International Initiative for Impact Evaluation

Rapid evidence assessment brief

Water, sanitation and waste management

Do large-scale water infrastructure interventions reduce disease?

Access to clean water and sanitation is widely understood to have numerous benefits, including improved health and economic prosperity. However, many households across the world still do not have access to basic water and sanitation services. As such, water, sanitation and hygiene (WASH) interventions are of critical importance. However, recent highly publicized WASH trials found no resultant health improvement, leading some to suggest that WASH interventions must be delivered at a 'transformative' scope and scale in order to realize a population-level health benefit.

Transformative WASH includes large-scale infrastructure interventions, such as piped drinking water and sewerage that move beyond point-of-use water treatment or basic pit latrine installation to provide access to clean water and sanitation. In high-income countries, such infrastructure investments dramatically improved child health when they were first introduced. Though these interventions are needed to reduce disease burden, the ways in which they are implemented significantly impact their effectiveness.

Highlights

- Most of the included studies focused on sewerage interventions, with very few looking at chlorination and none looking at the effects of drainage alone.
- Chlorination and sewerage interventions, when implemented alone, were successful in reducing disease burden.
- Sources of contamination included general lack of improved water and sanitation, the nearby environment (such as open sewers or garbage pits), household hygiene practices and issues with maintaining infrastructure systems.
- Infrastructure maintenance issues such as intermittent water supply, leaky pipes and ineffective chlorination affected the implementation and effectiveness of these interventions.
- For these interventions to be effective, the infrastructure should have a predetermined maintenance plan with dedicated long-term funding, and households must be supported to engage in proper hygiene practices through the integration of behavior change interventions.

Created by the US Congress in 2004 with strong bipartisan support, the Millennium Challenge Corporation (MCC) is an innovative and independent US government foreign assistance agency helping to lead the fight against global poverty. MCC partners with developing countries that are committed to good governance, economic freedoms and investing in their own citizens to deliver large-scale grant programs to reduce poverty through economic growth. MCC is investing in WASH infrastructure in Timor-Leste and commissioned 3ie to answer the question: What impacts do three specific WASH infrastructure interventions (sewerage, drainage and piped water chlorination) have in reducing disease burden? 3ie conducted a rapid evidence assessment to synthesize the available rigorous impact evaluations of these large-scale urban WASH infrastructure interventions.

Main findings

We identified 1,920 articles; 18 studies met all eligibility criteria. Eight studies focused on the effects of sewerage alone, and three focused on chlorination alone. Five studies reported on the effects of combined sewerage and drainage studies. Two studies focused on chlorination and sewerage, and no studies reported on the effects of drainage alone.

Piped water chlorination had mixed effects on communicable disease outcomes. One study carried out in Turkey showed that chlorination reduced the likelihood of developing gastroenteritis. However, a study in Montenegro found that chlorination increased the likelihood of developing acute gastroenteritis. The final chlorination-only study did not find any effect.

Sewerage reduced disease. Six of the eight studies that focused on sewerage alone found that sewerage interventions reduced disease. The remaining two studies did not find a statistically significant effect.

Combining sewerage with chlorination or drainage interventions did not increase effectiveness. Three of the five combined sewerage and drainage studies found that the interventions reduced disease. One of these combined studies found that disease burden increased after the intervention, and the final study did not find any effect. Both of the sewerage and chlorination combined studies found that the interventions increased disease burden; however, one also found a non-statistically significant decrease from interventions in coastal areas.

Study authors proposed various contamination sources that caused persistent disease. These included a lack of improved WASH; the nearby environment, such as living near open sewers or garbage pits; household hygiene practices; and issues with maintaining infrastructure systems.

Table 1: Effects from included studies in the rapid evidence assessment

Study	Country	Intervention type	Effect of intervention on disease burden
Baltazar et al. (1988)[i]	Philippines	Chlorination	No effect
Barreto et al. (2007)[ii]	Brazil	Sewerage	Reduced disease burden
Butala et al. (2010)[iii]	India	Sewerage & drainage	Reduced disease burden
Clasen et al. (2010)[iv]	Multiple	Sewerage	Reduced disease burden
Costa et al. (2005)[v]	Brazil	Sewerage	Reduced disease burden
de Oliveira Serra et al. (2015)[vi]	Brazil	Sewerage	No effect
Ferrer et al. (2008)[vii]	Brazil	Sewerage & drainage	No effect
Gasem et al. (2001)[viii]	Indonesia	Chlorination & sewerage	Increased disease burden
Klasen et al. (2012)[ix]	Yemen	Chlorination & sewerage	Mixed effects
Kolahi et al. (2008)[x]	Iran	Sewerage	Reduced disease burden
Moraes et al. (2003)[xi]	Brazil	Sewerage & drainage	Reduced disease burden
Norman et al. (2010)[xii]	Multiple	Sewerage	Reduced disease burden
Prasad et al. (2018)[xiii]	Fiji	Sewerage	Reduced disease burden
Rosas-Aguirre et al. (2015)[xiv]	Peru	Sewerage & drainage	Reduced disease burden
Sezen et al. (2015)[xv]	Turkey	Chlorination	Reduced disease burden
Stewart-Ibarra et al. (2014)[xvi]	Ecuador	Sewerage	No effect
Turley et al. (2013)[xvii]	Multiple	Sewerage & drainage	Reduced disease burden
Werber et al. (2009)[xviii]	Montenegro	Chlorination	Increased disease burden

Considerations for implementation, maintenance, sustainability and evaluation of large urban WASH infrastructure interventions

- **Infrastructure projects must be designed and installed properly.** If piped water systems are not designed to have a holding tank, the chlorination will not have sufficient time to reduce pathogen exposure. Sewerage systems must include a treatment plant, as raw sewage that discharges into local water sources will lead to household water contamination.
- **Overall issues with infrastructure maintenance impact the intervention's effectiveness.** As water infrastructure ages, its pipes may not be properly maintained. Improperly repaired pipes could allow for bacterial contamination and may affect the residual chlorine concentration in the water.
- **Intermittent water supply increases disease burden.** Intermittent water supply can be caused by electrical pump failures, clogged pipes or a lack of utility payments from consumers. If the supply is unreliable, households are more likely to store water, revert to less safe water sources, or reduce hygiene behaviors to conserve water.
- **Leaky pipes in the water distribution system or sewer lines increase exposure to pathogens.** Leaky pipes can occur when water infrastructure ages without adequate maintenance. If such pipes are located near sewer lines, wastewater can be sucked into them, which then negates the chlorination. If placed near households, leaky sewer pipes can contaminate crops, which then introduce a new pathway of contamination through food sources.

Implications

For programming and policy: Large infrastructure projects must include a plan to properly maintain and sustain infrastructure after it has been installed. During installation, appropriate spacing between sewer and water pipes is imperative. There needs to be a monitoring system in place that provides real-time information on residual chlorine levels and water pressure. The pipes should also be checked frequently to assess corrosion, and funds should be allocated to replace pipes after an appropriate amount of time.

In addition, behavior change interventions should be conducted, as WASH infrastructure interventions will not be effective without proper hygiene behavior practices.

For impact evaluations: There must be further research on the effects of piped water chlorination and drainage on disease outcomes. Since these are large infrastructure projects, it may be challenging to randomize and identify adequate control groups. In addition, there may be an additive effect if multiple WASH interventions are implemented. There should be careful consideration of model identification strategies before commencing any research project.

Research projects should make sure to collect data on water reliability, household coping strategies for intermittent water supply and other disease transmission sources, as these all will impact interventions' effectiveness. In addition, seasonality and geographic variation should be considered when assessing water quality or disease prevalence.

Endnotes

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What is a rapid evidence assessment?

A rapid evidence assessment is a targeted systematic review. Similar to a systematic review, it uses a systematic approach to search and screen studies for inclusion in the review. To make it rapid, the search strategy may be limited to certain databases and the scope may be narrowed to focus only on a few intervention types.

About the rapid evidence assessment

This brief is based on the MCC-funded rapid evidence assessment *Rapid evidence assessment of the impacts of sewerage, drainage, and chlorination in urban settings of low- and middle-income countries*, by Sridevi Prasad, Charlotte Lane and Douglas Glandon. The authors found and appraised the quality of 18 impact evaluations and systematic reviews on large-scale urban WASH infrastructure interventions in low- and middle-income countries.

About this brief

This brief was authored by Sridevi Prasad. She is solely responsible for all content, errors and omissions. This study is made possible by the generous support of the US Government through the Millennium Challenge Corporation (MCC). The contents are the responsibility of the International Initiative for Impact Evaluation (3ie) and do not necessarily reflect the views of MCC or the United States Government. This brief was designed and produced by Akarsh Gupta and Anushruti Ganguly.

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