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Clean water, clean hands or new vaccines?

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Summary Throughout human history, pathogens transmitted through feces from person to person have caused substantial mortality. Over a century ago civil engineers in high income countries developed approaches to collect and remove feces from the environment that in communities with high incomes and strong governments markedly reduced the burden of enteric disease. These approaches, however, have not been successfully extended to impoverished communities in low income countries. Water/sanitation/hygiene professionals have attempted, with only limited success, to reduce fecal exposure and human disease in the absence of definitive civil engineering approaches. Medical professionals have worked to develop vaccines against some of the most important fecal oral pathogens. Each of these approaches needs further development and adaptation to optimally address the burden of fecally transmitted diseases in impoverished communities.

Background

Historically, enteric disease has been a leading cause of child death. Three different professional groups have advocated different approaches to prevent these diseases. First, urban civil engineers have designed centralized infrastructure to capture the feces generated by community residents, transport it out of the community, and treat it. This approach minimizes community exposure to human feces, including minimizing fecal contamination of community water and food supplies. Second, water and sanitation program specialists have concluded that the definitive civil engineering approaches are prohibitively expensive for impoverished communities, and so developed lower cost efforts to improve toilets, water treatment and promote handwashing as an intermediate step to reduce community exposures to feces. Third, infectious disease specialists promote pathogen specific vaccination for addressing the most important enteric pathogens as a primary strategy for reducing enteric disease burden.

Because these three different approaches are championed by professionals with different educational background and professional socialization, there is more discourse within professional communities about how to advance their profession's approach, rather than constructive discourse across professional disciplines. The advice that

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implementers in highly constrained settings receive about how best to invest limited resources to reduce disease burden, more commonly depends upon the educational background of whom they ask, rather than a balanced consideration of alternatives.

This article briefly describes the context where each of these three approaches have been successful in reducing enteric disease burden, and the contexts where each fails. This strives to support a constructive discussion on how best to reduce enteric disease burden in resource constrained communities.

Civil engineering strategies

Historically, major civil engineering works that have improved drinking water quality have resulted in marked improvement in community health. Over 100 years ago William Sedgwick reviewed data from 7 cities in the US and Europe that adopted major improvements in drinking water quality. Following these interventions, the cities experienced a mean 78% reduction in deaths from typhoid fever and a 19% reduction in all-cause mortality.[1] These remarkable improvements have been replicated in subsequent analyses of various cities across the United States.[2,3] The pattern is unambiguous. When cities removed feces from drinking water, public health was hugely improved. This impressive historical record has been used to advocate for major civil works in low income countries where drinking water remains highly contaminated with human feces and diarrheal disease remains an important cause of child death.

Although we have over a century of evidence and experience, there has been limited success in extending the same civil engineering approaches that proved effective in settings of high income, sufficient water supply and strong governance to poor communities in rapidly growing low income country cities. In India, no city provides water 24 hours a day 7 days a week to all of its residents.[4] Indeed, I am aware of no city in a low income country with a population >1 million that provides water 24 hours a day 7 days a week to all of its residents. When a water utility does not provide water continuously to its city residents, but instead delivers water intermittently, then water will be contaminated. All water distribution systems have leaky pipes, even water distribution systems in high income countries. When water is turned off in a piped network, contaminants that surround the pipe seep into the pipe, so that when water is turned back on these contaminants are pumped through the system.[5,6] Thus, a water distribution system that supplies water intermittently inherently distributes contaminated water. Since intermittently functioning water distribution systems are characteristically paired with poor sanitary infrastructure that leaves substantial fecal environmental contamination throughout the city, an intermittently functioning water supply efficiently distributes fecal contaminants to community residents.

In addition, intermittently supplied water requires households to store water to meet water needs when the municipal supply is not available. Household stored water commonly becomes contaminated with fecal organisms from the households environment[7] and increases the risk of illness from transmission of enteric pathogens.[8] Stored household water also provides a breeding site for mosquito larvae that can be important vectors for a number of serious human infections.[9]

The fact that no low income country city has solved this problem, suggests that the core problem is not a failure of political will to implement sound policy. Rather, it suggests that expensive centralized civil engineering approaches that are effective in high income countries are not fit for purpose in contexts where the amount of wealth in the community is one or two orders of magnitude less, where available water supplies are often critically short[10,11] and where government institutions are unable to collect charges for water and complete essential routine maintenance. Residents of low income communities where enteric disease is a leading cause of death are typically dependent upon tanker trucks or other sources where they pay 10–100 times more per liter for water than the rich who have a piped supply servicing their home.[4] Because politicians typically receive substantial financial kickbacks from tanker contractors and other providers of substandard services to marginalized communities,[12,13] they have strong incentives to avoid extending high-quality services to low income neighborhoods.

WASH strategies

Faced with the failure of major civil engineering works to reach impoverished communities, nongovernmental and civil society organizations have proposed lower cost alternatives. Water and sanitation program specialists basically accept the constraints of poverty and weak governance in low income country municipalities, and look for approaches that can improve community health within these constrained circumstances. Examples include efforts to improve supply of water to the community, for example through community taps that are connected to the municipal supplies that a local organization works to collect use fees to pay for the water. Household level interventions include establishing access to toilets and encouraging washing hands with soap.

These water/sanitation/hygiene (WASH) focused interventions have not demonstrated the same remarkable impact on community health achieved by large civil engineering interventions in high income countries. Randomized control trials promoting handwashing or drinking water treatment demonstrate that if people wash their hands regularly with soap and water and if people treat their drinking water with a technique that reduces bacterial contamination, their children experience less diarrhea.[14,15] However, these household level interventions require households to expend time and money. The poorest families are the families whose children are at greatest risk of death from enteric disease[16] and it is precisely these poorest families who have the least disposable income to purchase household level interventions.

Impoverished families are overstretched with demands on their time and money for tasks and goods required for daily family survival. Although washing hands with soap and treating drinking water seem like good ideas, it remains unclear on a subsistence budget, whether investment in soap and water disinfection is a wise investment for families, or whether families would be better spending that money on nutrient dense food or educational opportunities for their children. Although results from randomized control