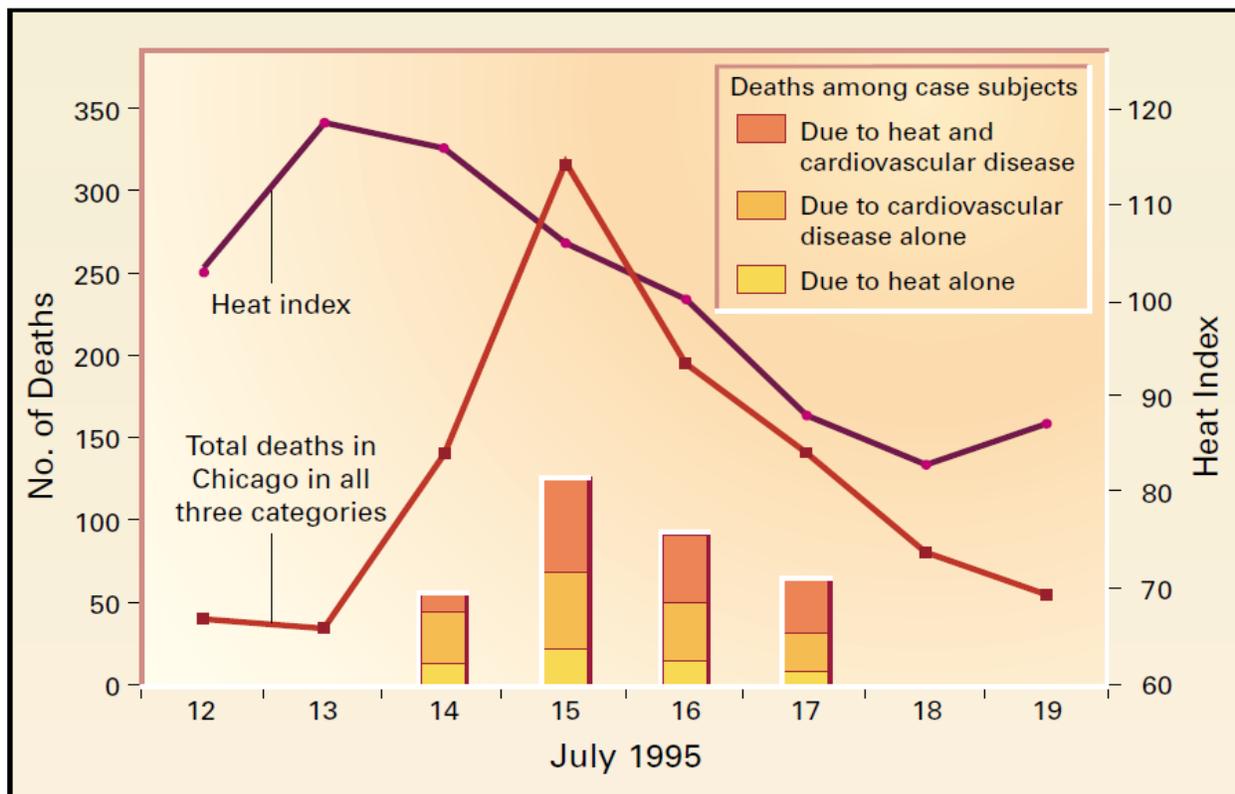
Conservative estimates show that, on average, 240 heat-related deaths occur annually in the United States; in a 1980 heat wave, there were 1700 deaths (McGeechin et al., 2001) while over a 5-year period, from 1999 to 2003, a total of 3442 heat-related deaths were reported (an annual average of 688) (Luber et al., 2008). Earlier in the previous century, more than 500 heat related deaths were identified per year in 1952, 1953, 1954, 1955, 1966 while in the 1936 heat wave which is considered as the worst of the nation, 3900 deaths were reported in a 8-day period. In 1980, a heat wave produced more than 10000 deaths while heat waves accompanying the 1988 drought caused between 5000 and 10000 deaths (Changnon et al., 1996). More recent heat wave cases that will be discussed below are the 1995 Chicago heat wave and in 2006, California. Generally heat related mortality and morbidity in the U.S. vary among cities and regions due to differences in climate and adaptations to extreme temperatures. Historically though, extreme heat events have had the greatest impact in the Northeast and Midwest and the least impact in the South and Southwest. Worth mentioning is also the fact that heat waves are the most prominent weather related death cause in the United States (Luber et al., 2008).

4.1. The 1995 Chicago Heat Wave

During July, the Midwestern United States experienced a severe heat wave that killed an estimated 718 persons in 10 states (Changnon et al., 1996), with media reports indicating that the deaths in Chicago, Illinois related to this extreme heat event were among the highest in the

history of U.S. (Whitman et al., 1995). The duration of the heat wave was 5 days from 12 to 16 July where maximum temperatures ranged from 93 to 104 °F (34 to 40°C). The number of deaths reported increased by 85% while the number of hospital admissions increased by 11% compared with the number recorded at the same period of the previous year (McGeechin et al., 2001). Five hundred fourteen July 1995 deaths were diagnosed as heat related in Chicago; the first 4 deaths occurred on July 13 and then 2 days later, the daily number peaked at 181. It was also apparent that the elderly population was much more affected by the heat wave. Specifically, people 65 years of age and older accounted for 72% of the heat-related deaths due to the mid-July 1995 heat wave. In addition, the heat-related mortality rate ratio for people 65 years of age and older relative to people less than 65 years old was 14.55 (P < .001, 95% CI = 11.92, 17.77) (Whitman et al., 1995).

Figure 1: Association between the heat index and total deaths recorded in Chicago during the heat wave (Semenza et al., 1996)



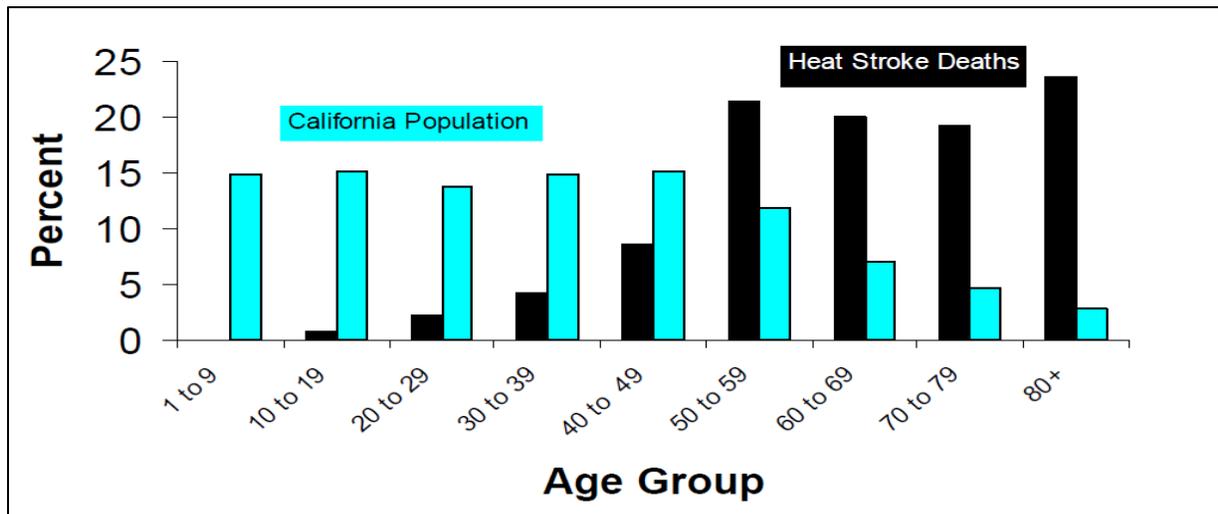
In addition, Whitman and colleagues took into account the excess deaths that occurred in that period apart from the heat related deaths, showing that that the heat wave had contributed to 182

more deaths than those that were initially attributed to it by the Cook County Medical Examiner's Office, resulting in a total of 696 excess deaths. Specifically, from July 14 through July 20, there were 739 excess deaths and 485 heat related deaths, meaning that the heat wave had contributed to 254 more deaths (Whitman et al., 1995). Sources also hint towards a much higher death toll in the first days than the one announced by the media, due to the hospital and ambulance services being overwhelmed. For example, Changnon and colleagues mention that on 16 July, Chicago examiners reported 116 heat related deaths, while 270 more bodies were still left to be examined. Whatever the death toll, it was without a doubt a great disaster for the city of Chicago and generally for the U.S.

4.2. The 2006 California Heat Wave

During mid- to late July 2006, an extreme heat wave affected the larger parts of the state of California, breaking daily maximum temperature records at seven sites and exceeding minimum temperature records at 11 meteorological stations, especially from 16 through 26 July (Knowlton et al., 2009). The intensity and the duration of the heat wave were exceptional and records for most consecutive days reaching ≥ 100 °F were broken in the Central Valley region (Kozlowski and Edwards 2007). Also some stations in central and southern California recorded the warmest July in the history of the state.

Figure 2: Percentage age distribution of estimated 2005 California population (U.S. Census) versus heat stroke deaths, July 15 – August 1, 2006 (California Department of Health Services)



In the period between 15 July and 1 August 2006, 140 deaths attributed to extreme heat were recorded by the medical examiners. Knowlton and colleagues in addition to the related mortality observed a dramatic increase across a wide range of morbidities statewide, with excess emergency department visits far outpacing excess hospitalizations. Specifically, 501,951 ED visits were recorded between 15 July and 1 August compared to last year's 485,785 during the same period (Knowlton et al., 2009).

4.3. The 1999 Midwestern U.S. Heat Wave

In July 1999 another heat wave hit the central and eastern U.S. Approximately 309 fatalities in 21 states were reported and classified as heat related deaths, with most of them (78%) occurring in Illinois, Missouri, Ohio and Wisconsin. Especially the states of Illinois and Missouri were hard hit by this extreme heat event with 110 heat related deaths being recorded in Chicago and 36 in St.Louis. In comparison with the disastrous 1995 incident however, the heat wave death toll in Chicago was reduced by more than 80%, perhaps, due to the physical nature of the event and especially the preparedness and responsiveness of the municipalities to the unfolding events. The National Oceanic and Atmospheric Administration (NOAA) and the Federal Emergency Management Agency (FEMA) estimate that about 175 people die annually directly due to heat, concluding that the relative magnitude of the 1999 heat wave fatalities were comparable to an average year (Palecki et al., 2001).

5. Preventive Measures

There is nothing that can stop the temporal evolution of a heat wave; however, preventive measures exist for the minimization of the heat waves' impacts on human health. Luber and colleagues state that public health efforts to prevent illnesses during heat waves require attention to both individual and community level risk factors. Elderly, disabled or homebound people should be checked frequently or transported immediately to cooling shelters, strenuous outdoor activities should be reduced or eliminated, showers should be frequently taken, increase the consumption of non-alcoholic fluids and wearing lightweight and light colored clothing. Parents should also pay extra attention to their kids. In addition, the use of fans in rooms without air

conditioning should be minimized because it can increase heat stress (Luber et al., 2008). Bernard and McGeehin also proposed five essential criteria that should be taken into account during response plan development. First a lead agency responsible for the emergency should be identified, as well as any collaborating agencies. Specific criteria should be established about the activation or deactivation of a response plan, including ambient temperature, humidity, extreme daytime highs etc. An effective communication plan should be devised in addition to public education tools. Risk factors should also be defined, high-risk populations must be determined and methods should be developed in order to reach those populations fast in case of a heat wave. Finally, after the emergency event, a method that can evaluate the effectiveness of the plan must exist and any deficiencies must be eliminated or revisited (Bernard and McGeehin 2004).

6. Conclusions

Heat waves are a significant public health menace in the United States. The future looks grim, since the ever increasing warming of our planet does nothing but to exacerbate the problem and increase both the frequency and intensity of heat waves. Moreover, as urban areas and urban population continue to grow, it is likely that heat related mortality and morbidity are likely to increase in the future, unless effective preventive strategies and adaptations are established that will help mitigate the problem. Knowing that heat waves don't affect only human health, but also other sectors such as farming, forestry, water supply, and technological operations (Poumadere et al., 2005) we should reconsider our actions as a whole with regards to global greenhouse emissions, which appear to be the main driver for the deadly extreme heat events we are experiencing not only in the United States but all over the world.

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