Effect of water, sanitation and hygiene interventions on pathogens in the environment: Individual participant data meta-analysis

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# Abstract

(to write)

# Background

Water, sanitation and hygiene (WASH) improvements aim to reduce childhood enteric infections, subsequent diarrheal disease and growth faltering by reducing child exposure to fecal-orally transmitted pathogens in the environment. Until recently, trials of WASH interventions have primarily focused on documenting health outcomes such as caregiver-reported diarrhea without quantifying intermediate outcomes along the causal chain, such as detection of pathogens in environmental samples and in human biological specimens. Without measuring these causal intermediates, trials are limited to a “black box” understanding, where underlying mechanisms of interventions are unknown and investigators can only speculate about reasons for intervention success or failure. Inspecting the causal chain is especially important given the small or null effects on child diarrhea and growth achieved in recent well-conducted trials of WASH interventions.1–3

Additionally, studies that have collected environmental samples to date have primarily focused on drinking water (and, to a smaller extent, hands and food) while other pathways such as soil and surfaces in the domestic environment have received less attention.4 Furthermore, most studies have relied on measuring indicator organisms in the environment as a proxy for pathogens; these indicators can originate from non-fecal sources,5 cannot differentiate between human vs. animal fecal contamination, 6 and correlate poorly with the presence of pathogen.7 Recent advances in DNA-based diagnostics now allow detection of a range of enteropathogens in human biological specimens and environmental samples,8 as well as distinction between human vs. animal fecal sources through molecular source tracking (MST) markers.9

We aimed to assess the effect of WASH interventions on specific pathogens, pathogen types (viruses, bacteria, protozoa, helminths) and human vs. animal MST markers in the environment. We conducted a systematic review of WASH intervention studies that have measured pathogens and/or MST markers in environmental samples, and we conducted an individual participant data (IPD) meta-analysis of WASH trials that have measured pathogens and/or MST markers in the environment to explore causal relationships between WASH interventions and pathogen and MST presence and abundance in the environment.

# Methods

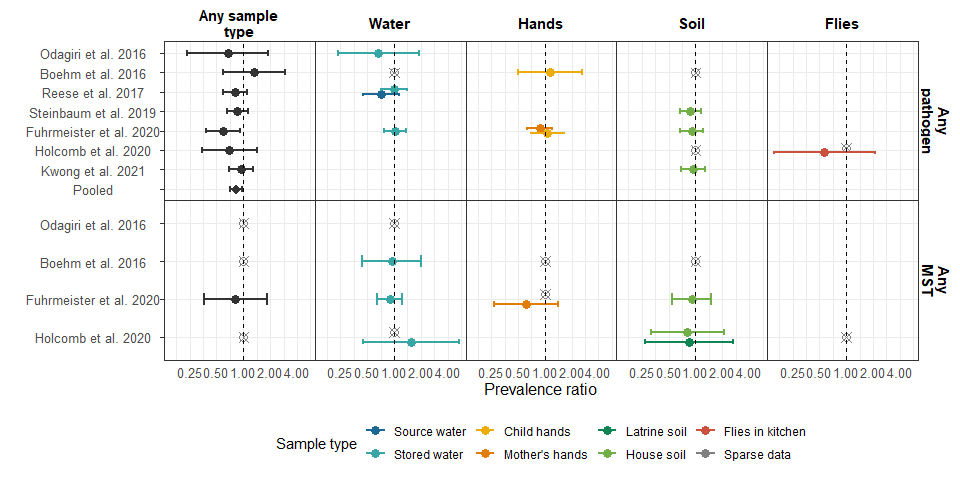
# Results

* Studies included
* Limitations

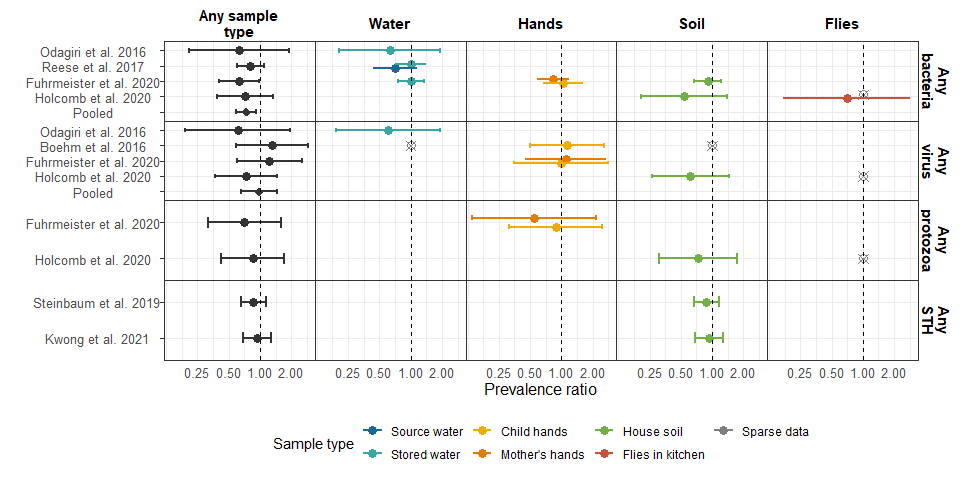
# Discussion

* Limitations
  + Sparse in many categories

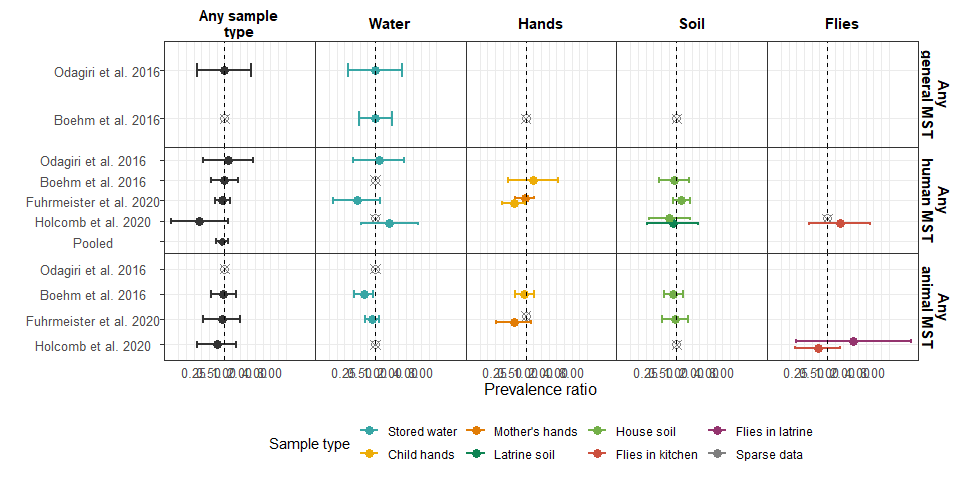
# Figures



**Figure 1.** Forest plots of intervention effects on any enteropathogen, and any MST markers in different samples of environmental samples. Pooled estimates are presented when there are four or more study-specific estimates for a specific sample and target combination.



**Figure 2.** Forest plots of intervention effects on any virus, any bacteria, any protozoa and any STH



**Figure 2.** Forest plots of intervention effects on any general, human and animal MST markers in different samples of environmental samples.

# Tables

# References

1. Humphrey, J. H. *et al.* Independent and combined effects of improved water, sanitation, and hygiene, and improved complementary feeding, on child stunting and anaemia in rural Zimbabwe: A cluster-randomised trial. *The Lancet. Global Health* **7**, e132–e147 (2019).

2. Luby, S. P. *et al.* Effects of water quality, sanitation, handwashing, and nutritional interventions on diarrhoea and child growth in rural Bangladesh: A cluster randomised controlled trial. *The Lancet Global Health* **6**, e302–e315 (2018).

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