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[Harrison Tasoff](#)

Hot, humid conditions during pregnancy undermine child health much more than heat alone

The dangers of heat and humidity are so well known it's become cliché to mention them. But the impacts can extend farther than even scientists and doctors realized.

In a [paper](#) published in *Science Advances*, researchers at UC Santa Barbara looked at the effect of prenatal exposure to extremely hot, humid conditions on the health of children in South Asia. They found that humidity worsens the impacts of heat exposure, in part because it prevents pregnant women from cooling down. Accounting for humidity quadrupled the effect of extreme heat on child health.

"Exposure to hot, humid conditions in-utero is dangerous for child health, and more dangerous than just hot temperatures alone," said lead author [Katie McMahon](#), a doctoral student under Professor [Kathy Baylis](#) in the Geography Department.

By focusing on the effects of temperature only, many researchers, doctors and public health officials may be underestimating the true impacts of extreme weather. This is particularly concerning given that these conditions are predicted to become more frequent and extreme due to climate change. What's more, some of the most densely populated regions on Earth are hot, humid areas along rivers and coastlines. Populations are also growing rapidly in many of these locations.

Fortunately, understanding this phenomenon can help guide interventions. Even simple actions could have significant benefits, the authors claim.

How we measure matters

Humidity in the forecast doesn't just make heat more miserable; the "feels like" temperature has an actual basis in our biology. Humans cool by sweating. But evaporation slows when air is humid. "And when evaporation can't happen, then cooling can't happen," McMahon said. "All that heat builds up in our bodies, causing heat stress." And this can happen at much lower temperatures under humid conditions.

That's why the wet-bulb globe temperature (WBGT) was invented in the 1950s. Unlike a simple temperature measurement, this metric accounts for four of factors that affect heat stress: air temperature, humidity, radiant heat sources, and airflow. This is precisely what McMahon and her coauthors tracked in their investigation.

As for the health effects, the authors looked at height-for-age: a ratio of a child's height compared to the average for their age. This ratio is a commonly-used indicator of chronic health status for children under age five.

The researchers culled data on child health data from the Demographic and Health Surveys (DHS), a large-scale and comprehensive household survey of public health and demographics. Their daily weather data was produced by the [Climate Hazards Center](#) at UCSB.

Much of the work involved linking demographic data and surveys with heat and humidity data to identify prenatal heat exposure. After this, the authors ran the data through their statistical models with carefully selected temperature, humidity and growth thresholds.

These thresholds were 35° Celsius (95° Fahrenheit) for temperature and 29° C (84° F) for WBGT. "We needed our hot and hot-humid thresholds to be comparable," McMahon said, "and this approach led us to two thresholds that occur with nearly equal frequency in South Asia."

The researchers found that exposure to extreme heat was bad, but humidity made outcomes even worse. For example, looking at exposure during the third trimester

revealed that heat and humidity was approximately four times worse than heat alone, Baylis explained. The results suggest that a child who experienced a one-standard deviation increase in heat and humidity in the year before birth would be 13% shorter for their age than expected. In contrast, a one-standard-deviation increase in extreme heat exposure translated to a 1% reduction in height for age.

The pregnancy factor

Pregnant women are particularly susceptible to heat stress for a number of reasons. The added weight causes them to produce more heat, and hormonal changes also make them more vulnerable to overheating. Combining these with the effects of high humidity can spell real trouble for a woman and her future child.

The worst times were very early and very late in pregnancy, the team found. “At the beginning of pregnancy, the fetus is very vulnerable,” McMahon explained, “while at the end of pregnancy, the mother is more vulnerable.” For example, heat stress can induce premature labor late in pregnancy, leading to infants who are not yet fully developed. This setback could then carry on into childhood, causing developmental issues and poor health that are never fully overcome.

On the opposite end, a particularly risky time for heat exposure was right around the beginning of pregnancy, possibly even right before conception. A woman herself may not know she’s in this critical time for her future child, or that she’s pregnant at all.

Across cultures, women late in pregnancy are often treated with particular care, “but my guess is that almost nobody appreciated these risks during the first trimester — including me, before this study,” said co-author [Chris Funk](#), Director of the Climate Hazards Center.

Robust results

The authors acknowledge that the paper has several limitations. For instance, they weren’t able to access exact birth dates and pregnancy lengths, so they can’t completely account for the effects of premature births. For instance, if a baby were born a month premature, they would actually be about 0.9 years old

developmentally at their first birthday. The researchers said that they would love better, more granular health data from more regions.

Still, the team also says the study's findings are strong enough to make causal claims. They checked their results under a variety of alternative thresholds and considered other factors that may have influenced their findings. "We show versions of the results that use five different sets of alternative thresholds," McMahon said. "No matter the threshold, our main conclusion remained the same."

They even looked at the effect of prenatal WBGT on birthrates and infant mortality. "It does not look like early death or failed pregnancies are seriously impacting the results of our study," Funk said.

Far-reaching ramifications

The results have a number of implications. Assessing risk based solely on temperature misses humid coastlines and river valleys. "These are literally the cradles of civilization," Funk said. "And so they're the most densely populated places on the planet." [Scientists have estimated](#) that about 38% of the global population lived within 100 kilometers of the coast as of 2018, and an even higher percentage live in close proximity to a river or lake.

South Asia — a region of over 1.7 billion people — could be hit particularly hard in the coming years. If exposed to conditions expected by 2050 under a high-emissions scenario, around 3.5 million children would've experienced stunting in the study region alone. "Even if societies succeed in limiting warming to 2°C above preindustrial levels, South Asia is expected to suffer from deadly heat events every year," the authors write.

What's more, a lot of research on the effects of extreme weather looks at deaths rather than health impacts. "But, extreme weather harms many more people than it kills," McMahon said. Focusing only on mortality leaves out a large part of how these conditions affect people's lives. "This affects our calculus of the cost of climate change for human health and society overall."

Poor health also generates large economic impacts, which can be multigenerational, creating a cycle of further poverty and poor health, Funk explained. "The picture

painted by this research is grim, but it could lead to a lot of potentially positive interventions.”

It’s important to note that many vicious cycles are virtuous cycles run in reverse, meaning that small interventions could yield dramatic, far-reaching effects. Relatively simple education and messaging campaigns could produce big increases in resilience and adaptive behaviors, the researchers said.

Funk and his colleagues at the Climate Hazards Center are working on extreme heat forecasting and early warning systems, such as a project with the Kenyan meteorological department to improve the forecasts for the Kakuma refugee camp in northern Kenya. By tracking WBGT, the organization running the refugee camp can take adaptive measures when a heatwave is imminent.

The center is also studying the conditions that drive these heatwaves to understand their connection to regional weather systems. The team is working with Microsoft’s AI for Good Lab to harness machine learning for weather modeling to forecasting conditions in refugee camps.

Baylis’s group is investigating how hazards compound upon each other, such as the effects of heat and air pollution. McMahon will look into some of the nuances of heat exposure, such as which mothers, babies and children are most vulnerable to this hazard, as well as how these disparities may evolve in the future.

McMahon also plans to continue investigating the effect of heat and humidity on vulnerable populations, including farmworkers in California. She will work with a group of health clinics in the Salinas Valley to understand how extreme these conditions affect rates of heat-related medical visits in farm-working communities. Heat stress among farmworkers is well documented in the media and a number of qualitative studies, she said, but this work will help quantify this serious health problem in one of California's key agricultural regions.

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Media Contact

Harrison Tasoff

Science Writer

(805) 893-7220

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