Module 2: Heat Related Illness - Societal Implications and Methods of Prevention

Arizona Climate & Health

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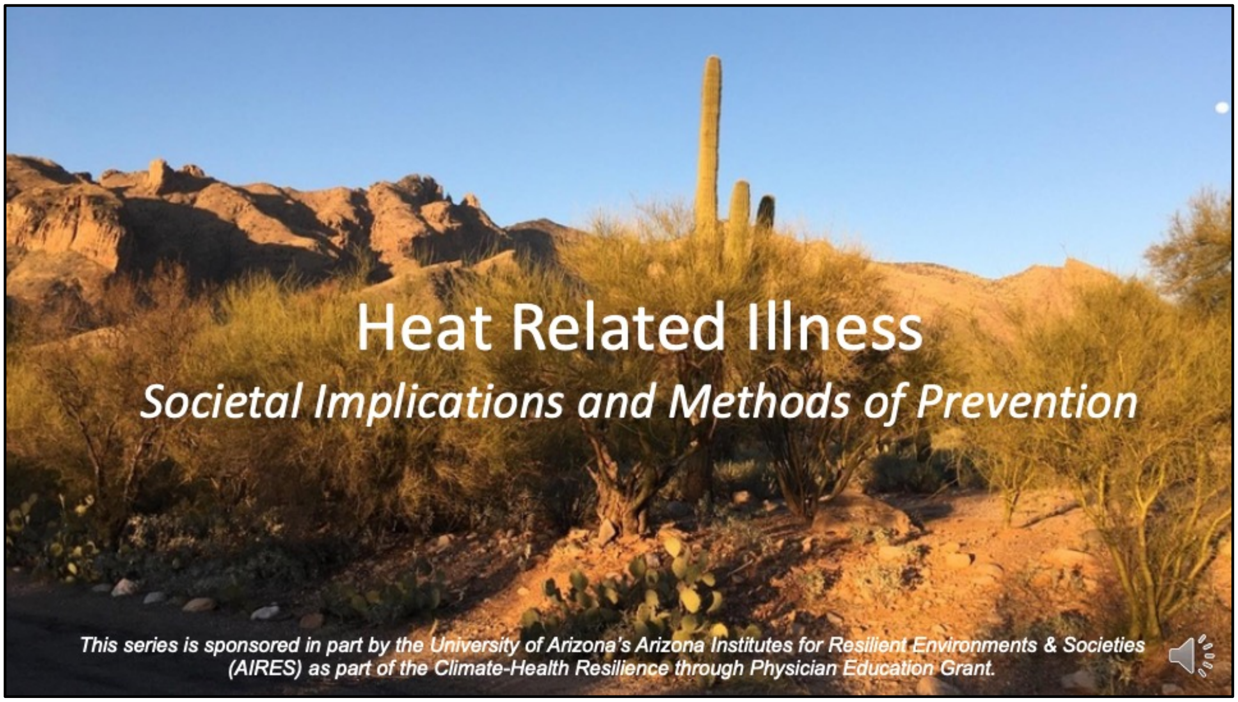


Welcome to the second discussion in our Heat-Related Illness Module. This is designed for physicians, medical students and other clinicians and trainees. It will be particularly applicable for those practicing in primary care, obstetrics, pediatrics, geriatrics and emergency medicine, and will expand your knowledge from the individual patient level into the societal and public health realm. Awareness of patient vulnerabilities and specific actions that you can take to help prevent serious heat-related illness in your patients as well as ways to mitigate heat-related risks in your community will augment the medical knowledge discussed in the Heat Related Illness *Effects on the Individual* Module.

This series is sponsored in part by the University of Arizona's Arizona Institutes for Resilient Environments & Societies (AIRES) as part of the Climate-Health Resilience through Physician Education Grant.

LEARNING OBJECTIVES
• Identify risk factors for heat-related illnesses
• Understand the local, national and global impacts of increasing temperatures
• Understand measures used to prevent heat-related illness
• Describe mitigation methods that improve both health and impact changes in climate
• Describe how physicians can increase long-term impacts on illness in the community

Upon completion of this lecture, the listener should be able to identify which patients are particularly vulnerable to developing heat-related illnesses, with intent to help clinicians reduce risks for their individual patients. We will discuss the public health and societal impacts of HRI, and help you gain greater understanding of the local, national and global impacts of increasing temperatures on health. We then will move to realizing the ways that individuals and communities can prevent and mitigate heat-related illnesses. Finally, we will conclude with how physicians can increase their impact on long-term illness prevention and health in their communities.

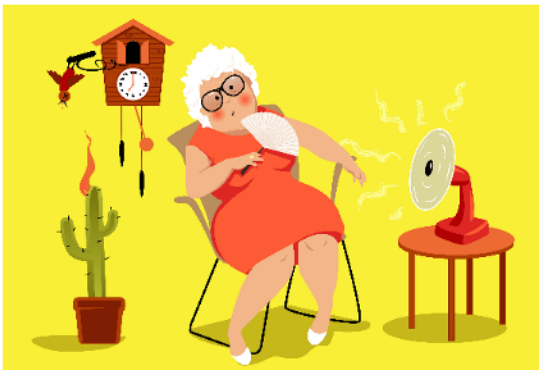
Heat Vulnerability and Impacts

Biologic Risk Factors

Social/Environmental Risk Factors

Let us begin with a look at which populations of people carry greater vulnerability to heat-related illnesses. When we begin to evaluate levels of risk in our patients, we look at two broad categories of vulnerability: Biologic and Social/Environmental. Of course, there is significant overlap between these two categories and this picture we provide now is a simplified one.

Biologic Risk Factors



- Extremes of Age
- Pre-Existing Medical Conditions
- Pregnancy
- Prescription Medications
- Alcohol & Illicit Drug Use

Ogden CL et al., *MMWR,* 2018; Cheshire WP, *Auton Neurosci Basic Clin,* 2016; CDC, *Heat-Related Illness Picture of America Report*; Jung et al., *BMC Public Health,* 2021; Heat - Reproductive Health | NIOSH | CDC, 2021

Beginning with biologic variability, we see the most vulnerability to heat at the extremes of age, both in infants and children under age 4 and in adults over the age of 65. Pre-existing medical conditions also play a role, with greater risk seen in those who are overweight or obese and those who have underlying diabetes, cardiovascular, respiratory, mental health, autonomic nervous system dysfunction and renal diseases. Pregnant women are also more likely to suffer from heat-related illness. As discussed in the previous lecture, certain prescription medications may also increase risk, including the many medications which have anticholinergic effects. Finally, alcohol and illicit drugs can also play a significant role.

Let's think back to the physiologic mechanisms discussed in the previous module. How do the pre-existing medical conditions, pregnancy and medications and substances we just listed contribute to increased heat vulnerability?

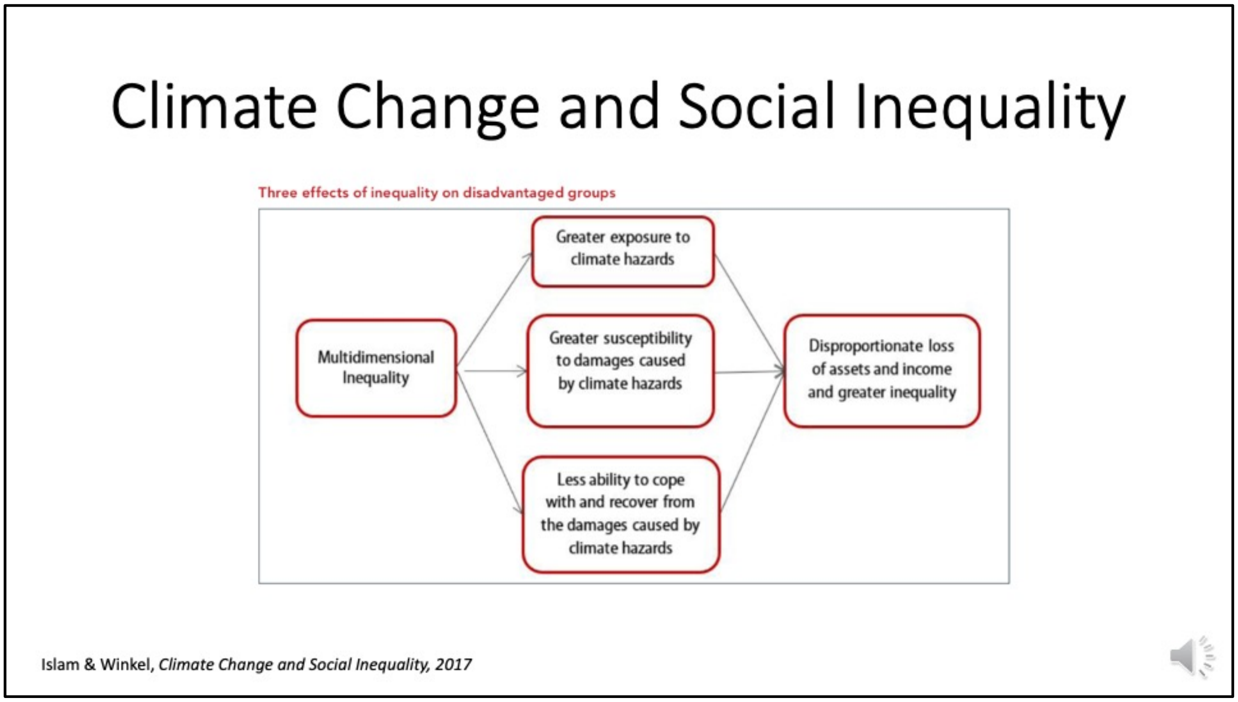
Social and Environmental Risk Factors

- Social Isolation
- Homelessness
- Poverty and Low Socioeconomic Status
- Occupation & Activities

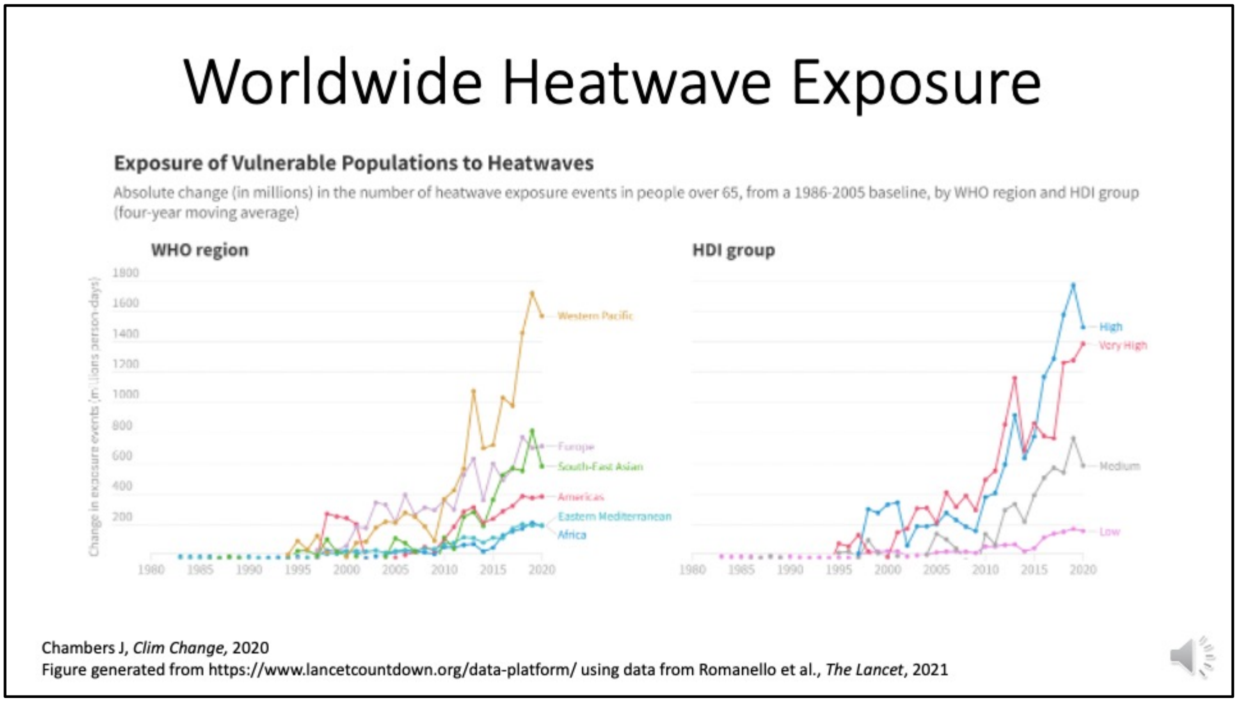
Ogden CL et al., *MMWR*,2018; CDC, *Heat-Related Illness Picture of America Report*; Jung et al., *BMC Public Health,* 2021

Next we turn our attention to the social and environmental risk factors which play an equal if not greater role in patient vulnerability. The classic example of heat-related illness is of an athlete exercising in extreme temperatures. It is important to remember that in situations like this with healthy young individuals who have good access to medical care and resources, the mortality rate is low.

Many individuals; however, are not so fortunate. Those who are socially isolated and/or unhoused have increased risk of serious heat-related illness. Greater rates of heat-related illness are associated with poverty and low socioeconomic status. Lack of access to air conditioning, living in environments with more heat absorbent surfaces and fewer cooling green spaces all play a role in this increased risk. Lack of access to health care is also important in both access to treatment when injury occurs as well as the greater presence and inadequate control of pre-existing conditions. Without healthcare access, a patient may have limited knowledge of their own risk factors for heat-related illness. Finally, individuals may also be exposed to greater risk due to their employment. For example, those who work in hot and/or humid environments such as agricultural work or construction and those in the military are at increased risk. In a painful conundrum, those who face heat-related risks through their work are the ones with little financial or social cushion to rely upon to avoid working during times of extreme heat.



Globally, underserved populations are disproportionately affected by climate change. As demonstrated by the figure, this is due to multiple factors including increased exposure to climate hazards, greater susceptibility to damages caused by climate hazards, and difficulty coping and recovering from these events. In combination, these challenges can lead to a disproportionate loss of assets and income and, thus, ultimately worsen inequality.



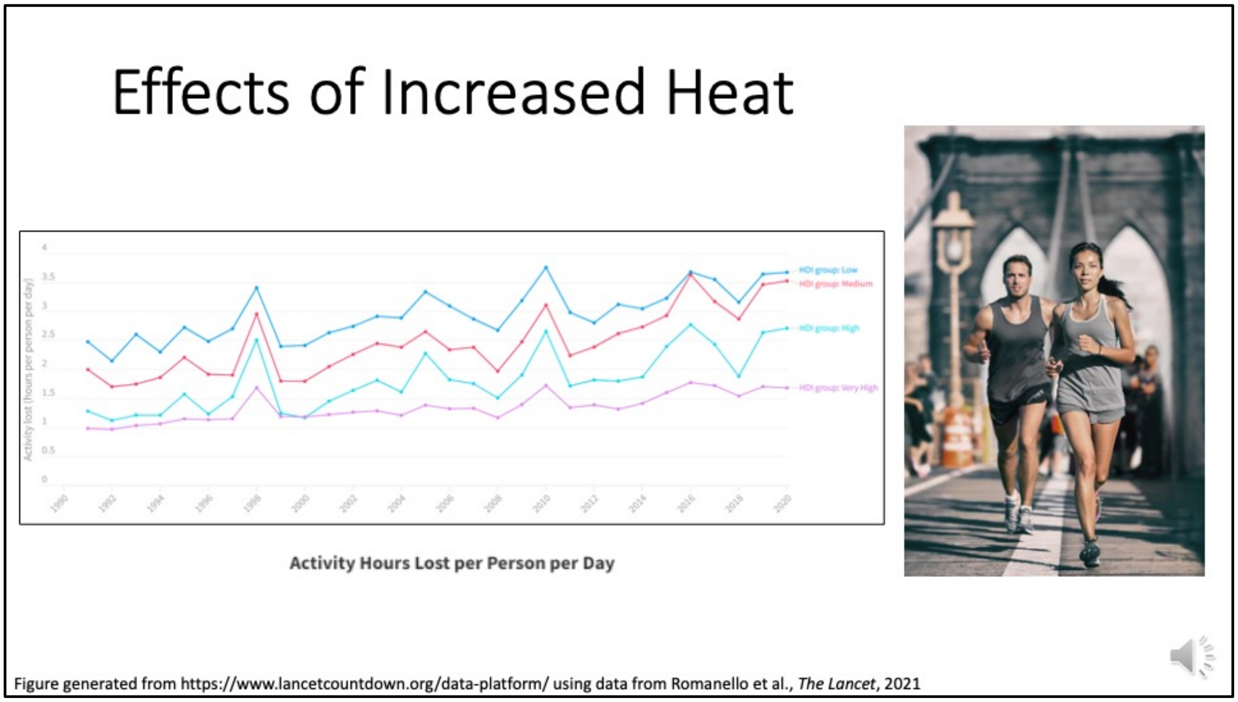
These next few slides will help us understand the impacts of heat on a local, national and global scale. With this slide, we will widen our lens to gain a greater understanding of the effects of heatwaves globally and then narrow down to the local effects being seen in Arizona.

We just spoke of extremes of age being a biologic vulnerability to extreme heat events. We are seeing increasing exposure to extreme heat in vulnerable populations. In 2020, globally there were over 3 billion **more** person-days of heatwave exposure than baseline in adults over 65 and 626 million **more** in children under 1.

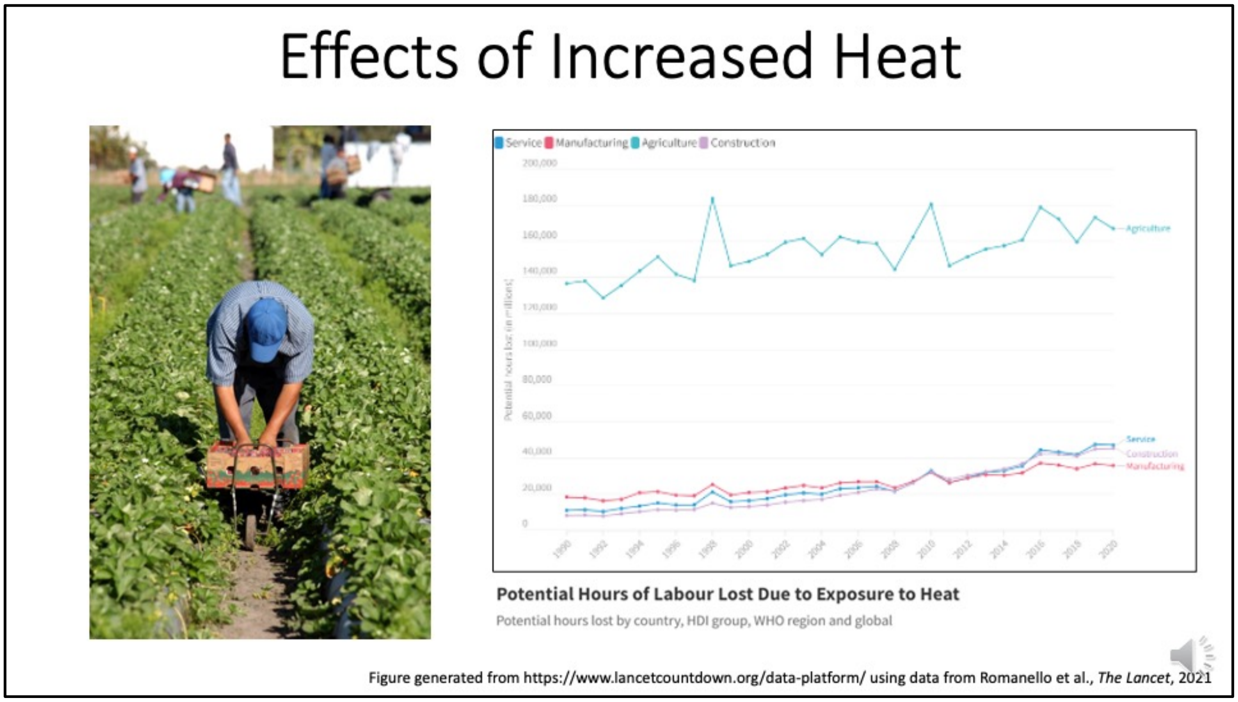
We can visualize this increased exposure using data from The Lancet Countdown. These figures compare heatwave exposure data in people over age 65 to a baseline, using the average exposures from 1986-2005. This data is divided in two ways, World Health Organization region and Human Development Index, or HDI, group. The HDI group is the UN measure of development, which takes into account life expectancy, education, and standard of living.

On the left, we see this broken up by WHO region, with the Americas shown in red. On the right, we see this divided by HDI group. For reference, the United States is in the red “Very High” group. These figures highlight the unequivocal increase in heatwave exposure that vulnerable populations are experiencing throughout the world.

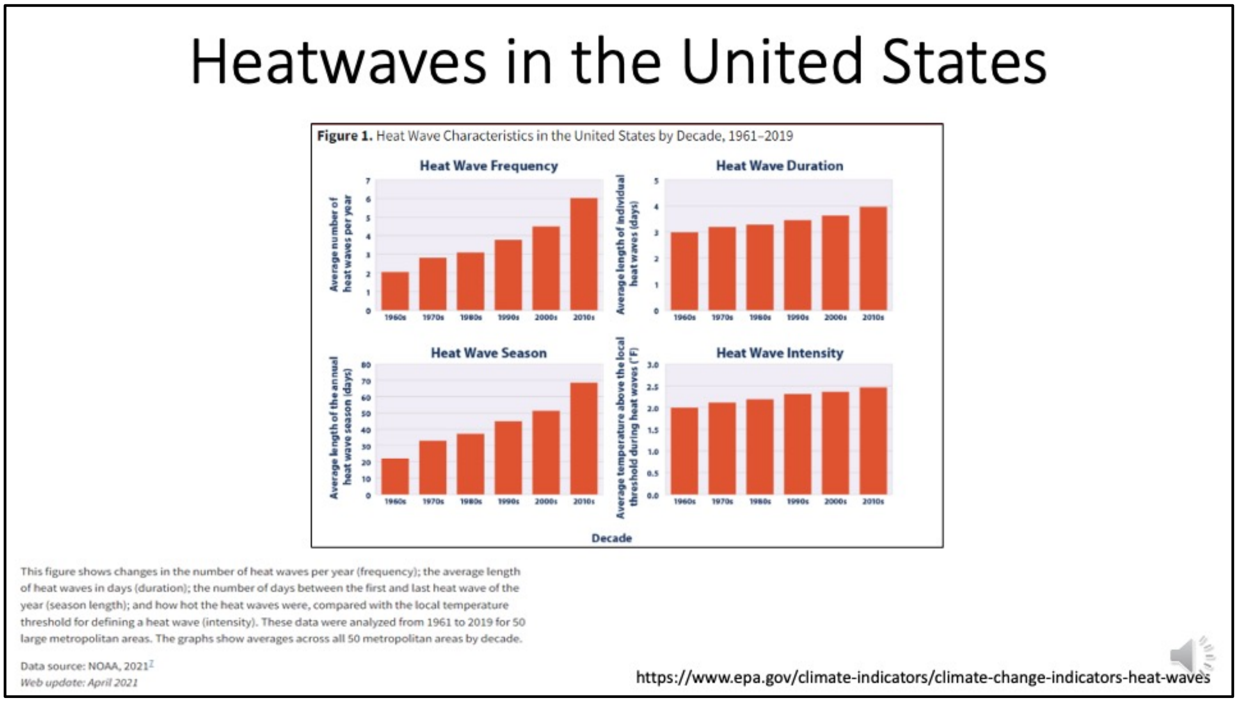
Understandably, increased heatwave exposure results in increases in heat-related deaths. In 2019, a record high number of heat-related deaths were seen worldwide in people > 65 years of age, estimated to be about 345,000 deaths.



So what are some of the overall effects of increased heat worldwide? This figure using The Lancet Countdown data demonstrates one way that increased heat affects humans, by loss of safe outdoor physical activity. This figure shows the number of hours of safe physical activity that have been lost since the 1990s due to high wet bulb globe temperatures, divided again by HDI index, with the United States represented in the purple “Very High” group. An average loss of as much as **3.7 hours per day** of safe physical activity was seen in low HDI countries.



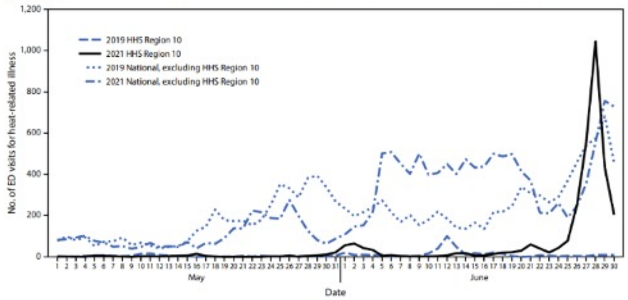
The loss of safe physical activity leads into what we see in this figure, also using data from the Lancet Countdown. This shows the amount of labor lost by industry due to heat-related factors since 1990. Potential work lost due to extreme heat in 2020 was estimated at 295 billion hours, with the majority, not-surprisingly occurring in the agriculture sector in many countries.



We turn our attention now to information about heat waves in the United States. As shown in this graph from the EPA looking at 50 large metropolitan areas, the frequency, duration, intensity, and length of season of heatwaves have all been increasing since the 1960s. Our patients are and will continue to be increasingly exposed to heat waves.

Pacific Northwest Heat Wave June 2021

FIGURE. Number of emergency department visits for heat-related illness* in U.S. Department of Health and Human Services Region 10† and nationwide (excluding Region 10), by year§ — National Syndromic Surveillance Program,¶ United States, May 1–June 30, 2019 and May 1–June 30, 2021



Schramm PJ et al., *MMWR*, 2021

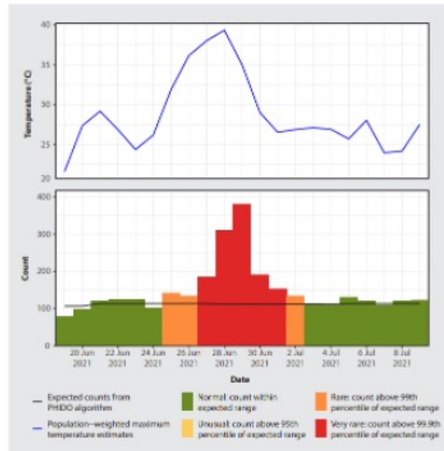
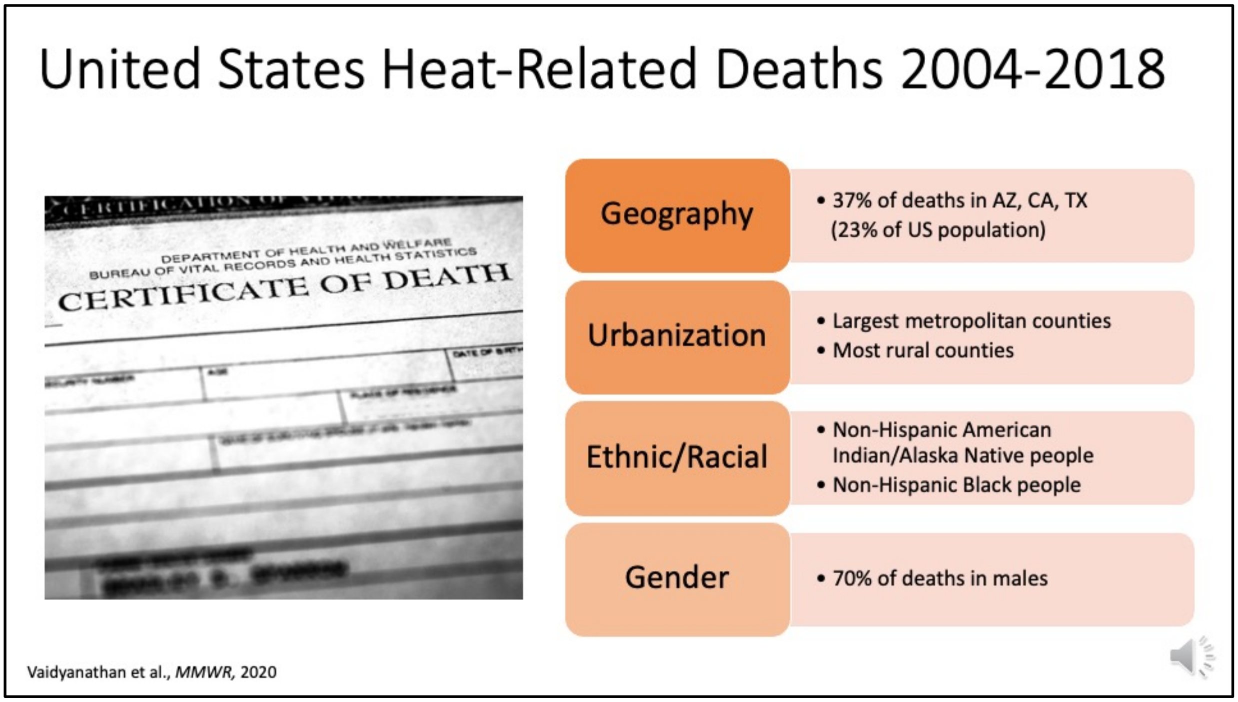


FIGURE. Time series of population-weighted maximum daily temperatures in British Columbia before, during, and after the heat dome (top) shown with daily counts of all-cause mortality across the province (bottom). The bars on the bottom are colored according to their deviation from expected values using the Public Health Intelligence for Disease Outbreak (PHIDO) algorithm used by the BCCDC for anomaly detection.

Henderson SB et al., *BC Med J*, 2021

We have experienced a very recent example of a severe heat wave in the Pacific Northwest. From June 25-30, 2021, most of Oregon and Washington were under excessive heat warnings, with hot conditions lasting in parts of the region through at least July 14, 2021. The impact was particularly significant for Oregon, with the Portland metropolitan area experiencing temperatures up to 116 degrees Fahrenheit, 42 degrees Fahrenheit hotter than average June temperatures there.

This graph from the CDC shows in black the spike in visits to the ED in one Pacific Northwest region during this time period as compared to 2019, which is the broken blue line at the bottom of the graph. The middle lines represent national data during the same time period. The populations most represented in the ED visits were males and those greater than 75. The figure on the right from British Columbia demonstrates daily temperatures in the top portion and all-cause mortality in the bottom portion during this same time period, showing highly unusual numbers of deaths. This unprecedented heat wave is estimated to have resulted in the deaths of over 1000 people in Oregon, Washington, Idaho and Canada.



As we spoke earlier about individual patient vulnerabilities to extreme heat, we will look closer at some data published in MMWR. This outlines the demographics of heat-related deaths in the United States from 2004-2018, showing which vulnerabilities are more likely to result in heat-related deaths. It is important to realize that the available data very likely underestimates the true number of deaths, as this reflects only when heat is reported as an underlying or contributing factor on the death certificate, a fact which may go unnoticed or unrecorded. The data also does not include non-US citizens.

Geographic differences in heat-related deaths are seen, with Arizona, California, and Texas accounting for 37% of heat-related deaths, though together they make up only 23% of the US population. Additionally, urbanization affects death rates, with the highest rates seen in the largest metropolitan counties and the most rural counties.

Gender, ethnic and racial differences are also seen. The highest heat-related death rates are seen in Non-Hispanic American Indian/Alaskan Native people followed by Non-Hispanic Black people. Finally, 70% of heat-related deaths occur in men. As we see temperatures continuing to rise, without effective mitigation, we would expect deaths in these populations to rise as well.

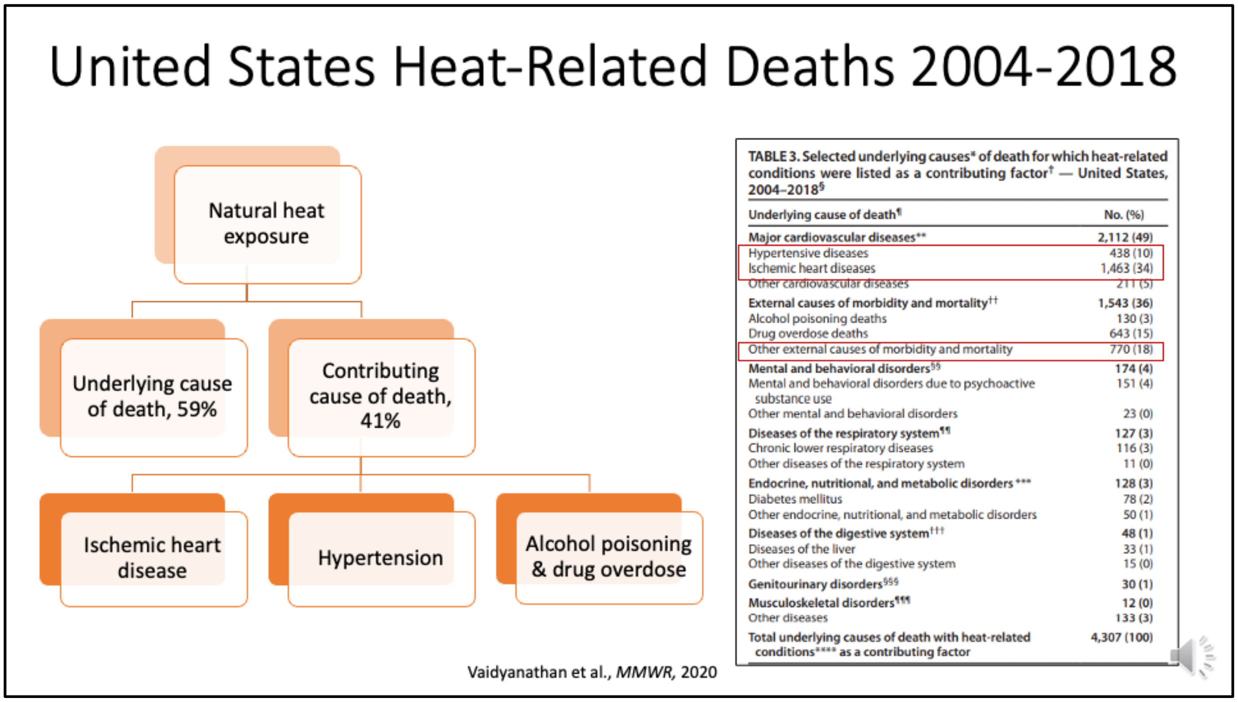


TABLE 3. Selected underlying causes* of death for which heat-related conditions were listed as a contributing factor† — United States, 2004–2018§

Underlying cause of death¶	No. (%)
Major cardiovascular diseases**	**2,112 (49)**
Hypertensive diseases	438 (10)
Ischemic heart diseases	1,463 (34)
Other cardiovascular diseases	211 (5)
External causes of morbidity and mortality††	**1,543 (36)**
Alcohol poisoning deaths	130 (3)
Drug overdose deaths	643 (15)
Other external causes of morbidity and mortality	770 (18)
Mental and behavioral disorders§§	**174 (4)**
Mental and behavioral disorders due to psychoactive substance use	151 (4)
Other mental and behavioral disorders	23 (0)
Diseases of the respiratory system¶¶	**127 (3)**
Chronic lower respiratory diseases	116 (3)
Other diseases of the respiratory system	11 (0)
Endocrine, nutritional, and metabolic disorders***	**128 (3)**
Diabetes mellitus	78 (2)
Other endocrine, nutritional, and metabolic disorders	50 (1)
Diseases of the digestive system†††	**48 (1)**
Diseases of the liver	33 (1)
Other diseases of the digestive system	15 (0)
Genitourinary disorders§§§	**30 (1)**
Musculoskeletal disorders¶¶¶	**12 (0)**
Other diseases	133 (3)
Total underlying causes of death with heat-related conditions** as a contributing factor**	**4,307 (100)**

Additional data from the MMWR article breaks down the causes of heat-related mortality in the United States from 2004-2018. Natural heat exposure was the **underlying** cause of death in 6,219 deaths or in 59% of all heat-related deaths. 41% of heat-related deaths listed natural heat exposure as a **contributing factor** on the death certificate. The chart on the right lists the underlying cause of death in all 4,307 cases in which heat was listed as a contributing factor. In these cases, heat was a contributing factor most often in deaths related to ischemic heart disease, hypertension, alcohol poisoning and drug overdose.

Heat-Caused & Heat-Related Deaths in Arizona Residents by Year (2010-2020)

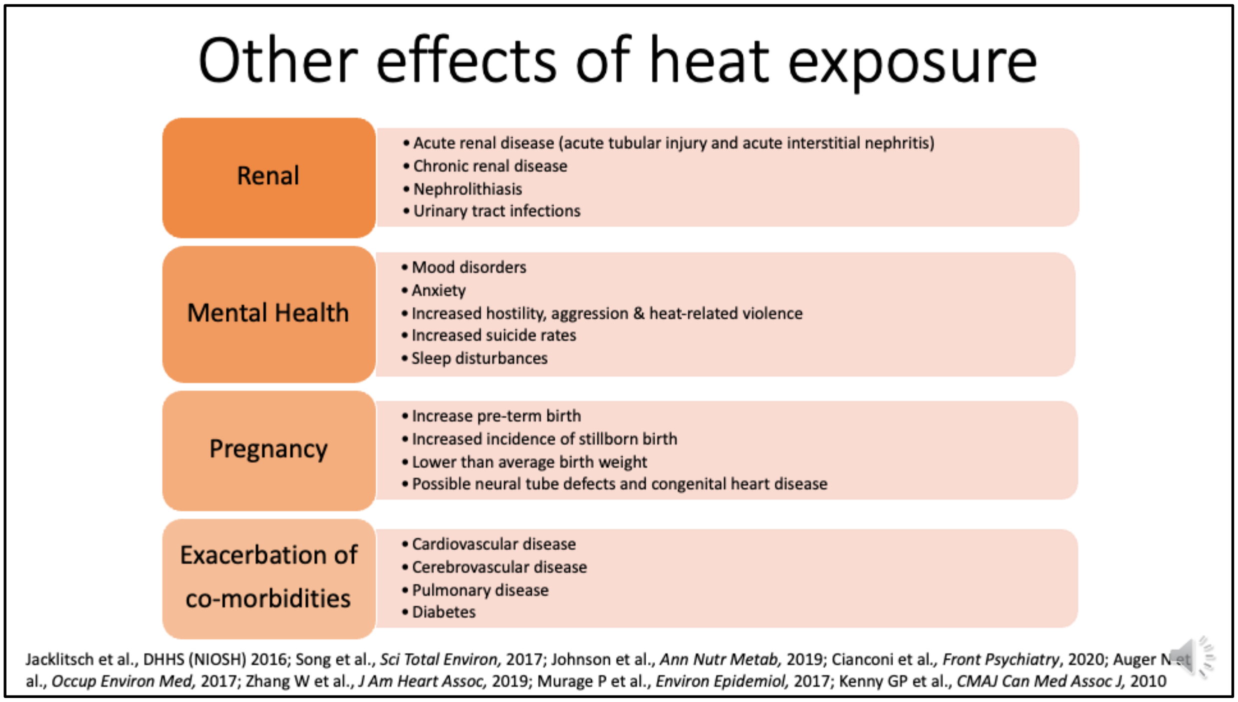
Deaths from Exposure to Excessive Natural Heat				
Year	Heat – Caused Deaths		Heat – Related Deaths	
	Count	Rate (per 100,000)	Count	Rate (per 100,000)
2010	50	0.8	96	1.5
2011	57	0.9	108	1.7
2012	53	0.8	109	1.7
2013	56	0.8	96	1.4
2014	32	0.5	74	1.1
2015	42	0.6	88	1.3
2016	98	1.4	165	2.4
2017	105	1.5	227	3.2
2018	92	1.3	187	2.6
2019	117	1.6	220	3.0
2020	207	2.9	378	5.3

Heat-caused deaths are deaths where the primary cause of death is listed as exposure to excessive natural heat. **Heat-related** deaths are deaths where exposure to excessive natural heat is listed anywhere on the death record and include those that were heat-caused.
Rates calculated here use the 2020 Vintage estimates from US Census; 2020 rates use the 2020 Census population.

ADHS, *Heat-Related Illness Summary 2010-2020 Arizona Residents and Non-Residents* (figure); Iverson et al., *Public Health Rep,* 2020

Now we shift our focus to local effects of heat in Arizona. This chart from the Arizona Department of Health Services lists death counts and rates from 2010 to 2020 related to excessive natural heat exposure. On the left we see deaths caused by heat exposure and on the right, deaths where heat-exposure was a related or a contributing factor. As you can see, the rates of death caused by and related to heat exposure have been rising over the last decade. Remember, as mentioned previously, our estimates of heat-related deaths are likely underestimates.

A study from Maricopa County evaluating death certificate and demographic information provides some insights into heat-associated deaths and highlights some important areas for intervention. One of these is that in the heat-associated deaths that occurred indoors where presence or absence of air conditioning was documented, all deaths occurred in an inadequately cooled space. 21% did not have an air conditioning unit, whereas an average of 99% of homes in the Phoenix metropolitan area contain air conditioning units. Of those that did have air conditioning, 34% were functional but turned off, 53% were non-functioning and 13% had electricity to the residence turned off. Reasons stated for not using functional units included cost of electricity and cost of repairs. These represent important areas of intervention for vulnerable populations. Some have even suggested physician air-conditioner prescription programs for vulnerable patients, such as has been used with some respiratory conditions!



Increased heat has many effects on the body beyond the specific heat illnesses we discussed in the prior lecture in this series. We will now illustrate a few different ways that increased heat exposure can result in chronic conditions or exacerbate underlying disease.

Heat can affect the kidneys through different mechanisms. Acute renal diseases not infrequently accompany heat stroke with two differing patterns of injury. The first is acute tubular injury associated with rhabdomyolysis. The second is a pattern of acute interstitial nephritis, more commonly seen in episodic heatstroke. While these may resolve fully, some do result in chronic renal disease with findings of chronic tubulointerstitial nephritis on biopsy. Much of this data comes from agricultural workers around the world. Also, increases in kidney stones are being seen globally and are thought to be related to increasing temperatures and dehydration. Similarly, urinary tract infections are thought to have a relationship with dehydration and increased temperatures.

Changes in mental health and behavior have shown associations with increasing temperatures as well. The heat stress associated with heat waves has been correlated with increases in mood disorders and anxiety. Increased discomfort leads to more aggressive thoughts and hostility and violence have been shown to increase with heat. Suicide rates have also shown increases with heat. The lack of cooling at nights has been not only associated with increased overall temperatures, but can interfere with sleep and exacerbate physical and psychological effects of heat exposures.

Heat effects on pregnant women have also been seen, with increases in pre-term birth, stillbirth, and low-birth weight. Possible links have also been seen with neural tube defects and congenital heart disease.

Finally, increased heat stress can exacerbate chronic conditions. This has been seen with diabetes, cardiovascular, cerebrovascular, and respiratory diseases. This can occur through multiple mechanisms, including impaired blood flow to the skin, neurologic effects on sweating, inability to increase cardiac output, sensitivity to dehydration, and increases in heat-related inflammation and clotting.

Our final consideration of the effects of heat moves to an area deeply entwined with human health, though frequently not considered by many of us practicing in the medical field in the United States. One Health, for those who are unfamiliar with this term, is the recognition that the health of humans, animals and the environment are interdependent and closely linked. To illustrate this point, let us consider a few ways that heat waves affect animals and the environment and the subsequent effects this has on the health of humans.

Let us start with a look at potential changes in infectious diseases related to heat waves, as infectious diseases in humans are impacted by animals, disease vectors and the environment. We will speak mainly of health effects, but for many of these causes, economic effects are also significant, with their ultimate downstream effects on human health. This is a broad topic and one not easily studied as there are many variables which contribute to infectious diseases, including how extreme events impact infection transmission and the outcome of those infections, prior precipitating climactic events, possible alterations in human immune systems and the ability to respond to infection (including effects from malnutrition), the characteristics of outbreaks, the health of plants and animals, and finally, the level of public health preparedness.

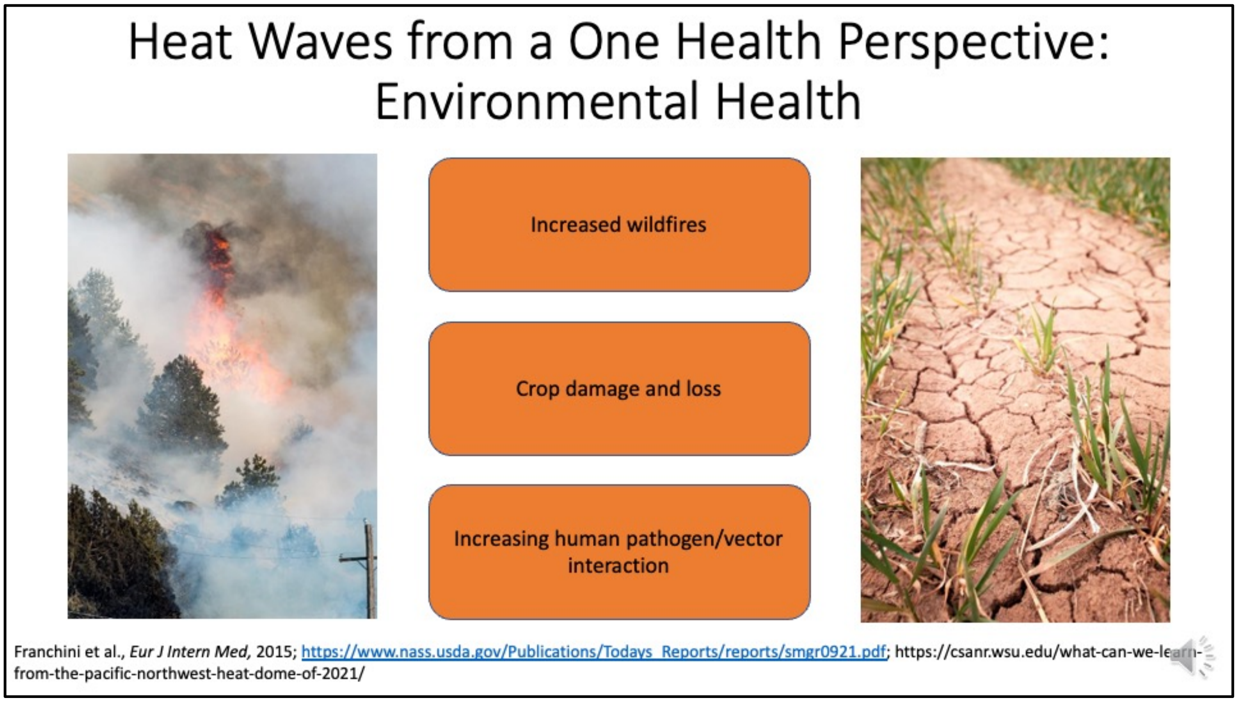
Heat stress may increase the survival and growth of some pathogens or their vectors. For example, increased temperatures increase the replication of West Nile Virus in mosquitoes. In addition, increased temperatures decrease the time interval between mosquito blood meals, shorten the time period from when a mosquito is infected to when it becomes infectious, increase the evolution of viral genotypes and increase the efficiency of viral transmission to birds. A clear association with West Nile Virus outbreaks has been shown following several heat waves. For example, in Israel, a WNV outbreak was seen with a lag of 3-9 weeks following a summer of increased heat and heat waves; similar weather patterns were seen with outbreaks in the Danube Valley, Romania in 1996 and NYC in 1999. Interestingly, AZ had its largest spike of WNV in September 2021 following a heatwave the previous June.

Heatwaves may also change the proximity of humans to disease carrying vectors. Rodents tend to move indoors to seek food and water, thus increasing their interaction with humans and the potential to transmit disease.

Heat stress also affects animals. Increased mortality has been seen in dairy cows, pigs, and poultry, with the mortality frequently increasing with the length of heat waves. Studies have suggested that heat stress results in immune suppression in food-producing animals. Immune suppression facilitates infection and impairs reproductive efficiency and may require increased use of antimicrobials, bringing the potential to increase antimicrobial resistance. Studies have suggested that heat stress decreases immunoglobulins in colostrum of dairy cows with resulting decreased survival and immunization of calves. In addition, decreased lymphocyte function in heat stressed dairy cows carries the potential to bring a decreased response to vaccination and increased vulnerability to pathogens. Consider how these changes in domesticated animals that spend a great deal of time in proximity to humans can affect infectious diseases (not to mention the economic effects of these losses).

Additional considerations for extreme heat, particularly in tropical and less developed countries includes the fact that heat is the largest barrier to use of mosquito-nets overnight, with the potential to aggravate mosquito transmitted illnesses like malaria. Also, heat extremes increase the volume of water needed and in places with limited clean drinking water, need may exceed supply of safe water sources and thus lead to an increase in water-borne diseases.

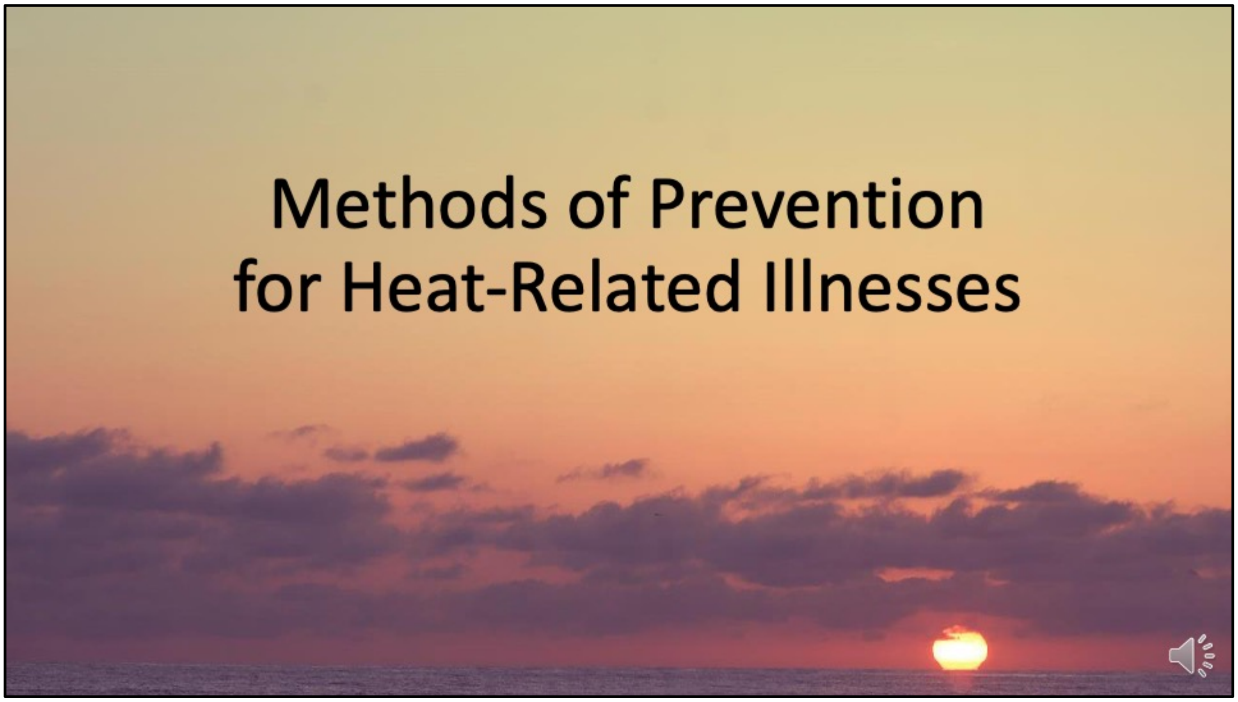
These are but a few examples in an area that is being increasingly studied as we attempt to predict how the changing environment will change patterns of disease.



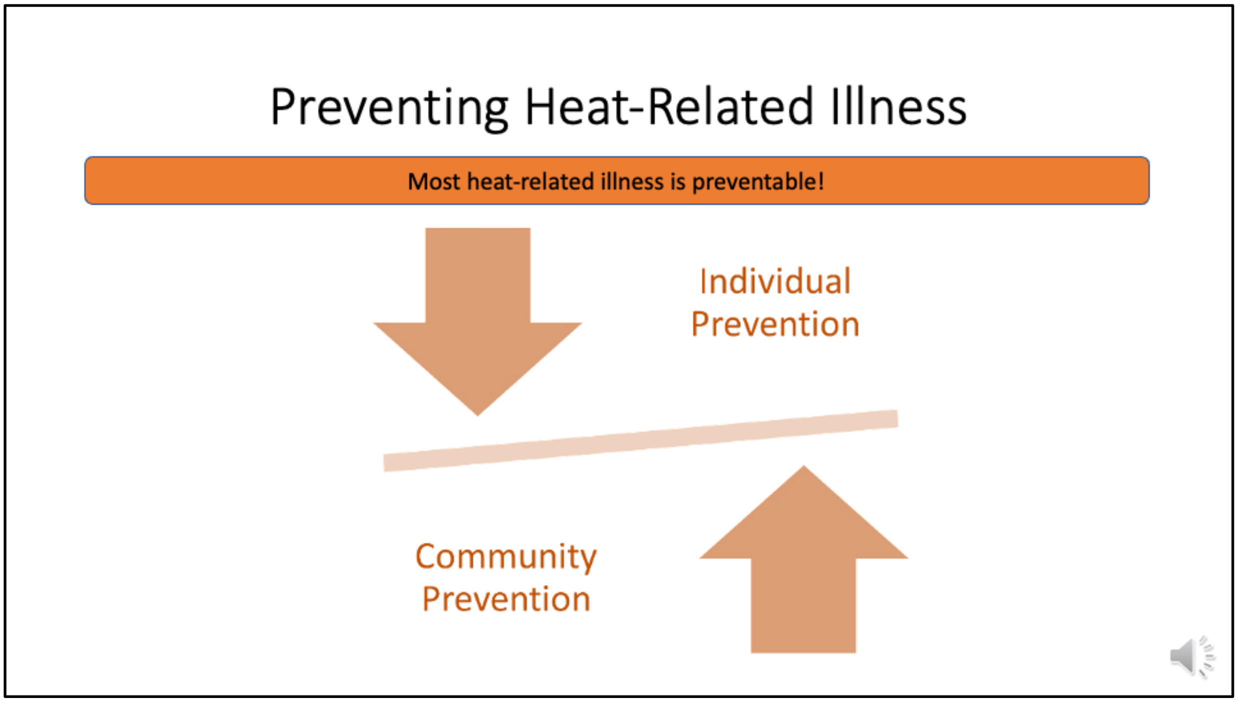
One way in which heat waves affect the environment with subsequent effects on human health is with wildfires. Heat and drought are large contributors to wildfires, which studies have estimated cause as many as 339,000 deaths annually. In addition, emergency room visits and hospitalizations for both respiratory and cardiac causes spike in response to wildfire smoke exposure.

Environmental health, of course, also includes the production of food. We have recently seen examples of how heat waves can drastically affect this. For examples, using the 2021 Pacific Northwest heat wave example again, the total wheat yield for Washington, which was the fourth highest wheat producing state in 2020, fell nearly in half. In addition, the majority of tree fruit and berries comes from the Pacific Northwest and 2021 saw reductions in raspberry, blackberry and blueberry yields, ranging anywhere from 50-100%. We can't talk about food production without discussing the labor involved. When temperatures soar, it becomes unsafe for agricultural workers to be in the fields, with subsequent effects on the growing and harvesting of food. In parts of the world which will be significantly affected by climate change and already suffers from limited food supplies, such as sub-Saharan Africa and South Asia, malnutrition is expected to be a significant problem.

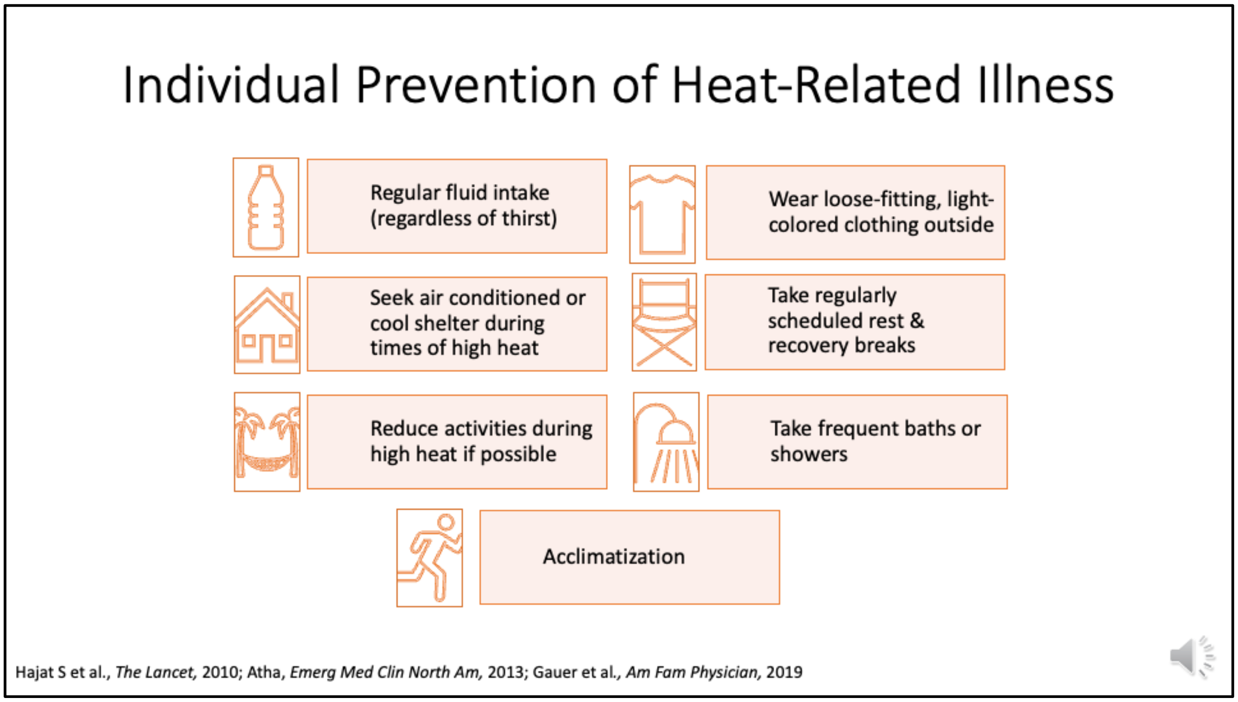
As we discussed in the previous slide, the environmental conditions which accompany heat waves, such a drying water sources, have the potential to increase human exposure to pathogens and vectors. These are but a few examples of ways that the health of the environment can and does affect the health of humans.



In Part 1 of this lecture series, we discussed treatments and various types of cooling methods for heat-related illness. While treatment is feasible in isolated situations where heat-related illness is promptly recognized, during heat waves, if vulnerable populations lack knowledge of or access to preventative measures, hospitals can easily become overwhelmed and lack sufficient resources to provide emergency care to a large number of severely ill individuals. The goal is to move our communities to a resilient position, where plans are in place and resources are available when extreme heat events arise. In this light, we will now move to discuss methods of prevention.

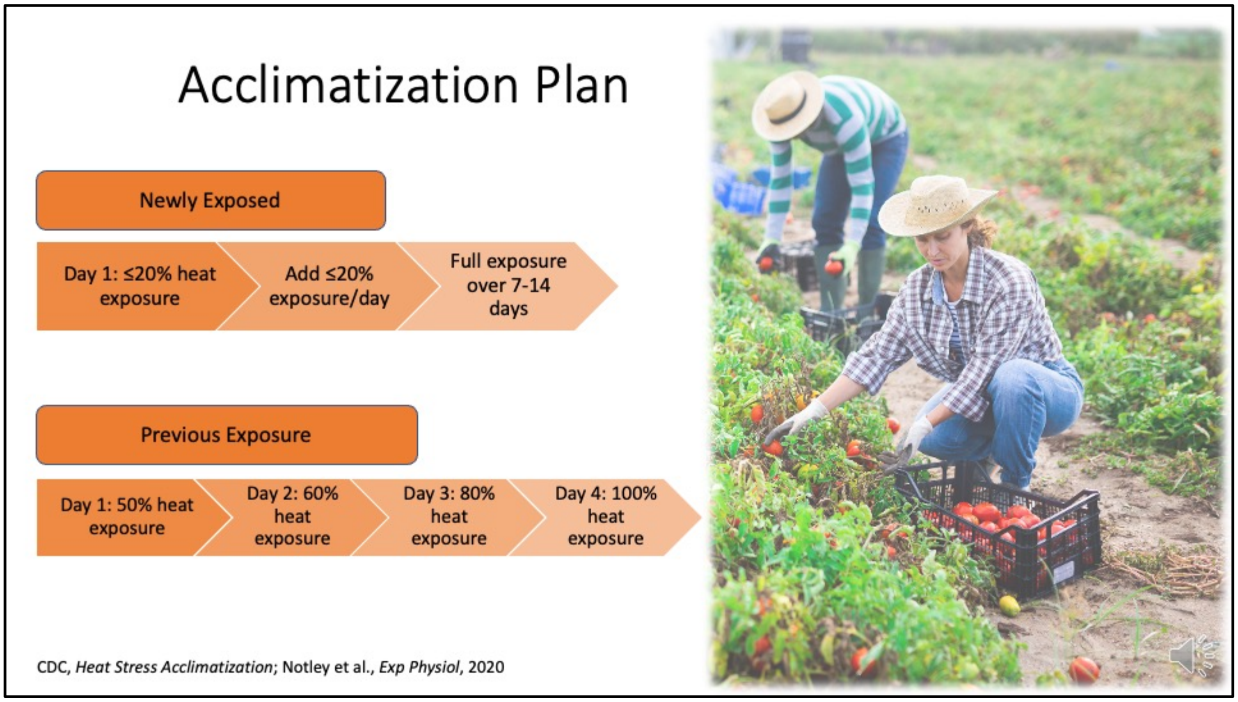


As we begin this discussion of prevention, let us not forget that many heat-related illnesses are entirely preventable when appropriate knowledge and resources are available! Prevention strategies take many forms but can be divided into the methods an individual can perform and the methods that a community can provide. Physicians have a critical role to play in both of these.



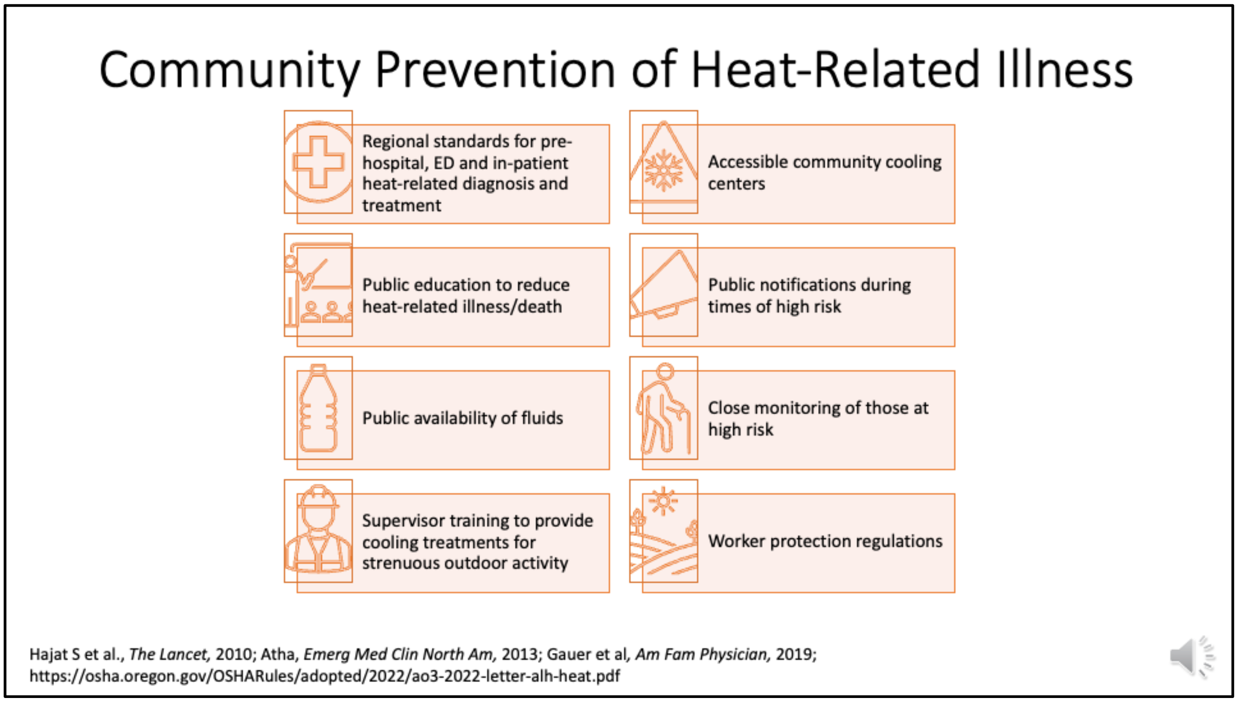
There are many simple ways that individuals can prevent heat-related illness. One of the most important roles a physician can play is educating their patients so that they are aware of when they are at increased risk. We previously discussed biologic risk factors, including age, underlying medical conditions, pregnancy, prescription medications and alcohol and drug use. We also discussed social and environmental risk factors, such as social isolation, occupation and high-risk activities, poverty and low-socioeconomic status and homelessness. Physicians can use this knowledge to thoughtfully inform their patients about their individual vulnerability and particular risk of heat-related illness. They can then advise them in preventative methods and guide them to available resources

These methods include encouraging the following activities during hot times: regular fluid consumption–regardless of thirst (especially in elderly who are prone to losing their thirst alert from hypothalamus), reducing activities, seeking cooled shelter, and taking cooling baths or showers. For those who must work out in the heat, prevention methods include taking regular breaks and wearing loose-fitting, light-colored clothing. As mentioned in Part 1 of the lecture series, physiologic acclimatization can mitigate individual vulnerability to succumbing to heat related illness and following an acclimatization plan, particularly in outdoor workers, can play an important role in prevention.

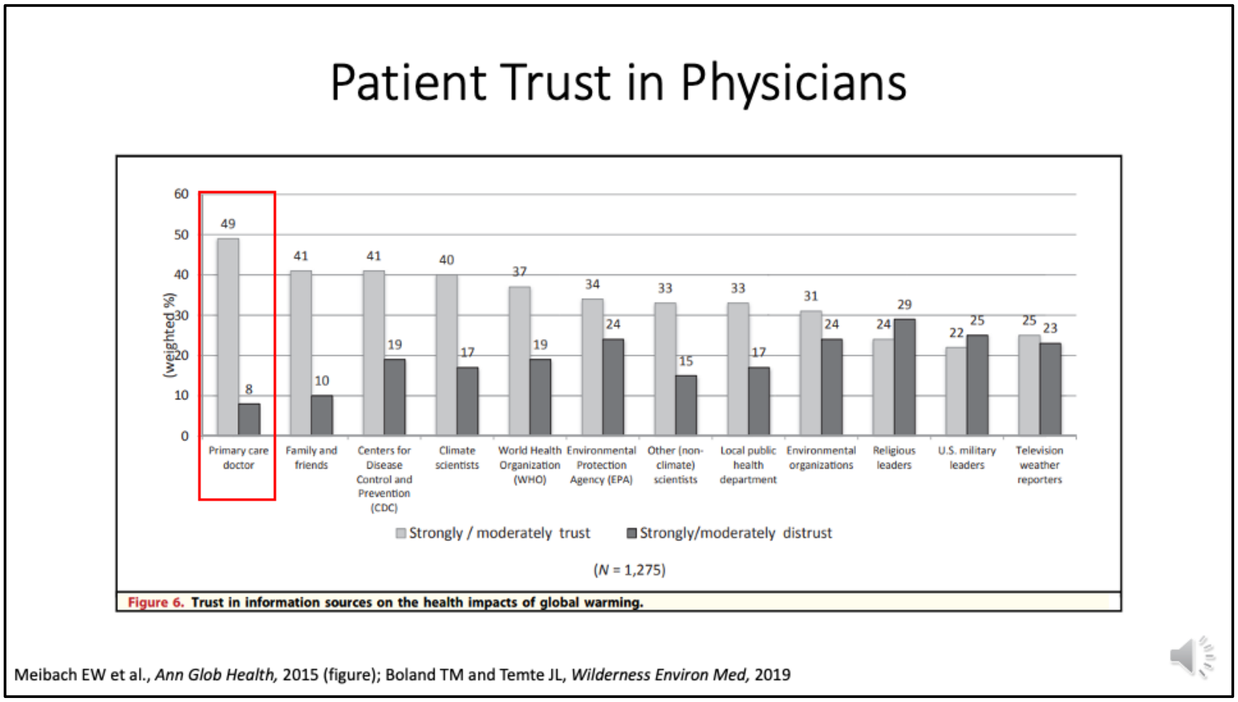


Physiologic acclimatization has been effective in reducing heat-related illnesses in workplace settings in otherwise healthy people. Recall from the previous lecture the ways in which the body acclimates physiologically to heat.

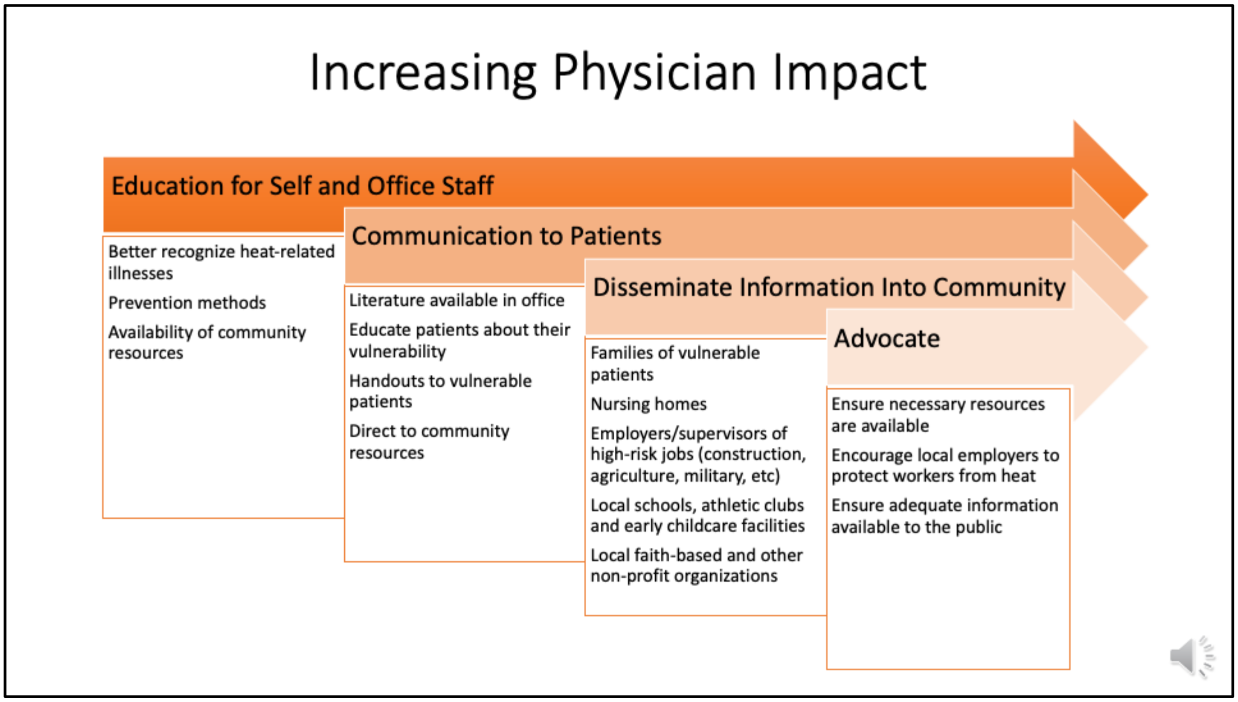
In those with new exposure to heat, gradual increases in daily exposure over 7-14 days are recommended. In those who are re-acclimatizing, exposure can be increased more quickly, over 4 days. When away from similar heat exposures for a week or more, some level of re-acclimatization is typically necessary. Limited data exists suggesting that acclimatization may also be helpful in improving heat response in older patients; however, caution should be used in interpreting these studies. When demographic data was reported, these studies had small sample sizes and selected older patients without chronic medical conditions, who were not taking medications and who were either fit or highly fit. Though this information is interesting, it should not be generalized to all geriatric patients and patients should be cautiously selected for this type of intervention.



There is much that a community can do to prevent heat-related illness. This presents a major opportunity for physicians to save lives on many levels. Having regional standards for the diagnosis and treatment of heat-related illnesses in pre-hospital, emergency department and in-patient settings can reduce morbidity and mortality if heat-related illness occurs. Family members and community groups, such as faith-based and other non-profit organizations and public service agencies can monitor and assist vulnerable people during times of high heat. Community cooling centers and fluids can be made available to those in need. Public education can be provided for how individuals can prevent heat-related illness and public notifications can alert vulnerable people when to prepare and take preventative measures with heat warnings. Workplace and activity supervisors can be trained to recognize early signs of heat stress and provide appropriate cooling treatments. Finally, state laws can protect workers from heat, as has been recently done in Oregon with required breaks from the heat, access to shade, adequate supplies of drinking water, acclimating workers to heat and having heat illness prevention plans in place.



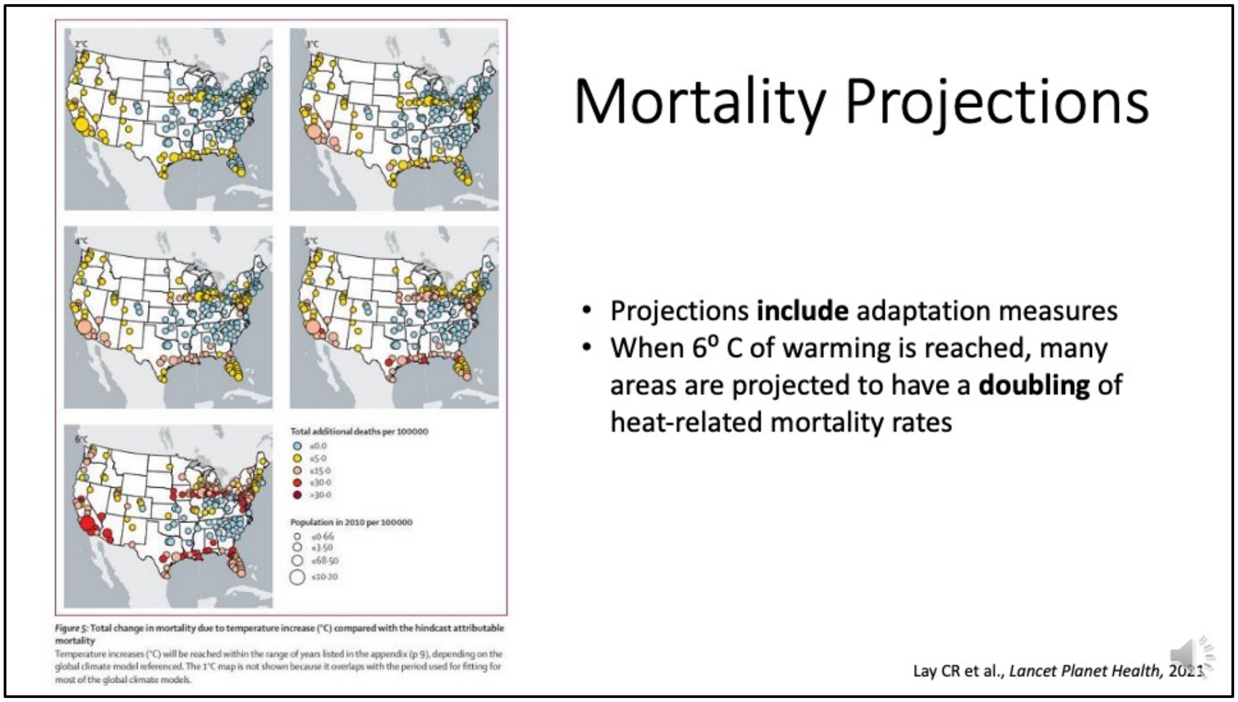
Studies have looked into who people trust for information about the health implications of climate change and environmental issues. As you can see from this chart, the investigators found people reported primary care doctors to be the most trusted source of information on the health impacts of global warming. Another study looked at who patients trust for information regarding environmental issues and the primary sources of information they access. Their data demonstrates that physicians are a highly trusted yet underutilized source of information for patients. These studies both support the notion that physicians are uniquely poised to guide patient and community education regarding heat-related illnesses.



Our final slides will discuss ways that physicians can increase their involvement in prevention with their patients and in their communities. This begins with what you are doing right now, educating yourself. You can be equipped to better recognize and report heat-related illness. Beyond this lecture, you can familiarize yourself with resources available in your community. This knowledge can then be passed along to your office staff and colleagues.

You can directly educate your patients by letting them know when they are vulnerable due to medication, pre-existing condition or age. Preventative handouts can be given or patients can be directed to community resources in times of need. This is especially important for patients who have already experienced a heat-related illness, demonstrating their vulnerability. It is also important to educate families how to monitor and support their vulnerable loved ones during times of high heat. In addition, educating community groups to assist those in need can multiply the impact. Reaching out to local employers in high-risk settings like agricultural work and construction, with information on prevention and warning signs, can prevent heat-related illnesses or decrease morbidity and mortality if it does occur. Working with nursing homes and schools can also help at-risk populations.

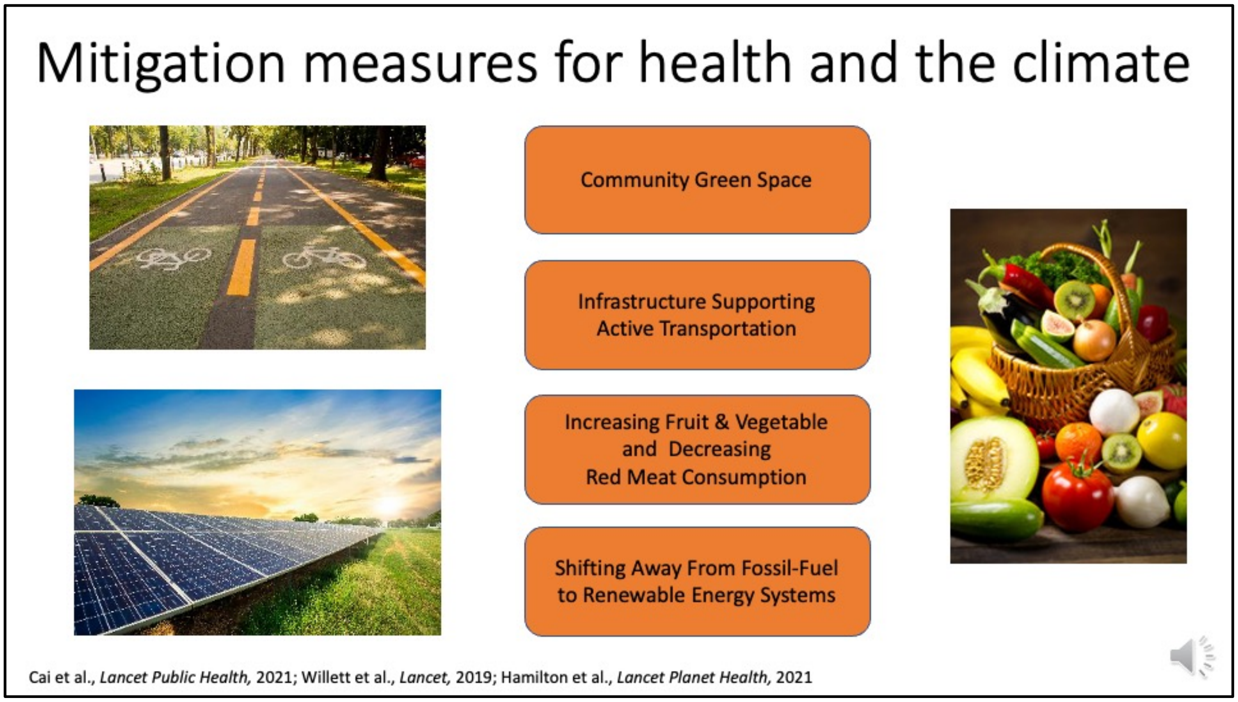
Finally, when you see that local resources are lacking, using your voice to advocate for these can be highly effective both for your patients and all vulnerable members of your community.



Let us now discuss some long-term implications of a warming climate and how it may affect heat-related illnesses. In many parts of the US, various preventative measures have been implemented and effectively decreased the morbidity and mortality from extreme heat. While this is great news, preventative measures alone may not be enough as warming continues.

This study from Lancet Planetary Health illustrates this. They use modeling to make projections about future heat-related mortality, taking into account various methods of adaptation or prevention that are in place. The color of the dots demonstrate how heat-related mortality is projected to increase based on various climate warming scenarios, ranging from 2 to 6 degrees Celsius. Blue dots are regions where there is no change and dark red is the most change, with greater than 30 additional deaths per 100,000 people due to heat. As you can see, with each degree of warming, mortality increases are seen in many regions despite using adaptation methods. When a 6-degree warming is modeled, a doubling of heat-related mortality is seen in many areas.

These models show us that preventative methods will help and are necessary, but there are limits to how much it can mitigate heat-related deaths as warming continues. Additional measures to prevent further climate warming are imperative to prevent increased morbidity and mortality from heat-related illnesses.



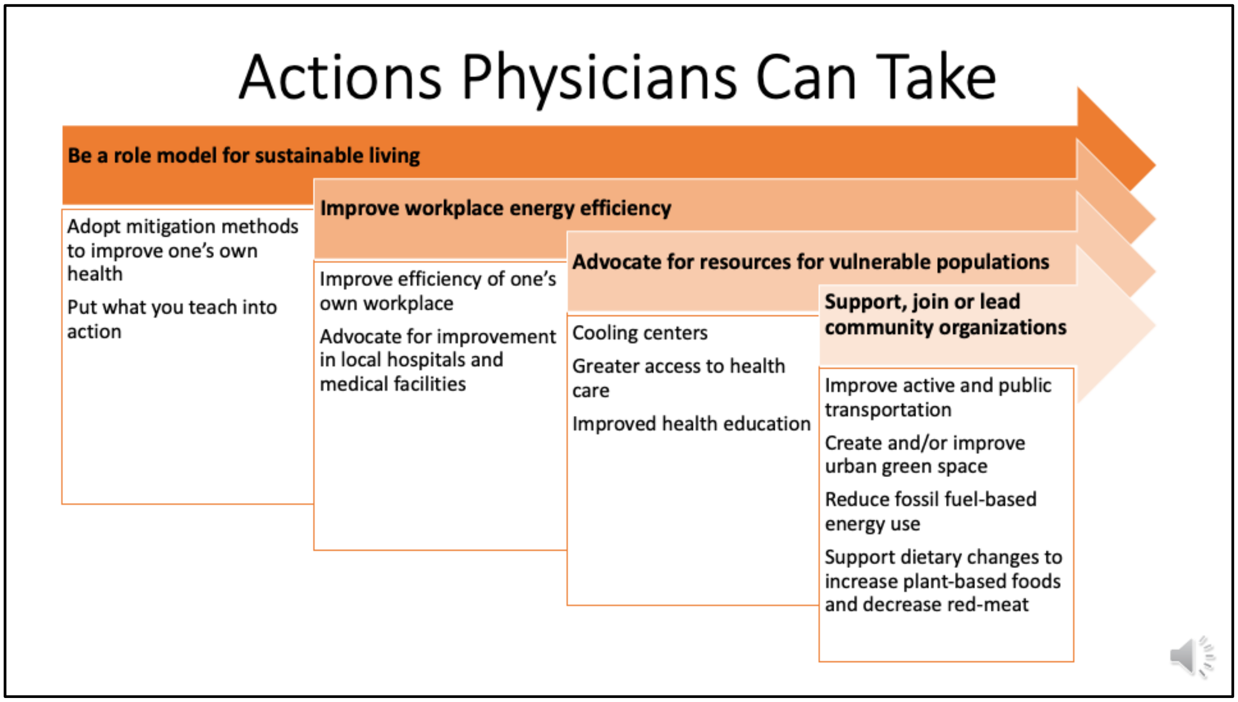
Many opportunities exist for people and communities to make beneficial changes that will improve their health while mitigating climate change. These are sometimes known as "double wins." Physicians can increase their impact on future climate warming and health by supporting and encouraging these types of changes.

For example, increasing well-designed green spaces, or areas that are partially or completely covered with vegetation and/or trees, provides local cooling benefits. This is particularly helpful in low-income areas, which frequently have much less green spaces. The presence of green spaces is associated with reduced exposure to air pollution, stress relief, increased physical activity and increased social interaction. While improving health, green spaces also provide carbon sequestration to help mitigate climate changes.

Another example is community infrastructure that supports active transportation, like walking, bicycling and using public transportation, which is associated with greater levels of physical activity. This decreases carbon emissions, while increasing physical activity and decreasing air pollution exposure.

Making changes in the way we generate energy with a shift to renewable energy systems also provides multiple benefits. Shifts to solar and wind-based methods and avoiding fossil fuel-based ones decrease carbon emissions while also reducing air pollution exposure. Again, these changes are especially important in reducing exposure in low-income areas, where air pollution exposure is greater.

Finally, changes that people make in their diet with reductions in red meat consumption and increases in fruit and vegetable consumption, have been associated with decreases in chronic diseases like obesity, diabetes, coronary heart disease, stroke and cancer. This also significantly reduces agricultural greenhouse gas emissions relating to the production of beef, a significant portion of overall agricultural emissions.



As trusted voices in the community, actions taken by physicians can have significant impact. The skills that you bring to your community extends beyond patient care. The healthy practices you adopt teaches others by example, while improving your own health. Improving the energy efficiency of your workplace and advocating for improvements in facilities you work with, can help bring down the fossil fuel emissions related to health care while also lowering energy costs.

Access to cooling centers, education and to medical care can prevent illness and save lives, yet many in our communities lack access to these. You can be a powerful voice in your community advocating for more resources and better access to them for these vulnerable patients.

Finally, supporting the mitigation methods we discussed on the previous slide, can yield multiplying returns to your community now and for future generations. This can take the form of decreased chronic illness, air pollution, and heat exposure while working toward long-term emission reductions to mitigate changes in climate into the future. Adopting many of these methods are likely to benefit our environmentally and socially vulnerable patients, who often have the greatest exposure to heat and air pollution and the fewest options available to prevent illness. Physicians can and must be a voice for these people. We likely all entered into the practice of medicine to help people and the need and opportunity for physician action has never been greater.

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