**How extreme heat from climate change distorts human behavior**

On a sweltering summer afternoon almost a decade ago, Meenu Tewari was visiting a weaving company in Surat in western India. Tewari, an urban planner, frequently makes such visits to understand how manufacturing companies operate. On that day, though, her tour of the factory floor left her puzzled.“There were no workers there … only machines,” says Tewari of the University of North Carolina at Chapel Hill.The missing employees weren’t far away; they were resting in the shade under a nearby awning. Scorching temperatures had been causing workers to make mistakes or even faint near the dangerous machinery, Tewari’s guide told her. So the company had mandated that workers come in earlier and leave later so that they could rest during the midday heat.Physiologically, people’s bodies aren’t built to handle heat beyond wet bulb temperatures — a combined measure of heat and humidity — of around 35° Celsius, or about 95° Fahrenheit (SN: 5/8/20). Mounting evidence shows that when heat taxes people’s bodies, their performance on various tasks, as well as overall coping mechanisms, also suffer. Researchers have linked extreme heat to increased aggression, lower cognitive ability and, as Tewari and colleagues showed, lost productivity.With rising global temperatures, and record-breaking heat waves baking parts of the world, the effects of extreme heat on human behavior could pose a growing problem (SN: 6/29/21).And lower-income people and countries, with limited resources to keep cool as climate change warms the world, are likely to suffer the most, researchers say.  “The physiological effects of heat may be universal, but the way it manifests … is highly unequal,” says economist R. Jisung Park of UCLA.Scientists have been documenting humans’ difficulties coping with extreme heat for over a century. Much of that work, however, has taken place in laboratory settings to allow for a high degree of control.For instance, a few decades ago, social psychologist Craig Anderson and colleagues showed undergraduates four video clips of couples engaged in dialog. One clip was neutral in tone, while the remaining three showed escalating tension between the duo. The undergraduate students watching the clips were each sitting in a room with the thermostat set to one of five different temperatures, ranging from a cool 14° C to a hot 36° C. The researchers then asked the students to score the couples’ hostility level. Anderson, now of Iowa State University in Ames, found that students in uncomfortably warm rooms scored all the couples, even the neutral one, as more hostile than students in rooms with comfortable temperatures did. (Interestingly, students in uncomfortably cold rooms also scored the couples as more hostile.)Heat tends to make people more irritable, says Anderson, whose findings appeared in the 2000 Advances in Experimental Social Psychology. And as a result, “they tend to just perceive things as being more nasty when they’re hot than when they’re comfortable.”Research suggests that such perceptions can give way to actual violence when people lack an escape hatch. But this “heat-aggression hypothesis” has been hard to demonstrate outside the lab because teasing out the effect of heat from other environmental or biological variables linked to aggression is tricky in the messy real world. Studies in the last few years, however, have started confirming the idea.  For instance, a July working paper out of the National Bureau of Economic Research came close to re-creating the level of control found in a lab by focusing on inmates in Mississippi prisons and jails that lack air conditioning. Economists Anita Mukherjee of the University of Wisconsin–Madison and Nicholas Sanders of Cornell University looked at rates of violence across 36 correctional facilities from January 1, 2004, to December 31, 2010. Overall, each facility averaged about 65 violent acts per year. But the pair found that on days above around 27° C — which occur about just over 60 days per year — the probability of violence among inmates rose 18 percent.  Though that doesn’t seem that hot, most of those days of had an average maximum temperature of roughly 34° C; nor do those temperature readings account for Mississippi’s high humidity, Mukherjee says. Moreover, many of the country’s aging correctional facilities lack both air conditioning and proper ventilation, and temperatures inside the facilities often exceed temperatures outside.Politicians often frame providing inmates with air conditioning as a matter of comfort, Mukherjee says. “When we’re talking 120-plus degrees [Fahrenheit] inside a prison for many days a year, it becomes a moral issue.”Extrapolating from the Mississippi data, Mukherjee and Sanders estimate that heat generates an additional 4,000 violent acts each year in U.S. correctional facilities.Research also suggests that violence spikes alongside heat outside of prisons. For instance, for the months May to September from 2010 to 2017, violent crime in Los Angeles was about 5.5 percent higher on days with temperatures from about 24° C to 32° C (75° to 89° F), compared with days below those temperatures, researchers reported in the May Journal of Public Economics. Violent crime was almost 10 percent higher on even hotter days, the researchers found.The relationship between heat and human behavior extends well beyond violence. Consider students taking exams in hot school buildings. Park, the UCLA economist, zoomed in on students in New York City sitting for standardized subject-specific high school exams. Each take about three hours and are administered at the student’s home school for a two-week period at the end of June. Temperatures at that time can vary from 15° C to almost 37° C.Park looked at scores for almost 1 million students and about 4.5 million exams from 1999 to 2011. That analysis, appearing March 2020 in the Journal of Human Resources, found that students who take the exam on an approximately 32° C day are 10 percent less likely to pass a given subject than if they had taken that exam on a 24° C day.  Park and colleagues also looked at how hot temperatures might affect students’ performance across the country. This time, they zoomed in on the PSAT, a standardized exam administered to high schoolers in October that measures college readiness and provides a pathway to scholarships. The team evaluated 21 million scores from nearly 10 million students who took the exam at least twice from 1998 to 2012. That way, the researchers could compare how students performed relative to themselves. The team also correlated exam scores with daily temperature data from around 3,000 weather stations across the country, as well as information about each student’s access to air conditioning.Student scores typically increase between the first time they take the exam and the second. But even when the researchers factored in that rise, students in schools without air conditioning scored lower than would have been expected, the researchers reported in the May 2020 American Economic Journal: Economic Policy. What’s more, Black and Hispanic students were more likely to attend school and test in hotter buildings than their white counterparts, and the researchers estimate that the resulting temperature differences explained 3 to 7 percent of the PSAT’s racial achievement gap.That sort of performance decline doesn’t just happen in academic settings; it extends to the workforce too. Following Tewari’s visit to the weaving factory in Surat, she began combing through data on worker output in India — where industrial air conditioning can be rare — at several weaving and garment sewing factories and a steel company that supplies rails for railways.Tewari and colleagues observed workers from roughly one to nine years, depending on the industry. When temperatures climbed beyond 35° C, average daily production in weaving dropped by about 2 percent and garment sewing by as much as 8 percent, compared with days under 30° C, the researchers estimate in the June Journal of Political Economy.The team then scaled up to industries across India using national survey data. That analysis showed that productivity started dropping when average daily maximum temperatures rose above 20° C. The researchers’ calculations suggest that average annual output will decrease by 2.1 percent if average daily temperatures warm by 1 degree C over current conditions; annual gross domestic product, or the value of goods and services produced in a single year, would drop by 3 percent.The takeaway: Extreme heat hurts some countries’ bottom line, Tewari says.The burdens of high heat are often borne by a country’s poorest residents. For instance, in the United States, a long legacy of discriminatory housing policies means poor people often live in the hottest parts of a city, a July report from Climate Central, an independent climate science research and communications organization, notes. In these concentrated pockets of heat, called “urban heat islands, midafternoon temperatures can rise by 8° to 11° C above outlying areas. The effects tend to be worse in poor neighborhoods due to high density, limited green space and shade and an abundance of paved roads and surfaces that absorb rather than reflect heat.Similarly, in that study linking intense heat to violent crime spikes in Los Angeles, researchers found strong geographic differences. “Beverly Hills doesn’t have much violent crime on any of those days. But in the poorest communities in Los Angeles, you see a larger correlation between heat and violence,” says environmental economist Matthew Kahn of the University of Southern California in Los Angeles. Compared with wealthier city residents, poor people in Los Angeles have less space and far fewer air conditioning units, Kahn adds.Given these inequities, the simplest choice is to provide everyone with air conditioning, Kahn says. But cooling buildings is far from free. Cooling equipment, including primarily air conditioners, accounted for about 17 percent of the world’s total electricity demand in 2018, according to a 2020 United Nations report. Estimates suggest that air conditioning use in emerging economies alone will lead to 33 times as much energy consumption by the year 2100. And, at the moment, most of that energy comes from nonrenewable sources, chiefly oil, coal and gas, so meeting that demand would contribute to global warming.    The choice over whether or not to install an air conditioning unit in a given facility, as with many things, comes down to relative costs and benefits, Tewari says. Even with soaring temperatures, air conditioning entire factories remains more expensive than giving workers midday siestas or selectively air conditioning only those rooms where precision is most required.Moreover, better cooling options exist, say Tewari and others, including maintaining or increasing tree cover in cities and using “cool” building materials that reflect sunlight (SN: 4/3/18).  “Air conditioning is not sustainable,” Tewari says. “There are urban planning mechanisms through which you can reduce ambient temperatures.”But Kahn says poor people deserve access to air conditioning. The long-term solution is not to keep overheating the poor, but to expedite efforts to green the energy grid, he says. “The poor have the least capacity to adapt. In a fair society, I hope we don’t just shrug at that fact.”