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Perspective

Can we 'WaSH' infectious diseases out of slums?

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ABSTRACT

The world is becoming increasingly urban and most of this growth is taking place in urban slums of the developing world. The current (2019) global population stands at 7.7 billion, with approximately one billion (13%) living in urban slums. By 2030 the world's population is projected to grow to 8.5 billion, with an estimated two billion (24%) living in slums. Slums are typically overcrowded, with most residents sharing a single room with four to five family members. There is usually no formal sewage or waste disposal system. Open sewage, with antimicrobial-resistant organisms, typically flows just outside the door, which during the rainy season often enters the home and contaminates the household drinking source. Hygiene is difficult if not impossible to maintain, hence the significant burden of infectious diseases, especially those with a faecal–oral mode of transmission. Transmission is year-round and the leading enteric pathogens are rotavirus, *Cryptosporidium*, *Shigella*, *Campylobacter*, *Salmonella typhi*, and *Vibrio cholera*. Water, sanitation, and hygiene (WaSH) will be crucial components of a future integrated control strategy for infectious diseases in slums. Cheap WaSH interventions have been trialled, but their impact has been modest and short-lived. More expensive WaSH alternatives that will provide lasting change now need to be explored. Can we 'WaSH' infectious diseases out of slums?

No WaSH

There have been a number of vaccine trials conducted in the slums of Dhaka, but the results indicate that a stand-alone strategy of introducing individual vaccines against enteric infections may not be sufficient (Naylor et al., 2015; Qadri et al., 2015; Islam et al., 2019; Nelson et al., 2016). The results of a rotavirus vaccine trial for infants conducted in urban Dhaka slums (i.e., two doses of the oral vaccine Rotarix at 10 and 17 weeks) showed the vaccine to be far less efficacious (31%) than levels of efficacy seen in infants and young children in industrialized settings (Naylor et al., 2015). A similar trial at our rural clinical site in Matlab yielded an almost identical outcome (28%) (Naylor et al., 2015). A recent oral cholera vaccine (OCV) trial (i.e., two doses of the bivalent whole-cell inactivated vaccine Shanchol) demonstrated a total vaccine protective effectiveness of 53% against severely dehydrating cholera 2 years after vaccination, but the vaccine efficacy was only 16% for children under 5 years of age (Qadri et al., 2015). Herd protection is of limited duration (<3 years), thus it will be difficult to meet the 2030 cholera elimination goals proposed by the World Health Organization (WHO).

Cheap WaSH

Water, sanitation, and hygiene (WaSH) interventions are diverse, potentially including improvements in water access (e.g., water quality, water quantity, and distance to water), sanitation access (e.g., access to improved latrines, latrine maintenance, and faecal sludge management), and hygiene practices (e.g., handwashing before eating and/or after defecation, water treatment, soap use, and water storage practices) (Prasad et al., 2016; Turley et al., 2013; Ross et al., 2019). Interventions often include multiple components while also providing hygiene education. Figure 1 below illustrates a number of cheap WaSH interventions (typically <$100 000 USD per item) that we and others have shown to be effective in community trials in both rural and urban settings (Katukiza et al., 2012; George et al., 2019; Pickering et al., 2019). They are now being used in combination with vaccination, and we experienced modest improvements in overall vaccine efficacy (Qadri et al., 2015; Nelson et al., 2016). For example, when the OCV was combined with 'cheap WaSH' (i.e., handwashing and treatment of drinking water with chlorine) as part of another trial arm, the total vaccine protective effectiveness

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Figure 1. Cheap evidenced-based WaSH interventions for the control of diarrhoeal disease in urban slums.

increased modestly from 53% to 58% (Qadri et al., 2015). Even in the setting of a cholera outbreak, free point-of-use water treatment had poor uptake in Kenya (12%), Nepal (19%), and Haiti (24%) (Pickering et al., 2019). It is evident that vaccination in slums may have to be supplemented with a higher level of WaSH than that achievable with cheaper options (Nelson et al., 2016; Pickering et al., 2019).

Emergency WaSH

Cheap WaSH, health education, and mass media in combination with vaccination, can play a role during outbreaks of enteric diseases (Qadri et al., 2015; Islam et al., 2019; Nelson et al., 2016). A potential outbreak response programme could be deployed at three levels: a mass strategy, slum strategy, and household strategy. A 'mass strategy' could be deployed within a city, where residents will be informed of the 'vaccination programme' in their respective slum via the following: SMS text phone messages, local health centres, Expanded Programme On Immunization (EPI) centres, pharmacies, trained community and religious leaders, and community notice boards. 'Health education' would focus on mothers and the risk factors for diarrhoeal disease and better hygiene practices. Mass media, on cholera for example, could showcase 'The story of cholera' and 'Protect your family' videos to illustrate effective WaSH practices to lower risk. As part of a 'slum strategy' an early warning surveillance system could be deployed in endemic slums using rapid diagnostic testing (e.g., Crystal VC dipstick test for suspected cholera cases) at health facilities and local hospitals, Android-based phone reporting of real-time test results, GIS risk mapping of patient addresses, and enhanced health education. A family emergency WaSH kit could be utilized as a 'household strategy' for families of diagnosed cases. The kit for cholera could comprise a UNICEF prevention poster for the family on how to minimize the risk of acquiring and transmitting cholera, boiled (1 min) or chlorinated drinking water tablets (Aquatabs, sodium dichloroisocyanurate) sufficient for a family of five or more for 30 days, a 'soapy water' package (soap and three dispensers) sufficient for a family of five or more for 30 days, and household disinfectant with bleach (3–6% sodium hypochlorite).

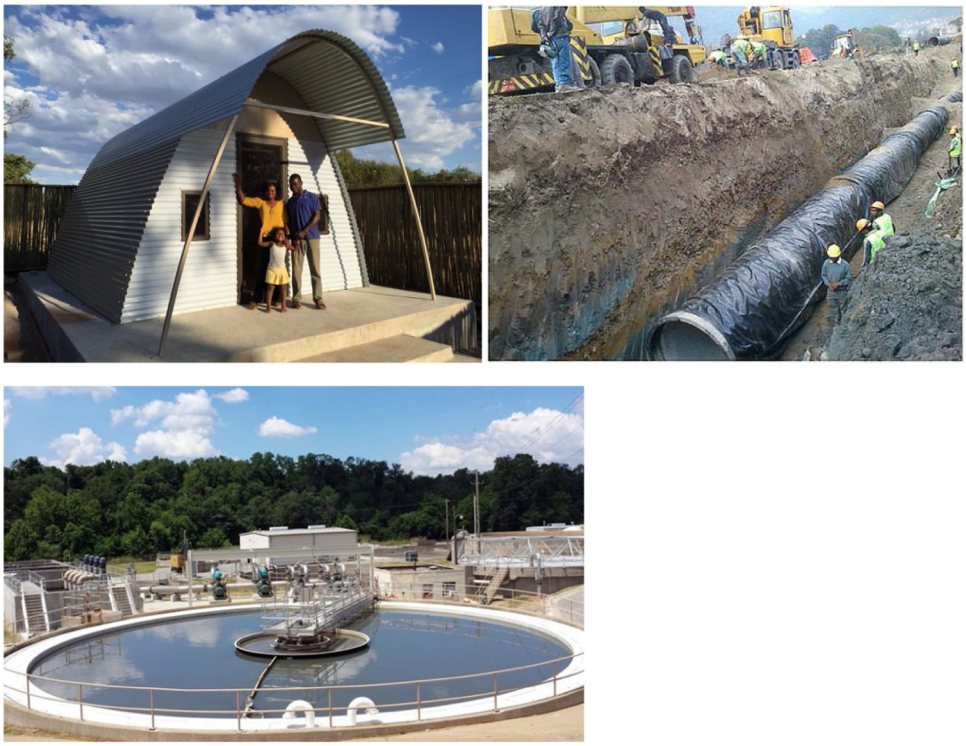

Figure 2. Expensive WaSH. Left panel: ABOD shelters in Africa. Middle panel: the Kathmandu Valley water supply project funded by the Asian Development Bank. Right panel: the soon to be installed sanitation system in the Rohingya camps supplied by Oxfam.

Expensive WaSH

Many in the WaSH sector believe that lasting change will come only when we bulldoze slums and rebuild them from the ground up with formal sewage systems, piped chlorinated water, and low cost housing (Ross et al., 2019; Pickering et al., 2019). High-income countries currently treat approximately 70% of their wastewater, while low income countries only treat 8% (Luby et al., 2019). In Dhaka, 99% of the population have access to a toilet, but 98% of the faecally contaminated wastewater is discharged back into the environment by vacuum truck operators or open drainage pipes (Luby et al., 2019). Funding donors appear unwilling to invest in community trials of 'expensive WaSH' interventions (typically >$1 million USD per item) in order to provide the evidence required to address this growing humanitarian need. Even if scientists were able to come up with a sustainable blueprint for slums, what low income country would be prepared to bring it to scale for the poorest segment of their society? ABOD shelters (https://www.abodshelters.com/) in the USA are presently providing low cost housing in nine countries in Africa (Figure 2) (Ross et al., 2019). In Kathmandu, the Asian Development Bank is providing funding to overhaul the centuries-old water supply system. So, there are solutions and funding available.

Future directions

In the Rohingya camps, we recently conducted the largest pre-emptive cholera vaccination campaign in history, which has to date prevented an outbreak (Qadri et al., 2018). There are a number of non-governmental organizations (NGOs) working within the camps providing a range of WaSH solutions, from cheap low cost WHO drinking water solutions to the expensive Oxfam sanitation system (Figure 2). The evidence to date suggests that OCV alone will not contain an outbreak of cholera, thus we believe the NGO WaSH interventions have worked synergistically with mass vaccination in halting the outbreak within the camps (Islam et al., 2019). What aspects of WaSH made this possible, and at what level of coverage? In sum, a range of low cost WaSH solutions have been trialled but their impact has been modest when deployed with vaccination. Community trials of more expensive WaSH options are required in order to determine the best available technology at an affordable price. This will be critical for enteric diseases (e.g., *Cryptosporidium*, *Shigella*, *Campylobacter*, *Salmonella typhi*), for which vaccines are currently not available. We can WaSH infectious diseases out of slums, but at what cost?

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Ethical approval

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Conflict of interest

We declare no conflict of interest.

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