

Water is delivered at an Ahmedabad market. Before 2010, residents worked through extreme heat. Today, they take more precautions.

# THE HEAT IS

A vibrant outdoor market scene in Ahmedabad, India. The foreground features a red cart filled with yellow and purple produce. A woman in a brown sari stands behind the cart. In the background, many people are walking and shopping under large, colorful umbrellas. The scene is bustling and lively.





The School's experts are racing to help communities worldwide build resiliency to high temperatures, pollution, and other effects of a rapidly evolving climate emergency.

By Tim Paul

ON

IN AHMEDABAD, INDIA (POPULATION 9,062,000), DAY-TIME TEMPERATURES IN THE SPRING ROUTINELY REACH THE UPPER 90s F (36 C). BUT MIDWAY THROUGH MAY 2010, THE CITY EXPERIENCED A NEW KIND OF HELL: BLISTERING CONDITIONS CLIMBING AS HIGH AS 116 F (47 C)—THE HOTTEST DAY IN NEARLY A CENTURY. At Sheth Vadilal Sarabhai Hospital in the city center, a line of people seeking treatment for heat-related illnesses stretched out of the doorway and onto the street outside. Ultimately, records showed that there were more than 1,300 deaths above what would typically be expected in a summer month, excess mortality attributable to the heat. Eight hundred people died in a single horrific week. Most were older adults and people with preexisting conditions.

The Ahmedabad heat wave, which made headlines around the world, spurred the government to act. The Ahmedabad Municipal Corporation and partners, including the Indian Institute of Public Health and the Natural Resources Defense Council (NRDC), developed a Heat Action Plan (HAP)—India's first. Kim Knowlton, DrPH '05, assistant clinical professor of

Environmental Health Sciences and former NRDC senior scientist, was part of the multiyear effort. “Heat is often called the invisible killer, but in heat waves like the one in Ahmedabad, unfortunately, you see people suffering and perishing before your eyes,” Knowlton explains. “It’s not only heatstroke, but it’s a whole range of respiratory and cardiovascular causes of death, because those organ systems are enormously challenged and compromised by trying to thermoregulate the body.”

Released in 2013, the Ahmedabad HAP was built on a rigorous assessment of heat vulnerability—age, medical status, and occupation were among factors studied. The result was a road map to protect residents. The plan created an early warning system to alert government agencies, health officials and hospitals, emergency responders, and community groups when a heat wave was imminent. It ensured that healthcare workers were trained on how to recognize and respond to heat-related illnesses. And it launched a campaign to educate residents—not easy in a place where people traditionally take pride in carrying on despite the heat.

Five years later, Knowlton and collaborators looked at whether the HAP had made a difference. It had certainly been tested. In 2016, Ahmedabad experienced another record high, reaching 118.4 F (48 C)—two degrees Fahrenheit above the 2010 extreme. To the team’s relief, the HAP proved its worth: 1,100 deaths were avoided each year during the heat season in the years since the plan’s release, versus a comparable earlier period. In the intervening years, India has created dozens of HAPs for cities across the country modeled after the one in Ahmedabad. Meanwhile, Ahmedabad’s HAP has continued to evolve, for example, by directing resources to the most vulnerable neighborhoods. A similar effort launched in 2017 introduced an air quality index. Attitudes in the city have been changing, too. Before 2010, residents would shrug off heat waves as a fact of life. These days, Knowlton asserts, they emphasize the danger and urge one another to take precautions.

**THE FIELD OF CLIMATE AND HEALTH WAS IN ITS INFANCY 20 YEARS AGO, WHEN KNOWLTON EARNED HER DrPH. COLUMBIA MAILMAN SCHOOL WAS A PIONEER—THE FIRST PUBLIC HEALTH SCHOOL TO LAUNCH A CLIMATE AND HEALTH PROGRAM IN 2011.**

As the number of heat-related deaths grew to what is now an estimated 489,000 per year, the School established itself as a leader in the science documenting the myriad health impacts of climate change and in training front-line responders and policymakers. The latter is done through the Global Consortium on Climate and Health Education (GCCHE), housed at Columbia Mailman School. All the while, median global temperatures have continued to rise—this year, the world shot past the 1.5 C (2.7 F) excess temperature benchmark established in the 2015 Paris climate meeting.

Extreme weather events like Ahmedabad’s are becoming more frequent and intense. To prepare for this new reality, in early 2025, the School launched the Center for Achieving Resilience in Climate and Health (C-ARCH) to serve as a “solutions lab” developing concrete ways to protect populations from the growing health impacts of climate change.

Across disciplines, the School’s scientists are working to design, deploy, and evaluate evidence-based solutions to reduce all manner of climate-related health risks—from obvious hazards like heat waves, hurricanes, flash floods, and wildfire smoke to less obvious ones like food insecurity and mental health crises. Led by Darby Jack, PhD, professor of Environmental Health Sciences, and Kiros Berhane, PhD, Cynthia and Robert Citron-Roslyn and Leslie Goldstein Professor and Chair of Biostatistics, C-ARCH is spurring creative solutions like hurricane vulnerability mapping and controlled burning to prevent wildfires. While federal grants for health-related climate research, always limited, have dried up, the work continues.

“We’re seeing the effects of climate change worsening. It’s unequivocal that the health and lives of millions around the world are being stressed in new ways,” says Jack. “That’s why it’s so urgent that we identify the resources and the strategies to build resilience and help the world adapt to the shifting ground of the changing climate.”


**EVERY COUNTRY ON EARTH IS AFFECTED BY CLIMATE CHANGE. BUT CLIMATE CHANGE ISN’T EXPERIENCED THE SAME WAY EVERYWHERE, AND MANY POORER COUNTRIES ARE LESS EQUIPPED TO PREDICT AND ADAPT TO ITS IMPACTS.**

Of course, fossil fuel emissions driving these impacts have largely happened outside their borders; the U.S. is responsible for more atmospheric CO<sub>2</sub> than any country—one-quarter of all historical emissions. In a study in Ghana funded by the Wellcome Trust, Jack and colleagues at the Kintampo Health Research Centre (part of Ghana’s Ministry of Health) are measuring the effects of heat on overall mortality, as well as the specific impacts on birth outcomes and child development. Even as the data analysis is ongoing, Jack is developing a text-based system designed to warn pregnant people about extreme heat. Because air-conditioned cooling stations aren’t an option, recommendations include reminders to find shade, avoid physical activity, and drink water.

“The U.S. and other wealthy countries have extensive data on population-level health. By contrast, in low- and middle-income countries, where climate impacts and vulnerabilities might look very different, these national datasets are lacking. Our study aims to help fill this gap. Our goal is to help protect the population as extreme heat becomes more commonplace,” he explains.

Air pollution, whether from cookstoves or industrial smokestacks, is intertwined with climate change; the emis-





As the director of the Global Consortium on Climate and Health Education at Columbia Mailman School, Cecilia Sorensen, MD, is helping to prepare health professionals to respond to climate crisis.

## EDUCATING FOR A RESILIENT WORLD

**THE RAPID PACE OF CLIMATE CHANGE DEMANDS THAT HEALTH PROFESSIONALS QUICKLY GET UP TO SPEED ABOUT ITS THREATS TO HEALTH.** The Global Consortium on Climate and Health Education (GCCHE) develops curricula and standards for teaching climate and health to future doctors, nurses, public health professionals, health system administrators, and health policy makers. Over 400 health professions schools worldwide are now members. In recent years, as part of its global effort to build coalitions and knowledge, the GCCHE and partners have also joined with community organizations and government partners to directly train front-line health professionals. One nine-week course, offered online in English, Spanish, and French, covered topics such as how to prevent and treat climate-sensitive health conditions.

Director Cecilia Sorensen, MD, associate professor of Environmental Health Sciences and Emergency Medicine, is gearing up to offer another course with partners including the Pan American Health Organization, Health Canada, the World Health Organization, the United Nations University, and the Inter-American Institute for Global Change Research. Its goal: Equip health workers with the knowledge and tools needed to rapidly scale up adaptation, mitigation, and resilience efforts. “Participants will explore the emerging, unprecedented threats that climate change poses, moving beyond traditional single-hazard thinking to understand compounding, cascading, and cumulative climate impacts,” she says.

sions both harm human health and heat the atmosphere. Children bear the brunt of both: Their bodies are more susceptible to air pollution, and most of them will live to see the worst effects of climate change later in the century. Since 2007, Jack has worked with collaborators in Ghana to study the health risks of traditional cookstoves that burn organic matter and the benefits of switching to devices that use liquefied petroleum gases like propane or butane. The Ghana Randomized Air Pollution and Health Study (GRAPHS) has followed a group of mothers and children for years, documenting improved heart and lung health in children using the newer cookstoves.

Much like Jack’s GRAPHS study, researchers at the Columbia Center for Children’s Environmental Health (CCCEH) have documented all kinds of health risks related to air pollution exposure. A study of children in Krakow, Poland, reported evidence of developmental, respiratory, and cognitive and behavioral challenges linked to dirty air. The findings were instrumental in prompting the government there to ban coal burning in homes. According to an estimate by CCCEH founder Frederica Perera, MPH ’76, DrPH ’82, PhD ’12, and colleagues at the Jagiellonian University in Krakow, the resulting decline in fine particulate matter in the air meant avoiding hundreds of preterm births, infant deaths, child hospitalizations, and cases of asthma. Similarly, they found that children’s health in New York City benefited following the introduction of climate-friendly policies, including low-emissions city buses.

Documenting health risks is critical to provide the evidence necessary to garner support for regulations or spark behavioral changes. But so too are the follow-up studies like the evaluation of the Ahmedabad HAP and of the policy changes in Krakow and New York. “Telling these good-news stories is important,” Perera says. “We want to show how

these policies can make a difference and share examples of success with everyone—community members, collaborators, policymakers, and funders.”

**THE WARMING ATMOSPHERE DOESN'T JUST HEAT THE AIR. THE OCEANS ARE WARMING, TOO. HEAT RISING OFF THE OCEANS GENERATES KINETIC ENERGY THAT CREATES HURRICANES AND TROPICAL CYCLONES.** At the same time, sea levels are rising, leaving coastal communities more exposed to danger. Robbie M. Parks, PhD, assistant professor of Environmental Health Sciences, has analyzed the aftermath of these storms, finding that Americans in their path have elevated death rates—not just drownings and injuries, but also infectious and parasitic diseases, cardiovascular and respiratory diseases, and mental illness. A related study Parks did of 179 cyclones over 32 years found that older adults and socially vulnerable populations were most affected.

According to Parks, vulnerability to storms and flooding is due to lack of awareness of the risks and timely warnings. In ongoing work, he's developing a system to anticipate the impact of hurricanes with greater precision than a traditional flood zone map. To do this, he feeds images of hurricane-damaged housing in New York City taken from Google Street View into a machine-learning algorithm. “The idea is to create a map of vulnerability, including for neighborhoods that haven't been directly in the path of the hurricane,” he explains.

Thinking about climate change often creates anxiety. More directly, higher temperatures also drive higher rates

of mental illness and related challenges. In one study, Parks linked high temperatures with hospital visits due to drug and alcohol use. People spend more time outdoors, get dehydrated and intoxicated, and behave in a way that leads to injury. Another Parks paper found that hospitalizations due to violence—interpersonal and self-inflicted—climbed in the first two days after exposure to heat stress. Separately, to assess strategies to address mental health risks of heat, Parks examined 83 HAPs in 24 countries. Most acknowledged the risks, yet few proposed interventions like neighbor check-ins to protect the vulnerable. India was the only nonwealthy country to include mental health in its HAPs.

Another unexpected way heat puts us at risk: Pedestrian falls increase. High heat affects us physiologically and causes sidewalks to buckle; both increase the risk of falls. As the climate gets hotter and the number of unsteady older adults swells, the problem could worsen, notes Andrew Rundle, MPH '94, DrPH '00, professor of Epidemiology. In a paper to be published in the *American Journal of Epidemiology*, Rundle and colleagues report that tree canopy cover—and the cooling shade it provides—appears to prevent these falls.

**HUMAN AGRICULTURE EMERGED IN THE AFTERMATH OF THE LAST ICE AGE, 12,000 YEARS AGO.** Since then, the climate has been remarkably stable until relatively recently, only dipping less than 0.5 C during the Little Ice Age period between 1600 and 1800. Feeding 8 billion people is a miracle possible only after the invention of chemically synthesized fertilizers and pesticides in the 20th century. Now, our increasingly unstable

A portrait of Robbie M. Parks, a man with dark curly hair and a mustache, wearing a dark button-down shirt. He is looking slightly to his right with a thoughtful expression. The background is a dense, out-of-focus green hedge.

"The idea is to create a map of vulnerability, including for neighborhoods that haven't been directly in the path of the hurricane." —Parks



Extreme heat has continued to plague Ahmedabad. Children cooled off on the outskirts of the city during a 2015 heat wave.



climate is creating more droughts and heavy flooding—both of which ruin crops. In a pair of journal articles, Berhane and collaborators observed that the African continent faces a larger burden of health impacts from climate change than anywhere else in the world. Food systems are particularly vulnerable, “lacking resilience to climate shocks,” they wrote.

Plant biologist Lew Ziska, PhD, associate professor of Environmental Health Sciences and a former scientist at the U.S. Department of Agriculture, has been documenting the wide-ranging impacts of climate change on plants and agriculture for more than 25 years. “This is not about polar bears on ice anymore. Climate change is directly affecting your health and the quality of your life—everything from the availability of plant-based medicines to the quality of the nutrition of the food that you consume to the potential toxicity of that food,” Ziska says. “We’re under the gun to not only produce enough safe, nutritious food to feed to 8 billion people, but also to feed an additional billion people in the next 15 to 20 years.”

Beyond too much or too little rain, crops contend with more aggressive weeds and insects, which are increasingly resistant to pesticides. While farmers use more pesticides, evidence suggests these chemicals are bad for our health.

In early 2025, Ziska published research on how higher temperatures and carbon dioxide concentrations raise arsenic levels in paddy rice, a staple food that feeds half the world’s population. Consuming arsenic is linked with risk for heart disease, diabetes, and cancer. An ongoing study suggests that even a single hot year can increase levels of the toxin. On the plus side, it’s possible to roughly predict the amount of arsenic in a harvest, and there is a method to prevent arsenic by draining and refilling rice paddies halfway through the growing season. Unfortunately, the process is labor intensive so farmers may resist doing it.

Another possible way to prevent arsenic accumulation is trying new rice varieties. Ziska recalls an encounter with a Thai rice farmer growing 20 rice varieties on his 2-acre plot. “I was blown away. His way of farming was so different than the American corporate mode of going all in on a single variety. I asked him, ‘Why are you growing 20 varieties?’” Ziska says. The farmer’s answer was a testament to the importance of planning and resilience. “He answered, ‘Because, no matter what happens, I will always have food for my family.’” ●

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