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BANGLADESH: Can automated chlorination at shared water taps reduce disease in urban slums?

WATER AND SANITATION

Safe drinking water is essential for healthy human development and survival, but millions of poor people in low-income countries only have access to contaminated drinking water. For children, the problem is particularly dangerous and deadly, with diarrheal diseases like typhoid and cholera responsible for approximately 800,000 child deaths each year.

Yet addressing the problem of unsafe drinking water is difficult and complex, especially in large and growing city slums. Poor urban areas often have inadequate infrastructure, and installing traditional water and sanitation infrastructure can be prohibitively expensive. Even where water treatment plants exist and function, drinking water is often re-contaminated by sewage as it travels in unpressurized pipes to water collection points in different parts of the city. Given these challenges, there has been a big push to get families to treat their own water by filtering or chlorinating it at home. However, this approach hasn't been very successful either. Home treatment requires that people remember to buy, measure, and use the chlorine, and the poorest families, who are at highest risk of their children dying of diarrhea, typically do not have the means to take on the expense and responsibility of treating their own drinking water.

Another less-explored option is treating water at the shared taps and pumps where most poor city dwellers get their water, but finding a reliable and cost-effective system has been a challenge in many contexts.

As part of this effort, the World Bank's Strategic Impact Evaluation Fund (SIEF) supported an impact evaluation of a novel water treatment technology designed to help reduce the burden of water-related illness. The research team developed and implemented a system that automatically chlorinated water at public taps and shared hand pumps. The evaluation found that the chlorination method significantly improved water quality and reduced child diarrhea, providing strong evidence that drinking water quality affects children's health and that improvements in drinking water *quality* should be a focus of policy, not just the *quantity* of water provided. Further, these results hold promise for achieving global progress towards the Sustainable Development Goal of attaining universal access to safe and affordable drinking water.

Context

In Dhaka, Bangladesh, more than 20 percent of the city's 15 million residents live in slums and almost all rely on shared taps or handpumps for water. Because of water shortages in the city, water is not always available; it is sent to different parts of the city at different times during the day. Because the water system isn't fully pressurized at all times, contamination and sewage seep into the water. Before this project began, 87 percent of taps in the study's Dhaka neighborhood were contaminated with E. coli, and 50 percent of taps in nearby Tongi – the other study site – contained the fecal indicator bacteria.

In Bangladesh, there has been a big push to market in-home disinfection technologies such as chlorine products and filters, but these efforts have generally not succeeded. One study found that even when chlorine was provided for free, only a small proportion of people actually used it. Dhaka's public water utility company had not considered installing disinfecting solutions at shared community taps before because cost-effective technologies weren't available. But the approach held promise: getting treating water at the taps would be automated, as people filling containers with water would not have to do anything to make it clean.

This policy note is based on: Pickering, Amy J., Yoshika Crider, Sonia Sultana, Jenna Swarthout, Frederick GB Goddard, Syed Anjerul Islam, Shreyan Sen, Raga Ayyagari, and Stephen P. Luby. "Effect of in-line drinking water chlorination at the point of collection on child diarrhoea in urban Bangladesh: a double-blind, cluster-randomised controlled trial." The Lancet Global Health 7, no. 9 (2019): e1247-e1256.

Evaluation

In Bangladesh…

- 34.6 percent of people have access to safe drinking water.
- 99 million people drink water that is contaminated with microbes.
- 41.7 percent of people's water source is contaminated with fecal bacteria.
- 61 percent is infected with fecal bacteria by the time it is consumed.

Source UNICEF (2018)

Researchers conducted a clustered randomized controlled trial in urban Bangladesh to evaluate how an automated chlorination system, based at water collection points, affects the quality of water stored in homes and child health. The study took place in two sites: a low-income comwmunity within the city of Dhaka and a low-income community known as Tongi on the outskirts of the city.

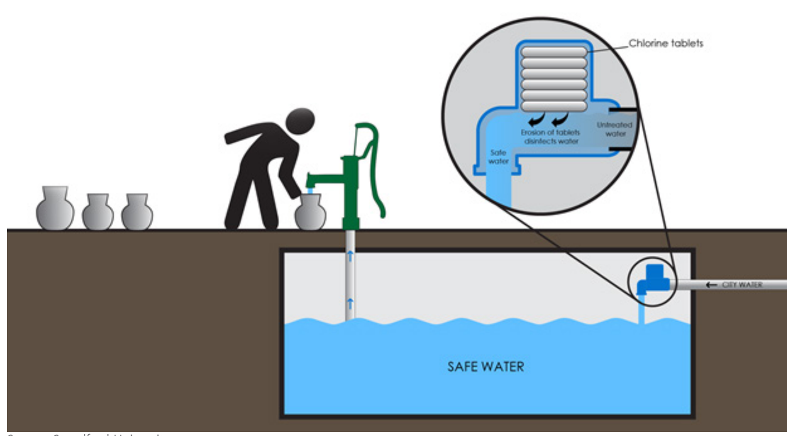
The research team first enrolled 920 eligible households, with a total of 1,036 children younger than 5 years at baseline. After the initial baseline survey in July-November 2015, researchers randomly assigned 100 shared water collection points with water storage tanks to either a treatment group, which received the chlorine treatment, or to an active control group, which received vitamin C dosers that looked visually identical to the chlorine dispensers. The research team installed the chlorine dispensers in storage tanks connected to manual handpumps in the treatment group, and installed the vitamin C dosers in the control group.

The evaluation was "double-blinded," meaning neither the study field staff nor the participants knew which study group the communities were a part of. This design reduced the likelihood of bias in the follow-up survey, when participants may have reported what they thought researchers wanted to hear or what they – or researchers – thought should have happened.

The system used in this study, the Aquatabs Flo (manufactured by Medentech, Inc) automatically doses chlorine into water as it flows through the device into a water storage tank. Researchers picked the device after implementing two pilot studies in Dhaka that tested various low-cost products that automatically chlorinate water. The Aquatabs Flo device has no moving parts and does not require electricity to operate, although the research team did have an engineer working full time on the project to ensure that the devices functioned properly. Unlike home treatment or other systems that require people to add in chlorine themselves, the technology studied here was "passive" – requiring no additional effort or action on the part of the end user.

A local partner organization conducted a one-hour education meeting with each household before the pumps were equipped with the device. Follow-up promotional visits were held every two months for the first six months, then once every four months for the next eight months. The partner was responsible for resupplying chlorine to the dispenser every week.

Researchers collected data from households and at the water collection points every two months for 14 months. After 14 months, the team compared outcomes between households linked to shared water points with chlorine dispensers and households linked to shared water points that received the vitamin C. The primary outcome of interest was caregiver-reported child diarrhea (based on the World Health Organization's definition of more than three loose or watery stools in a 24-hour period). Researchers also tracked impacts on another measure of diarrhea (that is, how caregivers defined it), child weight-for-age, child height-for-age, acute respiratory illness, illness-related health-care expenditures, water quality, and chlorine in households' stored drinking water. They also collected additional information from enrolled households on demographics, education, employment, dwellings, and assets.



Source: Standford University

Findings

Children living in treatment communities experienced a notable reduction in diarrheal disease as a result of the automated chlorine dispensers.

Based on caregiver reports, 7.5 percent of children in the treatment group had experienced three bouts of diarrhea in a 24-hour period in the last week (the WHO definition) compared to 10 percent of children in the control group—a difference that corresponds to a statistically significant reduction of 23 percent. When caregivers were free to define what they thought constituted a diarrheal episode, the dispensers also led to a similar reduction in disease.

The device was reliable and effective at chlorinating the water, which led to a large reduction in fecal bacteria in the water.

The research team detected chlorine in the water treatment group taps 83 percent of the time, as opposed to zero percent of the time in the control group, revealing the device was reliable in treating the water. Looking at home drinking water, researchers found that 45 percent of households in the treatment group had chlorine in stored drinking water compared to no households the control group. (It is worth noting that treatment households – though blinded to whether their water was treated with chlorine or just vitamic C – were slightly less likely to treat their water at home.)

Importantly, the device led to a dramatic decrease in *E. coli* in water in treatment communities: *E. coli* contamination at the point of collection decreased from a prevalence of 64 percent in control taps down to 15 percent in treatment taps.

The positive impact on child health – the reduction in diarrheal disease – was larger in Dhaka than in Tongi, possibly because water quality in Dhaka was worse to begin with.

Children in the treatment group in Dhaka saw a 38 percent reduction diarrhea compared to an 18 percent reduction in the Tongi group. The reasons for this aren't completely clear, but researchers have a couple of theories. Although both study sites had intermittently supplied water, water quality in Dhaka was poorer at baseline than in Tongi. Another potential explanation for difference across study sites could come from the fact that the different areas may have different pathogens; chlorination is not effective against certain parasites such as *cryptosporidium*, for example.

Source: GMB Akash

There were other indications that children were sick less often as a result of the chlorination, but the improvements in water quality did not translate into improved child growth.

Caregivers in the treatment group reported spending less money on illness-related expenditures in the previous two months compared to what caregivers reported spending in the control group – a difference that amounted to 40 Bangladeshi taka (or $1.35 USD after adjusting for purchasing power parity) per child. Caregivers in the treatment group were also slightly less likely to report that their child had consumed antibiotics in the past 2 months (with 40 percent of parents reporting antibiotic use in treatment compared to 44 percent in control). There were no significant differences between the groups in respiratory illness or other related illnesses, or measures of child growth (weight-for-age, height-for-age).

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The proper dosage of chlorine also appears to be critical for ensuring community members accept the chlorinated water.

The chlorine doser was designed to minimize the taste of the chlorine. In the piloting phase and in some sites during the main study, community members complained of the chlorine taste in the water. Researchers believe that accurate and automated chlorine dosing – that is, below the level where people can detect the taste, but still at a level where it is effective at disinfecting the water – will help ensure community members accept and drink the water.

The relative low-cost of the system suggests it may be more scalable than other alternatives.

The device was not on the market during the study period, but Medentech's estimated sale and refill price for a single device were $20 and $25, respectively. Adding in the cost of installation, maintenance, and communication, researchers estimate the cost of the full system to be $US 3.62 per household a month, or $0.90 per person a month. In comparison, the initial investment cost of provision of household water connections in Asia is estimated to cost $204,000 per person. Point-of-use treatment could be much cheaper–an estimated $260 per person, but this kind of approach requires behavior change, which has been a challenge to sustain.

Conclusion

These results suggest that technologies that disinfect water at the point of collection can be developed to reduce disease in burgeoning slums in low-resource settings. Unlike home water treatment, the approach evaluated here is likely effective because it is "passive"— the chlorine is automatically added to the water so it doesn't require any change of habits or behaviors of community members.

Given its effectiveness and relatively low cost, this decentralized approach to water treatment has the potential to be implemented at scale and may represent a sound public investment. Although the Aquatabs Flo is currently only compatible with water collection points connected to storage tanks, other automated chlorination technologies for disinfecting water at the point of collection have emerged that are low cost and compatible with other types of water infrastructure, expanding the potential for scale up in low-income settings.

The difference in impact between the two study sites suggests that the intervention might have the largest health benefits in settings where users are accessing water points connected to large piped water networks supplying water intermittently. Further research in other settings will be needed to clarify where this intervention can have the most health benefits.

The Strategic Impact Evaluation Fund, part of the World Bank Group, supports and disseminates research evaluating the impact of development projects to help alleviate poverty. **The goal is to collect and build empirical evidence that can help governments and development organizations design and implement the most appropriate and effective policies for better educational, health, and job opportunities for people in low and middle income countries.** For more information about who we are and what we do, go to: http://www.worldbank.org/sief.

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