



AMERICAN
PSYCHOLOGICAL
ASSOCIATION

ESSENTIAL SCIENCE CONVERSATIONS:

THE EFFECTS OF HEAT AND AIR POLLUTION ON THE BRAIN AND BEHAVIOR (JULY 20, 2023)

TRANSCRIPT

Scott Barstow: Good afternoon. Welcome to today's central science conversations webinar on the effects of heat and air pollution on the brain and behavior. I'm Scott Barstow, and I'm Senior Director of Congressional and Federal Relations in the APA advocacy office, and a member of our internal staff team working on climate change. On behalf of APA and both the Climate Psychiatry Alliance and the Climate Psychology Alliance, thank you so much for joining us. Next slide, please.

Before proceeding further, I need to take a moment to respectfully acknowledge that the ancestral land upon which the APA central office sits in Washington DC is the occupied territory of the Nacotchtank and Piscataway peoples, who were forcibly displaced in the 1600s. That we also recognize or acknowledge the unpaid labor and forced servitude of enslaved Africans and their descendants, and recognize the painful legacies of displacement, slavery, and inequity that continue to persist. This inequity extends to both heat and air pollution. Neighborhoods that were redlined in the 1930s have summer surface temperature profiles that are significantly higher than other neighborhoods.

Across almost all of the 175 largest urbanized areas in the continent of US, people of color face new heat extremes close to 2 1/2 degrees Fahrenheit higher than non-Hispanic whites. While air pollution has decreased substantially over the past decades, thanks to the Clean Air Act, members of racial and ethnic minority groups and low-income communities are still disproportionately impacted. Now, of course, it's coming for all of us. Statistically, about a quarter of you are probably experiencing extreme heat and/or air pollution today.

When we started planning this event with Dr. Robin Cooper months ago, we didn't know much of the US would be in the midst of extreme heat waves, or that wildfire smoke would've blanketed wide swaths of the US, or that there would be simultaneous heat waves occurring in Southern Europe, China, and the Middle East. We didn't know this would happen, but it was a really, really safe bet. In May, the World Meteorological Organization projected that there's this 98% chance, the next five years will be the warmest on record. Burned areas in the US from wildfires have quadrupled over the past four decades. Already this year an area roughly the size of Kentucky has burned in Canada.

I can tell you that inside my apartment at the end of last month, I had levels of fine particulate matter, aka PM2.5, that were two to three times higher than is considered healthy even with the windows closed. Neither the human body nor our infrastructure were built for this, and we're doing it to ourselves. Next slide. Scientists have known this for decades, of course, but the US Global Change Research Program's most recent climate science special report from the Trump administration summarizes this very clearly. Sadly, US greenhouse gas emissions have gone up the last two years since the COVID-19 dip when they need to be dropping rapidly. Every degree counts.

The probability of an extremely hot day at 2 degrees of warming is projected to be almost double that at 1 1/2 degrees of warming. The probability of multiple days or weeks of heated strains is projected to increase at an even faster rate as we go from 1 1/2 to 2 degrees of average warming. A study published in March of last year projected that even under strong mitigation scenarios, increasing wildfires will drive summertime PM2.5 levels in the Western US up by around 50%. We have to act fast. Healthcare professionals are trusted messengers and have a critical role to play in addressing climate change. Psychologists and other mental health professionals have to be part of this.

We're in an all-hands-on-deck situation, and after all the climate changes we're seeing stem from human behavior. Doing justice to the many ways that climate change is affecting our mental health and well-being would require much, much more than an hour. Today, we're only focusing on heat and air pollution. Our goal is to provide you with a solid understanding of their effects to prepare you for talking with patients, friends, colleagues, and with policymakers about the need for action. We urge you to do this. To paraphrase the line from the movie *Fight Club*, the first rule of climate change should be that we talk about climate change. We hope this webinar contributes to that.

With that, let me introduce our two panelists. Joe Taliercio, PhD is the coordinator of research and a licensed staff psychologist at Cognitive and Behavioral Consultants, a large group practice located in the cities of New York and White Plains. He is a member of the Joint Advocacy and Outreach Committee of the Climate Psychiatry and Climate Psychology Alliances of North America and is credentialed as a health service psychologist. Prior to completing his graduate training in psychology, Joe was a certified emergency medical technician.

Dr. Robin Cooper is a psychiatrist in private practice in San Francisco, where she has treated patients for 40 years. She is Associate Clinical Professor in the Department of Psychiatry and Behavioral Sciences at the University of California, San Francisco as voluntary faculty. Since learning about the threats of climate disruption over a decade ago, Dr. Cooper co-founded and is currently president of the Climate Psychiatry Alliance, a national group of over 925 psychiatrists and mental health professionals dedicated to understanding, educating, and advocating about the impacts of climate change on mental health.

Before I turn things over to Joe, a couple of announcements. First, many thanks to those of you who submitted questions for today's program when you registered. We'll try to get to as many of those questions as possible, but hopefully, many of them will be answered by the presentations themselves. You can also ask a question as the program is taking place here in real time. There is a Q&A feature on the dashboard, please feel free to enter your questions there. Finally, this program is being recorded, so everyone who registered will receive an email in two to four weeks with a link to the recording. We'll also post a link to the recording on our central science webpage. With that, let me turn it over to Joe.

Dr. Joseph Taliercio: Thank you, Scott. Hi, everybody. Thank you for having me. I'm here to present on the impacts of heat. If we look at our window, I'm sure we're all very familiar with some of those things now. I want to talk specifically about the impacts we'll have on our mental health, which is something we don't often consider. If we go to the next slide, please. Just first off, I have no conflicts of interest to disclose. Next, please. Just an outline of what we'll be talking about today. First, we're going to talk about why we have to have this conversation now. Then we'll talk about the direct impacts of both mental health and cognitive functioning.

We'll talk about what is happening below the surface? Why is our brains acting this way when we experience extreme heat? We'll also consider the systematic effects that are created in our

environment that contribute to the worsening of these effects. Finally, we'll end on a little bit happier note, I don't want it to all be dark, and we'll talk about some ways we can maybe get out of this. Next, please. I want to start by actually sharing with everybody some of my vacation plans from the past two years. I promise, I have a purpose for this. Two years ago, my wife and I, we visited Hawaii. We visited a friend who's actually finishing their postdoc.

It was a wonderful time except it was hotter than anyone had anticipated. If you can just go to the next image, please. This is actually the temperature from the week we were there. You can see that top line in that bar represents what the temperature actually was versus what it was supposed to be the second line. It was about 10 degrees warmer. In talking with someone who lived there, talking with a taxicab driver, actually, they had said that the wind had stopped flowing across the island. I was in Honolulu at the time throughout that week. Nobody in Honolulu, or very few actually have air conditioning because they rely on the natural cooling that is typically present.

A really highlighted is the impact that if we can't rely on these natural cooling processes, people are going to suffer. Next slide, please, or next image. This is a weather map from last year. My wife and I had our delayed honeymoon in New York last year. When we were there, was this unprecedented heat wave, some of you might recall this. It was so hot that on our train ride from Munich, or Berlin to Munich, we were stuck for four hours because the electrical equipment of the train melted in the heat. Shortly after this image was taken, two weeks later, I have a friend who lives in London, and he sent me a photo of the London skyline on fire. They are not used to heat. Those buildings actually, some of them spontaneously combusted. The fire department had not been that active since the Nazi Blitz of London during World War II. Just one more trip that I took just two months ago at this point. Next image, please. My wife and I had the opportunity to travel to South Korea and Japan. During this time, the temperature was supposed to be in the mid-70s, and we were closer to 100. At that time, Japan had experienced the earliest waves, excuse me, ever on record.

I'm sharing these stories, not to highlight my travels, but to highlight that there's something significantly happening across the world. We can no longer rely on our typical natural cooling processes. We're seeing stronger heat waves than ever before, and we're seeing them earlier than ever before. Next slide, please. When I started prepping for this presentation a few months ago, *The New York Times* actually just came out with this article entitled, *Heat Will Likely Soar to Record Levels in Next 5 Years, New Analysis Shows*. This was actually based on analysis by the UN. At the time, that report had said in the next five years, we were going to violate or agreed upon a restriction of 1.5 degrees Celsius, and we were probably going to experience a one in five chance of the hottest year ever on record. Now, this article came out two months ago, it is outdated. For people who are following the news closely, the start of July, multiple days in a row consistently passed the hottest days ever recorded on Earth.

Looking at the news, you will see 150 degrees currently in the Middle East, 130, 140 in California. Phoenix just had its 20th consecutive day of 110 degrees or more. This is two months old this report, and it's already outdated, really highlighting the severity of what is going on today. Next slide, please. This isn't just a new thing. In reality, if we look at temperatures in the US, they have been steadily increasing since the 1970s in almost the majority of the country, with a little exception in the center of the US. Next slide, please. Even before this sudden increase of heat waves that we're seeing this summer, I really want to hammer home how serious this is.

This is a chart of US-related deaths due to weather. The middle red bar represents death by heat. That is so much higher than anything else. This is before the unprecedented heat waves we're experiencing this summer, just to highlight how serious this can be. Next slide, please. I know

we're going to be talking about mental health, but just physical health. Some of us, unfortunately, might have some experience with things like sunburn, heat cramps, heat exhaustion, heat stroke. These are going to become more common. Heat-related illness already costs the United States \$1 billion each year in damages. *The New York Times* article really did highlight the physical health impacts.

However, it did fail to recognize the mental health impact, which many reports on climate do actually miss out on. That's what I want to focus on right now. Next slide, please. Simply put, heat makes mental health worse. For those who have psychiatric diagnoses, heat is going to make things worse. Substance use tends to increase, psychosis poses symptoms tend to increase, depression, anxiety. If somebody has bipolar disorder, elevated heat actually increases the chances of a switch. Someone might go from a depressive episode to a manic episode, or manic to depressive. Across the board, psychiatric conditions get worse in extreme heat.

There was a recent report out of South Korea that found 15% of all psychiatric ER visits in that country were attributed to increased heat. 15%, that's pretty significant. Unfortunately, not just the impact of the psychiatric functioning, but there seems to be this link with mortality and those with psychiatric diagnoses. For every degree Celsius or 1.7 degrees Fahrenheit that the temperature increases, there is as much as a 2.2% increase of mortality. This isn't just sticking to people with psychiatric conditions are suffering more and more. We're also actually seeing increased death rates, unfortunately.

Even for those who do not have any prior psychiatric conditions, mood is significantly impacted by heat. There was a very interesting study looking at Facebook posts. They found that in areas where the temperature went above just 70 degrees, we're talking about 110, 120, 130 right now, 150 in some parts of the world, above 70 degrees, we are seeing people were posting less positive messages and posts on Facebook. They were posting more about negative emotions, they were posting about how tired they were, and how fatigued they were.

This just highlights that we were seeing these negative impacts at 70 degrees, what is going to happen when we're climbing up to past 100 degrees? Next slide, please. A few people had posted some questions earlier about this potential connection with heat, and anger, and aggression, and it's absolutely true. It is very well documented that as heat increases, anger increases, and thereby aggression. There's a direct relationship here. As heat increases, we're more likely to have aggressive urges, we're going to be less inhibited, and we will be more likely to act out on our aggressive thoughts.

However, something that we often don't consider is indirect impact as well. As heat rises, we are going to see increased famine, increased drought, and there's going to be a lack of resources. Humans, one thing we can count on is when we are pushed to the edge, we attack, we push back. This leads to increased fighting; this leads to in-group-out-group biases. People are coming to steal my resources, I got to protect myself from those. Now, couple this with the fact that people flee. People cannot stay where they are living if the temperatures get too hot. This causes mass migration.

Now, couple mass migration with in-group-out-group bias, we're seeing increases of xenophobia. We see hatred, we see just full-on anger against groups of people. Even taking this one step further, terrorism has been linked with the effects of heat. People are pushed so far, people are struggling with resources, people have turned to terrorism. The sudden rise of ISIS partially has been linked to increased drought and famine in the Middle East. We are seeing very, very drastic impacts here.

Next slide, please. This impact has been observed in naturalistic studies. It was noticed that on hot evenings, police officers are significantly more likely to draw their weapons in the line of duty. We also know that this aggression could be triggered in experimental studies. Simply having people imagine being hot and uncomfortable, increases their tendency to view neutral stimuli as aggressive stimuli. There are some estimates that say for every degree Celsius that increases, there's as much as 6% more homicides or 25,000 more violent assaults a year. Those are drastic numbers. If we can just forward it one bullet point, please. Unfortunately, this form of aggression also applies to individuals. Suicide is known to increase as temperature increases. People who are contemplating suicide are already suffering, already struggling, now throw the inability to escape the heat.

Physical suffering is exasperated, and suicide increases. The exact estimates vary, but it can be as high as 4% increase for suicide for every degree Celsius that increases. There was actually a very large study looking at a heat wave that struck England in 1995. It was a month-long, and they found during that month in that country, 50% increase in suicide. Really substantial numbers that we have to start to think about. Could we go to the next slide, please. Shifting away from psychiatric diagnoses in particular, we know that there is significant cognitive impairment as heat increases.

We know that people are more likely to be impulsive. They are more likely to make errors, engage in unsafe behaviors, have decreased tracking and scanning abilities. They're less likely to pick out details. They are going to have impaired working memory. We actually know many work-related accidents do occur when it is hotter out. There have been attempts to try to study this. We can see that there are actually changes in someone's frontal and occipital parietal lobes as heat increases. There are physical parts of the brain that turn on and turn off as heat increases.

I want to use this as a jumping-off point to make the bigger questions of why is heat impacting our mental health at all? Could we go to the next slide, please. Really, there are plenty of theories out there. In reality, as the rule general for psychology is, if there's multiple theories, maybe the answer is somewhere a combination of them all. Biologically, let's just start with that. When it gets hotter, our body is able to cool down. We sweat, we change our breathing rate. However, when temperature goes above 104 degrees, our body actually needs to use more energy to help it cool down.

The problem is if it's 105 degrees, we are therefore using some of the energy that we might typically be using to regulate our emotions, we're using that to cool down. Our body actually start to divert that energy that we typically use to self-regulate to help our body from becoming overheating. Some other theories that are proposed, popular one is the temperature aggression hypothesis. It's this idea that as temperature increases, we become more uncomfortable, we are more primed towards aggressive behaviors, and we're more likely to follow aggressive-related scripts.

The routines activities theory, is one I actually personally I find very interesting. Simply just think, when it is cold out where we typically are, we stay inside, we stay warm, maybe some hot chocolate, tea, coffee. When it is hotter out, we're actually going to be surrounded by more people. We go to beaches, parks, we might drink in public. There are simply more opportunities to have aggressive experiences and encounters. Sleep also plays a significant role here. Human body prefers sleeping around 60 degrees. As we sleep, the temperature in our body actually increases, which is why we might wake up in the middle of night sweating when we were actually comfortable when we went to sleep. The problem is, if we're talking about hot nights, we're going to be woken up sweating over and over and over again. We're going to get really poor-quality

sleep. We know when sleep quality is down, we're more likely to experience more intense emotions. Hydration also plays a role here. When we sweat, it's a natural way to cool down, which is great. However, we lose essential nutrients there. We typically think of things like vitamin D and C is good for our physical health, but every nutrient plays a role with our mental health. D plays a role in combating depression; vitamin B helps us combat stress.

If we're actually sweating, we are losing essential nutrients that help us regulate ourselves. Another theory that commonly pops up here is inflammation. We now know the human brain becomes physically inflamed when experiencing psychological stresses. This is why something like Motrin can actually help somebody with social anxiety. However, if a brain is already inflamed and stressed due to psychological stressors, throwing additional heat is not going to necessarily be helpful for that. You're going to over-strain the brain. Next slide, please. I want us to recognize that there's more factors here. The way our society is set up creates systematic problems that exasperate the problems of heat.

If you can forward to the first bullet point, and the first thing is geography. Now, I know there are people from literally all around the world who came onto this call. However, I want to focus on just the US for a moment. When heat increases, everyone is impacted, we see aggression across the board. However, the aggression is significantly elevated in southern US states. Now, there can be a number of reasons there. Easier access to weapons, cultural violence, a need to defend yourself, thus, exact reasons are uncertain. However, the impact of aggression or the relation between aggression and heat is far more tangible in southern US states.

Next bullet point, please. We also know the crowding effect plays a role here. Taking away heat for a moment. When humans feel crowded, when we're surrounded by more people, we have less space, we feel aggressive. We more are likely to act out on the urges, we have trouble inhibiting our emotions. Think about crowding effects in a very crowded city that is hot. I live in New York City, very crowded city, experiencing really hot summer. We're going to have exasperated effects of heat on mental health here. Next bullet point, please. We also have this thing called the heat island effect to consider.

The heat island effect is this tendency that downtown areas tend to be significantly hotter than non-downtown areas of cities. It can be as high as 7 degrees Celsius or 13 degrees Fahrenheit in downtown areas versus just outside of that downtown area. If you can go to the next slide for a moment, I have an image of how this looks. Nighttime, we also see the heat island effect a little to a lesser degree. As we move away from downtown area, the temperature decreases. I live not far from Central Park in New York City. On a summer night, if I'm walking from Times Square or Hell's Kitchen where it's really condensed, and as I walk up, you do feel a very significant drop in temperature.

Recognizing certain areas of cities, therefore are going to experience the impact of heat much more so than other areas. We go to the next slide. I also want us to consider the role of psychiatric medications. One in six Americans are on some form of psychiatric medication. However, many of us fail to recognize that psychiatric medications disrupt our ability to handle heat. The exact mechanism varies, but these drugs impact our parasympathetic and sympathetic nervous system, which are also our body's way to cool and heat up our body.

If we go to the next slide, I have a way this breaks down. Just very generally, there are significant impacts from it.

We can see all different classifications, but let's just stick with SSRIs. Very common antidepressants, stuff like Zoloft. Somebody take an SSRI will have a decreased tolerance to heat. Meaning, they'll feel the impacts of it more. They will have hypotension, which on paper sounds great why we always talk about wanting a lower blood pressure. However, this is not great for heat. If we have hypotension, we have less blood flow, there's less pressure circulating the blood in our body. That circulation is how our body cools down. Actually, hypotension in the heat is actually really problematic. It causes the heat to stay trapped in us, which causes more damage.

Someone taking SSRI might also have increased chance of fainting from the heat, might have excessive sweating. Thinking back to the nutrients we talked about, we need all those nutrients to regulate. We'll also see impact of someone's cognitive functioning confusion with it. We have to recognize that if one in six people are taking these medications, there's going to be a significant impact that maybe they don't even realize is happening to them. Next slide, please. Scott, brought this up a little bit earlier, but we also have to recognize that people from lower SES classes, lower socioeconomic classes, are also more susceptible to the heat. They'll be able to less likely to afford things like air condition.

They have less likely access to parks, pools, these natural cooling properties. They're also most likely to be living in older buildings. Older buildings were built with heavier material, which traps the heat. Scott, you brought up redlined districts. We know redlined districts are significantly, significantly hotter than non-redlined districts. One study estimates that they're 94% hotter than non-redlined districts. There's this cyclic pattern that we have to consider here. Sorry, I bring this all up just to recognize we talk about heat, you also have to consider all these other factors that are going on.

Next slide, please. What do we do about this? Listen, we're here to educate, to inform, but also to help us shift forward because there are some things we can do. First off, we go to the first bullet, please, is we can focus on ourselves. The very severe impacts such as the 150 degrees, we're going to be limited to what we can do for ourselves in those moments. However, wearing light and loose clothing, it's going to be helpful here. Staying hydrated, lowering the shades. If you have to go out, reducing your exposure to the sun and the heat as much as you can, going out earlier in the morning, or later in the day.

If you have to exercise outside restricting exercise to those windows. I want to also highlight, and I have a picture of a fan here. Fans can be helpful, but only to a degree. If the temperature is hotter outside than is your internal body temperature, so 97, 98, 96, depending on the individual, do not use a fan. Fans do not cool us down, they just push hot air around. If it's 100 degrees and you're using a fan, you're actually pushing 100-degree temperature directly onto you. That's actually going to increase your discomfort, and it's going to increase your internal heat.

Next point, please. We also have to think of big picture changes. We can create some systematic changes here. Planting more trees, very helpful. Natural cooling process. That is why in New York, for example, the area surrounding Central Park is significantly cooler. The park does act as a natural air conditioner. We could reconstruct rooftops to make them more green, planting trees and grass. There are building materials that do a better job reflecting the sunlight back and reflecting the heat back, rather than holding onto them. Even the way buildings are built. Buildings are typically established in a north, south, east, west angle. If we angle them at 45 degrees, we can create natural shade.

Next point, please. We also can get educated. Every single one of you here are here learning. Now, we have to have a discussion about that. Keep this conversation going. Let more people recognize

the impacts that are here, and the resources that are available. Next bullet, please. We also have to integrate this for those of us who are clinicians into the grace into clinical work. Recognizing the impacts that are impacting our patients, while also recognizing the impact that might have on our own work. We are not immortal or completely protected against these factors too.

Finally, one last point before I turn it over, also get political. Listen, I know all this stuff is to some people do not like talking about climate change, people refute it, and we need to be more vocal about this. We need to create some systematic changes on a legal level. I know I'm going to turn it over, but I just want to go to the next slide is just my contact information. People can reach out to me with any questions and references. I think we'll come back for questions in just a little bit. Thank you.

Dr. Robin Cooper: Joe, that was absolutely incredible. I'm going to jump in right away to presenting on what I'm going to be talking about today and add to this huge body of information that you've just presented on heat. I'm going to shift to the psychiatric, and brain, and emotional impacts of air pollution. I just want to recognize how enthusiastic this audience has already been in submitting questions, and I've tried to integrate some of those questions that we got ahead of time into my slides.

Next slide, please. For air pollution, air pollution is considered such a threat to mortality. 7 million people die prematurely, annually. Air pollution is considered one of the greatest environmental catastrophes in the world today. These rivals, what Joe has already pointed out in his talk about heat. Next slide, please. Despite the broad awareness that air pollution has significant impacts on pulmonary and cardiovascular health and is a leading cause of illness and death worldwide, there's recognition of the significant impacts on the brain and neuropsychiatric functioning of air pollution.

There's developing current information about the role of particulate matter exposure on the wide range of neurodevelopment and neurodegenerative illnesses, cognitive function, and even mood impacts. Now, although the science on this is in the very earliest stages, much earlier than our understanding of pulmonary and cardiovascular impacts, we are seeing new information at a rapid pace indicating serious concern about the impacts of air pollution on human behavior, brain function, and mental health.

Now, I'm going to take my psychiatric prerogative as a mental health expert and toggle back and forth. Some folks will say it's all about feelings. Others, it's all about the brain. Well, I'm going to say no, it's both. I'm going to toggle back and forth between those two and walk that tightrope as we look at this more fully. Next slide. I want to connect the talk that Joe has given about heat with the one that I'm going to look at more fully on air pollution. Heat and air pollution add together in our multipliers and make things much worse. Next slide.

Now, we know that heat and sunlight has an impact on the pollutants that are already in the air, causing a chemical reaction that-- Oh, I'm so sorry. I just noticed you couldn't see me. Sorry, not that my presence in a picture is all that important, but I want to go back to where I was. Heat has an important impact on changing the chemical composition to the air pollutants that already exist, and then creating more air pollution through ozone and smog. What Joe has already laid out and the air pollutants that I'm going to talk about have an integral additive impact together. Next slide.

What we're all experiencing, many of us, is that smoke, wildfire smoke that's being generated in these huge fires related to climate change in Canada have been moving across large swaths of areas in the United States, causing massive air pollution from wildfires. Actually, in those earliest weeks

of this fire, the air pollution in New York City, where Joe lives, was the worst in the entire nation. Next slide.

Air pollution is not only created by wildfires, what we're all in a tizzy about at this moment. Air pollution is contributed by things that we do. It is human caused largely. Scott has already mentioned that in the introduction. This slide just gives us an overview of those significant areas. That gives us a tool for where we can intervene. Oil production, transportation, agriculture, processing of industrial materials. Next slide.

Now, I'm going to shift to us looking at these issues in air pollution, particularly. Size matters when it comes to air pollution. This slide indicates that the size of air pollutants has a direct impact on where in the body these air pollutants will travel. It is not just the particular chemical composition of an air pollutant, things that we call criteria pollutants: ozone, nitrous oxide, carbon dioxide, carbon monoxide, sulfur dioxide, lead, et cetera. These particles have access to the brain through circulating through the blood system and then crossing the blood-brain barrier, breaks there. I'm going to be looking particularly at this area, those tiny ones, ultrafine particles. Next slide, please.

Now, a bit more science about this, about how air pollutants directly impact the brain. There is direct access not through just our breathing, through the olfactory nose and the epithelial lining of our nasal passages where these tiny particles can directly be brought into the brain. The access of the brain's impact from air pollution is both this direct breathing and breathing through the lungs and then through our vascular system. Just breathing, that essence of life, brings these particles into our brains. Next slide.

This is a picture of the size and relational size between the various air pollutants. As I said, we measured those by size. These ultrafine particles so, so tiny, also called nanoparticles, are those that we're referring to about that access to the brain. There are 500 ultrafine particles just in the diameter of a human hair. These are the ones that we need to be concerned about. 2.5, 10 particulate matter have regulatory controls that are somewhat useful, not completely. There are absolutely no regulations for ultrafine particle exposure. Next slide.

This is just an electron microscope picture of those ultrafine particles. For those who can see this, who understand the way to look at this, they can see that these ultrafine particles which have high surface charge, clump together and cause a really sticky, gooey muck. These are the things that get into our brains, next slide, cause significant damage. I'm just going to briefly talk here about the mechanism by which these particles cause damage in the brain. These are inflammatory processes causing what we say are neuroinflammation in the material in our brains.

One of those processes is what we call cytokine reactions. Cytokines are protein cells that are activated to regulate our immune and inflammatory response. In these situations, those cytokine reactions that can be helpful in other areas are on overdrive, what we call cytokine storm. This, combined with a mechanism of oxidative stress, oxidative where molecules are very unstable, we call those free radicals, can lead then to cell tissue damage and even death. These are the mechanisms by which those tiny, yucky, mucky particles can actually impact our brains. Next slide, please.

Now, air pollution is both a climate change, acute disaster, aggravating climate change, and also drives some of the-- It creates these damages in our brain. The exposure to air pollution is particularly concerning for those with respiratory distress and asthma, as well as the medically ill elderly and children. I'm going to talk more about the impacts of this. Next slide.

Those damaged parts of the brain or air pollution can cause illness and contribute, not causative, but additive to both physical illness and the neuropsychiatric disorders. Those are listed on the right side of this slide with intrauterine growth retardation in fetal development, premature birth, developmental delays, ADHD. I'm going to look at these a little bit more so I'm going to move along to the next slide.

I am particularly concerned about the impact on the developing fetus and children since impacts at these crucial early stages of development have long-lasting impacts across the entire lifelong functioning. Children are uniquely vulnerable with breathing faster, their lungs take in more air. They are outside more. Their bodies are not developed with the appropriate needs to protect. Air pollution has a range of very profound impacts on fetal development and on children, autism impaired IQ, lower developmental delays, and even anxiety and depression. Next slide.

At the other end of the life spectrum, the elderly, it's increasingly clear that air pollution is a significant factor to neurodegenerative processes of aging, particularly Alzheimer's disease, Parkinson's. There is a two to fourfold higher rate in dementia, particularly for women. Next slide. What about feelings? Now, this is an area that's much more difficult to evaluate and study, but there is new information that air pollution has an impact on those states of feeling.

With greater anxiety and depression, increases in general distress particularly when we are associated with those acute exposures and events. We know that there are higher rates of hospitalization and emergency room visits during periods of extreme air pollution exposure. Next slide, please. There are hypotheses that are based in the biology of how our brain works. The serotonin impacts that likely-- the damage done by that neuroinflammation has impacts on this vital neurotransmitter. I'm going to move more quickly since I want to have time to talk with you more. Next slide.

These are both short-term and long-term exposures. The short-term exposures listed on the left are those mood changes and anxiety, the trigger of psychotic events, attention, learning trouble. Children do not learn well, and we do not think well with exposures to acute air pollution. The longer-term impacts with sustained exposure to air pollution has significant brain impacts. Next slide.

Now, Scott already mentioned this, but it needs to be said over and over. There are inequities, and although people of color bear the greatest burden of air pollution impacts and have much greater and significant impacts than those who come from more wealthy communities and those who are not from people of color. Scott also mentioned that about heat also. White Americans have a pollution advantage, and Blacks and Latinos have a pollution burden that is greater than White populations.

The next slide represents just another way of us looking at this same information. Next slide, please. Again, the same information. People of color bear the greatest burden and have the greatest exposure to all forms of air pollution and Blacks have the most. Next slide. I just want to rehash this very quickly. The overview of climate change has impacts and there are multiple risk factors with implications for brain diseases. Those have multiple direct impacts and exposures with serious impacts on many functions, including physical and psychological stress. Next slide.

This is not an act of God. This is what we have done, and that means there are things that we can do. Next slide. I'm showing you this particular article because it's scientific in the scientific literature, but rarely do these scientific papers end with this kind of quote. Solutions have to come from official policies and politics. That means we need to be engaged in what we do. Next slide. I

am going to stop at this in just a moment, but let you know the next several slides have ways for intervening, both in advocacy, which is essential. I will tell you, I met Scott when we both attend the American Lung Association weekly meetings where advocacy is the core issue on air pollution. Next slide.

I also want you to know that there are ways that we can mitigate the impacts individually. I want to have you see this link, which is on my website [@climatepsychiatry.org](https://climatepsychiatry.org), about ways to individually protect yourself. Next slide. Those are outlined in this slide and the next one, and these slides are available to you. I think it's time for us to turn it over. Next slide. Some ways to manage the anxiety about it. Next slide.

You have access to my references. Let's move through this. You can get those through the resources after. Next slide. I will turn this over back to Scott so that we can engage in a discussion together about these topics. I hope you're not too freaked out, but enough so that you will engage in that activism work.

Scott Barstow: Thank you very much, Robin and Joe. That was excellent. Lots and lots of really good information. There have been some questions posted in the chat. I suspect we might get others here, but a couple that I wanted to ask to start out with. One is whether or not there's a difference between indoor and outdoor air pollution. That might be more of a question for you, Robin, and also any considerations regarding exercise and air pollution specifically, or heat? I'll throw that to both of you.

Dr. Robin Cooper: Let's just start with the easy one. Exercise. Heat and air pollution have an impact on our physical capacity for exercise. When it is very hot or when there is significant air pollution, those are times that we have to curtail our ability to exercise. That's a problem because exercise is also one of the ways that we modulate and contain some of our anxiety and of course, for children, children need to be outside playing. Both extreme heat and air pollution limits that ability. We do need to toggle down our exercise during these extreme periods, but it is at a cost.

One of the vulnerable populations, of course, for air pollution and heat are youth athletes. I want to underscore that. The issue of indoor air pollution versus outdoor air pollution, I'll shift to that, is a really complex one. We could talk, we could have a whole seminar on that alone. One of the things that Scott and I have had some conversations with at the American Lung Association is the active work that is being done to create regulations and some policies around indoor air pollutants.

One of the groups that's leading on some of this is Physicians for Social Responsibility. One of the things that they're wanting to do is look at air pollution as an indoor air pollution, where we create difficulties in our environments indoors through gas stoves and appliances in our homes. Think about indoor air pollution as either what we bring in from the outside or what we create within our homes.

Those can be, as I said indoor air pollutants can be those appliances in our homes, asbestos, carbon monoxide, lead paint. In regard to our conversation today, some of those things that contribute to climate change, like using fossil fuels, and the appliances that we use in our homes are also contributors to health impacts on indoor air pollution. Then at the other end, we're freaked out about this, these smoke impacts that are coming from Canada. When there are cracks or leaks in our homes that bring in that air pollution from the outside, we now have situations in our homes that can get worse. Scott also already told us about how he saw the increase in air pollutants in his register during these periods.

It's complicated because if we seal up those areas that bring in air pollution, we create circumstances of less ventilation, creating more heat in our homes. We could go on and on about this, but I want to give time for some other questions. Actually, [crosstalk] before I go on, I just want to dampen the anxiety. Acute exposures in our home are usually time limited in terms of health impacts, and we usually can resolve and get over the eye irritation and our noses and our throats being all troubled and headaches as that brief short periods resolve.

Scott Barstow: Joe, anything to add to that? Perhaps focusing on heat.

Dr. Joseph Taliercio: Sure. Listen, the impacts, even if we think we have a higher tolerance, heat doesn't bother me as much, recognizing there's a limitation for yourselves, there is the temperature outside versus internal. Everyone's a little bit different internally, but when you go outside and you're exercising, you are going to raise your temperature, and at some point, there's going to be more heat on the inside than the outside. We got to make sure that doesn't happen.

We have to recognize that when we're out there exercising, we're increasing our temperature naturally, and then the heat is also impacting us there. When you start getting to higher and higher temperatures, your cells break down. Some of those don't recover. Some of those internal injuries do not recover. Yes, you can drink water if you're dehydrated. If you have heat exhaustion, yes, take it some time outside.

When you get to such intense exposure, heat stroke. A lot of times we actually mislabel heat exhaustion as heat stroke, but heat stroke actually requires medical intervention. You're talking about neurological damage, exercising that much. This goes back to the issue I presented earlier with people from lower SES class are going to be more vulnerable here. People from lower SES can't afford going to the gym as much where there might be air condition where you can exercise indoors.

Again, recognizing these factors here, but when it is hot, we do have to limit that exposure outside. There's just too much of a risk there to play around. Especially now with increased humidity, it's going to be even worse, you're going to cool down to a lesser degree because you can't sweat as effectively. I want us to consider all this when we're exercising, and maybe sit this one out or maybe wait until it's after sunset.

Scott Barstow: Can I expand on that a little bit and ask a related question? Can you say anything about how long it takes to recover from heat stroke, and related question, what the impacts of extreme heat are on chronic health conditions? Not necessarily mental health conditions, but more generally.

Dr. Joseph Taliercio: One of the first slides I presented was a breakdown of those injuries from heat. Some of those can be quicker. My in-laws are from south Texas, San Antonio. When I go down there, we have to brace for that heat. I have gone in heat exhaustion just by being outside for a half hour, walking in shade. I remember I was watching a movie, I think I'm seeing John Wick 3, so this is a few years ago, and I remember it was in theaters, and all of a sudden, I just felt completely nauseous. I couldn't focus on the movie. I felt horrible. My mother-in-law was an ER nurse, so she recognized it immediately and she just put two bottles of water in front of me and was like, "Just drink them right now."

It was so hard because I really felt like I was going to vomit in that moment. That is heat exhaustion. That is the weaker of the versions. Again, heat stroke, you have to go to an emergency room. There is going to be significant-- you can have significant brain damage if that's the case.

Some parts of our body can recover. I can drink the water, stay indoors, lower my temperature, that's helpful.

Again, if we are going to hotter and hotter temperatures, if our internal temperature goes above 105, our cells start to die. That is too much energy for them to take in. They break down. Our proteins denature, our enzymes denature. Those don't recover necessarily depending on what is being damaged there. Some of that damage can be temporary and we can recover with some cool water and relaxing. Others, that damage is going to be permanent. I don't know about anyone else, but I don't want to risk like, "Oh, I think I'm good, if I wait in here for another, if I just don't stay out there for 10 more minutes, I won't cross that barrier." Consider this, some of this, we can't recover from.

Dr. Robin Cooper: I just want to, Joe gave the example that his mother-in-law does much better than he did coming from his northern city. In heat, people in hot areas are acclimated to the heat, but it takes somewhere in the range of two to three weeks to acclimate if this is not an area that you are used to. That's part of why this experience that Joe had on his vacation was significant, but above a certain level, no one is able to acclimate.

The extremes that we're seeing now throughout the world are deadly for everyone. It does explain that ability to acclimate within a range is why those differences can be experienced and why it's not a great idea to exercise if you're going down for your tropical vacation. Make sure that you are hydrated. Brief periods of dehydration can have significant health impacts, particularly on some renal disease.

Dr. Joseph Taliencio: Oh yes, that reminds me of the second part of the other chronic conditions. We do know people have chronic pulmonary conditions, chronic cardiovascular conditions. These conditions are already stressing our body's natural cooling property. We talked about blood pressure playing a role, and when we exhale, we breathe out the heat. We actually know that if you have these conditions, you're going to experience those compounds much more intensely.

Unfortunately, there are also other conditions. Fibromyalgia, pain will get worse in that heat where your body is already stressed out enough, it's already inflamed. Then also something like sickle cell. People with sickle cell, there is increased pain, increased mortality significantly as the temperature increases. Let's also recognize, sickle cell is most prevalent in Africa, which is also extremely vulnerable to the effects of climate change. Just again, more compounding systematic problems there.

Dr. Robin Cooper: I know that [crosstalk] we're going to be cut off--

Scott Barstow: Thank you. Robin, I'm sorry, I'm going to have to close this off because we're getting close to the very top of the hour. Let me thank you both. Thanks to the Climate Psychiatry Alliance and Climate Psychology Alliance, it's very excellent presentations. Very much appreciated. I'd also like to thank my APA colleagues, Corbin Evans and Shandol Hoover for their essential work in organizing and hosting this essential science conversation. You should receive a one-minute survey to complete after today's broadcast and we hope you'll give us feedback. You can email us at science@apa.org with any recommendations for future events.

Last, we invite you to subscribe to Science Spotlight, a free e-newsletter. As I mentioned in the opening, next month, we'll send all registrants an email with some link to the recording, the slides and resources, and our contact information for everyone. Finally, for those attending the APA Convention beginning on August 2nd, please join us for presentations and discussions being held

as part of the Climate Summit on August 4th, I believe. Thank you all again. [crosstalk] Thank you, Robin and Joe.

Dr. Robin Cooper: Scott, I'm just going to end with, if there is anything today, use this information to get active. Those have been laid out in many ways. This is a time of urgency and we all need to address this in the multiple ways that we interact in our professional organizations in the world.

Scott Barstow: Thank you. It's a very, very good closing sentiment. Thank you everyone for joining us today and stay safe.