

Improved nutrition, sanitation linked to beneficial changes in child stress and epigenetic programming

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Tubewells are a typical drinking water source in rural Bangladesh and can sometimes have high levels of contaminants. Credit: WASH Benefits

We're increasingly aware of how environmental factors influence a

child's early development and health trajectory. We've mostly learned this through research involving direct observations of how ambient conditions like air pollution or a lack of nutritious food affect how our genes function, and over time, what diseases we might develop.

However, a new study led by a global health researcher at UC Santa Cruz provides some of the clearest and most comprehensive evidence to date on what is known about stress physiology and "epigenetic programming."

In a large-scale randomized controlled trial conducted in rural Bangladesh, the research team found that an integrated intervention that included drinking water, sanitation, handwashing, and nutrition affected the set point, reactivity, and regulation of the physiological stress system in early childhood.

The findings, published in *Nature Communications*, detail how the [health interventions](#) had [measurable effects](#) on the children in the study at the genetic level—including enhanced functioning of their stress-response system, reduced [oxidative stress](#) in the body, and reduced methylation levels of their DNA.

Oxidative stress can damage cells, proteins, and DNA, which can contribute to aging and lead to diseases such as diabetes, cancer, and Alzheimer's. Methylation is a chemical modification of DNA or other molecules often triggered by environmental conditions that may persist as cells divide.

Rigorous research design

This research is the latest in a series of findings based on a massive landmark study in Bangladesh that started with more than 5,500 [pregnant women](#) and the children they birthed. The women were placed in 720 study clusters and allocated to one of seven groups.

Participants in four of the groups received either clean drinking water, sanitation, handwashing stations, or nutrition counseling plus nutrient supplements. The remaining three groups received either combined interventions of water/sanitation/handwashing or water/sanitation/handwashing/nutrition, or no interventions at all (the control group).

The researchers say the design and scale of that study, known as the "WASH Benefits Bangladesh" trial, resulted in more scientifically rigorous findings than the majority of stress physiology and epigenetic research done thus far, which relies on one-dimensional studies that lacked experimental interventions and control groups for comparison.

"Here, we see differences in outcomes between an intervention group and a control group, both of significant size," said Audrie Lin, who joined the UC Santa Cruz faculty in July 2023 as an assistant professor of microbiology and environmental toxicology.

"When we began setting up the WASH Benefits trial in 2009, its scale was unprecedented in the health- and nutrition-research fields."

Global relevance

This study is also more relevant on a global scale because of the trial's location in a low-resource region. Many previous studies were conducted in high-income countries like the United States or United Kingdom, where access to [safe drinking water](#), sanitation, and hygiene is relatively high in comparison with the rest of the world.

"This is really representative of the conditions that a majority of the world's population contends with," said Lin, who lived in Bangladesh and Kenya for six years to help set up the WASH trial and train teams on the ground.

"When this type of research is done in high-income countries, you're not really capturing all of these important stressors that could affect a child."

What also sets this study apart from others in the literature is the use of physical interventions to improve stress physiology in young children in a low-resource context, instead of psychosocial measures like behavioral therapy or parental coaching.

By introducing safe drinking water, nutrition, sanitation, hygiene, and improved nutrition—and showing precisely when and how they change a child's physiology—those measures might be easier for a government to introduce than psychosocial interventions.

And yet, Lin said the improvements that her team reported showed that the physical interventions were on par with the impact of psychosocial measures. In their paper, the study's authors wrote, "The magnitude of the effects of this environmental and nutritional intervention on cortisol production is within the range of intervention effects of psychosocial interventions reported in early childhood."

Combining these physical interventions with psychosocial interventions could achieve even greater health benefits, Lin explained.

Continued research

The WASH Benefits trial enrolled its first participants in 2012, and researchers continue to monitor them. The hope is that the trial will evolve into a [longitudinal study](#) that will allow researchers to see the downstream effects of physiological changes triggered by interventions introduced during the first two years of a child's life.

"You often hear that what happens in the womb affects you for the rest of your life, especially in regards to your health and the development of

certain diseases," Lin said.

"The experimental design of this trial will serve as a powerful platform to find links between the interventions we introduced early on and the health trajectories of the participants in our study."

Lin will teach her first course at UC Santa Cruz in the fall, fittingly, on research methodology. It will be housed in the university's Microbiology and Environmental Toxicology Department, and included as part of the interdisciplinary Global and Community Health Program.

More information: Audrie Lin et al, A cluster-randomized trial of water, sanitation, handwashing and nutritional interventions on stress and epigenetic programming, *Nature Communications* (2024). [DOI: 10.1038/s41467-024-47896-z](https://doi.org/10.1038/s41467-024-47896-z)

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