Clean water programmes can improve cognitive development

By Sonia Bhalotra

Around 2.2 billion people globally do not have access to safe water. A further 1.37 billion people lack handwashing facilities at home. As proper hand hygiene is one of the most effective ways to stop the spread of pathogens — including COVID-19 — these numbers are alarming.

2m+

GLOBAL DEATHS PER ANNUM FROM WATERBORNE DISEASES

The first scientific research on water disinfection proposing chlorination was published in 1894. In 1897, Maidstone in England was the first town to have its entire water supply treated with chlorine. Permanent water chlorination began in 1905, when it was effectively used to stop a serious typhoid fever epidemic in Lincoln. More than a century later, despite the technology being available and the cost of water disinfection being relatively low, millions of people in developing countries do not have access to clean water.

Each year more than 2 million people die from waterborne diseases. Young children are especially vulnerable, and diarrhoea is the second leading cause of child death in the world. The death toll from diarrhoea is widely known and often referenced in public health debates. What is less known is that there are persistent negative impacts on survivors. Our research indicates that infants born into an environment with clean water exhibit stronger cognitive performance in adolescence and earn more as adults. They are also taller as adults — a marker of long-term nutrition. ▶

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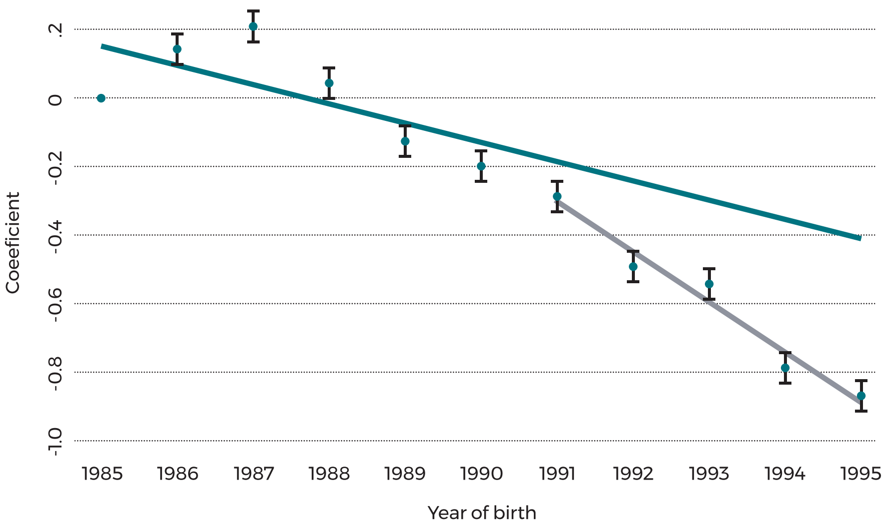
Identifying a link between infectious disease and cognitive development

Infancy is a period of rapid growth. The brain doubles in size in the first year, and by age three it has reached 80% of its adult volume (Nowakowski, 2006). On account of this, brain growth is sensitive to nutrition and infection. It is estimated that 85% of calorie intake in infancy is used to build brains, and severe or repeated infections in infancy may divert nutrients away from brain development (Finch and Crimmins, 2004). The release of inflammatory molecules during infections may also directly impact the developing brain by changing the expression of genes involved in the development of neurons and the connections between them (Deverman and Patterson, 2009).

These biological mechanisms suggest that the higher prevalence of infectious diseases, such as diarrhoea, might explain why children in developing countries tend to perform less well on international intelligence tests. However, the prevalence of infectious disease is correlated with other factors like poverty, making it important to devise a research strategy that purges these other factors and allows us to identify whether there is a causal link between infection and brain development.

Our research strategy leverages a policy experiment. We analysed the impacts of a large-scale municipal water disinfection programme implemented in 1991 in Mexico, which led to water chlorination coverage in urban areas increasing from 58% to over 90% within 18 months. The Mexican government acted swiftly in response to a cholera epidemic raging through neighbouring countries. This helps the research design because the change was sharp, and it was a reaction to conditions outside the country rather than to internal changes.

Figure 1: Trends for diarrhoea mortality rates of children under the age of five in Mexico relative to mortality rates from respiratory diseases



Notes: This plot shows trends for Mexico in diarrhoea mortality rates of children under the age of five relative to mortality from respiratory diseases (which is not directly affected by clean water), adjusted for regional factors and common trends in health and income. While mortality from both conditions was declining over the period, the plot shows that diarrhoeal mortality started to fall far more sharply immediately after the clean water policy was implemented in 1991. The vertical axis (coefficient) plots the estimated marginal effect of the policy (of exposure to clean water at birth) on diarrhoea mortality rates relative to respiratory mortality rates, conditional on municipality and year fixed effects.

Assessing the impact of Mexico's clean water programme

First, we identified the impact of the clean water programme on reducing diarrhoea mortality rates in Mexico. We measured the impact of the reform by cohort of birth — analysing the difference in infection rates between infants exposed to dirty water and those exposed to clean water. We crossed this with variation in the impact of the reform by region — which we proxied with the pre-reform diarrhoea burden — showing that regions with higher initial diarrhoeal disease burdens saw larger declines in diarrhoea after the reform. We used data on respiratory infection mortality rates as a control on the premise that respiratory infections are not a direct result of pathogens in water. We estimate that the program reduced childhood diarrheal disease mortality rates by between 45 and 67% (Bhalotra et al., forthcoming).

Next, we studied the impact of the programme on infant cognitive performance. We found that the reform led to improved cognitive performance measured independently on Raven tests (used to assess abstract reasoning) conducted at age 9–14 in a household survey, and in maths and reading tests at age 15 taken at school as part of the international PISA assessment (Bhalotra and Venkataramani, 2013).

In work in progress, we are re-examining the evidence using more fine-grained, municipality-level data and tracking individual outcomes right from infancy to early adulthood (Bhalotra, Brown and Venkataramani, in progress). We find that access to clean water in infancy led to a 6% increase in cognitive performance scores and a 0.11 standard deviation increase in height during adolescence, and that similarly sized effects persist into early adulthood. Tracking those infants into adulthood (age 17–26), we find evidence that early life access to clean water resulted in significant gains to productivity, as measured by earnings per hour.

Policy implications

The importance of clean water for reducing death from waterborne diseases is well known. However, international organisations and governments evaluating public policy priorities systematically underestimate impacts of clean water for individuals who survive infection. Our research shows that clean water can enhance cognitive skill, improve academic achievement and increase productivity over a long time horizon. Clean water programmes are therefore a good investment not only in health but also in ensuring that individuals attain their cognitive potential and in raising living standards worldwide. ◀

About the author

Sonia Bhalotra is Professor of Economics at the University of Warwick and a CAGE Associate.

Publication details

This article is based on the papers:

Bhalotra, S.R., Brown, R., and Venkataramani, A.S. (2020) Clean Water Policy — Impacts on Cognitive and Physical Development. (Unpublished work in progress).

Bhalotra, S.R., Diaz-Cayeros, A., Miller, G., Miranda, A., and Venkataramani, A.S, (2021). Urban Water Disinfection and Mortality Decline in Lower-Income Countries. *American Economic Journal: Economic Policy.* Forthcoming.

Bhalotra, S.R. and Venkataramani. A.S. (2013). Cognitive Development and Infectious Disease: Gender Differences in Investments and Outcomes. IZA Discussion Paper (No. 7833).

The research is summarised in the video short 'Clean Water; a dirty matter' by Sameera Bhalotra Bowers, available on the CAGE YouTube Channel.

References

Deverman, B. E. and Patterson. P.H. (2009). Cytokines and Cns Development. *Neuron*, 64: 61–78.

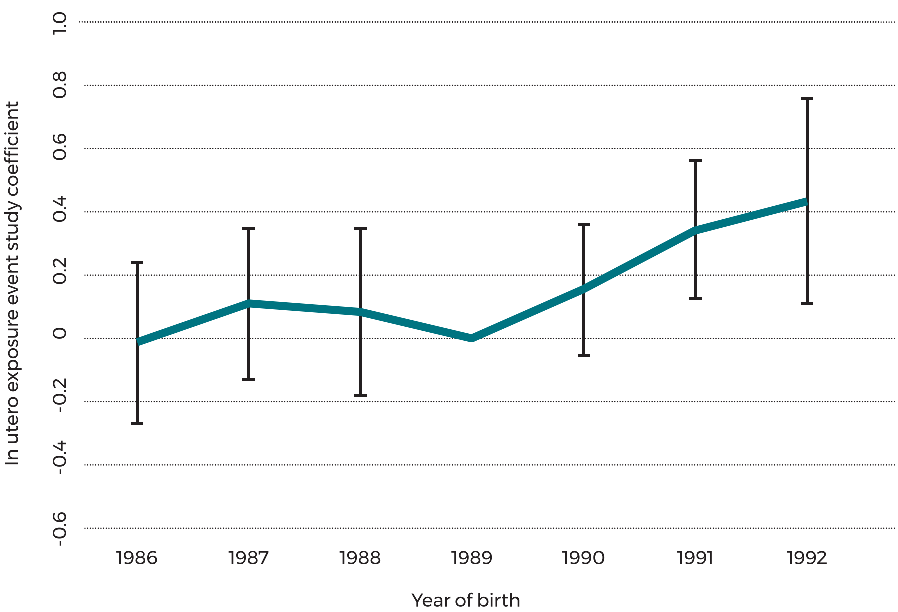
Finch, C. E. and Crimmins, E.M. (2004). Inflammatory exposure and historical changes in human life-spans. *Science*, 305(5691), 1736–1739.

Nowakowski, R. S. (2006). Stable neuron numbers from cradle to grave. *Proceedings of the National Academy of Sciences of the United States of America*, 103(33), 12219–12220.

6%

INCREASE IN COGNITIVE PERFORMANCE WITH ACCESS TO CLEAN WATER

Figure 2: The effect of clean water exposure at birth on Raven test scores in Mexico (conducted age 9–14)



Notes: The graph shows that Raven test scores (which measure pattern recognition skills) improve among Mexican children born after the water policy reform (1991). The vertical axis (coefficient) plots the estimated marginal effect of the policy (of exposure to clean water at birth) on the Raven test score, conditional on municipality and year fixed effects.

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