

Water, Health and Development: Challenges and Solutions in the Developing World

By Jenna Davis and Alexandria Boehm

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The Challenge: Contaminated water is a killer

Each year, diarrhea kills an estimated 1.8 million people worldwide, the vast majority children under the age of 5. What makes the problem especially tragic is that it is preventable. Diarrhea is a symptom of several diseases caused by water, food or hands contaminated with human feces. These gastrointestinal illnesses are common in developing countries where people lack access to clean water or sanitation. Globally, about one billion people do not have adequate freshwater supplies, and 2.8 billion lack basic sanitation.

In the United States, virtually all households have access to high-quality water and sewage services, typically through individual connections to piped networks. But for many developing countries, the cost of installing modern water and sewer networks is too high. As a result, governments are turning to more affordable “non-networked” options, such as shared wells and household latrines. A variety of reliable, low-cost non-networked systems have been installed in developing countries throughout Africa and Asia. But people are still getting sick, and many, especially children, are dying.



Jenna Davis (2nd from left), Ali Boehm (2nd from right), Stanford researchers and a Tanzanian collaborator in Dar es Salaam.

ABOUT THE AUTHORS

Jenna Davis' research interests focus on the intersection of economic development and environmental management, with particular emphasis on cost-effective, sustainable water supply and sanitation service delivery in developing countries. She has conducted fieldwork in more than a dozen countries, including Tanzania, the Philippines, Mozambique and Bolivia. Davis is an assistant professor of civil and environmental engineering and a fellow at the Woods Institute for the Environment.

Alexandria Boehm's research interests encompass different aspects of water quality. Her work focuses on understanding environmental and anthropogenic variables that influence the presence of pathogens and fecal indicator bacteria in water. Boehm is the Clare Booth Luce Associate Professor of Civil and Environmental Engineering.



Children living in a neighborhood on the outskirts of Dar es Salaam.

CHANGING BEHAVIOR IMPROVES FAMILY HEALTH

To find out why, our team (led by Jenna Davis and Ali Boehm from the Stanford School of Engineering) has been working with officials in Dar es Salaam, Tanzania, where the municipal water utility has installed non-networked services consisting of community wells and simple public latrines.

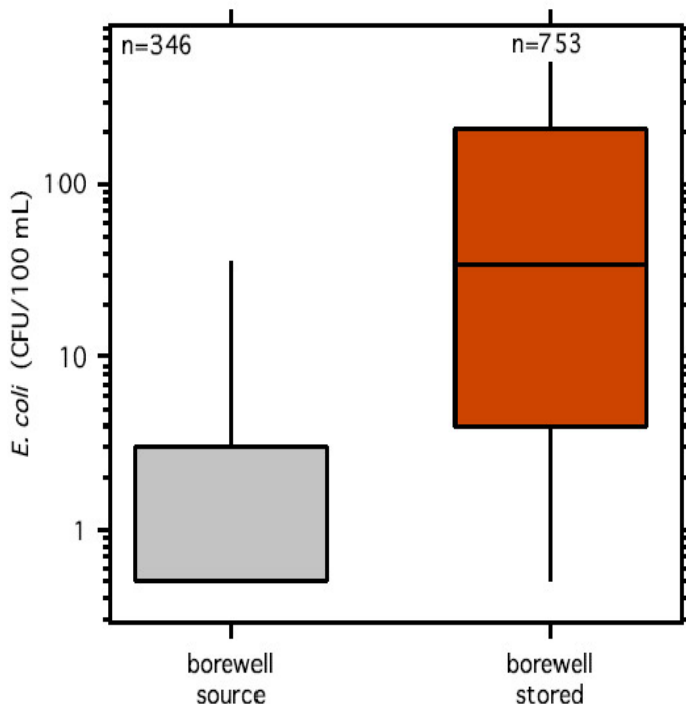
Despite the improved sanitation services and the availability of clean drinking water, health officials observed no change in the incidence of water-related diseases in Dar es Salaam. Our research goal is to understand why residents of Dar es Salaam are still getting sick.

In 2006, we were awarded a Woods Institute Environmental Venture Projects grant to find solutions to the problem of diarrhea-related deaths among children in sub-Saharan Africa. In addition to several Stanford graduate students, our team includes three human health experts from the Stanford School of Medicine: Gary Schoolnik, professor of medicine; Abby King, professor of epidemiology; and Cynthia Castro, research associate.

Our first task was to confirm that the well water supplied by the City of Dar es Salaam was indeed clean. We tested the water coming out of the community taps and found that it generally met World Health Organization standards for safe drinking water.

Next, we needed to determine how people were coming into contact with feces. There were several possible pathways, including the recontamination of stored drinking water by people using fecal-contaminated hands to scoop water out of their home storage containers

E. coli concentration of source versus stored water.



Hauling water often limits the amount available for hand washing.

HOUSEHOLD SURVEYS

In summer 2008, our team traveled to Dar es Salaam to study 335 households over a 10-week period. We hired and trained Tanzanian university students to conduct surveys and interact directly with the households. The students visited each household four times. On the first visit, they collected behavioral information and tested stored water and the hands of family members for evidence of fecal contamination. It turned out that mothers and children had very high concentrations of *E. coli* on their hands, as did the stored household drinking water.



Testing hands for bacterial contamination.

Our surveys determined that a major challenge facing each household is distance. Some homes are 200 yards from clean tap water, and a typical water container weighs 44 pounds. Past studies have found that when people haul water from a distance, the first thing they do is drink it, then they cook and finally they wash their kids, themselves and sometimes their animals. With limited supplies in most of Dar es Salaam, there may not be enough water for adequate personal hygiene.

In addition, water stored in the home provides numerous opportunities for fecal contamination through the dipping of cups, hands and other items. Also, non-networked sanitation services often include low-quality latrines that do not adequately keep excreta out of the environment. These findings help explain why non-networked water and sanitation services in Dar es Salaam deliver limited health benefits.

Our team also conducted household surveys to determine whether personalized messages about hygiene would be more effective than the generic public health campaigns that have been conducted in Dar es Salaam over the past 20 years.

Our researchers separated the households into four groups. One group received only generic information about how germs are spread through the five F's - feces, flies, field, food and fingers. A second group got the generic information plus the results of their home water test. The third cohort got the generic information and their hand test results. The fourth group got everything: generic information, water test results and hand test results.



Briefing Tanzanian President Kikwete.

Our findings suggest that more information is not necessarily better. Groups that received hand data or water data alone had a more positive response than households that got both hand and water test results. In addition, for those households who were told they had good hygiene, repeat visits showed that their hygiene had actually gotten worse.

In May 2009, we briefed Tanzanian President Jakaya Mrisho Kikwete on the results of the research during his visit to Stanford. The president expressed his administration's support for a yearlong follow-up study in 2010. Our results could lead to low-cost policy solutions that ultimately reduce the incidence of diarrhea for tens of millions of children in sub-Saharan Africa and throughout the developing world.

For more information on this research project:
<http://www.stanford.edu/group/jennadavis>

Woods Institute for the Environment

As a neutral third-party convener and trusted source of research and information, the Woods Institute for the Environment brings business, government and NGO leaders together with experts from Stanford and other academic institutions to create practical solutions on key environmental policy issues.



Testing samples for bacteria contamination.

PROMOTING CLEAN WATER SUPPLIES AND SANITATION IN DEVELOPING COUNTRIES

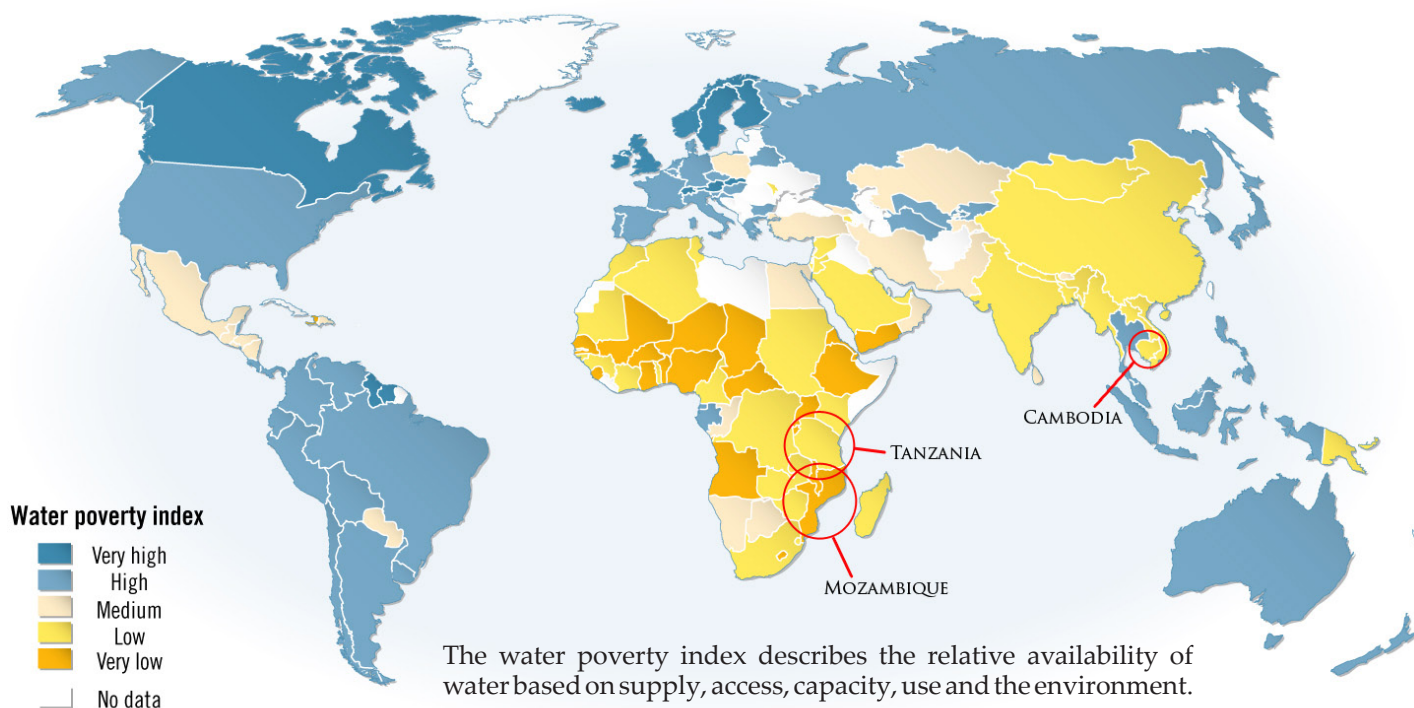
Based on our experience in Tanzania, we have initiated a comprehensive research program with other Stanford faculty to address knowledge gaps and identify solutions for providing clean water in other developing countries. Specifically, the **Program on Water, Health and Development** will: 1) address pressing research needs related to non-networked water supply and sanitation service delivery; 2) enhance capacity within developing countries for sustainable water and wastewater management; 3) establish long-term partnerships to assure that research is translated into practice; and 4) offer unique training and learning opportunities for faculty and students at Stanford and partner institutions.

The research program will expand activities in Cambodia and Mozambique, where strong public health collaborations already exist with Stanford faculty. In Cambodia, Earth scientist Scott Fendorf and other Stanford researchers are working with partners to identify low-cost approaches for serving non-networked populations at risk of arsenic poisoning. In Mozambique, our research team is evaluating the impacts of an experiment to legalize water resale to non-networked

populations. In Tanzania, our team is continuing to investigate household water management and hygiene issues. In each country, we envision implementing multi-scale, multidisciplinary research projects that have direct bearing on pressing environmental, health and economic development policy issues.

The **Program on Water, Health and Development** is based on the principal that local, national and international partnerships are essential for developing lasting solutions that are linked to “real world” decision-making and policy formulation. The program is building upon existing networks between Stanford faculty and governments, international development agencies, NGOs and research institutions working to improve conditions in Cambodia, Mozambique and Tanzania. At the same time, the program is actively disseminating the results of our research across Asia and sub-Saharan Africa, where three-quarters of those lacking access to improved water supply and basic sanitation live. Over time, the Program on Water, Health and Development will scale out to establish new country partnerships in both regions.

Research locations for Program on Water, Health and Development.



For information on the Program on Water, Health and Development or additional freshwater research: <http://woods.stanford.edu/freshwater>