Policy Brief:

The Effect of Water, Sanitation and Hygiene on the Prevention of Schistosomiasis

Summary: Schistosomiasis is a disease caused by infection with blood flukes of the genus *Schistosoma*. Morbidity in schistosomiasis results primarily from immunologic reactions to the eggs trapped in the body; chronic infection can lead to organ damage, anaemia and malnutrition, and is associated with increased risks of bladder cancer and HIV infection and mortality. Schistosomiasis is controlled primarily with praziquantel, a safe, cheap and effective drug that kills adult schistosomes. However, improving access to clean water and sanitation are also important control measures, since infection occurs during contact with infested water, and transmission is sustained when eggs in urine or faeces enter fresh water containing intermediate host snails. Additionally, soap is toxic to snails and to free-living schistosomes, suggesting that its use during water contact (a form of good hygiene) may protect from infection. In a recent systematic review and meta-analysis, we found that people with access to safe water and adequate sanitation had significantly lower risks of schistosome infection. We found no studies quantifying the impact of soap use on risk of infection.

Background. It is estimated that around 440 million people are either infected with schistosomes or suffer the effects of past infections [1]. Three species of schistosome account for the majority of the human schistosomiasis burden. *Schistosoma mansoni* and *Schistosoma japonicum* cause intestinal schistosomiasis, in which the eggs are released in the faeces, while *Schistosoma haematobium* causes urogenital schistosomiasis, in which the eggs are released in the urine [1, 2].

The schistosome life cycle is shown on page 3. People become infected when cercariae, released by intermediate host snails, penetrate through the skin during water contact. In turn, infected people sustain transmission by allowing eggs in their urine (*S. haematobium*) or faeces (*S. mansoni* and *S. japonicum*) to enter fresh water containing these intermediate host snails, where the eggs release miracidia which infect snails [1, 2]. Children are particularly afflicted, with infection rates in endemic areas typically rising rapidly until the second decade of life, then gradually decreasing [3]. Schistosomiasis morbidity results primarily from immunologic reactions to the eggs, many of which are retained within the host rather than excreted in the urine and faeces. Typical consequences of chronic infections include enlargement of the liver and spleen, malnutrition, anaemia and impaired physical and cognitive development [1]. Schistosome infections also appear to increase the risk of developing bladder cancer, and the risks of contracting HIV and subsequently developing AIDS [4, 5].

Current control strategy. Schistosomiasis is easily treated with praziquantel, a safe, cheap and effective drug that kills adult worms and is therefore instrumental in reducing both schistosome transmission and morbidity [6, 7]. The WHO recommends annual treatment of school-age children in areas of high prevalence (prevalence >50%), biennial treatment of school-age children in areas of moderate risk (prevalence 10-50%) and treating school-age children twice during their primary school years in areas of low risk (prevalence 1-10%) [8]. However, praziquantel is not effective against juvenile worms and it does not prevent reinfection [6]. Water and sanitation are therefore advocated as complementary measures to mass drug administration [8], the rationale being that clean water supplies should prevent water contact, thereby protecting people from infection, and proper sanitation should contain urine and faeces and prevent their passage into water, thereby preventing snail infections. In 2012, the World Health Assembly passed resolution 65.19, declaring schistosomiasis elimination to be feasible in some member states. Water and sanitation are considered components of the integrated strategy required to achieve such elimination.

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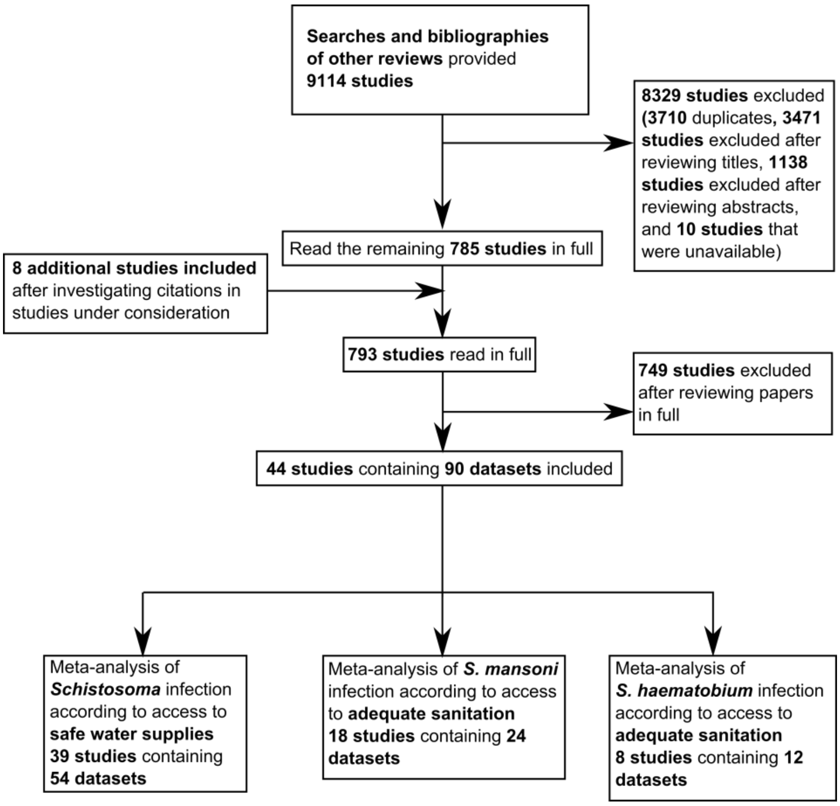
Methods. We carried out a systematic review to compare *Schistosoma* infection rates in people with and without access to 'safe' water (i.e. water which would not be expected to contain cercariae), 'adequate' sanitation (i.e., facilities which would not be expected to allow eggs in urine and faeces to enter fresh water) and 'good' hygiene (defined as the use of soap during water contact). Reasons for inclusion and exclusion of studies are summarised in the flow diagram to the right. We searched PubMed, Embase, Web of Science, and the Cochrane Library using keywords such as water, borehole, standpipe, sanitation, latrine, toilet, pit, open defecation, open urination, shower, laundry, hygiene, detergent, soap, risk factor, schistosome, schistosomiasis, bilharzia and snail fever. We also scanned the bibliographies of similar systematic reviews. In total we started with 9122 articles. Studies were excluded when two independent reviewers agreed that the title, abstract, or full text showed that they contained no usable data. After excluding 3710 duplicates and 5368 irrelevant papers, we identified 44 eligible studies. These studies contained 90 datasets comparing infection rates with access to safe water and adequate sanitation.



Flow diagram of study inclusion and exclusion

Findings

Water. While we looked for studies comparing safe water access with infection with any human schistosome species, we only found studies on the three main schistosome species. People with access to safe water had significantly lower risks of infection with *S. mansoni* (odds ratio, OR = 0.53; 95% confidence interval, CI: 0.45-0.63; 35 datasets), *S. haematobium* (OR = 0.57, 95% CI: 0.45-0.71, 17 datasets) and *S. japonicum* (OR = 0.37, 95% CI: 0.30-0.46, 2 datasets). Overall, safe water was associated with significantly reduced odds of *Schistosoma* infection (OR = 0.53, 95% CI: 0.47-0.61, 54 datasets).

Sanitation. As in the water analysis, we looked for studies on any human schistosome species, but we only found studies comparing sanitation with *S. mansoni* and *S. haematobium*. Access to adequate sanitation was associated with significantly lower odds of infection with both *S. mansoni* (OR = 0.59, 95% CI: 0.47-0.73, 24 datasets) and *S. haematobium* (OR = 0.69, 95% CI: 0.57-0.84, 12 datasets).

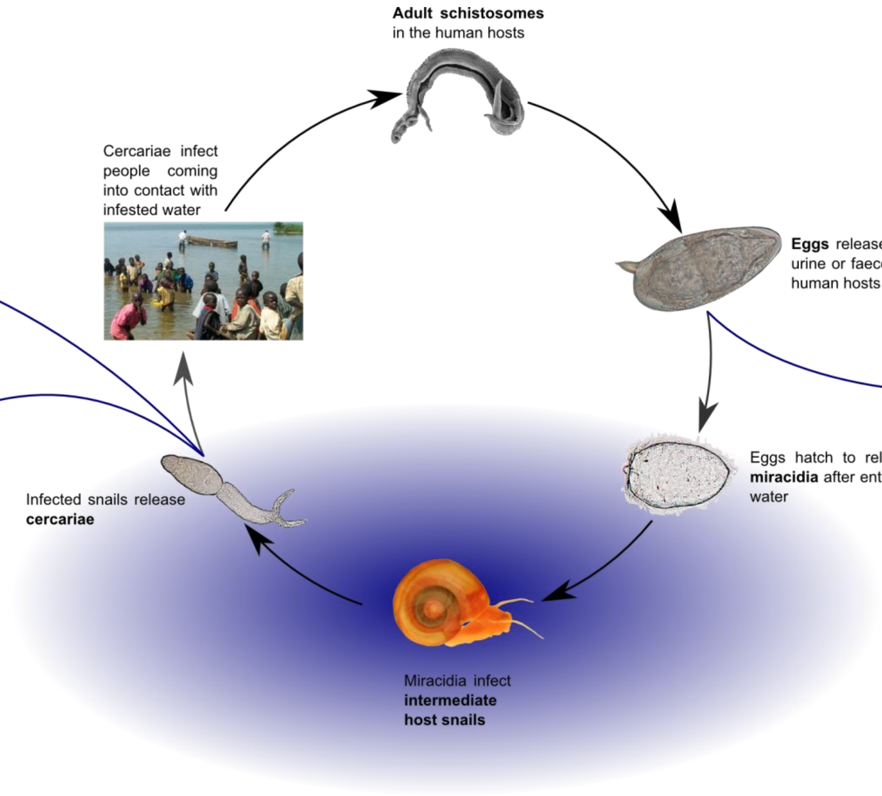
Hygiene. We found no eligible studies comparing soap use during water contact, with schistosome infection.

Water and sanitation was rarely defined in detail, with definitions including the presence or absence of a 'latrine' or 'safe water source'. Water and sanitation were always assessed through questionnaires rather than direct inspections, which might have been more reliable. Few studies distinguished between the mere presence *versus* active use of sanitation facilities.

The results are displayed on the next page, along with the schistosome life cycle and the mechanisms through which water, sanitation and hygiene (WASH) might disrupt schistosome transmission:

WATER SUPPLIES
Safe water supplies should prevent water contact and thus protect people from infection. Access to safe water supplies was associated with significantly lower odds of infection:

***S . mansoni*: OR = 0.53**, 95% CI: 0.45-0.63
***S. haematobium*: OR = 0.57**, 95% CI: 0.45-0.71
***S. japonicum*: OR = 0.37**, 95% CI: 0.30-0.46
Overall: OR = 0.53, 95% CI: 0.47-0.61



SANITATION
Sanitation should prevent snail infections by containing eggs and miracidia. Reduced snail infection rates should then cause reductions in human infection rates. Access to adequate sanitation was associated with significantly lower odds of infection:

***S. mansoni*: OR = 0.59**, 95% CI: 0.47-0.73
***S. haematobium*: OR = 0.69**, 95% CI: 0.57-0.84

HYGIENE
Using soap during water contact should kill cercariae and thus protect people from schistosome infection. However, we found no studies comparing soap use during water contact, with odds of infection.

ABBREVIATIONS
OR Odds Ratio, **CI** Confidence Interval

IMAGE CREDITS
nhm.ac.uk adult schistosomes, egg, miracidium, cercaria and water contact images, **vectorbase.org** snail image, **bbc.co.uk** borehole image, **Ferdinand Reus** laundry image, **wsscc.org** latrine image

The schistosome life cycle and meta-analysis results

Public health implications

All the analyses demonstrated that those with better access to water and sanitation have significantly lower odds of schistosomiasis, suggesting that water and sanitation protect from schistosome infection by reducing both contact with infested water and faecal or urinary contamination of environmental water. However, the included studies are all observational, i.e., they compare people's infection rates with their WASH, rather than assessing the impact of an intervention. This raises the possibility that the associations may have arisen because of confounding factors. For example, people of higher socioeconomic status will usually have better access to WASH, but may be also be protected from schistosomiasis by virtue of non-WASH factors such as better knowledge about the disease, better nutrition, better access to healthcare and treatment, and being less likely to have an occupation that involves contact with infested water (such as fishing).

WASH intervention studies are required to remove this confounding. Future studies should also focus on specific parts of the schistosome lifecycles, to elucidate the relationship between water supplies, water contact and infection, sanitation, urinary/faecal contamination of environmental water and risk of future infection, and use of soap, schistosome populations and risk of infection. Key WASH definitions should be agreed to allow better aggregation of future studies' findings, and more use should be made of the WHO/UNICEF Joint Monitoring Programme definitions [9]. Definitions of WASH for schistosomiasis control might assess infrastructure that goes beyond the supply of drinking water and includes other facilities such as sinks, laundry basins, showers and swimming pools, all of which may be necessary to reduce contact with infested water.

Furthermore, in contrast to other diseases such as soil-transmitted helminthiasis and trachoma, schistosomiasis transmission requires intermediate host snails. It therefore usually occurs not within the household, but at water contact sites in the community. It is important to recognise that exposure results from the WASH practices of whole communities, rather than only those of co-habiting family members. WASH interventions for schistosomiasis control should therefore be targeted towards whole communities rather than households. Water supply interventions for schistosomiasis control should not only provide drinking water, but should prevent as much contact with environmental water as possible.

Schistosomes can live for many years [10] and praziquantel is therefore certainly needed to treat current infections. However, if transmission is not disrupted through measures such as improving WASH and providing health education, reinfection is inevitable and elimination will not be achieved. In addition to schistosomiasis, WASH are recognised to be important control measures for diarrhoeal disease, soil-transmitted helminthiasis, trachoma and many other diseases [11-14].

Key messages for schistosomiasis-endemic communities:

People with better water and sanitation are significantly less likely to be infected with schistosomes. Water supply interventions should prioritise reducing contact with schistosome-contaminated rivers and lakes as much as possible. Such interventions may include providing facilities for bathing and washing clothes and dishes. Urination and defecation into or near such water bodies should be prevented, and latrine use should be encouraged. WASH interventions should be directed towards whole communities rather than individual households, and health education should accompany infrastructure provision. Future studies should use standardised WASH definitions, in order to enhance comparability between studies.

References:

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