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Interventions to improve water, sanitation, and hygiene for preventing soil-transmitted helminth infection (Review)

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TABLE OF CONTENTS

[Intervention Review]

Interventions to improve water, sanitation, and hygiene for preventing soil-transmitted helminth infection

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ABSTRACT

Background

It is estimated that 1.5 billion people are infected with soil-transmitted helminths (STHs) worldwide. Re-infection occurs rapidly following deworming, and interruption of transmission is unlikely without complementary control efforts such as improvements in water, sanitation, and hygiene (WASH) access and behaviours.

Objectives

To assess the effectiveness of WASH interventions to prevent STH infection.

Search methods

We used standard, extensive Cochrane search methods. The latest search date was 19 October 2021.

Selection criteria

We included interventions to improve WASH access or practices in communities where STHs are endemic. We included randomized controlled trials (RCTs), as well as trials with an external control group where participants (or clusters) were allocated to different interventions using a non-random method (non-RCTs). We did not include observational study designs. Our primary outcome was prevalence of any STH infection. Prevalence of individual worms was a secondary outcome, including for *Ascaris lumbricoides*, *Trichuris trichiura*, hookworm (*Ancylostoma duodenale* or *Necator americanus*), or *Strongyloides stercoralis*. Intensity of infection, measured as a count of eggs per gram of faeces for each species, was another secondary outcome.

Data collection and analysis

Two review authors independently reviewed titles and abstracts and full-text records for eligibility, performed data extraction, and assessed risk of bias using the Cochrane risk of bias assessment tool for RCTs and the EPOC tool for non-RCTs. We used a random-effects meta-analysis to pool study estimates. We used Moran's I^2 statistic to assess heterogeneity and conducted subgroup analyses to explore sources of heterogeneity. We assessed the certainty of the evidence using the GRADE approach.

Main results

We included 32 studies (16 RCTs and 16 non-RCTs) involving a total of 52,944 participants in the review. Twenty-two studies (14 RCTs (16 estimates) and eight non-RCTs (11 estimates)) reported on our primary outcome, prevalence of infection with at least one STH species. Twenty-one studies reported on the prevalence of *A lumbricoides* (12 RCTs and 9 non-RCTs); 17 on the prevalence of *T trichiura* (9 RCTs and 8 non-RCTs); 18 on the prevalence of hookworm (10 RCTs and 8 non-RCTs); and one on the prevalence of *S stercoralis* (1 non-RCT). Sixteen studies measured the intensity of infection for an individual STH type. Ten RCTs and five non-RCTs reported on the intensity of infection of *A lumbricoides*; eight RCTs and five non-RCTs measured the intensity of infection of *T trichiura*; and eight RCTs and five non-RCTs measured the intensity of hookworm infection. No studies reported on the intensity of infection of *S stercoralis.*

The overall pooled effect estimates showed that the WASH interventions under study may result in a slight reduction of any STH infection, with an odds ratio (OR) of 0.86 amongst RCTs (95% confidence interval (CI) 0.74 to 1.01; moderate-certainty evidence) and an OR of 0.71 amongst non-RCTs (95% CI 0.54 to 0.94; low-certainty evidence). All six of the meta-analyses assessing individual worm infection amongst both RCTs and non-RCTs had pooled estimates in the preventive direction, although all CIs encapsulated the null, leaving the possibility of the null or even harmful effects; the certainty of the evidence ranged from very low to moderate. Individual studies assessing intensity of infection showed mixed evidence supporting WASH. Subgroup analyses focusing on narrow specific subsets of water, sanitation, and hygiene interventions did very little to elucidate which interventions might be better than others. Data on intensity of infection (e.g. faecal egg count) were reported in a variety of ways across studies, precluding the pooling of results for this outcome.

We did not find any studies reporting adverse events resulting from the WASH interventions under study or from mass drug administration (MDA).

Authors' conclusions

Whilst the available evidence suggests that the WASH interventions under study may slightly protect against STH infection, WASH also serves as a broad preventive measure for many other diseases that have a faecal oral transmission route of transmission. As many of the studies were done in addition to MDA/deworming (i.e. MDA was ongoing in both the intervention and control arm), our data support WHO recommendations for implementation of improvements to basic sanitation and adequate access to safe water alongside MDA. The biological plausibility for improved access to WASH to interrupt transmission of STHs is clear, but WASH interventions as currently delivered have shown impacts that were lower than expected. There is a need for more rigorous and targeted implementation research and process evaluations in order that future WASH interventions can better provide benefit to users. Inconsistent reporting of the intensity of infection underscores the need to define the minimal, standard data that should be collected globally on STHs to enable pooled analyses and comparisons.

PLAIN LANGUAGE SUMMARY

Interventions to improve water, sanitation, and hygiene for preventing soil-transmitted helminth infection

What is the aim of this review?

This review summarizes randomized controlled trials (RCTs) (studies where participants are randomly assigned to one of two or more treatment groups) and non-randomized trials (non-RCTs) evaluating the effect of water, sanitation, and hygiene interventions on preventing soil-transmitted helminth infections.

Soil-transmitted helminths (STHs) comprise a group of intestinal parasites that are transmitted to humans through ingestion of infective eggs or transcutaneous (through the skin) penetration of larvae excreted in human faeces which contaminate the soil and water sources. Even with deworming efforts, re-infection occurs rapidly, and interruption of transmission is unlikely without complementary control efforts. Environmental improvements, such as access to and use of safe and adequate water, basic sanitation, and hygiene (WASH), is thought to be essential to sustain reductions in re-infection and to reduce illness.

Key messages

The evidence suggests that the WASH interventions under study may slightly reduce STH infection. Many of these results were in studies coupled with mass drug administration in both the treatment arm(s) and the control arm, and therefore show the impact of WASH on STH infection above and beyond the application of mass drug administration alone.

What was studied in the review?

Previous reviews assessing WASH and STH infection have relied heavily on non-experimental studies. We investigated rigorous, experimental evidence assessing the role of WASH programmes to reduce STH infection.

What are the main results of the review?

We searched the scientific literature for relevant studies (published, unpublished, in press, and ongoing) up to 19 October 2021 and identified 32 studies (16 RCTs and 16 non-RCTs) enrolling a total of 52,944 participants. We found evidence that the WASH interventions

under study may result in a slight reduction of any STH infection. Pooling of 14 RCTs for analysis of this outcome showed a slightly lower (14%) odds of any STH infection amongst participants in the WASH group compared to those in the control group. Similarly, pooling of eight non-RCTS for analysis of any STH infection showed that the odds of any STH infection was 29% lower amongst participants in the WASH group compared to the control group. When considering the analyses assessing WASH interventions on individual worm species, the evidence was very uncertain; WASH interventions may result in little to no reduction in *Trichuris trichiura* infection and may result in a slight reduction in *Ascaris lumbricoides* and hookworm infection. Data on intensity of infection (e.g. faecal egg count) were reported in a variety of ways across studies, preventing the pooling of results for this outcome.

How up-to-date is the evidence?

The evidence is current to 19 October 2021.

SUMMARY OF FINDINGS

Summary of findings 1. Water, sanitation, and hygiene (WASH) intervention versus no WASH intervention for preventing soil-transmitted helminth infection

Water, sanitation, and hygiene (WASH) intervention versus no WASH intervention for preventing soil-transmitted helminth infection

Patient or population: children and adults

Setting: all settings with STH endemicity

Intervention: any water, sanitation, and/or hygiene interventions

Comparison: no water, sanitation, and/or hygiene intervention

Outcome (design)	Study design	Illustrative comparative prevalences (95% CI)*		Relative effect (95% CI)	No. of participants (studies)	Certainty of evidence (GRADE)	Comments
		Prevalence with no WASH intervention	Corresponding prevalence with WASH intervention				
Any STH prevalence	RCT	30 per 100	27 per 100 (24 to 30)	OR 0.86 (0.74 to 1.01)	36,055 participants (14 studies)	⊕⊕⊕⊖ Moderate[a] *Due to inconsistency*	These WASH interventions may result in a slight reduction in any STH prevalence.
	Non-RCT	57 per 100	48 per 100 (42 to 55)	OR 0.71 (0.54 to 0.94)	8880 participants (8 studies)	⊕⊕⊖⊖ Low[b] *Due to risk of bias*	
Ascaris lumbricoides prevalence	RCT	18 per 100	16 per 100 (14 to 18)	OR 0.87 (0.73 to 1.03)	25,576 participants (11 studies)	⊕⊕⊕⊖ Moderate[a] *Due to inconsistency*	These WASH interventions may result in a slight reduction in *A lumbricoides* prevalence, but some of the evidence is very uncertain.
	Non-RCT	28 per 100	23 per 100 (17 to 31)	OR 0.76 (0.51 to 1.15)	6585 participants (9 studies)	⊕⊖⊖⊖ Very low[c]	

						Due to risk of bias, imprecision	
Trichuris trichiura prevalence	RCT	10 per 100	9 per 100 (8 to 11)	OR 0.94 (0.77 to 1.14)	23,981 participants (9 studies)	⊕⊕⊖⊖ Low[d] *Due to imprecision*	These WASH interventions may result in little to no difference in *T trichiura* prevalence, but some of the evidence is very uncertain.
	Non-RCT	25 per 100	21 per 100 (15 to 29)	OR 0.81 (0.54 to 1.20)	5456 participants (8 studies)	⊕⊖⊖⊖ Very low[e] *Due to risk of bias, imprecision*	
Hookworm prevalence	RCT	6 per 100	5 per 100 (5 to 6)	OR 0.88 (0.75 to 1.04)	24,191 participants (9 studies)	⊕⊕⊖⊖ Moderate[d] *Due to imprecision*	These WASH interventions may result in a slight reduction in hookworm prevalence, but some of the evidence is very uncertain.
	Non-RCT	13 per 100	10 per 100 (7 to 14)	OR 0.75 (0.53 to 1.06)	7960 participants (8 studies)	⊕⊖⊖⊖ Very low[f] *Due to risk of bias, imprecision*	
Strongyloides stercoralis prevalence	RCT	—	—	—	— [g]	—	The evidence for the effect of these WASH interventions on *S stercoralis* prevalence is very uncertain.
	Non-RCT	3 per 100	3 per 100 (0 to 39)	OR 1.00 (0.05 to 20.83)	200 participants (1 study)	⊕⊖⊖⊖ Very low[h] *Due to risk of bias, imprecision*	

*Comparison group prevalence estimates come from pooled estimates of control groups with this information available. The corresponding prevalence with the WASH intervention (and its 95% confidence interval (CI)) is based on the prevalence in the comparison group and the relative effect (and its 95% CI).

CI: confidence interval; **OR:** odds ratio; **RCT:** randomized controlled trial; **STH:** soil-transmitted helminth; **WASH:** water, sanitation, and hygiene

GRADE Working Group grades of evidence

High certainty: we are very confident that the true effect lies close to that of the estimate of the effect.
Moderate certainty: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.

Low certainty: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect.
Very low certainty: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect.

[a]Downgraded one level for inconsistency: visual inspection of forest plot shows overlap between many effect estimates, and I^2 is indicative of heterogeneity. Imprecision was due in part to heterogeneity (inconsistency).
[b]Downgraded two levels for non-randomized design: non-random sequence generation, and allocation sequence not concealed (already downgraded for this as a non-RCT).
[c]Downgraded two levels for non-randomized design and one level for imprecision: large number of participants, but the CI includes the possibility of small or no effect.
[d]Downgraded one level for imprecision: large number of participants, but the CI includes the possibility of small or no effect.
[e]Downgraded two levels for non-randomized design and one level for imprecision: large number of participants, but the CI includes the possibility of small or no effect, and point estimate shows little appreciable benefit.
[f]Downgraded two levels for non-randomized design, one level for risk of bias, and one level for inconsistency. Incomplete reporting for many domains. Large number of participants, but the CI includes the possibility of small or no effect, and point estimate shows little appreciable benefit.
[g]Two studies assessed this outcome but they did not meet our endemicity inclusion criterion.
[h]Downgraded two levels for non-randomized design, one level for risk of bias, and one level for imprecision: single study with incomplete reporting for many of the risk of bias domains and very wide CIs.

BACKGROUND

Description of the condition

Soil-transmitted helminths (STHs) comprise a group of intestinal parasites that are transmitted to humans through ingestion of infective eggs or transcutaneous penetration of larvae excreted in human faeces which contaminate the soil and water sources (Montresor 2017). It is estimated that 820 million people are infected with roundworms (*Ascaris lumbricoides),* 460 million with whipworm (*Trichuris trichiura*), and 460 million with hookworms (*Necator americanus* and *Ancylostoma duodenale*) in 102 countries worldwide (WHO 2017).

These infections contributed to an estimated 3.4 million disability-adjusted life-years (DALYs) and 6000 deaths (Pruss-Ustun 2019). Whipworm is associated with undernutrition (Cappello 2004), and roundworm may lead to impaired fat digestion and poor vitamin absorption (WHO 2002). Chronic and heavy infections with STHs can cause iron deficiency (Gulani 2007; Stoltzfus 1998), poor nutrition and stunting (Crompton 2002; Stoltzfus 1997), cognitive delays, and absence from school (Miguel 2004). Death from STH infection is uncommon, and the largest trial of deworming found no evidence of deworming on rates of mortality in a lightly infected population in northern India (Awasthi 2013). Polyparasitism, that is infection with more than one STH, is common, and higher worm burden leads to greater morbidity (Al-Delaimy 2014; Sanchez 2013).

The World Health Organization (WHO) recommends preventive chemotherapy (PC) with albendazole or mebendazole alongside targeted health education and improved water and sanitation to control STH-related morbidity (WHO 2012). PC is provided by endemic countries utilizing drugs donated through the pharmaceutical industry and the WHO, using mass drug administration events (MDAs). MDAs commonly target schoolchildren, but may also be conducted at the community level, especially as part of the lymphatic filariasis-focused MDAs. Extensive and successful MDA is estimated to have had a high impact, with 20% reduction in ascariasis prevalence (Hotez 2017). However, a Cochrane Review found little convincing evidence of the impact of community-based MDA on children's growth, cognition, or school performance (Taylor-Robinson 2019). It is well-documented that the efficacy of these drugs is suboptimal and differs considerably between individual species of STH (Keiser 2008).

Description of the intervention

Re-infection occurs rapidly following deworming (Jia 2012), and interruption of transmission is unlikely without complementary control efforts (Freeman 2013b; Utzinger 2009; WaterAid 2012; WHO 2012). Environmental improvements, such as access to and use of safe and adequate water, basic sanitation, and hygiene (WASH), is thought to be essential to sustain reductions in morbidity (Bangert 2017).

STH is highly endemic amongst people who are poor, especially those with poor access to water and sanitation services. Improvements of water quantity for hygiene, water quality for drinking and cooking, basic sanitation, and hygienic behaviours may break transmission and lead to reductions in worm burden that complement deworming (Nery 2019a). The WHO Roadmap for Implementation for the control of neglected tropical diseases specifies the importance of water, sanitation, and hygiene improvements for control efforts, and recent efforts have attempted to prioritize interventions that align complementary WASH and treatment/chemotherapy (WHO 2020; WHO 2021).

How the intervention might work

The impact of WASH on health is well-documented (Bartram 2010). Reviews have found considerable evidence for the role of WASH in reducing diarrhoeal disease (Pruss-Ustun 2019), limiting trachoma infection (Stocks 2014), reducing schistosomiasis transmission (Grimes 2014), and improving nutrition (Dangour 2013). However, few rigorous studies have been conducted. A review including both observational studies and trials found a preventive relationship between sanitation and STH infection, but this association did not persist when restricting the analysis to only trials (Freeman 2017). Water improvements could include improvements to water quality, such as point-of-use water treatment with filters or chlorine (Clasen 2007), which would prevent ingestion of STH ova, or safe water storage, given the known role of water handling in water contamination (Wright 2004). Improvements to water supply - typically a community-level intervention – can impact both water quality and water quantity, especially if the new source is closer to the house (Howard 2003).

The WHO/UNICEF Joint Monitoring Programme for Water and Sanitation (JMP) defines 'improved' water supply as any source protected from recontamination, though evidence suggests that access to an improved source does not guarantee microbiological safety (Brown 2013). Sanitation improvements might include either demand-side promotion, such as community-led total sanitation (Kar 2008), or supply-side sanitation to promote increased access to, and use of, toilets. Hygiene improvements could include hygiene education, mass media campaigns, provision of educational materials to schools, or supply of soap. WASH interventions to control STH could include school- or community-based programmes and may be allocated by household, community, or school.

Why it is important to do this review

The Rockefeller Sanitation Commission Report in the early 1900s first documented the impact of sanitary improvements on STH infection (Horton 2003). Esrey 1991 first reviewed the associations between WASH and STHs, followed by Strunz 2014 and Ziegelbauer 2012, although all of these reviews relied predominantly on observational studies. Freeman 2017 only assessed the impacts of sanitation on STH infection, with separate analyses of trials and observational studies. Other studies have attempted to model the attributable fraction of infections caused by poor access to and behaviours related to WASH (Soares 2011). Understanding both the impact and costs of interventions are essential for establishing control policies for STH. Whilst the cost and cost-effectiveness of MDA has been quantified (Holland 2001; Leslie 2011), and costing tools are currently available to estimate the life-cycle costs of WASH programmes (IRC 2014), robust quantification of the effectiveness of WASH programmes on STH is lacking. WASH programmes may prove efficacious given long-time horizons estimated for controlling STH through MDA alone, but more data are needed.

Our review of the rigorous evidence of the role of WASH programmes on STH infection should add to the existing literature. Ziegelbauer 2012 found evidence of crude associations

between sanitation access and STH prevalence (odds ratios ranging between 0.46 and 0.58) and between sanitation use and individual STH infections (odds ratios ranging between 0.54 and 0.78). A second review found similar results using adjusted estimates for the relationship between sanitation and STH, as well as strong associations between water supply, water treatment, and hygiene and individual and any STH infection (Strunz 2014). These reviews relied on observational studies, which may be subject to reporting bias and lack of causality. As noted above, Freeman 2017 found preventive associations between sanitation and some STH worms (*A lumbricoides* and hookworm) in observational studies, but these associations did not persist in the experimental trials. Though reviews of lower quality observational studies may be useful for policy guidance, a review focusing on experimental designs, particularly randomized controlled trials (the gold-standard study design), was needed to assess the impact of WASH improvements on STH infection. This review might draw attention to the need for more robust evidence around effectiveness and, by extension, the cost-effectiveness of these interventions.

OBJECTIVES

To assess the effectiveness of WASH interventions to prevent STH infection.

METHODS

Criteria for considering studies for this review

Types of studies

We included all randomized controlled trials (RCTs), and separately all non-randomized trials with an external control group where participants (or clusters) were allocated to different interventions using a non-random method (referred to in the review as 'non-RCTs'). This includes interventions either individually allocated or assigned by cluster, such as household, village, school, or other group cluster. Study design definitions of the included studies are provided in Appendix 1**.** We designated studies using random allocation methods as RCTs if they included at least two units per trial arm. We excluded non-human animal studies and duplicate publications. We excluded all observational study designs.

Types of participants

Trials were conducted in contexts where STHs are endemic and transmitted, and trial participants were those that resided in the trial site. We included participants with or without STH infection at baseline. We considered all types of participants. We included trials with preschool-age children, adolescent, and adult participants.

Types of interventions

Interventions

Interventions included provision of water supply, latrine construction or sanitation promotion, hygiene education, and water quality improvements (such as safe storage and handling or water treatment). We included all interventions that improve WASH access or practices, or both, including those that employed multiple WASH strategies or an integrated approach that included MDA.

Comparators

Relevant comparators comprised trial participants or groups that followed their typical WASH behaviours rather than a prescribed intervention. Other interventions (e.g. MDA) had to be equally administered in both the intervention and control study groups.

Types of outcome measures

We included all studies that assessed any of our primary or secondary outcomes of interest.

Primary outcomes

1. Prevalence of infection with any STH species, defined by at least one ovum of *A lumbricoides*, *T trichiura*, hookworm, or *Strongyloides stercoralis* found in the participant's faeces.

Secondary outcomes

1. Prevalence and intensity of infection as measured by eggs per gram of faeces for specific STH type, including *A lumbricoides* (ascariasis), *T trichiura* (trichuriasis), hookworm (*A duodenale* or *N americanus*, or both), or *S stercoralis* (strongyloidiasis).
2. Any adverse events resulting from WASH interventions and MDA.

Search methods for identification of studies

We attempted to identify all relevant studies regardless of language or publication status (published, unpublished, in press, and ongoing).

Electronic searches

We searched the following databases up to 19 October 2021 using the search terms described in Appendix 2: Cochrane Infectious Diseases Group Specialized Register; the Cochrane Central Register of Controlled Trials (CENTRAL), published in the Cochrane Library, Issue 10 of 12, October 2021; MEDLINE (PubMed, from 1966); Embase (Ovid, from 1947); Science Citation Index-Expanded and Social Science Citation Index (Web of Science, from 1900); and LILACS (Latin American and Caribbean Health Science Information database (BIREME, from 1982). We also searched the World Health Organization International Clinical Trials Registry Platform (WHO ICTRP; www.who.int/clinical-trials-registry-platform) and US National Institutes of Health Ongoing Trials Register ClinicalTrials.gov (clinicaltrials.gov/) for trials in progress; both registers were searched on 19 October 2021. We searched the Chinese language databases available in the China National Knowledge Infrastructure and the Wanfang portal.

Searching other resources

Conference proceedings

We searched conference proceedings of the American Society of Tropical Medicine & Hygiene, and the Water and Health Conference for the previous two years.

Reference lists

We checked the reference lists of all included trials for potentially relevant research and reviewed authors' personal collections.

Data collection and analysis

Selection of studies

Two review authors (AM and JW) independently reviewed the titles and abstracts yielded by the search to identify all potentially relevant studies. We obtained the full-text articles of those studies deemed potentially relevant, and the same two review authors independently assessed the full-text articles for inclusion in the review using an eligibility form. Three review authors (JVG, RI, and MCF) were co-authors of some of the included and excluded studies. Study selection, extractions, and bias analysis of these studies were done by review authors AM and JW, who were not co-authors on any of the included studies.

When AM and JW did not initially reach a consensus, MCF made the final inclusion decision based on whether or not the study met the inclusion criteria. All eligible studies were analysed following the same analysis plan. When study eligibility was unclear, we wrote to the study authors for clarification. We scrutinized each trial report to ensure that we included multiple publications from the same trial only once. We documented all excluded studies along with their reasons for exclusion.

For publications written in languages other than English, external individuals assisted with translation and determination if the study met the inclusion criteria. When studies in other languages met the inclusion criteria, translators worked with AM and JW to identify relevant data to be extracted.

Data extraction and management

Two review authors (AM and JW) independently performed data extraction using a pre-designed data extraction form (Appendix 3). Any disagreements regarding data extraction were resolved by discussion with a third review author (MCF). If relevant data were unclear or unreported, we contacted trial authors for clarification. Authors were contacted with follow-up emails if they did not reply. We entered the extracted data into Microsoft Excel (Microsoft Excel).

We collected data regarding trial population (including age and sex distribution), setting (including country and urban status), participant inclusion and exclusion criteria, intervention description (including any non-WASH co-interventions), control details, diagnostic method, and statistical methods (including model covariates and modelling approach where applicable). We also collected information about STH prevalence and intensity (point estimates with standard errors (SEs)) where trial authors reported this information. The majority of authors focused on geometric means, so we preferably extracted the geometric mean eggs per gram (EPG) of faeces, and any measures of association that were available. We also extracted arithmetic means and medians when adequate information on the geometric mean was not available.

For each outcome, we extracted the number of participants randomized and analysed in each treatment group for each outcome. For dichotomous outcomes, we extracted the number of participants that experienced the event in each group and ratio measures with SEs, if available. For count outcomes, we extracted the number of events (EPG) in the treatment and control group and the rate ratio and SE, if available. There were no time-until-event outcomes.

We extracted information on the number of clusters, type of clusters (e.g. communities, households), average size of the cluster, unit of randomization, statistical methods used for correlated data, and estimates of the intraclass correlation coefficient (ICC) for each outcome.

Assessment of risk of bias in included studies

Two review authors (AM and JW) independently assessed the risk of bias of each included trial from the initial search using the Cochrane risk of bias assessment tool for RCTs and EPOC bias criteria for non-RCTs. Two review authors (AM and JVG) independently assessed the risk of bias of each included trial from the search update. The Cochrane risk of bias assessment tool and the EPOC bias criteria tool share several domains: selection bias (random sequence generation, allocation concealment), performance bias (blinding of participants/personnel), detection bias (blinding of outcome assessment), attrition bias (incomplete outcome data), reporting bias (selective reporting), and other bias (other prespecified, unique sources). The EPOC tool has several domains unique to non-RCTs, which we additionally used to assess non-RCTs, including: baseline characteristics similar, baseline outcomes similar, and imbalances in baseline characteristics (we also used this final domain to assess the randomization process in RCTs). Due to the nature of WASH interventions, most of the included interventions were allocated at the cluster level. As such, as part of our risk of bias assessment, we considered statistical adjustment for clustered data in the analysis. However, as we adjusted post hoc for clustering in all studies that did not originally make that adjustment (see below for description), we did not consider lack of clustering in our risk of bias assessment.

Across all domains, we rated a criterion as 'unclear' if details were insufficient or if the impact of specific methodological characteristics was unclear. We summarized risk of bias for each relevant outcome reported in each included trial. Two review authors (AM and JW) independently assessed risk of bias for each included trial from the initial search, after considering all documented threats to internal validity. When necessary, a third review author (MCF) facilitated discussion until consensus was reached. We recorded all assessments in risk of bias tables appended to forest plots.

Measures of treatment effect

We used random-effects meta-analysis to pool study estimates, weighting by the inverse of the variance. For dichotomous outcomes, we extracted and presented the odds ratio (OR). We presented all results with 95% confidence intervals (CIs). For continuous or count data, we extracted and presented a variety of measures including using faecal egg count reduction (FECR) ratios (defined as the EPG ratio minus one); EPG ratios (e.g. a ratio of counts using a log-linear model, assuming a negative binomial distribution); and differences in mean intensity (e.g. using regression or a T-test), and presented the reported measures of association in tabular format. No studies reported time-to-event data.

Unit of analysis issues

For cluster-RCTs, where cluster-adjusted ORs were reported we extracted these directly. We also extracted the raw data, along with any reported ICCs and design effects to adjust for clustering. If estimates were reported without adjustment for clustering, we

adjusted for clustering, using the design effect to calculate the effective sample size in each cell, then used the Review Manager 5 calculator to calculate the cluster-adjusted ORs (RevMan Web 2020). The design effect (DE) was calculated as DE = 1 + ((average cluster size −1) * ICC), where the ICC value was extracted from the paper; if no ICC was available, we used median estimates of ICCs from other similar trials.

If there was a 0 count of events in one of the cells, the RevMan calculator changed 0 cell counts to 0.5. If there was a 0 count of events in both the intervention and control arms, we excluded the study from that analysis as it did not meet the inclusion criterion of the study taking place in communities where that specific STH was endemic.

We included some trials with multiple trial arms in more than one comparison and halved (or split proportionally) the control arm if it was used for both (many) comparisons.

Dealing with missing data

We collected data on whether participants or trial clusters were lost to follow-up during the trial time period from each included study. We analysed data according to a complete-case analysis.

Assessment of heterogeneity

When we combined trials via meta-analysis, we assessed heterogeneity by inspecting forest plots to detect overlapping 95% CIs. We additionally used Moran's I^2 statistic to determine the heterogeneity between trials. We considered an I^2 statistic value of greater than 70% as indicative of significant heterogeneity.

We considered variations between interventions as an important potential source of heterogeneity. For the primary outcome (any STH), we deemed differences in prevalence between STH species as an important potential source of heterogeneity.

Assessment of reporting biases

We assessed publication bias by cross-checking public study protocols and trial registrations against completed publications. For trials with multiple publications available, we reviewed the reported outcomes in all publications to ensure that results were consistent before extracting data, and included here the study published with the final findings. We contacted trial authors regarding trials that were presented at conferences with no corresponding publication for disaggregated data. We also generated funnel plots for primary and secondary analyses.

Data synthesis

We compiled and analysed data using Review Manager 5 (RevMan Web 2020). Where possible, we recalculated effect estimates to ORs based on the available data. Given the diversity in WASH interventions, we expected substantial heterogeneity and employed a random-effects approach in meta-analyses using the DerSimonian and Laird method. Where strong heterogeneity was present, we presented forest plots and conducted additional subgroup analyses.

We narratively summarized included evidence that did not qualify for meta-analysis.

Subgroup analysis and investigation of heterogeneity

We investigated several potentially important sources of heterogeneity. If there were 10 or more included trials available for an intervention and outcome, we systematically investigated heterogeneity through subgroup analysis. We conducted the following subgroup analyses for each outcome.

1. Age (children or all ages)
2. Intervention type
3. Whether or not MDA for STH underpinned both treatment and control groups of a study
4. Whether the intervention was implemented in a school or community setting
5. Urban or rural setting
6. Studies conducted in Asia, sub-Saharan Africa, or other regions of the world

We added a post hoc subgroup analysis, stratifying based on more specific water, sanitation, and hygiene interventions implemented at either school or in the community, and on combinations of these individual components implemented in either school or community based.

Sensitivity analysis

We performed several sensitivity analyses for our primary outcomes of interest. We performed a sensitivity analysis to investigate the robustness of our results by including only studies with low risk of bias (i.e. only studies where all risk of bias domains were low risk except for blinding). We conducted a sensitivity analysis comparing subgroups using different types of cluster adjustment (e.g. OR used ICC that was extracted; OR used ICC that was estimated; or authors' original analyses presented OR that accounted for clustering).

Summary of findings and assessment of the certainty of the evidence

We assessed the certainty of the evidence using the GRADE approach. We used GRADEpro GDT to create summary of findings tables to summarize the certainty of the evidence (GRADEpro GDT). We separated all our analyses into bodies of evidence (i.e. RCTs versus non-RCTs, and by outcome type), and completed GRADE assessments for each body of evidence. The certainty of evidence using the GRADE approach may be scored as high, moderate, low, or very low. RCTs start with a high score, whilst non-RCTs start with a low score. The certainty of the evidence may then be downgraded based on five criteria: risk of bias, inconsistency, indirectness, imprecision, and publication bias (Guyatt 2011). A given body of evidence may be downgraded one to two levels depending if, for example, there are serious (−1) or very serious (−2) issues with any of the five downgrading criteria. We downgraded the certainty of the evidence as follows:

1. risk of bias: serious limitations for any of the risk of bias domains;
2. inconsistency: wide variance across studies with minimal CI overlap, and heterogeneity determined using the I^2 statistic;
3. indirectness: the interventions, populations, and/or outcomes of interest were not directly assessed;
4. imprecision: through the combination of wide CIs, small sample sizes (including small number of clusters), low event rates, and

95% CIs that encapsulated the null (imprecision driven by wide CIs and not inconsistency/heterogeneity);

5. publication bias: noted by visual inspection of funnel plots for symmetry.

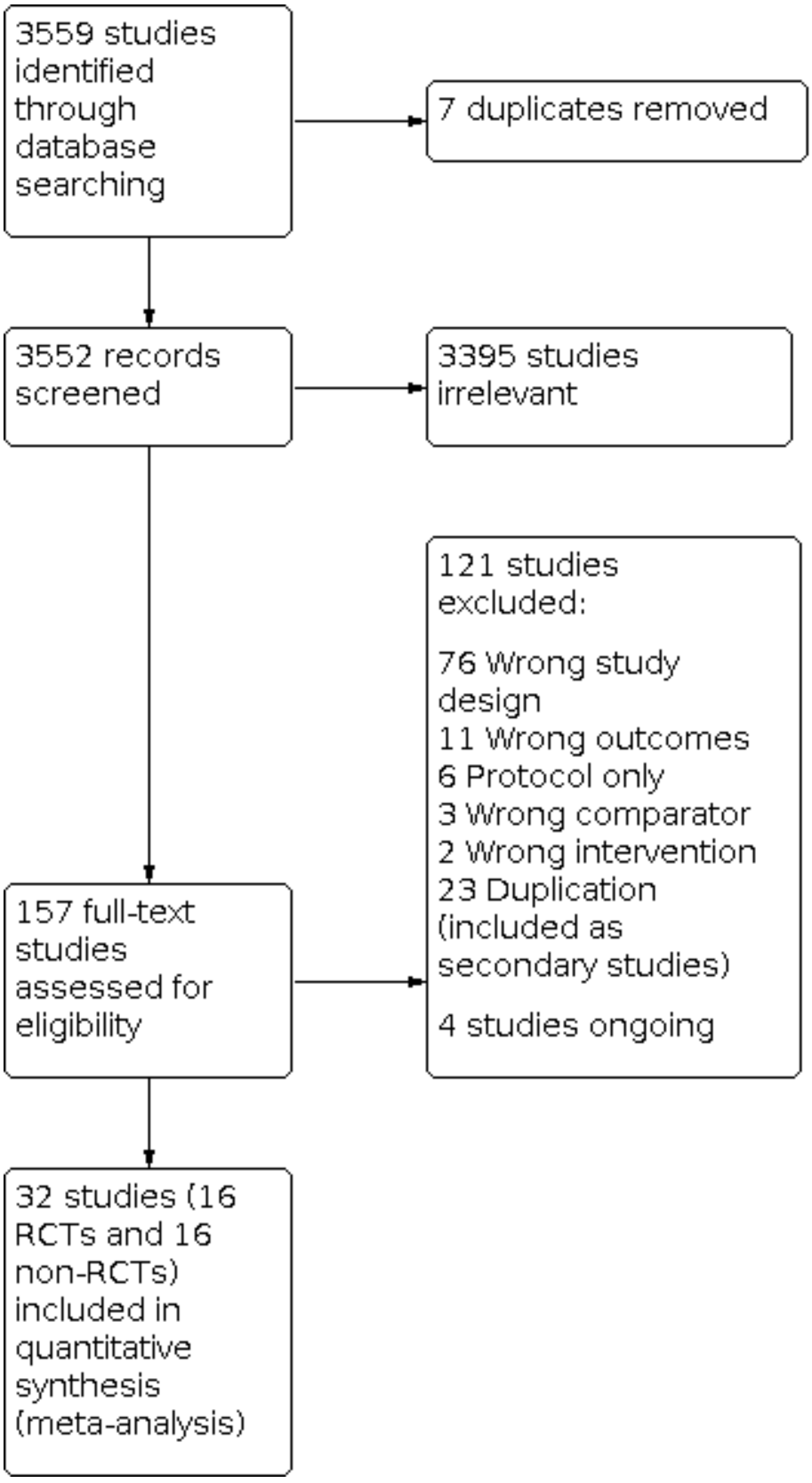
RESULTS

Description of studies

Results of the search

The searches identified 3559 records. We obtained 157 full texts after title and abstract screening, of which 32 studies met the inclusion criteria (Figure 1). Reasons for excluding studies at the full-text screening stage are documented in Figure 1 and Characteristics of excluded studies. Four studies appeared to meet our inclusion criteria but are still ongoing (see Characteristics of ongoing studies).

Figure 1. PRISMA flow diagram.



Included studies

For details, see Characteristics of included studies.

We included 32 studies involving a total of 52,944 participants in the review: 16 RCTs (Bassey 2020; Bieri 2013; Chard 2019; Clasen 2014; Dumba 2013; Ercumen 2019; Erismann 2017; Freeman 2013a; Gyorkos 2013; Han 1988; Hurlimann 2018; Mahmud 2015; Makata 2021; Nery 2019a; Patil 2014; Pickering 2019), and 16 non-RCTs (Albright 2006; Al-Delaimy 2014; Arfaa 1977; Duijster 2017; Gray 2019; Gungoren 2007; Hadidjaja 1998; Kamga 2011; Knee 2021; Mascie-Taylor 1999; Monse 2013; Muennoo 1997; Ndenecho 2002; Park 2016; Reese 2019; Steinmann 2014). The included studies assessed either our primary outcome (prevalence of infection with at least one STH species) or our secondary outcomes (prevalence of individual STH species, and the intensity of infection of individual STH species). Nearly all of the included studies had cluster-allocated interventions, typically through villages, health centres, or schools. The study from Han 1988 states that "children were randomly assigned", but the intervention appears to have been implemented at the household level, and it is not clear if multiple children were included in each household, or if the design was a cluster or individual RCT.

A description of populations and study settings is provided in Table 1.

Most RCTs evaluated children (13/16), with the exception of three studies (Clasen 2014; Hurlimann 2018; Nery 2019a), which assessed all ages or adults. Most non-RCTs (12/16) studied children as their study population (Albright 2006; Al-Delaimy 2014; Duijster 2017; Gungoren 2007; Hadidjaja 1998; Kamga 2011; Knee 2021; Mascie-Taylor 1999; Monse 2013; Ndenecho 2002; Park 2016; Reese 2019). One non-RCT evaluated multiple age groups (younger than five years, and five years and older) (Reese 2019). Three non-RCTs assessed a broad range of ages (Arfaa 1977; Gray 2019; Steinmann 2014), and one non-RCT did not report the study population ages (Muennoo 1997).

Seven RCTs were school-based studies (Bassey 2020; Bieri 2013; Chard 2019; Erismann 2017; Freeman 2013a; Gyorkos 2013; Makata 2021); the remaining RCTs were village or household based. Seven non-RCTs were school-based studies (Albright 2006; Al-Delaimy 2014; Duijster 2017; Hadidjaja 1998; Kamga 2011; Monse 2013; Ndenecho 2002); the remaining non-RCTs were village or household based.

Most RCTs were conducted in rural settings, with only two studies conducted in urban settings (Bassey 2020; Gyorkos 2013), and one study conducted in both urban and rural settings (Makata 2021). Most non-RCTs (9/16) were also conducted in rural settings, with the remaining studies including a mix of urban and/or suburban (Albright 2006; Duijster 2017; Hadidjaja 1998; Knee 2021; Park 2016), or all three settings (Ndenecho 2002); one study did not specify the setting (Monse 2013).

Eight RCTs took place in Africa (Bassey 2020; Dumba 2013; Erismann 2017; Freeman 2013a; Hurlimann 2018; Mahmud 2015; Makata 2021; Pickering 2019); one in South America (Gyorkos 2013), and seven in Asia (Bieri 2013; Chard 2019; Clasen 2014; Ercumen 2019; Han 1988; Nery 2019a; Patil 2014). Similarly, three non-RCTs took place in Africa (Kamga 2011; Knee 2021; Ndenecho 2002), and 13 non-RCTs were conducted in Asia (Albright 2006; Al-Delaimy 2014; Arfaa 1977; Duijster 2017; Gungoren 2007; Gray 2019; Hadidjaja 1998; Mascie-Taylor 1999; Monse 2013; Muennoo 1997; Park 2016; Reese 2019; Steinmann 2014).

Interventions

Characteristics of our intervention categorizations are described below; for specific details see Table 2.

Fifteen studies had broad multiple interventions including a mix of several water, sanitation, and/or hygiene components, of which eight were RCTs (Chard 2019; Clasen 2014; Ercumen 2019; Erismann 2017; Freeman 2013a; Nery 2019a; Patil 2014; Pickering 2019), and seven were non-RCTs (Arfaa 1977; Duijster 2017; Gray 2019; Knee 2021; Park 2016; Reese 2019; Steinmann 2014).

Fourteen primarily education interventions focused on the education of or promotion of WASH aspects, of which six were RCTs (Bassey 2020; Bieri 2013; Dumba 2013; Gyorkos 2013; Hurlimann 2018; Makata 2021), and eight were non-RCTs (Albright 2006; Al-Delaimy 2014; Gungoren 2007; Hadidjaja 1998; Kamga 2011; Mascie-Taylor 1999; Muennoo 1997; Ndenecho 2002). Education interventions were those that focused primarily on the improvement of knowledge, understanding, or behaviours related to WASH.

There were five single WASH aspect interventions focused on changes related to one WASH aspect, of which four were RCTs (Ercumen 2019; Han 1988; Mahmud 2015; Pickering 2019), and one was a non-RCT (Monse 2013).

Several studies were set up in factorial-like designs (Ercumen 2019; Pickering 2019), having multiple intervention comparisons carried out simultaneously, and are therefore included in both the broad multiple and single WASH aspect intervention categories.

Only eight of the included studies did not mention any form of deworming or MDA coupled with the study (Chard 2019; Gray 2019; Hadidjaja 1998; Han 1988; Kamga 2011; Mahmud 2015; Patil 2014; Reese 2019).

In the characteristics of the interventions (Table 2), we define 'hardware' interventions as interventions that emphasize provision of facilities, and 'software' interventions as those providing education or development aimed at changing behaviour or creating demand for services (Peal 2010).

Outcome measures

Fourteen RCTs measured our primary outcome, the prevalence of infection with at least one STH species, as defined by at least one ovum of *A lumbricoides, T trichiura,* hookworm species, or *S stercoralis* found in the participant's faeces (Bassey 2020; Bieri 2013; Chard 2019; Clasen 2014; Dumba 2013; Ercumen 2019; Erismann 2017; Freeman 2013a; Gyorkos 2013; Hurlimann 2018; Mahmud 2015; Makata 2021; Patil 2014; Pickering 2019). Eight non-RCTs measured this outcome (Albright 2006; Duijster 2017; Gray 2019; Gungoren 2007; Knee 2021; Monse 2013; Park 2016; Reese 2019). Twelve RCTs, Bassey 2020; Clasen 2014; Ercumen 2019; Freeman 2013a; Gyorkos 2013; Han 1988; Hurlimann 2018; Mahmud 2015; Makata 2021; Nery 2019a; Patil 2014; Pickering 2019, and nine non-RCTs, Al-Delaimy 2014; Arfaa 1977; Hadidjaja 1998; Kamga 2011; Knee 2021; Mascie-Taylor 1999; Muennoo 1997; Ndenecho 2002; Steinmann 2014, measured the prevalence of at least one

ovum of *A lumbricoides* found in the participant's faeces. Nine RCTs, Bassey 2020; Clasen 2014; Ercumen 2019; Freeman 2013a; Gyorkos 2013; Hurlimann 2018; Makata 2021; Nery 2019a; Pickering 2019, and eight non-RCTs, Al-Delaimy 2014; Kamga 2011; Knee 2021; Mascie-Taylor 1999; Muennoo 1997; Ndenecho 2002; Reese 2019; Steinmann 2014, measured the prevalence of at least one ovum of *T trichiura* found in the participant's faeces. Ten RCTs, Bassey 2020; Clasen 2014; Ercumen 2019; Freeman 2013a; Gyorkos 2013; Hurlimann 2018; Mahmud 2015; Makata 2021; Nery 2019a; Pickering 2019, and eight non-RCTs, Al-Delaimy 2014; Arfaa 1977; Kamga 2011; Mascie-Taylor 1999; Muennoo 1997; Ndenecho 2002; Reese 2019; Steinmann 2014, measured the prevalence of at least one ovum of hookworm species found in the participant's faeces. Two RCTs, Mahmud 2015; Nery 2019a, and one non-RCT, Steinmann 2014, aimed to assess the prevalence of at least one ovum of *S stercoralis* found in the participant's faeces, but all studies took place in areas with low endemicity of the worm. Only the study from Nery 2019a had high enough prevalence of the worm to meet our endemicity inclusion criteria for *S stercoralis*.

Sixteen studies measured the intensity of infection for an individual STH type (Al Delaimy 2014; Arfaa 1977; Bassey 2020; Clasen 2014; Ercumen 2019; Freeman 2013a; Gyorkos 2013; Hadidjaja 1998; Han 1988; Hurlimann 2018; Makata 2021; Mascie-Taylor 1999; Nery 2019a; Pickering 2019; Reese 2019; Steinmann 2014). Ten RCTs, Bassey 2020; Clasen 2014; Ercumen 2019; Freeman 2013a; Gyorkos 2013; Han 1988; Hurlimann 2018; Makata 2021; Nery 2019a; Pickering 2019, and five non-RCTs, Al-Delaimy 2014; Arfaa 1977; Hadidjaja 1998; Mascie-Taylor 1999; Steinmann 2014, reported on the intensity of infection of *A lumbricoides*, as measured by EPG of faeces. Eight RCTs, Bassey 2020; Clasen 2014; Ercumen 2019; Freeman 2013a; Gyorkos 2013; Hurlimann 2018; Makata 2021; Pickering 2019, and five non-RCTs, Al-Delaimy 2014; Hadidjaja 1998; Mascie-Taylor 1999; Reese 2019; Steinmann 2014, measured the intensity of infection of *T trichiura*. Eight RCTs, Bassey 2020; Clasen 2014; Ercumen 2019; Freeman 2013a; Gyorkos 2013; Hurlimann 2018; Nery 2019a; Pickering 2019, and five non-RCTs, Al-Delaimy 2014; Arfaa 1977; Mascie-Taylor 1999; Reese 2019; Steinmann 2014, measured the intensity of hookworm infection. No studies reported on the intensity of infection of *S stercoralis.*

No studies reported any adverse events resulting from WASH interventions and MDA.

Excluded studies

We identified 125 studies that were excluded or ongoing (Figure 1; Characteristics of excluded studies; Characteristics of ongoing studies.

Risk of bias in included studies

The risk of bias is summarized in the risk of bias graph in Figure 2, and risk of bias summary stoplight figures are appended to each of the overall forest plots (Figure 3; Figure 4; Figure 5; Figure 6; Figure 7; Figure 8; Figure 9; Figure 10).

Figure 2. Risk of bias graph: review authors' judgements about each risk of bias item presented as percentages across all included studies.

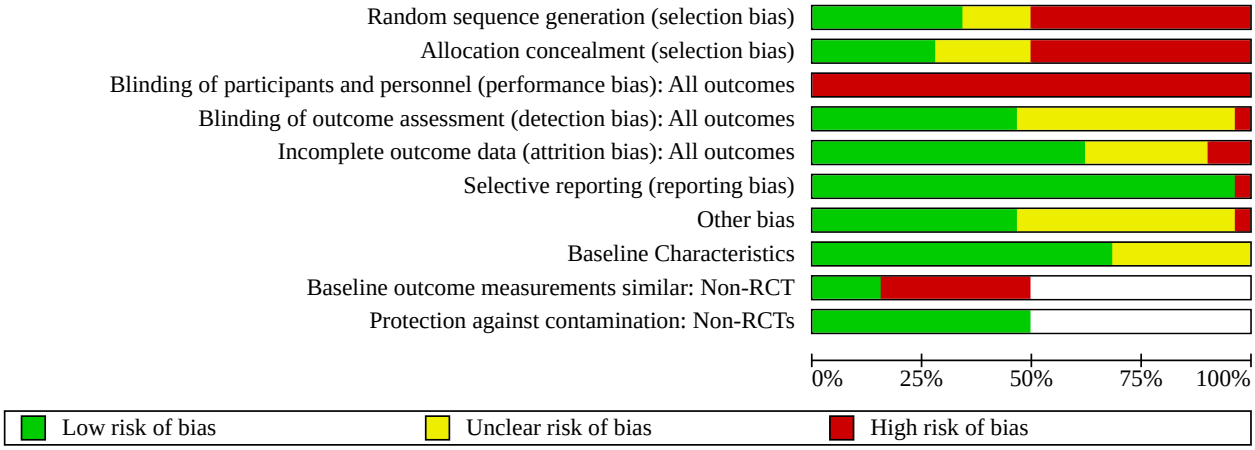
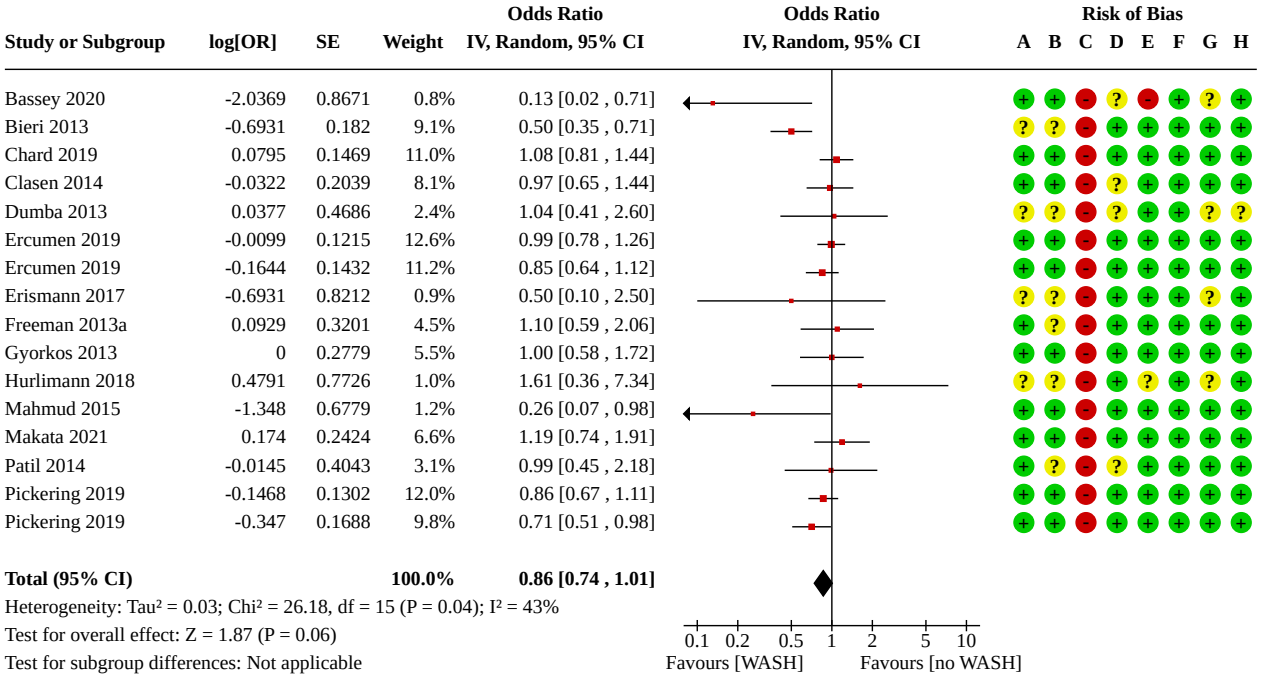


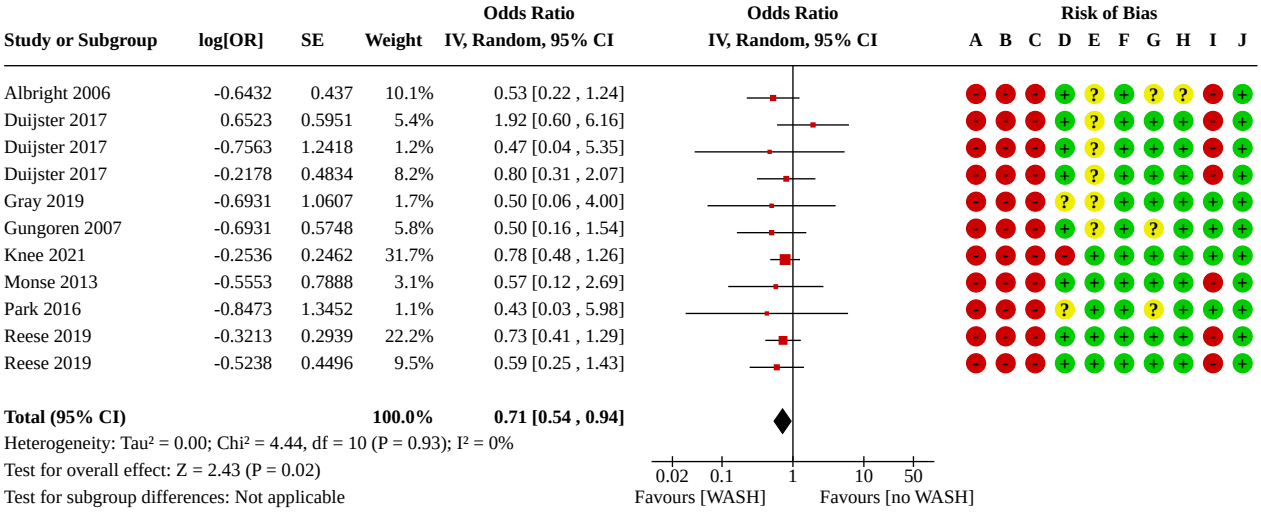
Figure 3. Forest plot of comparison: 1 WASH intervention versus control, outcome: 1.1 Any STH prevalence amongst RCTs.



Risk of bias legend

(A) Random sequence generation (selection bias)
(B) Allocation concealment (selection bias)
(C) Blinding of participants and personnel (performance bias)
(D) Blinding of outcome assessment (detection bias)
(E) Incomplete outcome data (attrition bias)
(F) Selective reporting (reporting bias)
(G) Other bias
(H) Baseline Characteristics

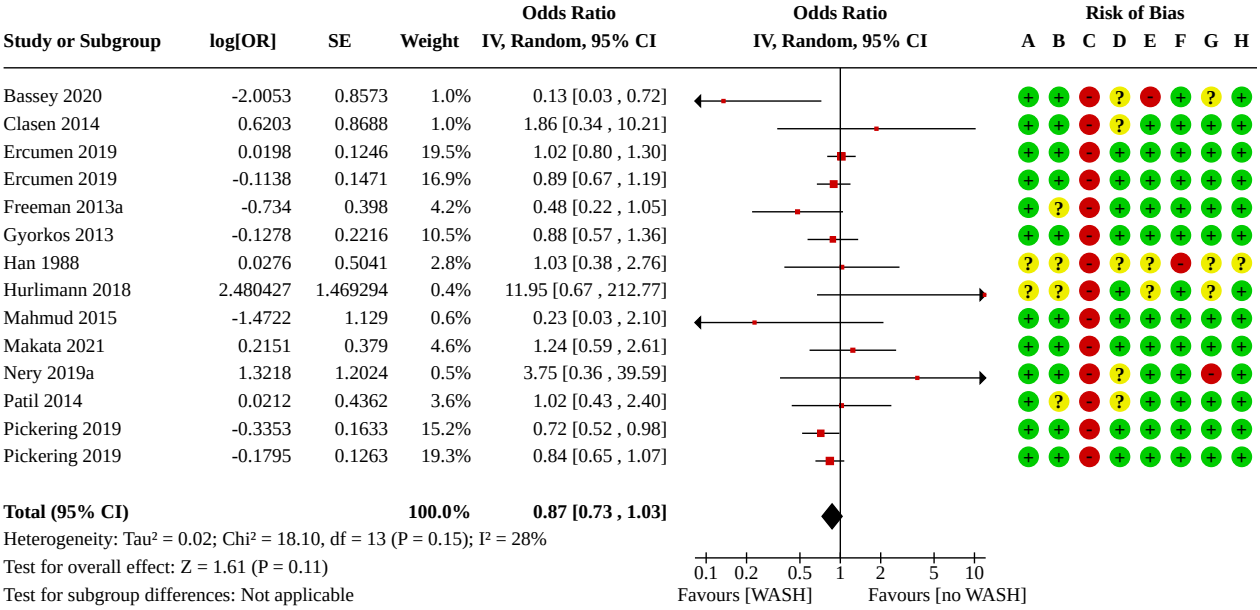
Figure 4. Forest plot of comparison: 1 WASH intervention versus control, outcome: 1.6 Any STH prevalence amongst non-RCTs.



Risk of bias legend

(A) Random sequence generation (selection bias)
(B) Allocation concealment (selection bias)
(C) Blinding of participants and personnel (performance bias)
(D) Blinding of outcome assessment (detection bias)
(E) Incomplete outcome data (attrition bias)
(F) Selective reporting (reporting bias)
(G) Other bias
(H) Baseline Characteristics
(I) Baseline outcome measurements similar: Non-RCT
(J) Protection against contamination: Non-RCTs

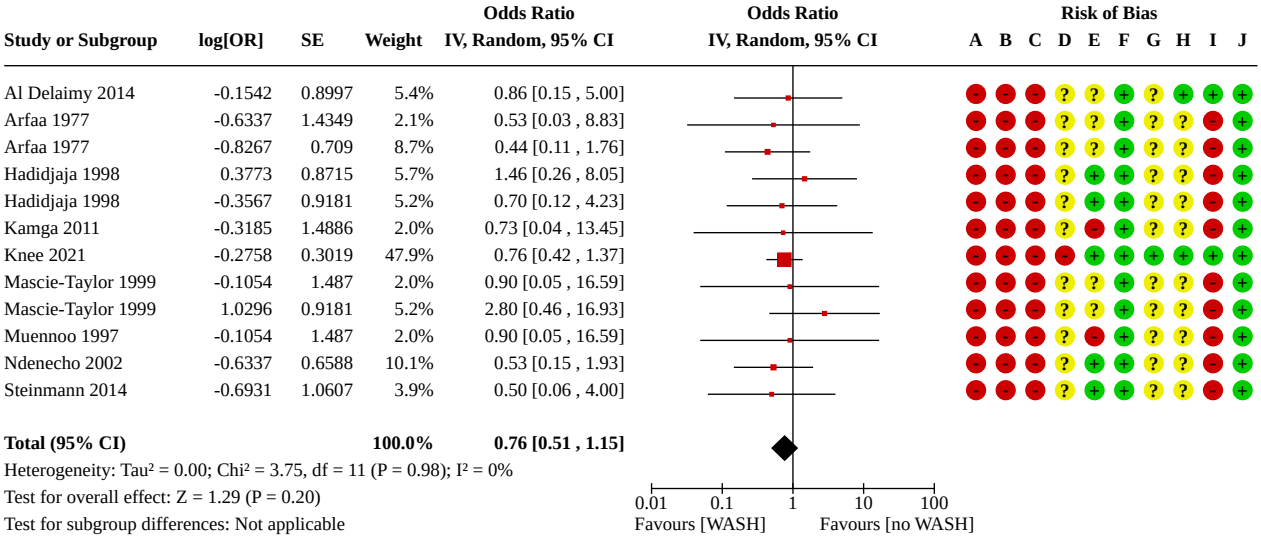
Figure 5. Forest plot of comparison: 1 WASH intervention versus control, outcome: 1.14 *Ascaris lumbricoides* prevalence amongst RCTs.



Risk of bias legend

(A) Random sequence generation (selection bias)
(B) Allocation concealment (selection bias)
(C) Blinding of participants and personnel (performance bias)
(D) Blinding of outcome assessment (detection bias)
(E) Incomplete outcome data (attrition bias)
(F) Selective reporting (reporting bias)
(G) Other bias
(H) Baseline Characteristics

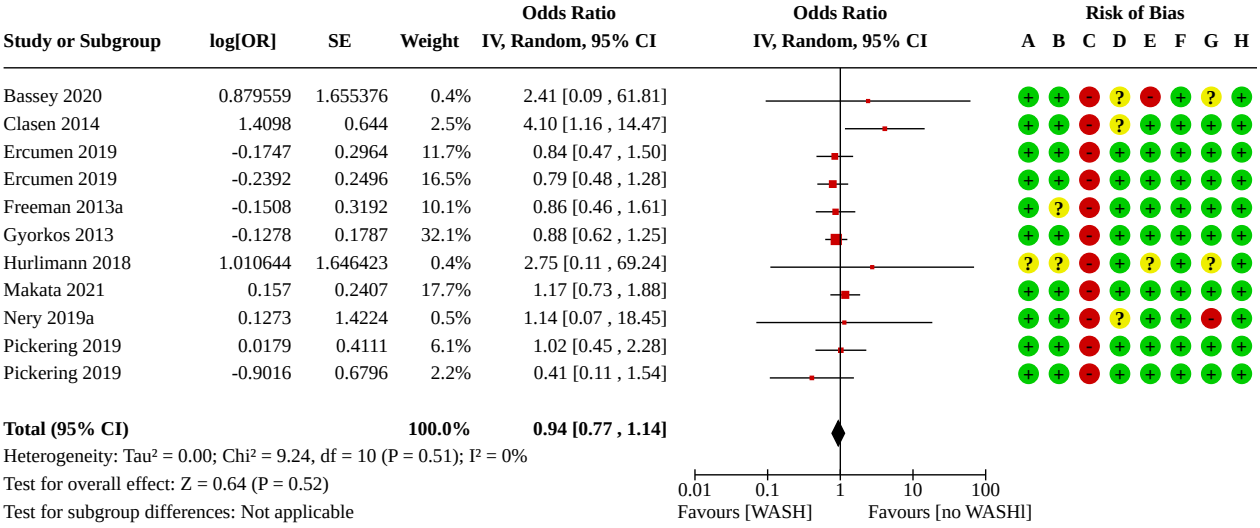
Figure 6. Forest plot of comparison: 1 WASH intervention versus control, outcome: 1.15 *Ascaris lumbricoides* prevalence amongst non-RCTs.



Risk of bias legend

(A) Random sequence generation (selection bias)
(B) Allocation concealment (selection bias)
(C) Blinding of participants and personnel (performance bias)
(D) Blinding of outcome assessment (detection bias)
(E) Incomplete outcome data (attrition bias)
(F) Selective reporting (reporting bias)
(G) Other bias
(H) Baseline Characteristics
(I) Baseline outcome measurements similar: Non-RCT
(J) Protection against contamination: Non-RCTs

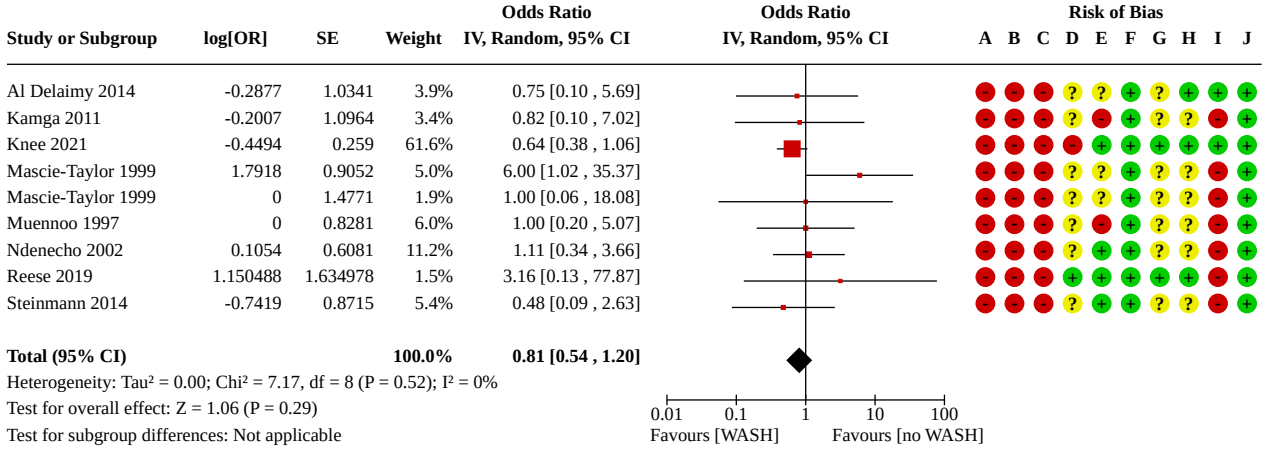
Figure 7. Forest plot of comparison: 1 WASH intervention versus control, outcome: 1.24 *Trichuris trichiura* prevalence amongst RCTs.



Risk of bias legend

(A) Random sequence generation (selection bias)
(B) Allocation concealment (selection bias)
(C) Blinding of participants and personnel (performance bias)
(D) Blinding of outcome assessment (detection bias)
(E) Incomplete outcome data (attrition bias)
(F) Selective reporting (reporting bias)
(G) Other bias
(H) Baseline Characteristics

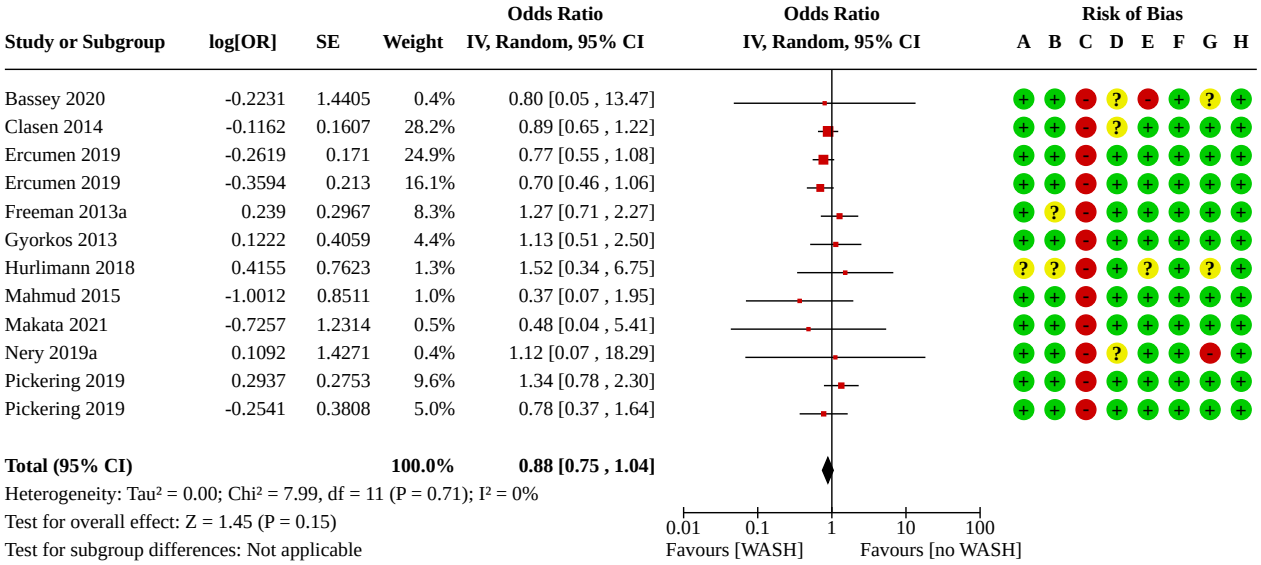
Figure 8. Forest plot of comparison: 1 WASH intervention versus control, outcome: 1.26 *Trichuris trichiura* prevalence amongst non-RCTs.



Risk of bias legend

(A) Random sequence generation (selection bias)
(B) Allocation concealment (selection bias)
(C) Blinding of participants and personnel (performance bias)
(D) Blinding of outcome assessment (detection bias)
(E) Incomplete outcome data (attrition bias)
(F) Selective reporting (reporting bias)
(G) Other bias
(H) Baseline Characteristics
(I) Baseline outcome measurements similar: Non-RCT
(J) Protection against contamination: Non-RCTs

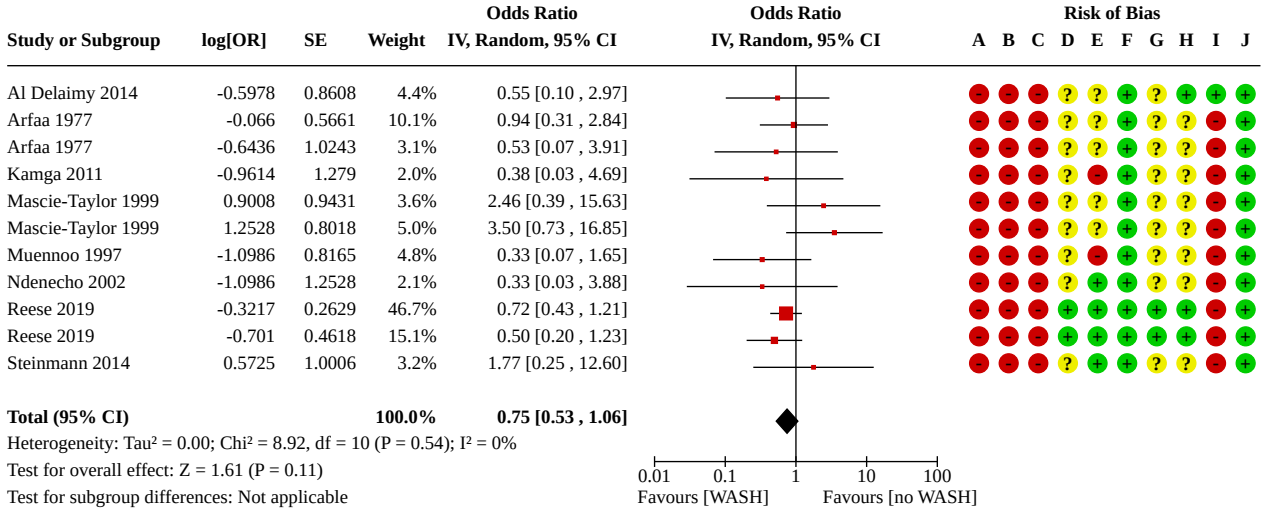
Figure 9. Forest plot of comparison: 1 WASH intervention versus control, outcome: 1.35 Hookworm prevalence amongst RCTs.



Risk of bias legend

(A) Random sequence generation (selection bias)
(B) Allocation concealment (selection bias)
(C) Blinding of participants and personnel (performance bias)
(D) Blinding of outcome assessment (detection bias)
(E) Incomplete outcome data (attrition bias)
(F) Selective reporting (reporting bias)
(G) Other bias
(H) Baseline Characteristics

Figure 10. Forest plot of comparison: 1 WASH intervention versus control, outcome: 1.37 Hookworm prevalence amongst non-RCTs.



Risk of bias legend

(A) Random sequence generation (selection bias)
(B) Allocation concealment (selection bias)
(C) Blinding of participants and personnel (performance bias)
(D) Blinding of outcome assessment (detection bias)
(E) Incomplete outcome data (attrition bias)
(F) Selective reporting (reporting bias)
(G) Other bias
(H) Baseline Characteristics
(I) Baseline outcome measurements similar: Non-RCT
(J) Protection against contamination: Non-RCTs

Allocation

Sequence generation

Amongst the 16 RCTs, the risk of bias for random sequence generation was low in all studies except five studies where the risk was unclear (Bieri 2013; Dumba 2013; Erismann 2017; Han 1988; Hurlimann 2018). The risk of bias for random sequence generation was high (by default) in the non-RCTs.

Allocation concealment

Eight RCTs were at low risk of bias for allocation concealment (Bassey 2020; Chard 2019; Clasen 2014; Ercumen 2019; Gyorkos 2013; Mahmud 2015; Nery 2019a; Pickering 2019), with the remainder at unclear risk. All of the non-RCTs were at high risk of bias for allocation concealment.

Blinding

Blinding of participants and personnel

All RCTs and non-RCTs were at high risk of bias for blinding of participants and personnel.

Blinding of outcome assessment

Ten RCTs were at low risk of bias for blinding of the outcome assessment (Bieri 2013; Chard 2019; Ercumen 2019; Erismann 2017; Freeman 2013a; Gyorkos 2013; Hurlimann 2018; Mahmud 2015; Makata 2021; Pickering 2019), with the remainder at unclear risk.

Five non-RCTs were at low risk for blinding of outcome assessors (Albright 2006; Duijster 2017; Gungoren 2007; Monse 2013; Reese 2019); one non-RCT was at high risk (Knee 2021); and the remainder were at unclear risk.

Incomplete outcome data

Amongst RCTs, one study was high risk for incomplete outcome data (Bassey 2020); two studies were at unclear risk (Han 1988; Hurlimann 2018); and the remaining studies were at low risk. Amongst non-RCTs, two studies were at high risk for incomplete outcome data (Kamga 2011; Muennoo 1997); seven studies were at low risk (Hadidjaja 1998; Knee 2021; Monse 2013; Ndenecho 2002; Park 2016; Reese 2019; Steinmann 2014); and the remaining studies were at unclear risk.

Selective reporting

One RCT was at high risk of selective reporting (Han 1988). The remaining RCTs and non-RCTS were all at low risk for this domain.

Other potential sources of bias

Other bias

Only one study was at high risk of other sources of bias, which was due to intervention contamination by an external government-led sanitation promotion (Nery 2019a).

Comparability of baseline characteristics (confounding bias)

Amongst RCTs, 14 studies were at low risk for baseline characteristics (Bassey 2020; Bieri 2013; Chard 2019; Clasen 2014; Ercumen 2019; Erismann 2017; Freeman 2013a; Gyorkos 2013; Hurlimann 2018; Mahmud 2015; Makata 2021; Nery 2019a; Patil 2014; Pickering 2019), and the remaining two studies were at unclear risk. Amongst non-RCTs, eight studies were at low risk for baseline characteristics (Al-Delaimy 2014; Duijster 2017; Gray 2019; Gungoren 2007; Knee 2021; Monse 2013; Park 2016; Reese 2019), and the remaining studies were at unclear risk.

Baseline outcome measurements similar (non-RCTs only)

Five non-RCTs were at high risk of imbalances in the outcome measurements (Al Delaimy 2014; Gray 2019; Gungoren 2007; Knee 2021; Park 2016).

Protection against contamination (non-RCTs only)

All non-RCTs were at low risk for contamination, as allocation was by community or institution.

Effects of interventions

See: **Summary of findings 1** Water, sanitation, and hygiene (WASH) intervention versus no WASH intervention for preventing soil-transmitted helminth infection

See Summary of findings 1 for the main prevalence results.

Primary outcome: prevalence of any STH

WASH and any STH prevalence - RCTs

Fourteen RCTs reported on the prevalence of any STH (Bassey 2020; Bieri 2013; Chard 2019; Clasen 2014; Dumba 2013; Ercumen 2019; Erismann 2017; Freeman 2013a; Gyorkos 2013; Hurlimann 2018; Mahmud 2015; Makata 2021; Patil 2014; Pickering 2019). The overall pooled effect estimate showed that participants in the WASH intervention arms had a slightly lower prevalence of any STH infection than participants in the control arms (odds ratio (OR) 0.86, 95% confidence interval (CI) 0.74 to 1.01; Figure 3; moderate-certainty evidence). There was moderate heterogeneity across these studies (I^2 = 43%), which appeared to be driven in part by a number of studies (e.g. Bassey 2020; Bieri 2013) that had more strongly preventative estimates than the rest of the studies. Sensitivity analyses restricting to the six studies (eight estimates) with low risk of bias for all domains except blinding of participants and personnel (as blinding is not possible in WASH studies) produced an OR of 0.91 with a 95% CI of 0.79 to 1.05 (Analysis 1.2). This point estimate was similar to that of the overall estimate. We evaluated whether our use of estimated ICCs to account for clustering produced different estimates than other studies with reported ICC estimates or other studies that adequately reported their own clustered effect measures, and found similar pooled estimates for all three subgroups (Analysis 1.3).

WASH and any STH prevalence - non-RCTs

Eight non-RCTs reported on the prevalence of any STH (Albright 2006; Duijster 2017; Gray 2019; Gungoren 2007; Knee 2021; Monse 2013; Park 2016; Reese 2019). Although no individual study reported a preventive effect, the pooled odds ratio comparing any STH prevalence between WASH and control arms showed a protective effect (OR 0.71, 95% CI 0.54 to 0.94; Figure 4; low-certainty evidence). There was low heterogeneity across the nine estimates (I^2 = 0%).

Our post hoc analysis focusing on specific subsets of water, sanitation, and hygiene interventions (Analysis 1.5) did not show subgroup differences between the different intervention categorizations (P = 0.95).

Subgroup analyses - RCTs

Subgroup analyses for any STH prevalence are shown in Table 3 (Analysis 1.6; Analysis 1.7; Analysis 1.8; Analysis 1.9; Analysis 1.10; Analysis 1.11).

When subgrouping by intervention type (i.e. primarily education, single WASH aspect, or broad multiple interventions), the test for subgroup differences indicated no differences between groups (P = 0.88, Table 3). The pooled effect estimates for the different intervention subgroups were all in the preventive direction, although each had CIs that encapsulated the null. We observed substantial heterogeneity for interventions that were primarily education (I^2 = 67%), and moderate heterogeneity for interventions with a single WASH aspect (I^2 = 51%), but little heterogeneity for broad multiple interventions (I^2 = 0%). Our post hoc analysis focusing on more specific subsets of water, sanitation, and hygiene interventions implemented at either school or in the community is shown in Analysis 1.12. We detected no subgroup differences between the different intervention categorizations (P = 0.62). Community-based studies implementing water, sanitation, and hygiene together showed a preventive effect (OR 0.78, 95% CI 0.63 to 0.96), and some other subgroups had effect estimates in the preventive direction with wide CIs.

For studies that assessed the prevalence of any STH within children, the pooled subgroup estimate was in the preventive direction (OR 0.85, 95% CI 0.72 to 1.00, Table 3), and the estimate amongst all age groups was null (OR 1.00, 95% CI 0.68 to 1.47; test for subgroup differences: P = 0.44). There was moderate heterogeneity amongst studies on children (I^2 = 49%), and low heterogeneity amongst studies assessing all ages (I^2 = 0%). Studies from school settings had substantial heterogeneity (I^2 = 69%), whereas village-based studies had low heterogeneity (I^2 = 0%).

For studies assessing the prevalence of any STH, there were no subgroup differences between studies that included drug treatment (MDA) in both the intervention arm(s) and control arm, compared to studies with no MDA (P = 0.98, Table 3). The subgroup estimate for the studies that included MDA was in the preventive direction (OR 0.85, 95% CI 0.72 to 1.00) with moderate heterogeneity (I^2 = 42%).

The subgroup estimate assessing WASH and the prevalence of any STH in studies from rural settings was in the preventive direction (OR 0.85, 95% CI 0.73 to 1.00, Table 3), and there was moderate heterogeneity across these studies (I^2 = 42%). The two studies that took place in urban settings both had wide CIs, and the two effect estimates were quite different from each other (heterogeneity: I^2 = 80%); this combination of low precision and high heterogeneity produced a pooled subgroup estimate that was highly imprecise for the urban studies, with the magnitude of the effect in the preventive direction (OR 0.43, 95% CI 0.06 to 3.05). There were no subgroup differences by world region (P = 0.84): the African (OR 0.83, 95% CI 0.64 to 1.09) and Asian (OR 0.87, 95% CI 0.69 to 1.09)

estimates were both in the preventive direction, although the 95% CIs encapsulated the null, and the one South America-based study had a null estimate (OR 1.00, 95% CI 0.58 to 1.72).

Secondary outcome measure: prevalence of infection with individual worms

Prevalence of infection with A lumbricoides

WASH on *A lumbricoides* prevalence - RCTs

Twelve RCTs reported on the prevalence of *A lumbricoides* (Bassey 2020; Clasen 2014; Ercumen 2019; Freeman 2013a; Gyorkos 2013; Han 1988; Hurlimann 2018; Mahmud 2015; Makata 2021; Nery 2019a; Patil 2014; Pickering 2019). Among RCTs, the prevalence of *A lumbricoides* infections was modestly lower in the WASH intervention arms compared to the control arms (pooled OR 0.87, 95% CI 0.73 to 1.03; Figure 5; moderate-certainty evidence). Heterogeneity was low across studies (I^2 = 28%). Several individual studies had effect estimates in the preventive direction, including studies from Bassey 2020 (OR 0.13, 95% CI 0.03 to 0.72); Pickering 2019 (OR 0.72, 95% CI 0.52 to 0.98); Freeman 2013a (OR 0.48, 95% CI 0.22 to 1.05); and Pickering 2019 (OR 0.84, 95% CI 0.65 to 1.07). Some of these studies reported wide CIs, including the possibility of null effects. Sensitivity analyses restricting to the five studies (seven estimates) with low risk of bias for all domains except blinding of participants and personnel produced an OR of 0.88 - a point estimate that was similar to that of the overall estimate, although with a slightly more precise 95% CI (95% CI 0.78 to 1.00; Analysis 1.14).

WASH and *A lumbricoides* prevalence - non-RCTs

Nine non-RCTs reported on the prevalence of *A lumbricoides* (Al-Delaimy 2014; Arfaa 1977; Hadidjaja 1998; Kamga 2011; Knee 2021; Mascie-Taylor 1999; Muennoo 1997; Ndenecho 2002; Steinmann 2014). None of the individual studies showed a protective effect from WASH, and the pooled analysis comparing *A lumbricoides* prevalence between WASH and control arms was OR 0.76 (95% CI 0.51 to 1.15; Figure 6; very low-certainty evidence). There was low heterogeneity across studies (I^2 = 0%). A study from Reese 2019 did not meet the endemicity inclusion criteria, as there were zero *A lumbricoides* cases in both the intervention and control arms.

Our post hoc analysis focusing on specific subsets of water, sanitation, and hygiene interventions (Analysis 1.16) did not show subgroup differences between the different intervention categorizations (P = 0.88).

Subgroup analyses - RCTs

Subgroup analyses for *A lumbricoides* are shown in Table 4 (Analysis 1.17; Analysis 1.18; Analysis 1.19; Analysis 1.20; Analysis 1.21; Analysis 1.22). When subgrouping by intervention type (i.e. primarily education, single WASH aspect, or broad multiple interventions), none of the pooled effect estimates for the different intervention subgroups was associated with *A lumbricoides* prevalence. The heterogeneity in our overall analysis may be partially explained by our subgroup analyses by intervention type, where we observed high heterogeneity for interventions that were primarily education (I^2 = 66%), but low heterogeneity for interventions that implemented a single WASH aspect (I^2 = 0%) or broad multiple interventions (I^2 = 10%). Our subgroup analysis focusing on more specific subsets of water, sanitation, and hygiene interventions implemented at either school or in the community is shown in Analysis 1.23. We detected no subgroup differences between the different intervention categorizations (P = 0.57), and whilst all six subgroup categories were in the preventive direction (some barely), width of the CIs often left the possibility of null or even harmful effects for many of the estimates.

There were subgroup differences across the different age categories assessed (P = 0.04, Table 4). The *A lumbricoides* studies on school-age children had a pooled effect estimate in the preventive direction (OR 0.85, 95% CI 0.73 to 0.99) with low heterogeneity (I^2 = 21%), whereas the pooled effect estimate for the two studies amongst all ages was in the harmful direction (OR 3.20, 95% CI 0.92 to 11.11) with low heterogeneity (I^2 = 0%).

There were no subgroup differences for *A lumbricoides* infection with either the MDA underpinning subgroup variable or the variable that assessed whether the studies took place in urban or rural settings (Table 4). The *A lumbricoides* studies that took place in Africa had a pooled effect estimate in the preventive direction (OR 0.73, 95% CI 0.51 to 1.06), whereas there was no strong association between WASH interventions and *A lumbricoides* prevalence in either Asia (OR 0.98, 95% CI 0.82 to 1.17) or South America (OR 0.88, 95% CI 0.57 to 1.36).

Prevalence of infection with T trichiura

WASH on *T trichiura* prevalence - RCTs

Nine RCTs reported on the prevalence of *T trichiura* (Bassey 2020; Clasen 2014; Ercumen 2019; Freeman 2013a; Gyorkos 2013; Hurlimann 2018; Makata 2021; Nery 2019a; Pickering 2019). The prevalence of any *T trichiura* infection was similar comparing the WASH and control arms (OR 0.94, 95% CI 0.77 to 1.14; Figure 7; low-certainty evidence), with low heterogeneity across the studies (I^2 = 0%). A study from Patil 2014 did not meet the endemicity inclusion criteria, as there were zero *T trichiura* cases in both the intervention and control arms. Sensitivity analyses restricting to the four studies (six estimates) with low risk of bias for all domains except blinding of participants and personnel produced an OR of 0.90 (95% CI 0.73 to 1.11; Analysis 1.25) - a point estimate that was similar to the overall estimate.

WASH on *T trichiura* prevalence - non-RCTs

Eight non-RCTs reported on the prevalence of *T trichiura* (Al-Delaimy 2014; Kamga 2011; Knee 2021; Mascie-Taylor 1999; Muennoo 1997; Ndenecho 2002; Reese 2019; Steinmann 2014). The prevalence of any *T trichiura* infection was similar comparing the WASH and control arms (OR 0.81, 95% CI 0.54 to 1.20; Figure 8; very low-certainty evidence), with low heterogeneity (I^2 = 0%) and wide CIs across most of the studies. Most of these studies only had a single intervention cluster and a single control cluster. The study from Knee 2021 had an effect estimate in the preventive direction (OR 0.64, 95% CI 0.38 to 1.06), although the CIs included the possibility of null effects.

Our post hoc analysis focusing on specific subsets of water, sanitation, and hygiene interventions (Analysis 1.27) did not show subgroup differences between the different intervention categorizations (P = 0.37).

Subgroup analyses - RCTs

Subgroup analyses for *T trichiura* prevalence are shown in Table 5 (Analysis 1.28; Analysis 1.29; Analysis 1.30; Analysis 1.31; Analysis

1.32; Analysis 1.33). The low heterogeneity across all studies contributed to all of our subgroup analyses also being rather homogenous. Similar to the *A lumbricoides* findings, there were also subgroup differences for *T trichiura* across the different age categories assessed (P = 0.02). The *T trichiura* studies done on children had a pooled effect estimate in the preventive direction (OR 0.90, 95% CI 0.73 to 1.10), whereas the pooled effect estimate amongst all ages was in the harmful direction (OR 3.23, 95% CI 1.09 to 9.53). There were no subgroup differences for any of the other subgroup comparisons. Additional subgroup analyses by more narrow intervention type are shown in Analysis 1.34.

Prevalence of infection with hookworm (N americanus and A duodenale)

WASH on hookworm prevalence – RCTs

Ten RCTs reported on the prevalence of hookworm (Bassey 2020; Clasen 2014; Ercumen 2019; Freeman 2013a; Gyorkos 2013; Hurlimann 2018; Mahmud 2015; Makata 2021; Nery 2019a; Pickering 2019). A study from Patil 2014 did not meet the endemicity inclusion criteria, as there were zero hookworm cases in both the intervention and control arms. The CIs for every study encapsulated the null, with the pooled estimate in the preventive direction (OR 0.88, 95% CI 0.75 to 1.04; Figure 9; moderate-certainty evidence). There was low heterogeneity across studies (I^2 = 0%). Sensitivity analyses restricting to the five studies (seven estimates) with low risk of bias for all domains except blinding of participants and personnel produced an OR of 0.83 (95% CI 0.67 to 1.03; Analysis 1.36) - a point estimate that was similar to that of the overall estimate.

WASH on hookworm prevalence - non-RCTs

Eight non-RCTs reported on the prevalence of hookworm (Al-Delaimy 2014; Arfaa 1977; Kamga 2011; Mascie-Taylor 1999; Muennoo 1997; Ndenecho 2002; Reese 2019; Steinmann 2014). The pooled OR comparing the prevalence of hookworm infection between WASH and control arms was 0.75 (95% CI 0.53 to 1.06; Figure 10; very low-certainty evidence), with low heterogeneity across studies (I^2 = 0%).

Our post hoc analysis focusing on specific subsets of water, sanitation, and hygiene interventions (Analysis 1.38) did not show subgroup differences between the different intervention categorizations (P = 0.79).

Subgroup analyses

Subgroup analyses for hookworm prevalence are shown in Table 6 (Analysis 1.39; Analysis 1.40; Analysis 1.41; Analysis 1.42; Analysis 1.43; Analysis 1.44). Due to the lack of heterogeneity across studies, there was also little heterogeneity in any of the subgroup analyses. There were no subgroup differences for any of the analyses, and the subgroup estimates were generally not appreciably different from the overall pooled estimate. Additional subgroup analyses by more narrow intervention type are shown in Analysis 1.45.

Prevalence of infection with S stercoralis

Several studies did not meet our endemicity inclusion criteria. Nery 2019a listed *S stercoralis* as an outcome and showed baseline results with a very low prevalence of *S stercoralis*, and in the final follow-up visit had zero prevalence of *S stercoralis* in both the intervention and control arms. Another non-RCT detected zero *S stercoralis* eggs in either the intervention or control arm at baseline (Mahmud 2015), and only one person in the intervention arm was infected at the postintervention visit.

One non-RCT assessed the prevalence of *S stercoralis* (Steinmann 2014), but the prevalence of the outcome was rare in both arms, and after adjusting for clustering the OR was 1.00 with very wide CIs (95% CI 0.05 to 20.83).

Secondary outcome measure: STH intensity

Sixteen studies measured the intensity of infection for an individual STH type (Al Delaimy 2014; Arfaa 1977; Bassey 2020; Clasen 2014; Ercumen 2019; Freeman 2013a; Gyorkos 2013; Hadidjaja 1998; Han 1988; Hurlimann 2018; Makata 2021; Mascie-Taylor 1999; Nery 2019a; Pickering 2019; Reese 2019; Steinmann 2014), including *A lumbricoides*, *T trichiura*, hookworms (*A duodenale* or *N americanus*, or both), or *S stercoralis* (strongyloidiasis). The study by Albright 2006 reported on intensity in the intervention arm only, and Ndenecho 2002 reported on intensity in both arms combined, so we did not include these studies. We were unable to meta-analyse the STH intensity results for several reasons. The studies that reported on STH intensity did not uniformly report their results. Arithmetic mean EPG of faeces, geometric mean EPG, and median EPG were all used in various studies. Measures of effect were often not reported, and the types of measures of effect that were reported varied widely, including using the faecal egg count reduction ratios (FECR is defined as the EPG ratio minus one); the rate/EPG ratios (e.g. using a log-linear model, assuming a negative binomial distribution); and the difference in mean intensity (e.g. using T-tests). Measures of variability such as standard deviation (SD) were often not reported. The STH burden (i.e. the mean measured EPGs) also varied widely across studies, creating substantial heterogeneity when trying to meta-analyse using a difference measure. For all the above reasons, we did not meta-analyse the STH intensity results, but rather have presented the data from individual studies in tabular format.

No studies reported any adverse events resulting from WASH interventions and MDA.

Intensity of infection with A lumbricoides

Ten RCTs reported on the intensity of infection as measured by EPG of faeces for *A lumbricoides* (Table 7) (Bassey 2020; Clasen 2014; Ercumen 2019; Freeman 2013a; Gyorkos 2013; Han 1988; Hurlimann 2018; Makata 2021; Nery 2019a; Pickering 2019). The study by Albright 2006 reported on intensity in the intervention arm only, and Ndenecho 2002 reported on intensity in both arms combined. Numerous studies did not report any measure of variability (e.g. an SD). Some studies did not report any measure of effect comparing the two groups, whilst others did report a measure of effect, but it was a measure that was not compatible with including the effect measure in the forest plot. Studies from Bassey 2020, Freeman 2013a, Gyorkos 2013, and Pickering 2019 had a lower intensity of *A lumbricoides* infection with WASH than with control.

Five non-RCTs reported on the intensity of infection as measured by EPG of faeces for *A lumbricoides* (Al-Delaimy 2014; Arfaa 1977; Hadidjaja 1998; Mascie-Taylor 1999; Steinmann 2014). Al-Delaimy 2014 found a lower intensity of *A lumbricoides* infection in the intervention arm compared to the control arm (Table 7).

Intensity of infection with T trichiura

Eight RCTs reported on the intensity of infection as measured by EPG of faeces for *T trichiura* (Table 8) (Bassey 2020; Clasen 2014; Ercumen 2019; Freeman 2013a; Gyorkos 2013; Hurlimann 2018; Makata 2021; Pickering 2019). The study by Albright 2006 reported on intensity in the intervention arm only, and Ndenecho 2002 reported on intensity in both arms combined. Several studies had a lower intensity of *T trichiura* infection with WASH than with control, including Freeman 2013a and Pickering 2019 (in the WASH arm) and Ercumen 2019 (in the sanitation and handwashing arms). Clasen 2014 reported an almost 10-fold higher EPG in the sanitation arm than in the control arm (EPG ratio = 9.90, 95% CI 1.98 to 46.62). Similar to the other intensity outcomes, most studies did not report any measure of variability (e.g. an SD) or any measure of effect comparing the two groups. Several studies had low intensity of *T trichiura* in both groups, including studies by Bassey 2020, Clasen 2014, Ercumen 2019, and Hurlimann 2018.

Five non-RCTs reported on the intensity of infection as measured by EPG of faeces for *T trichiura* (Al-Delaimy 2014; Hadidjaja 1998; Mascie-Taylor 1999; Reese 2019; Steinmann 2014). Al-Delaimy 2014 reported a lower intensity of *T trichiura* in the intervention arm compared to the control arm. The study by Reese 2019 reported mean EPG of zero in both the intervention and the control arms, as only one person was infected with *T trichiura*.

Intensity of infection with hookworm (N americanus and A duodenale)

Eight RCTs reported on the intensity of infection as measured by EPG of faeces for hookworm (Table 9) (Bassey 2020; Clasen 2014; Ercumen 2019; Freeman 2013a; Gyorkos 2013; Hurlimann 2018; Nery 2019a; Pickering 2019). Pickering 2019 observed lower hookworm intensity in the WASH arm, whereas Ercumen 2019 observed lower hookworm intensity in the WASH arm and the water arm. The majority of hookworm studies had similar levels of EPG in the WASH arms and in the control arms.

Five non-RCTs reported on the intensity of infection as measured by EPG of faeces for hookworm (Al-Delaimy 2014; Arfaa 1977; Mascie-Taylor 1999; Reese 2019; Steinmann 2014). Al-Delaimy 2014 reported a lower intensity of hookworm in the intervention arm compared to the control arm (Table 9).

Intensity of infection with S stercoralis

No RCTs reported on the intensity of infection as measured by EPG of faeces for *S stercoralis,* and no non-RCTs reported on the intensity of infection for *S stercoralis.*

DISCUSSION

Summary of main results

Thirty-two studies met the inclusion criteria, including a total of 52,944 participants. Twenty-two studies, including 14 RCTs (16 estimates) and eight non-RCTs (11 estimates) reported on our primary outcome, the prevalence of infection with at least one STH species. Twenty-one total studies reported on the prevalence of *A lumbricoides* (12 RCTs and 9 non-RCTs); 17 studies on the prevalence of *T trichiura* (9 RCTs and 8 non-RCTs); 18 studies on the prevalence of hookworm (10 RCTs and 8 non-RCTs); and one study on the prevalence of *S stercoralis* (1 non-RCT). Sixteen studies measured the intensity of infection for an individual STH type.

Amongst RCTs, meta-analysis revealed slightly lower (14%) odds of infection of any STH species in the WASH study arms compared to the control arms. Similar to the RCTs, the pooled effect for non-RCTs revealed that the odds of any STH infection was 29% lower in the WASH study arms compared to the control arms. We judged the certainty of the evidence for our primary outcome, prevalence of infection with any STH species, as moderate for RCTs and low for non-RCTs.

All six of the meta-analyses assessing individual worm infection amongst both RCTs and non-RCTs had pooled estimates in the preventive direction, although all CIs encapsulated the null, leaving the possibility of the null or even harmful effects. The certainty of evidence varied across these individual STH outcomes, ranging from very low to moderate, with RCTs having higher certainty of evidence. Many of the non-RCTs had a small number of participants and/or a small number of clusters (e.g. only two), therefore when we calculated the cluster-adjusted odds ratios, the CIs were often wide. There was less evidence of an effect of WASH on *T trichiura*, which may have been due in part to studies being underpowered because of low baseline incidence of disease and small sample sizes. Some of the heterogeneity for both *A lumbricoides* and *T trichiura* was explained in subgroup analyses that showed *T trichiura* infection to be lower in young children and higher in all ages. This finding of lower STH amongst children may be due to the higher burden of STH amongst school-age children, but also the common approach of PC within school populations. It is not clear why we observed higher prevalence of *A lumbricoides* and *T trichiura* infections in older age groups exposed to WASH interventions. It is plausible that adults and children interact with WASH interventions differently in ways that could be associated with infection in different directions (e.g. latrine cleaning).

The evidence was less clear for our secondary outcome assessing the intensity of STH infection. Meta-analysis of the intensity outcome was not feasible because studies did not report necessary metrics or reported different metrics across studies.

None of the included studies reported adverse events resulting from either WASH interventions or MDA.

Overall completeness and applicability of evidence

Thirty-two studies met the inclusion criteria of our review. A number of different participant types, study contexts, and intervention types were assessed, increasing the generalizability of our review. Most of the included studies were conducted in low- or lower-middle-income countries. A majority of studies were conducted in exclusively rural areas (22/31). Most of the included studies were conducted amongst child populations (25/31), and less than half of the studies (14/32) were conducted in schools.

There were myriad types and combinations of WASH interventions, and the quality of the implementation of these interventions varies greatly in real-world settings. Our review provides only limited evidence as to which types of WASH interventions are more effective. WASH interventions sometimes focused on individual WASH components (5/32), combinations of WASH components and strategies (15/32), or education (14/32). Two studies were factorial-like interventions with multiple WASH intervention arms to disentangle the differences in effect between different WASH components. WASH interventions were usually coupled with

deworming campaigns or inserted into a context where deworming was ongoing (24/32).

Quality of the evidence

We assessed the certainty of the evidence as moderate for the RCT analysis of our primary outcome, the prevalence of infection with at least one STH species, as well as for the *A lumbricoides* and hookworm RCT analyses, but we assessed the certainty of the evidence as low for the *T trichiura* RCT analysis. The main reasons for downgrading of the RCT evidence was inconsistency, as there was heterogeneity across some studies that was not explained by subgroup analyses, and imprecision, as there were sometimes wide CIs. Amongst RCTs, there was generally a low risk of bias, a large number of participants and clusters, and very little evidence of publication bias, with generally symmetrical funnel plots. Whilst the risk of bias analyses showed concerns across all studies regarding blinding, we did not believe that blinding was likely to influence the results of the review, as our outcomes were objectively measured. Our review focused specifically on trials, so the certainty of evidence could potentially be higher than in other previous reviews that primarily included observational studies (which are automatically downgraded). Amongst non-RCTs assessing individual worm infections, the certainty of evidence was rated as very low or low, downgraded for their non-randomized design, risk of bias, and imprecision.

Potential biases in the review process

We aimed to identify all eligible studies by conducting searches with no time or language restrictions, and we are confident that our review includes all relevant studies. The review authors independently screened and appraised the studies. Our title and abstract search process involved having two review authors check the titles and abstracts and exclude those that were clearly irrelevant. Two review authors conducted review of studies obtained as full text. Studies in which the study design, intervention components, outcomes, or ambiguity in control were unclear were always discussed with multiple review authors. We were not always able to extract or may not have targeted variables that might have explained some of the heterogeneity of our estimates. However, we had very little missingness in the variables that we did collect. Lack of information on variables such as non-adherence would have been important to understand if our estimates were likely to be biased towards the null.

Various studies reported different measures for the intensity of infection, making meta-analysis and comparability between studies difficult. Whilst means in the EPG of faeces were often reported in the separate study arms, studies inconsistently reported different types of measures of central tendency, including the arithmetic mean, the geometric mean, and/or the median. Furthermore, measures of variability and measures of effect were often not reported, and when measures of effect were reported, the types of measures of effect varied widely.

There was substantial variability in the intervention types assessed. Despite this variability, statistical heterogeneity was often low. However, there was evidence of statistical heterogeneity amongst RCTs for our primary outcome, any STH infection. The heterogeneity for this outcome is less surprising, as it consists of measuring infection with different worms that in some cases may have quite different transmission mechanisms. Whilst only a small number of studies often drove this heterogeneity, subgroup analyses did not always clarify which study characteristics might be the underlying factors contributing these anomalous results.

Studies with strong analysis plans and thorough results reporting were generally more common amongst RCTs than non-RCTs. The included non-RCTs often did not account for clustering in the analyses and often only had a small number of clusters (e.g. two); however, we adjusted for clustering after the fact for all studies that did not adjust for clustering themselves, so we feel this is not a major concern for bias. Sensitivity analyses restricting to the RCTs with low risk of bias for all domains except blinding of participants and personnel produced estimates similar to the pooled estimates including all RCTs.

Agreements and disagreements with other studies or reviews

This review of the impacts of WASH interventions on STH infection prevalence and STH intensity of infection updates previous reviews and reports, including new trials that were not previously completed, and adding subgroup variables and secondary outcomes (e.g. intensity) that were not previously reported. Ziegelbauer 2012 previously found evidence of crude associations between sanitation access and STH prevalence (pooled OR meta-analysis estimates ranging between 0.46 and 0.58) and between sanitation use and individual STH infections (pooled OR meta-analysis estimates ranging between 0.54 and 0.78). A review from Strunz 2014 also generally reported associations that were more strongly preventive than those in our review, although also possibly more prone to bias. These previous reviews relied heavily on observational studies. A review from Freeman 2017 focused more narrowly on sanitation interventions, and reported preventive associations between sanitation and some STH outcomes, but only when including the observational studies, whereas they found no association when the analysis was restricted to intervention studies. Our Cochrane Review focused on intervention studies, which are generally less prone to bias and confounding than observational studies. Another notable difference between observational and experimental studies is that observational studies make the distinct contrast of comparing a person (or cluster) who has the exposure to someone (or a cluster) who does not have the exposure, whereas intervention studies compare a person (or cluster) that has been *assigned to receive* some WASH intervention to control person (or cluster) without regard to adherence to that intervention. Due to issues in intervention uptake and participant adherence, differences in WASH coverage between the intervention and control areas are often only modest (Garn 2017), potentially leading to underestimates of the true effect of WASH on STH infection. The modest effects that we describe in our review are the effects of these specific WASH interventions *as currently delivered in these settings*, which may be appreciably different than the actual causal effect of WASH delivered under ideal circumstances (e.g. high adherence, higher-quality technologies, multifaceted WASH interventions, etc.).

AUTHORS' CONCLUSIONS

Implications for practice

Policymakers may take note of evidence in several areas that provide evidence in support of water, sanitation, and hygiene

(WASH) to reduce soil-transmitted helminth (STH) infection. Our a priori primary outcome, prevalence of infection with at least one STH species, showed that the odds of infection of any STH may be slightly lower in the WASH study arms compared to the control arms. Many of these results were in studies coupled with mass drug administration (MDA) in both the intervention arm(s) and control arm, and therefore show the impact of WASH on STH above and beyond the application of MDA alone.

For our primary analyses we used a broad exposure definition, in some cases combining interventions of different types. These exposure definitions for our primary analyses were defined a priori (i.e. before beginning any analyses), and our reasonings for this broad definition were several. With so many types of water, sanitation, and hygiene interventions, and then the numerous combinations of these individual components into multicomponent interventions, and then these interventions being delivered in either the school or community, we had concerns about overly reducing or attenuating pooled study findings into subgroups that were so small that they amounted to little additional meaning. We also believed that the type of intervention being implemented was often driven by the context in which the trial was conducted (e.g. there would be little interest in doing a sanitation trial where there was already good sanitation coverage). Most of the modest preventive effects that we observed were only elucidated through pooling. Pooling of various WASH intervention types and using a composite outcome increase study power, but are also limited in that our findings may not align neatly with the programming of specific interventions or with the varying levels of endemicity of different STHs in different areas.

Our post hoc analyses focusing on more narrow subsets of WASH interventions did very little to elucidate which interventions might be better than others. Whilst we observed many small effect estimates in the preventive direction, they usually had wide confidence intervals (CIs), and we did not detect any subgroup differences denoting that some interventions might be different than others. For our primary outcome, the effect estimate for community-based studies implementing water, sanitation, and hygiene together appears to be protective of any STH infection (odds ratio 0.78, 95% CI 0.63 to 0.96). The two study estimates in this subgroup, Ercumen 2019 and Pickering 2019, may differ from other studies as these were both part of a large-scale, efficacy trial, and these estimates were part of the most comprehensive WASH arm from that multifactorial study. Most of the other studies included in this review were smaller, effectiveness studies, and implemented less comprehensive interventions.

Whilst this evidence suggests that WASH may modestly protect from infection of multiple STHs, WASH also serves as a broad preventive measure for many other diseases that have faecal oral transmission routes. Recent efforts have attempted prioritize interventions that align complementary WASH and treatment/chemotherapy (WHO 2020; WHO 2021), and this review may support the inclusion of WASH as a component in the control of STHs. Current World Health Organization (WHO) guidance supports preventive chemotherapy (PC) with a single drug, but drug efficacy varies across the STH parasites; *Trichuris trichiura* is the least sensitive to a single drug intervention (Keiser 2008). After multiple years of successful PC, many long-standing programmes are now seeing areas of persistent high prevalence of *T trichiura*, underscoring the need to incorporate well-designed WASH and health education interventions along with the PC element to achieve the WHO and national goals. At the policy level, better co-ordination between the country-level WASH and health sectors would support the shared objectives of reaching the most vulnerable and better position each sector to achieve their respective Sustainable Development Goal (SDG) targets (Freeman 2013b).

The included studies were generally short in duration. Given the persistence of STHs in the environment, additional studies to assess the longer-term impact of WASH interventions coupled with MDA would be relevant. Future interventions should also target demographics at the highest risk of both infection but also of morbidity. Infection intensity may be more important for assessing morbidity than prevalence (Pullan 2014). Furthermore, the intensity of various worms varies by age (e.g. hookworm is more prevalent amongst adults, while other STHs are more prevalent amongst school-age children).

Implications for research

Our review found additional studies assessing faecal egg count (intensity of infection). The lack of studies assessing intensity of infection was a noted limitation and gap in the literature of previous reviews (Strunz 2014). The variety of reported measures of association made pooling of results difficult. This underscores the current policy gap and urgent need to define the minimal, standard data that should be collected globally on neglected tropical diseases, including STH, to enable pooled analyses and comparisons. This is critical, particularly as infection intensity is important for assessing morbidity (Pullan 2014). With limited investments in STH research, there is a need to align monitoring and evaluation measures and approaches across people and geographies in order to maximize efficiencies and make robust data available for informed global and local policies (Diaz 2020).

Previous reviews noted a gap in the literature relating to the impact of WASH on *Strongyloides stercoralis* infections (Strunz 2014). We found a dearth of evidence in this area, in part because studies that attempted to include *S stercoralis* outcomes often did not find any *S stercoralis* eggs. Future studies should take place in areas more highly endemic with *S stercoralis*. *S stercoralis* was recently added to the WHO STH worms for control (WHO 2030 roadmap) (WHO 2019), and is currently targeted for research to define its epidemiology and risk categorization, providing a unique opportunity for WHO and partners to proactively develop a clear research agenda that defines gap areas and metrics for which outcomes are to be determined, and to have a somewhat standardized approach so that the data collected can be analysed together. This may help overcome the current data challenges to reviews and meta-analyses such as ours by improving the robustness of results and increasing statistical power.

A wide variety of WASH interventions were implemented across studies. A possible area of research to be pursued further is understanding the importance of different intervention components and adherence to these interventions (Garn 2017). Our study attempted to understand the reasons for heterogeneity amongst the effects of these WASH studies on STH infection, although many of the analyses had surprisingly little heterogeneity in effects considering the substantial differences in populations, interventions, study designs, and approaches.

The biological plausibility for improved access to WASH to interrupt transmission of STH is clear (Pruss-Ustun 2019), but WASH interventions as currently delivered in geographies where STH remains endemic have shown lower than expected impacts. For WASH interventions to show improved benefit, there is a need for more rigorous and targeted implementation research, including development and context-specific adaptation of theory-informed behavioural interventions, as well as process evaluation to understand what works and how (Haque 2021).

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- Contact Editor: Professor Mical Paul
- Sign-off Editor (final editorial decision): Professor Paul Garner (Cochrane Infectious Diseases Group (CIDG) Co-ordinating Editor)
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* Indicates the major publication for the study

CHARACTERISTICS OF STUDIES

Characteristics of included studies *[ordered by study ID]*

Albright 2006

Study characteristics	
Methods	**Design**cNON-RCT**Allocation of clusters** 5 schools allocated to intervention; 45 to 50 to control (i.e. 9 to 10 control schools per intervention school)
Participants	3463 children ages 6 to 12
Interventions	Primarily education
Outcomes	Any STH
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Quote: "One school in each of five different districts located in central Java was selected for deworming and BRI. The children in these schools were the same as those involved in the previous study (Albright et al, 2005). Each school serves approximately 100 students in grades 1 through 6." Judgement Comment: Methods for sequence generation were not reported as random.
Allocation concealment (selection bias)	High risk	Judgement Comment: Is a non-RCT. Methods for allocation sequence were not reported.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Judgement Comment: Blinding could not be achieved due to the nature of the intervention.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "Each specimen was coded so that the examining parasitologists were unaware of the identities of the specimen donors."

Albright 2006 *(Continued)*

Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Quote: "Baseline data obtained during Phase 1 from the five prototypic schools has been reported previously (Albright et al, 2005). Six-to-seven months after Phase 1, a second parasitological survey was performed (Phase 2). Phases 1 and 2, which involved only the children from the five prototypic schools, were conducted during late 2003 and early 2004 (Phase 1) and early to mid 2004 (Phase2). Phase 3, involved the children of all the schools except the prototypic schools, extended over the same period, during 2004 and 2005." Judgement Comment: Methods not described, insufficient information to permit a judgement. The authors did multiple cross-sectional stool sample collections, so incomplete data hard to determine.
Selective reporting (reporting bias)	Low risk	Quote: "The first phase (see Albright et al, 2005) was a survey of prevalences and intensities of infection among more than 500 children (grades 1 through 6), an evaluation of factors which favor the acquisition of infection, and an assessment of the environmental and nutritional conditions of the children." Judgement Comment: Study protocol is not available, but published reports include all expected outcomes.
Other bias	Unclear risk	Judgement Comment: Insufficient information to permit a judgement
Baseline Characteristics	Unclear risk	Judgement Comment: Baseline tabular data reported in this paper consist only of sex and number of students. Tabular baseline data of the schools are presented in Albright and colleagues, 2005.
Baseline outcome measurements similar Non-RCT	High risk	Judgement Comment: Important differences were present and not adjusted for in analysis.
Protection against contamination Non-RCTs	Low risk	Judgement Comment: Allocation was by school, and it is unlikely that the control schools received the specific intervention.

Al Delaimy 2014

Study characteristics	
Methods	**Design**cNON-RCT**Allocation of clusters** 1 school allocated to intervention, 1 to control
Participants	317 children ages 7 to 11
Interventions	Primarily education
Outcomes	*Ascaris lumbricoides*; *Trichuris trichiura*; hookworm
Notes	

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	High risk	Quote: "Two primary schools in this area were selected purposively based on our previous surveys and after discussion with health officers in the Department of Orang Asli Development (JAKOA)."

Al Delaimy 2014 *(Continued)*

		Judgement Comment: Schools were selected purposively, and allocation to intervention or control group was not specified as random.
Allocation concealment (selection bias)	High risk	Judgement Comment: Is a non-RCT. Due to the nature of the intervention, allocation sequence could not be concealed; allocation was non-random.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Judgement Comment: Blinding could not be achieved due to the nature of the intervention.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Quote: "Fresh faecal samples were collected from each participant at baseline, again at 12–14 days after treatment and again monthly over the next 6 months. The faecal samples were collected into 100 ml clean containers with wide mouths and screw-fit caps before being transported (within 5 hours of collection) in suitable cool boxes at temperatures between 4 and 6°C for examination at the stool processing laboratory in the Department of Parasitology, Faculty of Medicine, University of Malaya." Judgement Comment: Methods not described, insufficient information to permit a judgement.
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Quote: "An additional 20% of the calculated sample size was added to avoid the effects of dropouts and potential losses in terms of failures to attend the follow up assessments. Overall, a total of 317 children were involved in this study (172 from SKB and 145 from SKKK)." Judgement Comment: No indication if data are missing or incomplete; methods not discussed - it is not specified whether 172 and 145 are consistent from baseline onward, and it is not reported whether there was loss to follow-up.
Selective reporting (reporting bias)	Low risk	Judgement Comment: Study protocol is available, and all of the study's relevant prespecified outcomes are reported in the originally specified way.
Other bias	Unclear risk	Judgement Comment: Insufficient information to permit a judgement
Baseline Characteristics	Low risk	Quote: "Faecal samples were collected from 317 schoolchildren (48.9% males and 51.1% females) aged between 6 and 12 years, with a median age of 9 years (interquartile range = 8, 11). Overall, 172 and 145 children from SKB and SKKK respectively were involved in this study. Poverty is predominant in these communities, with about two thirds of the families having a low monthly income (<RM500) that equated to being below the poverty income threshold for Malaysia. Moreover, 42.3% and 56.2% of the fathers and mothers, respectively, had no formal education. Only 30.6% and 5.7% of the fathers and mothers, respectively, were working; mainly as farmers or workers in rubber and oil palm plantations, forestry, fishing and other related occupations. Almost half of the houses (47.9%) were without toilets and 46.7% were without a piped water supply." Quote: "To investigate the impact of the health education pack- age on STH infections, the prevalence of STH infections were compared between the intervention group (SKB) and the control group (SKKK) by using a Chi-square test and an intention-to-treat approach for data analysis." Judgement Comment: Baseline characteristics of the study and control providers are reported and similar. Intention-to-treat analysis performed.
Baseline outcome measurements similar Non-RCT	Low risk	Judgement Comment: Outcomes were measured prior to the intervention, and no important differences were present across study groups.

Al Delaimy 2014 *(Continued)*

Protection against contamination Non-RCTs	Low risk	Judgement Comment: Allocation was by school, and it is unlikely that the control schools received the specific intervention.

Arfaa 1977

Study characteristics	
Methods	**Design**cNON-RCT**Allocation of clusters** 4 villages allocated to an intervention, 4 to corresponding control 3 villages allocated to another intervention, 3 to corresponding control
Participants	1155 and 580 participants of all ages
Interventions	Single WASH aspect
Outcomes	*Ascaris lumbricoides*; hookworm
Notes	

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	High risk	Judgement Comment: Methods for sequence generation were not reported as random.
Allocation concealment (selection bias)	High risk	Judgement Comment: Is a non-RCT. Methods for allocation sequence were not reported.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Judgement Comment: Due to the nature of the intervention, allocation could not be concealed. However, households were not told the purpose of the study.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Judgement Comment: Methods not described, insufficient information to permit a judgement.
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Judgement Comment: Methods not described, insufficient information to permit a judgement. Endline sample size not reported, and long-term follow-up not addressed.
Selective reporting (reporting bias)	Low risk	Judgement Comment: Study protocol is not available, but published reports include all expected outcomes.
Other bias	Unclear risk	Judgement Comment: Insufficient information to permit a judgement
Baseline Characteristics	Unclear risk	Judgement Comment: No tabular data of baseline characteristics reported. Only the village population and the number of men and women examined were reported.
Baseline outcome measurements similar	High risk	Judgement Comment: Important differences were present and not adjusted for in analysis.

Arfaa 1977 *(Continued)*
Non-RCT

Protection against contamination Non-RCTs	Low risk	Judgement Comment: Allocation was by village, and it is unlikely that the control villages received the specific intervention.

Bassey 2020

Study characteristics		
Methods	**Design**cRCT**Allocation of clusters** 3 schools randomized to intervention, 3 to control	
Participants	255 schoolchildren ages 5 to 10	
Interventions	Primarily education	
Outcomes	Any STH; *Ascaris lumbricoides*; *Trichuris trichiura*; hookworm	
Notes		
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Judgement Comment: This study employed an RCT design. 6 public primary schools were randomly selected out of the 49 public primary schools in the study area. Schools were first stratified into 2 clusters based on existing geopolitical zones, proximities to common boundaries, and road networks. For each cluster, 3 schools were randomly selected using the balloting.
Allocation concealment (selection bias)	Low risk	Judgement Comment: The schools were blindly assigned to the 2 treatments available
Blinding of participants and personnel (performance bias) All outcomes	High risk	Judgement Comment: Blinding could not be achieved due to the nature of the intervention.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Quote: "At the baseline, children's infection status was assessed by collecting one gram of faecal sample 154 from each participant using universal sample bottles and examined for STH infections using ether- 155 concentration method [23]."
Incomplete outcome data (attrition bias) All outcomes	High risk	Judgement Comment: Loss to follow-up not addressed.
Selective reporting (reporting bias)	Low risk	Quote: "DBB and UFE conceptualized the study, and prepared the protocol, while GAA, BIA, EMA and 486 ASO improved the protocol."
Other bias	Unclear risk	Judgement Comment: Insufficient information to permit a judgement
Baseline Characteristics	Low risk	Quote: "total of 372 children, 190 (51.1%) males and 182 (48.9%) females between the age group 5-10 193 years (197; 53%) and 11-15years (175; 47%) par-

Bassey 2020 *(Continued)*

	ticipated in this study with 212 (56.9%) in the 194 intervention group and 160 (49.1%) in the control group (Table 1)."

Bieri 2013

Study characteristics	
Methods	**Design**cRCT**Allocation** 19 schools randomized to intervention, 19 to control
Participants	1718 schoolchildren ages 5 to 14
Interventions	Primarily education
Outcomes	Any STH
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "The study was an unmatched, cluster- randomized intervention trial involving 38 schools (38 clusters) and was conducted over the course of 1 school year (September 2010 through June 2011) (Fig. 1A)." Judgement Comment: Randomly assigned, but the process used to generate the randomization list is unclear
Allocation concealment (selection bias)	Unclear risk	Quote: "The schools were randomly assigned, in a 1:1 ratio, to an intervention package (19 schools) or a control package (19 schools) (Fig. 1A, and Table S1 in the Supplementary Appendix)." Judgement Comment: Allocation sequence not reported.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Judgement Comment: Due to the nature of the intervention, allocation could not be concealed. However, households were not told the purpose of the study.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "the Kato–Katz thick-smear technique. 6 For quality control, 10% of the slides were re-checked by independent microscopists at the Hunan Institute of Parasitic Diseases."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "randomization units comprising 38 schools. A total of 1934 students were enrolled in the study, of whom 216 were lost to follow-up (Panel B). During the study period, 103 new students in the intervention schools and 107 in the control schools were registered; data from these students were excluded from the analyses. KAP denotes knowledge, attitudes, and practices." Judgement Comment: Missing outcome data balanced across intervention groups with similar reasons for missing data across groups.
Selective reporting (reporting bias)	Low risk	Quote: "the collection, analysis, interpretation, and completeness of the data; and the fidelity of this report to the study protocol, which is available at NEJM.org."

Bieri 2013 *(Continued)*

		Judgement Comment: Study protocol available, and outcomes reported as outlined in protocol.
Other bias	Low risk	Judgement Comment: Study appears to be free of other sources of bias.
Baseline Characteristics	Low risk	Quote: "There were 976 boys and 739 girls in the study (information on sex was not available for 3 students); 1641 of the students were in grade 4, and 77 in grade 5. During the study period, 210 new students (103 in the intervention schools and 107 in the control schools) were registered, but data from these students were excluded from the analyses."

Chard 2019

Study characteristics	
Methods	**Design**cRCT**Allocation of clusters** 50 schools randomized to intervention, 50 to control
Participants	9258 primary school-aged children
Interventions	Broad multiple
Outcomes	Any STH
Notes	

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "We conducted a cluster-randomized, controlled trial among 100 primary schools (50 intervention, 50 comparison). Study design, sampling, and data collection methods have been previously published [19]."
Allocation concealment (selection bias)	Low risk	Quote: "We used stratified random sampling to help ensure equal representation of control and intervention schools in each district, and that the number of schools selected in each district was proportional to the number of eligible schools in each district. We selected up to 40 pupils from grades 3-5 in each school using systematic stratified sampling, with grade and sex as the stratification variables."
Blinding of participants and personnel (performance bias) All outcomes	High risk	Quote: "First, the secondary health impact measures (diarrhea, symptoms of respiratory infection, conjunctivitis) were based on self-report by pupils, which may be subject to bias, and this evaluation was not blinded for either the beneficiaries or data collectors."
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "Each year, stool samples were collected from up to 50 pupils per school prior to distribution of preventative chemotherapy as part of the National School Deworming Programme. Stool samples were tested for Ascaris lumbricoides, Trichuris trichiura, and hookworm (Ancyclostoma duodenale and Necatur americanus) using the Kato Katz technique [23]."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "Figure 2. Flow diagram of school and pupil selection."

Chard 2019 *(Continued)*

		Judgement Comment: Reasons for LTFU addressed between intervention and control groups.
Selective reporting (reporting bias)	Low risk	Quote: "The study setting, baseline results, intervention components, intervention outputs and outcomes, and their fidelity and adherence have been described in detail elsewhere [19]."
Other bias	Low risk	Judgement Comment: Study appears to be free of other sources of bias.
Baseline Characteristics	Low risk	Quote: "The study setting, baseline results, intervention components, intervention outputs and outcomes, and their fidelity and adherence have been described in detail elsewhere [19]." Judgement Comment: Baseline levels of enrolment, sex parity, school WASH access (presence of a toilet, water point in school compound, presence of handwashing facilities), school wealth, pupil demographics (age, household wealth, household presence of a toilet, use of an improved water source, and presence of a handwashing facility equipped with soap and water), and primary and secondary impacts were evaluated to ensure that there were no significant differences across intervention and comparison groups and that the randomization process was successful.

Clasen 2014

Study characteristics	
Methods	**Design**cRCT**Allocation of clusters** 50 villages randomized to intervention, 50 to control
Participants	4294 participants of all ages
Interventions	Broad multiple
Outcomes	Any STH; *Ascaris lumbricoides*; *Trichuris trichiura*; hookworm
Notes	

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Judgement Comment: A member of staff who was not involved in either data collection or intervention delivery randomly assigned villages (1:1) using a computer-generated sequence.
Allocation concealment (selection bias)	Low risk	Judgement Comment: A member of staff who was not involved in either data collection or intervention delivery randomly assigned villages (1:1), using a computer-generated sequence, to undergo either latrine promotion and construction in accordance with the Total Sanitation Campaign, or to no intervention (control). Randomization was stratified by administrative block to ensure an equal number of intervention and control villages in each block.
Blinding of participants and personnel (performance bias)	High risk	Judgement Comment: Masking of participants was not possible due to the nature of the intervention. However, households were not explicitly told that the

Clasen 2014 *(Continued)*

All outcomes		purpose of enrolment was to study the effect of a trial intervention, and the surveillance team differed from the intervention team.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Judgement Comment: Methods not described, insufficient information to permit a judgement.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Judgement Comment: Missing outcome data balanced across intervention groups with similar reasons for missing data across groups.
Selective reporting (reporting bias)	Low risk	Judgement Comment: Study protocol is available, and all of the study's relevant prespecified outcomes are reported in the originally specified way.
Other bias	Low risk	Judgement Comment: Study appears to be free of other sources of bias.
Baseline Characteristics	Low risk	Judgement Comment: A baseline survey between September and October 2010 to obtain information about household demographic characteristics; socioeconomic status; water, hygiene, and sanitation conditions; and diarrhoea prevalence

Duijster 2017

Study characteristics	
Methods	**Design**cNON-RCT**Allocation of clusters** 10 schools allocated to intervention, 10 to control (Cambodia) 9 schools allocated to intervention, 9 to control (Indonesia) 22 schools allocated to intervention, 22 to control (Lao PDR)
Participants	478, 486, and 535 children ages 6 to 7
Interventions	Broad multiple
Outcomes	Any STH
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Quote: "Selection of the intervention schools was done by the respective MoEs on the basis of accessibility and support from the school administration." Judgement Comment: Methods for sequence generation were not reported as random.
Allocation concealment (selection bias)	High risk	Judgement Comment: Is a non-RCT. Methods for allocation sequence were not reported.
Blinding of participants and personnel (performance bias)	High risk	Judgement Comment: Blinding could not be achieved due to the nature of the intervention.

Duijster 2017 *(Continued)*

All outcomes		
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "Ten percent of stool samples were re-examined by a reference microscopist for quality control."
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Quote: "Parasitological, anthropometric and oral health parameters of the dropout children were similar to those children who were followed-up." Judgement Comment: Rationale for dropout not specified.
Selective reporting (reporting bias)	Low risk	Quote: "The study's original methodology and protocol was developed in the Philippines in 2009 [17]." Judgement Comment: Study protocol is available, and all of the study's relevant prespecified outcomes are reported in the originally specified way.
Other bias	Low risk	Judgement Comment: Study appears to be free of other sources of bias.
Baseline Characteristics	Low risk	Quote: "The child characteristics of the study sample are de- scribed in Table 1. The mean age of the children at base- line was 6.7 ± 0.5 years (range 6.0–8.0 years) in intervention schools and 6.8 ± 0.5 years (range 6.0– 8.0 years) in control schools ($P < 0.05$), and 48.4% and 53.9% were boys in intervention and control schools, respectively ($P < 0.05$). Around one-third of children came from large families with three or more siblings – a proxy indicator of lower SES." Judgement Comment: Baseline characteristics of the study and control providers are reported and are similar.
Baseline outcome measurements similar Non-RCT	High risk	Judgement Comment: Important differences were present and not adjusted for in analysis.
Protection against contamination Non-RCTs	Low risk	Judgement Comment: Allocation was by school, and it is unlikely that the control schools received the specific intervention.

Dumba 2013

Study characteristics		
Methods	**Design**cRCT**Allocation of clusters** 10 villages randomized to intervention, 9 to control	
Participants	558 children younger than age 5	
Interventions	Primarily education	
Outcomes	Any STH	
Notes		
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**

Dumba 2013 *(Continued)*

Random sequence generation (selection bias)	Unclear risk	Quote: "Two sub-counties, selected by simple random sampling, consisted of 4 parishes from which 19 study villages were studied." Judgement Comment: Whilst the study was a randomized community intervention trial with pre- and postintervention phases, it is not stated how the 19 study villages were selected.
Allocation concealment (selection bias)	Unclear risk	Judgement Comment: Methods for allocation sequence were not reported.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Judgement Comment: Blinding could not be achieved due to the nature of the intervention.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Quote: "19 study villages were studied. Stool samples from 727 eligible children were examined for presence of different types of helminth ova using Kato-Katz 8 technique. Semi-structured questionnaires were also administered" Judgement Comment: Methods not described, insufficient information to permit a judgement.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "Issue 2 June 2013 514 There was a high drop rate basically due to migration from study area; hence the difference in the two study populations during Phase 1 & 3 (727 and 558 respectively). Phase 3 data contains both experimental and control groups."
Selective reporting (reporting bias)	Low risk	Judgement Comment: Study protocol is not available, but published reports include all expected outcomes.
Other bias	Unclear risk	Judgement Comment: Insufficient information to permit a judgement
Baseline Characteristics	Unclear risk	Judgement Comment: No tabular data of baseline characteristics reported.

Ercumen 2019

Study characteristics		
Methods	**Design** cRCT**Allocation of clusters** 90 clusters randomized to water; 90 to sanitation; 90 to hygiene; 90 to WASH; 180 to control	
Participants	3685 and 1706 children ages 2 to 12	
Interventions	Single WASH aspect and broad multiple	
Outcomes	Any STH; *Ascaris lumbricoides*; *Trichuris trichiura*; hookworm	
Notes		
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**

Ercumen 2019 *(Continued)*

Random sequence generation (selection bias)	Low risk	Quote: "enrolled formed a geographic block. An off-site investigator (BFA) used a random number generator to block-randomize clusters into study arms, providing geo- graphically pair-matched randomization."
Allocation concealment (selection bias)	Low risk	Quote: "clusters enrolled formed a geographic block. An off-site investigator (BFA) used a random number generator to block-randomized clusters into study arms, providing geo- graphically pair-matched randomization."
Blinding of participants and personnel (performance bias) All outcomes	High risk	Quote: "Participants and field staff were not blinded as interventions entailed distinct hardware"
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "Specimens without preservatives were transported on ice to the field laboratory of the Inter- national Centre for Diarrhoeal Disease Research, Bangladesh (icddr,b) and analyzed on the same day. Laboratory staff were trained at the icddr,b parasitology laboratory using the Vestergaard Frandsen protocol to perform double-slide Kato-Katz and enumerate ova of A. lumbricoides, hookworm and T. trichiura. Two slides were prepared from each stool sample and enumerated within 30 minutes of slide preparation [32]. 10% of slides were counted by two technicians (within the 30 minute-window since slide preparation), and 5% were counted by a senior parasitologist (by sending the slides to the icddr,b parasitology laboratory in Dhaka 0–4 days following the original count at the field laboratory) for quality assurance. Two independent technicians double-entered slide counts into a database. "
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "Missing outcomes. Individuals that were lost at follow-up or failed to submit a specimen were classified as missing. To assess if the likelihood of missing data was differential by study arm and/or covariates, we compared the percentage of missing observations between arms and the enrollment characteristics of those with available vs. missing specimens. We also assessed the balance of baseline covariates between arms for households captured at follow-up. We conducted a complete-case analysis and an inverse probability of censoring-weighted (IPCW) analysis re-weighting the measured population to reflect the original enrolled population (see analysis plan) [36]." Quote: "Missing outcomes. Individuals that were lost at follow-up or failed to submit a specimen were classified as missing. To assess if the likelihood of missing data was differential by study arm and/or covariates, we compared the percentage of missing observations between arms and the enrollment characteristics of those with available vs. missing specimens. We also assessed the balance of baseline covariates between arms for households captured at follow-up. We conducted a complete-case analysis and an inverse probability of censoring-weighted (IPCW) analysis re-weighting the measured population to reflect the original enrolled population (see analysis plan) [36]."
Selective reporting (reporting bias)	Low risk	Quote: "The study protocol, pre-specified analysis plan, and a CONSORT checklist of trial procedures have been provided (S1–S3 Text)."
Other bias	Low risk	Judgement Comment: Study appears to be free of other sources of bias.
Baseline Characteristics	Low risk	Quote: "Household-level enrolment covariates measured at baseline were balanced between arms for index households captured at follow-up (Table 1) and for those with vs. without specimens (S1 Table). The prevalence of protozoan parasites measured among children aged 18– 27 months at baseline was balanced between arms [31]."

Erismann 2017

Study characteristics	
Methods	**Design**cRCT **Allocation** 4 schools randomized to intervention, 4 to control
Participants	360 children ages 8 to 15
Interventions	Broad multiple
Outcomes	Any STH
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Unclear risk	Quote: "The eight schools to participate in this study were randomly selected from the 30 VgtS project schools in Burkina Faso." Judgement Comment: Methods for sequence generation were not reported.
Allocation concealment (selection bias)	Unclear risk	Quote: "There were eight schools included in a baseline cross-sectional survey. The schools were randomly and evenly allocated by the study investigators to two study arms (“intervention” and “control” group)." Judgement Comment: Allocation concealment methods not reported.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Judgement Comment: Blinding could not be achieved due to the nature of the intervention.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "single stool sample was collected from each child on two consecutive days, subjected to the Kato–Katz technique (duplicate thick smears, using standard 41.7 mg templates) and a formalin–ether concentration technique for the diagnosis of helminths and intestinal protozoa." Quote: "10% of slides were counted by two technicians (within the 30 minute-window since slide preparation), and 5% were counted by a senior parasitologist (by sending the slides to the icddr,b parasitology laboratory in Dhaka 0–4 days following the original count at the field laboratory) for quality assurance. Two independent technicians double-entered slide counts into a database; To measure STH outcomes, field staff distributed sterile containers to primary caregivers of enrolled children, instructed them to collect stool from the following morning’s defecation event, and retrieved the containers on the morning of defecation"
Incomplete outcome data (attrition bias) All outcomes	Low risk	Judgement Comment: Missing outcome data balanced across intervention groups with similar reasons for missing data across groups.
Selective reporting (reporting bias)	Low risk	Judgement Comment: Study protocol available, and outcomes reported as outlined in protocol.
Other bias	Unclear risk	Judgement Comment: Insufficient information to permit a judgement

Erismann 2017 *(Continued)*

Baseline Characteristics	Low risk	Quote: "Mixed regression models were used to assess the impact of the interventions, controlling for baseline characteristics." Judgement Comment: Baseline data reported in Table 1; similar characteristics amongst groups.

Freeman 2013a

Study characteristics		
Methods	**Design**cRCT**Allocation of clusters** 20 schools randomized to intervention, 19 to control (1 lost)	
Participants	1113 children ages 7 to 13	
Interventions	Broad multiple	
Outcomes	Any STH; *Ascaris lumbricoides*; *Trichuris trichiura*; hookworm	
Notes		
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "All random selection and allocation was conducted by the research manager using a random number generator in Microsoft Excel (Redmond, WA)."
Allocation concealment (selection bias)	Unclear risk	Judgement Comment: Methods for allocation sequence were not reported.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Judgement Comment: Blinding could not be achieved due to the nature of the intervention.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "each stool sample was processed on two separate slides and read by different laboratory technicians. The mean of the two readings was calculated and designated as the value for that pupil. As a quality check, a random selection of 10% of slides were examined again by a different microscopist and if the number of worm eggs was different by 10%, slides were then reread. 24"
Incomplete outcome data (attrition bias) All outcomes	Low risk	Judgement Comment: Missing outcome data balanced across intervention groups with similar reasons for missing data across groups.
Selective reporting (reporting bias)	Low risk	Judgement Comment: Study protocol is available, and all of the study's relevant prespecified outcomes are reported in the originally specified way.
Other bias	Low risk	Judgement Comment: Study appears to be free of other sources of bias.
Baseline Characteristics	Low risk	Quote: "Aggregate school and household characteristics at baseline among randomly selected schools and communities in Nyanza Province Kenya, February 2007"

Freeman 2013a *(Continued)*

	Judgement Comment: Baseline characteristics of the study and control providers are reported and are similar (Table 1).

Gray 2019

Study characteristics	
Methods	**Design** cNON-RCT* **Allocation of clusters** 1 village randomized* to intervention, 1 to control
Participants	527 individuals ages 3 to 70
Interventions	Broad multiple
Outcomes	Any STH
Notes	*The study may have used a random mechanism to allocate the intervention, but there was only 1 intervention area compared to 1 control area, so randomization in this case not likely to have reduced confounding or imbalances.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Judgement Comment: Methods specify that a random selection was made from these 2 villages regarding which should receive the intervention and which should receive the control by researchers who had no prior knowledge or contact with the villagers. It then says a randomly selected cohort was followed for 8 months of the study. The report does not specify how the sequence was generated, however (no mention of random number generator or rolling of dice, for example).
Allocation concealment (selection bias)	High risk	Judgement Comment: Given the nature of the intervention, it could not be concealed if village was receiving the intervention or not.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Judgement Comment: Paper mentions that those who did the allocation to intervention and control had no prior knowledge of the villagers. Participants could not be blinded due to the nature of the intervention.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Judgement Comment: No information included regarding blinding of outcome assessors.
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Judgement Comment: Unclear if there was any loss to follow-up or how this was accounted for. The intervention and control groups are similar in size, and analyses adjusted for age and sex since villagers of all ages and sexes were allowed to participate.
Selective reporting (reporting bias)	Low risk	Judgement Comment: Paper states outcomes as prevalence of STH infection at baseline and follow-up, and these outcomes are reported on.
Other bias	Low risk	Judgement Comment: Study appears to be free of other sources of bias.

Gray 2019 *(Continued)*

Baseline Characteristics	Low risk	Judgement Comment: Baseline characteristics are similar; researchers describe characteristics and adjust for age and sex in analyses.
Baseline outcome measurements similar Non-RCT	Low risk	Judgement Comment: Outcomes were measured prior to the intervention, and no important differences were present across study groups.
Protection against contamination Non-RCTs	Low risk	Judgement Comment: Allocation was by village, and it is unlikely that the control village received the specific intervention.

Gungoren 2007

Study characteristics	
Methods	**Design**cNON-RCT**Allocation of clusters** 4 villages allocated to intervention, 1 to control
Participants	178 children ages 2 to 14
Interventions	Primarily education
Outcomes	Any STH
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Judgement Comment: Methods for sequence generation were not reported as random.
Allocation concealment (selection bias)	High risk	Judgement Comment: Is a non-RCT. Methods for allocation sequence were not reported.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Judgement Comment: Blinding could not be achieved due to the nature of the intervention.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "Two kinds of quality assessment of results were carried out: first, an internal quality assessment with 20% of samples being re-examined in the Laboratory of the Clinical Diagnos- tic Department of Tashkent Institute of Medical Postgraduate Education; second, an external quality assessment was con- ducted where parasitologists were provided with control samples, which contained different kinds of intestinal parasites."
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Judgement Comment: Endline data not reported, unable to determine if there was loss to follow-up; methods not described, insufficient information to permit a judgement.
Selective reporting (reporting bias)	Low risk	Judgement Comment: Study protocol is not available, but published reports include all expected outcomes.

Gungoren 2007 *(Continued)*

Other bias	Unclear risk	Judgement Comment: Insufficient information to permit a judgement
Baseline Characteristics	Low risk	Quote: "Table 1 Descriptive statistics of the three study groups (12 villages, Fergana valley, Uzbekistan)" Judgement Comment: Baseline characteristics of the study and control providers are reported and similar (Table 1).
Baseline outcome measurements similar Non-RCT	Low risk	Judgement Comment: Outcomes were measured prior to the intervention, and no important differences were present across study groups.
Protection against contamination Non-RCTs	Low risk	Judgement Comment: Allocation was by village, and it is unlikely that the control villages received the specific intervention.

Gyorkos 2013

Study characteristics	
Methods	**Design**cRCT**Allocation of clusters** 9 schools randomized to intervention, 9 to control
Participants	1089 children age 10
Interventions	Primarily education
Outcomes	Any STH; *Ascaris lumbricoides*; *Trichuris trichiura*; hookworm
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "Within each pair, one school was randomly allocated to deworming and health education (intervention schools) and the other to deworming alone (control schools). The allocation sequence was generated automatically using a custom function that allocated schools using a random number generator with a binomial distribution in R statistical software (The R Project for Statistical Computing, http://www.r-project.org/)."
Allocation concealment (selection bias)	Low risk	Quote: "The randomization was executed by an independent statistician blinded to school identity. The laboratory technologists (primary outcome assessors) were blinded to intervention status."
Blinding of participants and personnel (performance bias) All outcomes	High risk	Judgement Comment: Blinding could not be achieved due to the nature of the intervention.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "Once slides were prepared (according to the Kato-Katz method), they were examined within 40 minutes. Quality control procedures were performed on 25% of all slides. Laboratory supervisors re- read these slides and discussed any discrepancies with laboratory technicians."

Gyorkos 2013 *(Continued)*

Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "Figure 1. Trial profile." Judgement Comment: Missing outcome data balanced across intervention groups, with similar reasons for missing data across groups (Figure 1).
Selective reporting (reporting bias)	Low risk	Judgement Comment: Study protocol is available, and published reports include all expected outcomes.
Other bias	Low risk	Judgement Comment: Study appears to be free of other sources of bias.
Baseline Characteristics	Low risk	Quote: "Table 1. Baseline characteristics of Grade 5 students who completed baseline and follow-up assessments and were dewormed following baseline assessment (n = 1,089), and of participating schools (n = 18), by intervention status, in Belen, Peru, April–June 2010."

Hadidjaja 1998

Study characteristics	
Methods	**Design**cNON-RCT***Allocation of clusters** 1 school randomized* to intervention, and 1 corresponding control 1 other school randomized to different intervention, and 1 corresponding control
Participants	535 and 314 children ages 6 to 8
Interventions	Primarily education
Outcomes	*Ascaris lumbricoides*
Notes	*The study may have used a random mechanism to allocate the intervention, but there was only 1 intervention area compared to 1 control area, so randomization in this case not likely to have reduced confounding or imbalances.

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	High risk	Quote: "These schools were randomly assigned to receive either treatment with an antihelmintic (mebendazole), health education, mebendazole plus health education, or a placebo (a similar-looking tablet containing cassava flour mixed with sugar, but without mebendazole)." Judgement Comment: Randomly assigned, but allocation sequence not reported as random.
Allocation concealment (selection bias)	High risk	Judgement Comment: Methods for allocation sequence were not reported.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Judgement Comment: Blinding could not be achieved due to the nature of the intervention.
Blinding of outcome assessment (detection bias)	Unclear risk	Quote: "Kato-Katz technique before and after five months of an intervention."

Hadidjaja 1998 *(Continued)*

All outcomes		Judgement Comment: Not specified
Incomplete outcome data (attrition bias) All outcomes	Low risk	Judgement Comment: "Excluded: cases from the egg-negative group who changed to an egg-positive status, cases with missing data, and cases with T. trichiura infection (>500 epg)" is rationale for attrition.
Selective reporting (reporting bias)	Low risk	Judgement Comment: Study protocol is not available, but published reports include all expected outcomes.
Other bias	Unclear risk	Judgement Comment: Insufficient information to permit a judgement
Baseline Characteristics	Unclear risk	Judgement Comment: Only baseline nutritional status and education of mother presented tabularly.
Baseline outcome measurements similar Non-RCT	High risk	Judgement Comment: Important differences were present and not adjusted for in analysis.
Protection against contamination Non-RCTs	Low risk	Judgement Comment: Allocation was by school, and it is unlikely that the control schools received the specific intervention.

Han 1988

Study characteristics		
Methods	**Design**RCT**Allocation of individuals** 114 individuals randomized to intervention, 125 to control	
Participants	239 children ages 3 to 4	
Interventions	Single WASH aspect	
Outcomes	*Ascaris lumbricoides*	
Notes		
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "children were randomly assigned to intervention (n = 114) or control (n = 125) groups and were followed for 4 months." Judgement Comment: Randomly assigned, but allocation sequence not reported.
Allocation concealment (selection bias)	Unclear risk	Judgement Comment: Methods for allocation sequence were not reported.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Judgement Comment: Blinding could not be achieved due to the nature of the intervention.

Han 1988 *(Continued)*

Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Judgement Comment: Methods not described, insufficient information to permit a judgement.
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Judgement Comment: Methods not described, insufficient information to permit a judgement. Endline sample size not reported, and LTFU not addressed.
Selective reporting (reporting bias)	High risk	Judgement Comment: Outcomes stated are the prevalence of *A lumbricoides* and mean worm load determined in both groups, before and after intervention. Only reports on prevalence and mean worm load at the end of intervention. Group-specific *Ascaris* prevalence not reported; baseline prevalence not reported; baseline worm load not reported.
Other bias	Unclear risk	Judgement Comment: Insufficient information to permit a judgement
Baseline Characteristics	Unclear risk	Judgement Comment: No tabular data of baseline characteristics reported.

Hurlimann 2018

Study characteristics	
Methods	**Design**cRCT**Allocation of clusters** 4 villages randomized to intervention, 5 to control
Participants	810 participants all ages
Interventions	Primarily education
Outcomes	Any STH; *Ascaris lumbricoides*; *Trichuris trichiura*; hookworm
Notes	

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Unclear risk	Quote: "Communities were randomly assigned to the intervention and control group taking into account for matching characteristics such as population size, hygiene status, village affiliation and geographic position." Judgement Comment: Methods for sequence generation were not reported.
Allocation concealment (selection bias)	Unclear risk	Quote: "All residents of the villages and hamlets were invited to participate." Judgement Comment: Methods for allocation sequence were not reported.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Judgement Comment: Blinding could not be achieved due to the nature of the intervention.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "For quality control, 10% of the samples were re-examined by a senior laboratory technician and discrepancies discussed until accordance was reached."

Hurlimann 2018 *(Continued)*

Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Quote: "A total of 810 individuals had complete parasitological and questionnaire data from both the baseline and 1- year follow-up surveys and had received anthelminthic treatment after the second ODF evaluation in March 2012." Judgement Comment: Difficult to ascertain whether all 810 participants at baseline and 1-year follow-up are the same, or if there was loss to follow-up.
Selective reporting (reporting bias)	Low risk	Judgement Comment: Study protocol is not available, but published reports include all expected outcomes.
Other bias	Unclear risk	Judgement Comment: Insufficient information to permit a judgement
Baseline Characteristics	Low risk	Quote: "These villages and hamlets were selected because of their characteristics that are in favour of meaningful and successful implementation of CLTS, namely (i) small population sizes; (ii) clear signs of practiced open defecation; (iii) inhabitants that have the potential to become natural leaders; and (iv) relatively homogeneous population structure in terms of culture and socioeconomic status." Judgement Comment: Communities were randomly assigned to the intervention and control group taking into account matching characteristics such as population size, hygiene status, village affiliation and geographic position. Also, "Multivariable regression modelling adjusted for age, sex, socioeconomic status and ethnic origin showed no significant relationship between specific WASH indicators (e.g.toilet ownership and use) and intervention indicators (i.e.ODF status and group) with the 1-year follow-up"

Kamga 2011

Study characteristics	
Methods	**Design**cNON-RCT***Allocation of clusters** 1 school to intervention, 1 to control
Participants	370 children ages 5 to 15
Interventions	Primarily education
Outcomes	*Ascaris lumbricoides*; *Trichuris trichiura*; hookworm
Notes	*The study may have used a random mechanism to allocate the intervention, but there was only 1 intervention area compared to 1 control area, so randomization in this case not likely to reduce confounding or imbalances.

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	High risk	Quote: "The grouping was based on the fact that each pair was made of 2 rural communities sharing the same social, geographical and climatic features. The pair comprising Kake II and Barombi-Kang was randomly selected among five."

Kamga 2011 *(Continued)*

		Judgement Comment: Methods for sequence generation were not reported as random.
Allocation concealment (selection bias)	High risk	Judgement Comment: Methods for allocation sequence were not reported.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Judgement Comment: Blinding could not be achieved due to the nature of the intervention.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Quote: "All slides were read within 24 h of preparation to avoid the degeneration of Ancylostoma sp. eggs."
Incomplete outcome data (attrition bias) All outcomes	High risk	Quote: "the first phase, 370 samples were collected of which 208 (56.2%) were from Kake and 162 (43.8%) from Barombi-Kang. In the second phase, 368 samples were collected of which 208 (56.5%) were from Kake and 160 (43.5%) from Barombi-Kang." Judgement Comment: 2 students are unaccounted for between the first phase (370) and second phase (368) of stool sample collection.
Selective reporting (reporting bias)	Low risk	Judgement Comment: Study protocol is not available, but published reports include all expected outcomes.
Other bias	Unclear risk	Judgement Comment: Insufficient information to permit a judgement
Baseline Characteristics	Unclear risk	Judgement Comment: No tabular data of baseline characteristics reported.
Baseline outcome measurements similar Non-RCT	High risk	Judgement Comment: Important differences were present and not adjusted for in analysis.
Protection against contamination Non-RCTs	Low risk	Judgement Comment: Allocation was by village, and it is unlikely that the control village received the specific intervention.

Knee 2021

Study characteristics	
Methods	**Design** cNON-RCT **Allocation of clusters** 197 compounds allocated to intervention, 211 to control
Participants	545 children aged 1 to 48 months at the beginning of the study
Interventions	Broad multiple
Outcomes	Any STH; *Ascaris lumbricoides*; *Trichuris trichiura*
Notes	

Knee 2021 *(Continued)*

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Judgement Comment: Methods for sequence generation were not reported as random.
Allocation concealment (selection bias)	High risk	Judgement Comment: Is a non-RCT. Controlled before-after studies should be scored 'high risk'.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Quote: "It was not possible to blind participants or enumerators to intervention status." Judgement Comment: Blinding could not be achieved due to the nature of the intervention.
Blinding of outcome assessment (detection bias) All outcomes	High risk	Judgement Comment: Methods not described, insufficient information to permit a judgement. Not specified if assessors were blinded or if 10% of samples were rechecked.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Judgement Comment: Missing outcome data balanced across intervention groups with similar reasons for missing data across groups.
Selective reporting (reporting bias)	Low risk	Quote: "MapSan was a controlled before-and-after trial, and details of the study design and analysis plan have been published previously" Judgement Comment: Study protocol is available, and all of the study's relevant prespecified outcomes are reported in the originally specified way.
Other bias	Low risk	Judgement Comment: Study appears to be free of other sources of bias.
Baseline Characteristics	Low risk	Judgement Comment: Baseline characteristics of the study and control providers are reported (Table 1) and generally similar, and study controls for imbalances.
Baseline outcome measurements similar Non-RCT	Low risk	Judgement Comment: Analysis controlled for baseline imbalances.
Protection against contamination Non-RCTs	Low risk	Judgement Comment: Allocation was by compound, and it is unlikely that the control compounds received the specific intervention.

Mahmud 2015

Study characteristics	
Methods	**Design**cRCT**Allocation of clusters** 54 households randomized to intervention, 53 to control
Participants	178 children ages 6 to 15

Mahmud 2015 *(Continued)*

Interventions	Single WASH aspect
Outcomes	Any STH; *Ascaris lumbricoides*; hookworm
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "One of the investigators who did not participate in recruiting the study participants randomly allocated the intervention groups using computer-generated random numbers in pre-prepared sealed, numbered envelopes."
Allocation concealment (selection bias)	Low risk	Quote: "The assignment sequence was concealed from the researchers recruiting the study participants until interventions were as- signed."
Blinding of participants and personnel (performance bias) All outcomes	High risk	Quote: "Participating children (and their families) were aware of the intervention they received, but were blinded for the study hypothesis and the intervention(s) given to the other groups." Judgement Comment: Blinding could not be achieved due to the nature of the intervention.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "Laboratory personnel were blinded to group assignments and to the assessment out- comes." Quote: "Ten percent subsamples of stool smears were reexamined for quality control purposes."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "Results From the 369 school-aged children selected for the study, two were excluded before randomization and another two children were lost to follow-up because of a change in residential area (Fig 1)."
Selective reporting (reporting bias)	Low risk	Quote: "The planned primary out- come measure parasite reinfection rate was wrongly indicated as a secondary outcome in the initial registration of the trial (ClinicalTrials.gov, NCT01619254). The trial registration was corrected according the study protocol (S1 Protocol) on January 31, 2015."
Other bias	Low risk	Judgement Comment: Study appears to be free of other sources of bias.
Baseline Characteristics	Low risk	Quote: "At baseline, children in the four intervention groups were similar in terms of age and sex distribution, their personal hygiene and sanitation practices, and intestinal parasitic infection prevalence (Table 1)."

Makata 2021

Study characteristics

Methods	**Design** cRCT **Allocation of clusters** 8 schools allocated to intervention, 8 to control
Participants	3081 schoolchildren

Makata 2021 *(Continued)*

Interventions	Primarily education
Outcomes	Any STH; *Ascaris lumbricoides*; *Trichuris trichiura*; hookworm
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "3 representatives of the audience who drew numbered tennis balls from an opaque container. The sequence of the resulting digits indicated the chosen allocation on the list." Judgement Comment: Methods for sequence generation were not reported.
Allocation concealment (selection bias)	Low risk	Quote: "The final allocation of schools to their respective trial arm was performed by 3 representatives of the audience who drew numbered tennis balls from an opaque container." Judgement Comment: Allocation was by team and was performed on all units at the start of the study.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Judgement Comment: Blinding could not be achieved due to the nature of the intervention.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "Quality control was performed on 10% of randomly selected samples and a repeated examination was performed by the same technologists without knowledge of their initial results." Quote: "Data analysis was performed using STATA version 14.2, following a pre-specified analysis plan, by analysts who were blind to the trial group allocation"
Incomplete outcome data (attrition bias) All outcomes	Low risk	Judgement Comment: Missing outcome data balanced across intervention groups with similar reasons for missing data across groups (Figure 3).
Selective reporting (reporting bias)	Low risk	Quote: "This approach was chosen in keeping with the study protocol." Judgement Comment: Study protocol is available, and all of the study's relevant prespecified outcomes are reported in the originally specified way.
Other bias	Low risk	Judgement Comment: Study appears to be free of other sources of bias.
Baseline Characteristics	Low risk	Quote: "As expected due to the study design, the number of participants was balanced with regard to gender and students' age during both baseline and follow-up surveys (Table 2)." Judgement Comment: Baseline characteristics of the study and control providers are reported (Table 1) and generally similar, and study controls for imbalances.

Mascie-Taylor 1999

Study characteristics	
Methods	**Design**cNON-RCT* **Allocation of clusters** 1 area randomized* to intervention and 1 corresponding control; 1 other area randomized to different intervention and 1 corresponding control
Participants	1100 and 1100 children ages 2 to 8
Interventions	Primarily education
Outcomes	*Ascaris lumbricoides*; *Trichuris trichiura*; hookworm
Notes	*The study may have used a random mechanism to allocate the intervention, but there was only 1 intervention area compared to 1 control area, so randomization in this case not likely to reduce confounding or imbalances.

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Judgement Comment: Methods for sequence generation were not reported as being random. No mention of how 4 discrete geographic areas were selected.
Allocation concealment (selection bias)	High risk	Judgement Comment: Methods for allocation sequence were not reported.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Judgement Comment: Blinding could not be achieved due to the nature of the intervention.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Judgement Comment: Methods not described, insufficient information to permit a judgement.
Incomplete outcome data (attrition bias) All outcomes	Unclear risk	Judgement Comment: Methods not described, insufficient information to permit a judgement.
Selective reporting (reporting bias)	Low risk	Judgement Comment: Study protocol is not available, but published reports include all expected outcomes.
Other bias	Unclear risk	Judgement Comment: Insufficient information to permit a judgement
Baseline Characteristics	Unclear risk	Judgement Comment: No tabular data of baseline characteristics reported.
Baseline outcome measurements similar Non-RCT	High risk	Judgement Comment: Important differences were present and not adjusted for in analysis.
Protection against contamination Non-RCTs	Low risk	Judgement Comment: Allocation was by geographic area, and it is unlikely that the control areas received the specific intervention.

Monse 2013

Study characteristics		
Methods	**Design**cNON-RCT**Allocation of clusters** 4 schools allocated to intervention, 3 to control	
Participants	341 children ages 6 to 7	
Interventions	Single WASH aspect	
Outcomes	Any STH	
Notes		
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	High risk	Judgement Comment: Methods for sequence generation were not reported as random.
Allocation concealment (selection bias)	High risk	Judgement Comment: Is a non-RCT. Methods for allocation sequence were not reported.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Quote: "The examiners were blind as to the different groups, although it is probably realistic to assume that the examiners would soon have discovered that the control schools were located in a province where the EHCP did not exist." Judgement Comment: Blinding could not be achieved due to the nature of the intervention.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "For quality control of parasitological examinations, 10% of all slides were randomly selected and re-examined by a reference microscopist."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "In all, 32 children were lost to follow-up in the experimental group and 39 in the external concurrent control group. More boys dropped out than girls; otherwise, the socio-demographic and clinical parameters of the drop- outs were similar to those of the children at baseline in both groups."
Selective reporting (reporting bias)	Low risk	Judgement Comment: Study protocol is available, and published reports include all expected outcomes.
Other bias	Low risk	Quote: "Generally speaking, cohort studies have a number of advantages but also significant limitations and sources of bias. It has been suggested that four critical areas be examined when assessing the validity of a cohort study [33]." Judgement Comment: Other sources of bias are addressed and mitigated when possible.
Baseline Characteristics	Low risk	Quote: "Table 1 Mean" Quote: "Table 2 Mean" Judgement Comment: Baseline characteristics of the study and control providers are reported and similar (Table 1 and Table 2).

Monse 2013 *(Continued)*

Baseline outcome measurements similar Non-RCT	High risk	Judgement Comment: Important differences were present and not adjusted for in analysis.
Protection against contamination Non-RCTs	Low risk	Judgement Comment: Allocation was by school, and it is unlikely that the control schools received the specific intervention.

Muennoo 1997

Study characteristics		
Methods	**Design**cNON-RCT**Allocation of clusters** 1 village to intervention, 1 to control	
Participants	767 participants ages not available	
Interventions	Primarily education	
Outcomes	*Ascaris lumbricoides*; *Trichuris trichiura*; hookworm	
Notes		
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	High risk	Judgement Comment: Methods for sequence generation were not reported as random.
Allocation concealment (selection bias)	High risk	Judgement Comment: Is a non-RCT. Methods for allocation sequence were not reported.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Judgement Comment: Blinding could not be achieved due to the nature of the intervention.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Judgement Comment: Methods not described, insufficient information to permit a judgement. Not specified if assessors were blinded or if 10% of samples were rechecked.
Incomplete outcome data (attrition bias) All outcomes	High risk	Judgement Comment: Rationale for decrease in intervention group from baseline (802) to 1-year follow-up (393) not addressed (Table 1 and Table 2). Missing outcome data not addressed; results say that certain cases that were treated were re-infected, meaning that they followed the same people in time, but the authors do not discuss the significant decrease in sample size amongst the intervention group.
Selective reporting (reporting bias)	Low risk	Judgement Comment: Study protocol is not available, but published reports include all expected outcomes.
Other bias	Unclear risk	Judgement Comment: Insufficient information to permit a judgement

Muennoo 1997 *(Continued)*

Baseline Characteristics	Unclear risk	Judgement Comment: No tabular data of baseline characteristics reported.
Baseline outcome measurements similar Non-RCT	High risk	Judgement Comment: Important differences were present in some instances and not adjusted for in analysis.
Protection against contamination Non-RCTs	Low risk	Judgement Comment: Allocation was by village, and it is unlikely that the control village received the specific intervention.

Ndenecho 2002

Study characteristics	
Methods	**Design**cNON-RCT**Allocation of clusters** 3 schools allocated to intervention, 2 to control
Participants	148 children ages 8 to 15
Interventions	Primarily education
Outcomes	*Ascaris lumbricoides*; *Trichuris trichiura*; hookworm
Notes	

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	High risk	Judgement Comment: Methods for sequence generation were not reported as random.
Allocation concealment (selection bias)	High risk	Judgement Comment: Is a non-RCT. Methods for allocation sequence were not reported.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Judgement Comment: Blinding could not be achieved due to the nature of the intervention.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Judgement Comment: Methods not described, insufficient information to permit a judgement. Not specified if assessors were blinded or if 10% of samples were rechecked.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Judgement Comment: Missing outcome data balanced across intervention groups with similar reasons for missing data across groups (text and Table 3).
Selective reporting (reporting bias)	Low risk	Judgement Comment: Study protocol is not available, but published reports include all expected outcomes.
Other bias	Unclear risk	Judgement Comment: Insufficient information to permit a judgement
Baseline Characteristics	Unclear risk	Judgement Comment: No tabular data of baseline characteristics reported.

Ndenecho 2002 *(Continued)*

Baseline outcome measurements similar Non-RCT	High risk	Judgement Comment: Important differences were present and not adjusted for in analysis.
Protection against contamination Non-RCTs	Low risk	Judgement Comment: Allocation was by school, and it is unlikely that the control schools received the specific intervention.

Nery 2019a

Study characteristics	
Methods	**Design**cRCT **Allocation of clusters** 9 clusters randomized to intervention (3 excluded); 9 to control (3 excluded)
Participants	1178 participants ages 1+
Interventions	Broad multiple
Outcomes	*Ascaris lumbricoides*; *Trichuris trichiura*; hookworm
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	Low risk	Quote: "Informed by our sample size requirements, WaterAid provided a list of 24 eligible clusters to be enrolled in the study, which were randomly allocated to intervention and control arms by A. C. A. C. and S. V. N. using a computer random number generator."
Allocation concealment (selection bias)	Low risk	Judgement Comment: Computer-generated sequence by 2 investigators; no reason to believe others could see or predict the sequence.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Quote: "Because of the nature of the intervention, masking of clusters was not possible" Judgement Comment: Given the nature of the intervention, masking of clusters was not possible, and both participants and the research team were aware of the allocation.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Judgement Comment: Methods not described, insufficient information to permit a judgement.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "Replacement of each cluster was performed sequentially, one by one, as soon as they were deemed ineligible, using a list of replacement communities. Therefore, this process did not allow for random allocation to a study arm. WaterAid selected which cluster (community) to include as needed, accounting for geographical location and suitability of water source. One intervention community was subsequently lost to follow-up because the identified water source was no longer suitable for the water intervention, leaving 18 communities that followed the randomization protocol - nine intervention

Nery 2019a *(Continued)*

		and nine control communities. Considering the five replacement clusters that were not randomly allocated, 23 communities in total completed the study." Judgement Comment: Missing outcome data balanced across intervention groups with similar reasons for missing data across groups.
Selective reporting (reporting bias)	Low risk	Quote: "Full description of the trial setting and methods, including additional details regarding the intervention, sample size calculation, and randomization, can be found in the previously published protocol. 19" Judgement Comment: Study protocol is available, and published reports include all expected outcomes.
Other bias	High risk	Quote: "Contamination was minimized by making sure that communities were geographically well separated. However, by the third follow-up visit (18 months after baseline), three control clusters had been exposed to government-led sanitation promotion interventions."
Baseline Characteristics	Low risk	Judgement Comment: Baseline characteristics (Table 1) appear to be similar between intervention and control arms.

Park 2016

Study characteristics		
Methods	**Design**cNON-RCT**Allocation of clusters** 1 village allocated to intervention, 1 to control	
Participants	99 children ages 3 to 13	
Interventions	Broad multiple	
Outcomes	Any STH	
Notes		
Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	High risk	Judgement comment: Methods for sequence generation were not reported as random.
Allocation concealment (selection bias)	High risk	Judgement Comment: Is a non-RCT. Methods for allocation sequence were not reported.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Judgement Comment: Blinding could not be achieved due to the nature of the intervention.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Judgement Comment: Methods not described, insufficient information to permit a judgement. Not specified if assessors were blinded or if 10% of samples were rechecked.

Park 2016 *(Continued)*

Incomplete outcome data (attrition bias) All outcomes	Low risk	Judgement Comment: No missing data according to baseline intervention (50) and control (49) and follow-up baseline intervention (50) and control (49).
Selective reporting (reporting bias)	Low risk	Judgement Comment: Study protocol not available, but published reports include all expected outcomes.
Other bias	Unclear risk	Judgement Comment: Insufficient information to permit a judgement
Baseline Characteristics	Low risk	Judgement Comment: Baseline differences between the children in the control village and those in the intervention village were very small. In particular, we noted that in both villages, 20% of the children had STH infection at the time that the baseline data were collected.
Baseline outcome measurements similar Non-RCT	Low risk	Judgement Comment: Outcomes were measured prior to the intervention, and no important differences were present across study groups.
Protection against contamination Non-RCTs	Low risk	Judgement Comment: Allocation was by village, and it is unlikely that the control village received the specific intervention.

Patil 2014

Study characteristics	
Methods	**Design**cRCT**Allocation of clusters** 40 villages randomized to intervention, 40 to control
Participants	1150 children ages < 5
Interventions	Broad multiple
Outcomes	Any STH; *Ascaris lumbricoides*
Notes	

Risk of bias

Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "From the numbered list of eligible households, a random starting number was chosen and thereafter every n th household number was selected where n was determined by dividing eligible number of households by 25. For the follow-up survey we increased the sample size of households per village from 25 to 38 (see section on Sample Size)."
Allocation concealment (selection bias)	Unclear risk	Judgement Comment: Methods for allocation sequence were not reported.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Judgement Comment: Blinding could not be achieved due to the nature of the intervention.

Patil 2014 *(Continued)*

Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Judgement Comment: Methods not described, insufficient information to permit a judgement.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "Attrition was not differential by randomized group on the basis of observable characteristics (see Table S1). Of the 1,954 households enrolled at the baseline, 1,655 were located at the 21-month follow-up survey (15% attrition) without any significant difference between the intervention (16%) and the control (15%) groups. Characteristics remained balanced between intervention and control groups in remaining households."
Selective reporting (reporting bias)	Low risk	Quote: "The study protocol, questionnaires, and access to data collected in the study are available upon registration at http://microdata. worldbank.org/." Judgement Comment: Study protocol is available, and published reports include all expected outcomes.
Other bias	Low risk	Judgement Comment: Study appears to be free of other sources of bias.
Baseline Characteristics	Low risk	Quote: "baseline covariates in intervention and control groups were well balanced with four exceptions. First, 89% of the households in the intervention group had access to improved water sources - tap/piped water, tube well and protected dug wells - compared to 80% of households in the control group. In contrast, a larger proportion of control households (54%) were observed to have soap and water at hand-washing locations used after defecation than in intervention households (44%). On average, more children were found to be anemic in the control group (93%) than in the intervention group (88%). Finally, average height-for-age Z-scores were also slightly imbalanced (21.38 intervention versus 21.81 control)." Judgement Comment: Descriptive characteristics (Table 1) and baseline characteristics (Table 2) seem to be similar.

Pickering 2019

Study characteristics	
Methods	**Design** cRCT **Allocation** 77 randomized to water, 77 to sanitation, 77 to hygiene; 76 to WASH; 158 to control
Participants	4576 and 2226 children ages 2 to 15
Interventions	Single WASH aspect and broad multiple
Outcomes	Any STH; *Ascaris lumbricoides*; hookworm
Notes	

Risk of bias		
Bias	**Authors' judgement**	**Support for judgement**
Random sequence generation (selection bias)	Low risk	Quote: "Randomization and blinding A few weeks after enrollment, clusters were randomly assigned to intervention/control arms at the University of Cal-

Pickering 2019 *(Continued)*

		ifornia, Berkeley, by an investigator independent of the field research team (BFA) using a random number generator. Groups of 9 geographically adjacent clusters were block-randomized into the 6 intervention arms, the double-sized active control arm, and the passive control arm (the passive control arm was not included in the parasite assessment)."
Allocation concealment (selection bias)	Low risk	Quote: "Randomization and blinding <b>A few weeks after enrollment, clusters were randomly assigned to intervention/control arms at the University of California, Berkeley, by an investigator independent of the field research team (BFA) using a random number generator."
Blinding of participants and personnel (performance bias) All outcomes	High risk	Quote: "Blinding (masking) of participants was not possible given the nature of the interventions." Judgement Comment: Blinding could not be achieved due to the nature of the intervention.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "Data and stool sample collectors were not informed of cluster assignment, but could have inferred treatment status by observing intervention hard- ware. Lab technicians were blinded to intervention status. Two authors (AJP and JS) independently replicated the statistical analyses while blinded to intervention status."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "S4 Table. Characteristics of children included in analysis compared to children lost to follow-up, by treatment status."
Selective reporting (reporting bias)	Low risk	Quote: "The trial protocol and detailed methods are published [28]." Judgement Comment: Study protocol is available, and published reports include all expected outcomes.
Other bias	Low risk	Judgement Comment: Study appears to be free of other sources of bias.
Baseline Characteristics	Low risk	Judgement Comment: Baseline characteristics similar across intervention and control arms in Table 1.

Reese 2019

Study characteristics	
Methods	**Design**cNON-RCT**Allocation of clusters** 45 villages allocated to intervention, 45 to control
Participants	775 participants ages < 5, 1457 participants 5+
Interventions	Broad multiple
Outcomes	Any STH; *Trichuris trichiura*; hookworm
Notes	
Risk of bias	

Bias	Authors' judgement	Support for judgement

Reese 2019 *(Continued)*

Random sequence generation (selection bias)	High risk	Judgement Comment: Allocation sequence/method not reported as random.
Allocation concealment (selection bias)	High risk	Judgement Comment: Is a non-RCT. Due to the nature of the intervention, allocation sequence could not be concealed; allocation was non-random.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Judgement Comment: Blinding could not be achieved due to the nature of the intervention.
Blinding of outcome assessment (detection bias) All outcomes	Low risk	Quote: "Three slides were examined per sample, with all positives and 10% of negatives examined in duplicate. The mean of measurements was used to estimate eggs per gram of faeces and to quantify worm burden."
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "Patterns of missing household-level covariate data were similar across study arms and were handled with multi-level multiple imputation (R pan, version 1.4, and mitml, version 0.3–4, packages). 31,32 There was little missing individual-level covariate data; therefore, imputation was restricted to household-level covariates. The imputation model was run for 20 iterations, included all household-level covariates included in regression models, and was adjusted for clustering at the village level. Imputations were used in all subsequent analyses."
Selective reporting (reporting bias)	Low risk	Quote: "Deviations from the study protocol Outcomes and methods were prespecified, with the following exceptions. 18 Undernutrition was assessed in children <2 years old in addition to the targeted children <5 years old, to allow comparison with similar studies. Although we intended to assess STH reinfection by collecting a follow-up sample in round 4, this was dropped due to the low stool collection rate in round 2 (75% after two visits) and low STH prevalence."
Other bias	Low risk	Judgement Comment: Study appears to be free of other sources of bias.
Baseline Characteristics	Low risk	Quote: "Forty-five control villages were matched to the 45 intervention villages through a multi-step restriction, matching, and exclusion process to reduce potential bias due to baseline differences." Quote: "At follow-up, sociodemographic characteristics were generally similar across study arms, though intervention households were less poor (Table 1)."
Baseline outcome measurements similar Non-RCT	High risk	Judgement Comment: Did not report baseline prevalence of outcomes, and given that this is a non-randomized study, important differences may have been present.
Protection against contamination Non-RCTs	Low risk	Judgement Comment: Allocation was by community, and it is unlikely that the control communities received the specific intervention.

Steinmann 2014

Study characteristics	
Methods	**Design**cNON-RCT**Allocation of clusters** 1 village allocated to intervention, 1 to control

Steinmann 2014 *(Continued)*

Participants	200 participants ages 2+
Interventions	Broad multiple
Outcomes	*Ascaris lumbricoides*; *Trichuris trichiura*; hookworm; *Strongyloides stercoralis*
Notes	

Risk of bias

Bias	Authors' judgement	Support for judgement
Random sequence generation (selection bias)	High risk	Judgement Comment: Methods for sequence generation were not reported as random.
Allocation concealment (selection bias)	High risk	Judgement Comment: Is a non-RCT. Methods for allocation sequence were not reported.
Blinding of participants and personnel (performance bias) All outcomes	High risk	Judgement Comment: Blinding could not be achieved due to the nature of the intervention.
Blinding of outcome assessment (detection bias) All outcomes	Unclear risk	Judgement Comment: Methods not described, insufficient information to permit a judgement.
Incomplete outcome data (attrition bias) All outcomes	Low risk	Quote: "The intended sample size of about 100 individuals per village and stool sample collection campaign was met throughout the study."
Selective reporting (reporting bias)	Low risk	Judgement Comment: Study protocol is not available, but published reports include all expected outcomes.
Other bias	Unclear risk	Judgement Comment: Insufficient information to permit a judgement
Baseline Characteristics	Unclear risk	Judgement Comment: No tabular data of baseline characteristics reported.
Baseline outcome measurements similar Non-RCT	High risk	Judgement Comment: Important differences were present and not adjusted for in analysis. Quote: "First, the sample size was small as each intervention was implemented in only one village, and while these showed similar demographic, ecological and socioeconomic characteristics, subtle differences resulted in slightly different soil-transmitted helminth prevalences at baseline and likely influenced incidence and reinfection patterns."
Protection against contamination Non-RCTs	Low risk	Judgement Comment: Allocation was by village, and it is unlikely that the control village received the specific intervention.

Abbreviations: cNON-RCT: cluster-non-randomized controlled trial; cRCT: cluster-randomized controlled trial; non-RCT: non-randomized controlled trial; RCT: randomized controlled trial; SES: socioeconomic status; STH: soil-transmitted helminth; WASH: water, sanitation, and hygiene

Characteristics of excluded studies *[ordered by study ID]*

Study	Reason for exclusion
Abdoli 2017	Wrong study design
Abraham 2018	Wrong study design
ACTRN12613000523707	Protocol only
ACTRN12617001048370 (a)	Protocol only
ACTRN12617001048370 (b)	Protocol only
Addiss 2015	Wrong study design
Ai Ya 2011	Wrong study design
Akor 2021	Wrong study design
Albonico 1996	Wrong study design
Alegria 2015	Wrong study design
Alfano 2015	Wrong study design
Altinoz Aytar 2015	Wrong outcomes
Anantaphruti 2008	Wrong study design
Appleby 2019	Wrong study design
Asaolu 2003	Wrong study design
Basualdo 2009	Wrong study design
Benjamin Chung 2018	Wrong study design
Bentwich 2019a	Duplication with ongoing study
Bentwich 2019b	Wrong outcomes
Bieri 2014	Wrong study design
Bird 2014	Wrong intervention
Brito 2013	Protocol only
Brocklehurst 2014	Wrong study design
Brown 2015	Wrong study design
Cairncross 1987	Wrong study design
Campbell 2014	Wrong study design
Chandler 1954	Wrong study design
Chen 1969	Wrong intervention

Study	Reason for exclusion
Chen 2021	Wrong study design
Clarke 2018	Wrong comparator
Coffeng 2018	Wrong study design
Curtale 2003	Wrong study design
De Carneri 1992	Wrong study design
Dias 1981	Wrong study design
Falavigna Guilherme 2004	Wrong study design
Fan 2012	Wrong study design
Figueroa 1985	Wrong study design
Fort 1915	Wrong study design
Freeman 2012	Wrong study design
Freeman 2019	Wrong study design
Garn 2016	Wrong study design
Gelaye 2014	Wrong study design
Greene 2012	Wrong outcomes
Grimes 2016	Wrong study design
Hastings 2014	Wrong study design
Hayashi 1981	Wrong study design
Homeida 1994	Wrong study design
Hong Chun 2011	Wrong study design
Hosain 2003	Wrong study design
ISRCTN16961836	Wrong study design
ISRCTN17030361	Wrong study design
ISRCTN45013173	Protocol only
Jiang 2015	Wrong study design
Kobayashi 1984	Wrong study design
Krushinskaia 1976	Wrong outcomes
Kurscheid 2018	Wrong outcomes

Study	Reason for exclusion
Lansdown 2002	Wrong outcomes
Le Hung 2005	Wrong study design
Li 2011	Wrong study design
Liu 2017	Wrong comparator
Luong 2003	Wrong study design
Mao 2021	Wrong study design
Mara 2010	Wrong study design
Marwah 1958	Wrong study design
Means 2018	Wrong study design
Messou 1997	Wrong study design
Minamoto 2012	Wrong outcomes
Mogaji 2015	Wrong study design
Mogaji 2016	Wrong study design
Mohapatra 2015	Wrong study design
Mwanga 2015	Wrong outcomes
NCT02362932	Wrong study design
NCT02441699	Wrong study design
Nery 2014	Wrong study design
Nery 2015	Protocol only
Nery 2019b	Wrong study design
Nitulescu 1954	Wrong study design
Okoyo 2021	Wrong outcomes
Palmeirim 2015	Wrong study design
Pawestri 2021	Wrong study design
Pirumov 1973	Wrong study design
Purina 1961	Wrong outcomes
Puspita 2020	Wrong study design
Qian 2011	Wrong study design

Study	Reason for exclusion
Raccurt 1972	Wrong study design
Raso 2018	Wrong study design
Reese 2017	Wrong study design
Rukonge 1987	Wrong study design
Sadun 1954	Wrong comparator
Sahba 1967	Wrong study design
Scott 1938	Wrong study design
Stone 2018	Wrong outcomes
Sweet 1929	Wrong study design
Taiwo 2017	Wrong study design
Ting Jun 2011	Wrong study design
Torres 1982	Wrong study design
Zeng 2019	Wrong study design
Zhang 2011	Wrong study design
Zhu 2015	Wrong study design

Characteristics of ongoing studies *[ordered by study ID]*

Mationg 2020

Study name	Determining the impact of a school-based health education package for prevention of intestinal worm infections in the Philippines: protocol for a cluster randomized intervention trial
Methods	**Design** cRCT **Allocation of clusters** 20 allocated to intervention, 20 to control
Participants	2020 schoolchildren aged 9 to 10 years
Interventions	Primarily education
Outcomes	Unclear
Starting date	2016
Contact information	
Notes	

Mekete 2019

Study name	The Geshiyaro Project: a study protocol for developing a scalable model of interventions for moving towards the interruption of the transmission of soil-transmitted helminths and schistosome infections in the Wolaita zone of Ethiopia
Methods	**Design** Unclear **Allocation of clusters** Unclear
Participants	Unclear
Interventions	Broad multiple
Outcomes	"prevalence mapping" of STHs
Starting date	Unclear
Contact information	
Notes	

NCT04227834

Study name	Soil-transmitted helminth reinfection rates after single and repeated school hygiene education
Methods	**Design** cNON-RCT **Allocation of clusters** 1 intervention, 1 control
Participants	432 participants
Interventions	Primarily education
Outcomes	Any STH; *Ascaris lumbricoides*; *Trichuris trichiura*; hookworm
Starting date	2019
Contact information	
Notes	

Phillips 2019

Study name	Impact of water, sanitation and hygiene on community-level intestinal parasites in Ethiopia: the geshiyaro project
Methods	**Design** Quasi-experimental

Phillips 2019 *(Continued)*

	Allocation of clusters Unclear
Participants	11,086 individuals
Interventions	Broad multiple
Outcomes	"exposure to STH"
Starting date	2018
Contact information	
Notes	

Abbreviations: cNON-RCT: cluster-non-randomized controlled trial; cRCT: cluster-randomized controlled trial; STH: soil-transmitted helminth

DATA AND ANALYSES

Comparison 1. WASH intervention versus control

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1.1 Any STH prevalence amongst RCTs	14		Odds Ratio (IV, Random, 95% CI)	0.86 [0.74, 1.01]
1.2 Any STH prevalence amongst RCTs - low risk of bias	6		Odds Ratio (IV, Random, 95% CI)	0.91 [0.79, 1.05]
1.3 Any STH prevalence - ICC	14		Odds Ratio (IV, Random, 95% CI)	0.86 [0.74, 1.01]
1.3.1 Calculated effect estimate using estimated ICC	9		Odds Ratio (IV, Random, 95% CI)	0.88 [0.72, 1.08]
1.3.2 Calculated effect estimate using reported ICC	1		Odds Ratio (IV, Random, 95% CI)	0.93 [0.77, 1.11]
1.3.3 Study reported cluster-adjusted effect estimate	4		Odds Ratio (IV, Random, 95% CI)	0.79 [0.47, 1.32]
1.4 Any STH prevalence amongst non-RCTs	8		Odds Ratio (IV, Random, 95% CI)	0.71 [0.54, 0.94]
1.5 Any STH prevalence - narrow WASH categories amongst non-RCTs	8		Odds Ratio (IV, Random, 95% CI)	0.71 [0.54, 0.94]
1.5.1 Community water and sanitation	1		Odds Ratio (IV, Random, 95% CI)	0.68 [0.42, 1.11]
1.5.2 Community sanitation and hygiene	2		Odds Ratio (IV, Random, 95% CI)	0.47 [0.09, 2.41]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1.5.3 Community water, sanitation, and hygiene	2		Odds Ratio (IV, Random, 95% CI)	0.72 [0.47, 1.13]
1.5.4 School hygiene	3		Odds Ratio (IV, Random, 95% CI)	0.77 [0.46, 1.28]
1.6 Any STH prevalence amongst RCTs (intervention type subgroup)	14		Odds Ratio (IV, Random, 95% CI)	0.86 [0.74, 1.01]
1.6.1 Primarily education	6		Odds Ratio (IV, Random, 95% CI)	0.80 [0.48, 1.31]
1.6.2 Single WASH aspect	3		Odds Ratio (IV, Random, 95% CI)	0.87 [0.65, 1.17]
1.6.3 Broad multiple	7		Odds Ratio (IV, Random, 95% CI)	0.90 [0.78, 1.05]
1.7 Any STH prevalence amongst RCTs (age subgroup)	14		Odds Ratio (IV, Random, 95% CI)	0.86 [0.74, 1.01]
1.7.1 Children	12		Odds Ratio (IV, Random, 95% CI)	0.85 [0.72, 1.00]
1.7.2 All ages	2		Odds Ratio (IV, Random, 95% CI)	1.00 [0.68, 1.47]
1.8 Any STH prevalence amongst RCTs (school village subgroup)	14		Odds Ratio (IV, Random, 95% CI)	0.86 [0.74, 1.01]
1.8.1 School	7		Odds Ratio (IV, Random, 95% CI)	0.82 [0.56, 1.20]
1.8.2 Village	7		Odds Ratio (IV, Random, 95% CI)	0.88 [0.78, 0.99]
1.9 Any STH prevalence amongst RCTs (MDA subgroup)	14		Odds Ratio (IV, Random, 95% CI)	0.86 [0.74, 1.01]
1.9.1 Underpinned with drug treatment	11		Odds Ratio (IV, Random, 95% CI)	0.85 [0.72, 1.00]
1.9.2 No drug treatment	3		Odds Ratio (IV, Random, 95% CI)	0.84 [0.46, 1.54]
1.10 Any STH prevalence amongst RCTs (rural urban subgroup)	13		Odds Ratio (IV, Random, 95% CI)	0.87 [0.74, 1.01]
1.10.1 Rural	10		Odds Ratio (IV, Random, 95% CI)	0.85 [0.73, 1.00]
1.10.2 Urban	2		Odds Ratio (IV, Random, 95% CI)	0.43 [0.06, 3.05]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1.10.3 Urban and rural	1		Odds Ratio (IV, Random, 95% CI)	1.19 [0.74, 1.91]
1.11 Any STH prevalence amongst RCTs (world region subgroup)	14		Odds Ratio (IV, Random, 95% CI)	0.86 [0.74, 1.01]
1.11.1 Africa	8		Odds Ratio (IV, Random, 95% CI)	0.83 [0.64, 1.09]
1.11.2 Asia	5		Odds Ratio (IV, Random, 95% CI)	0.87 [0.69, 1.09]
1.11.3 South America	1		Odds Ratio (IV, Random, 95% CI)	1.00 [0.58, 1.72]
1.12 Any STH prevalence - narrow WASH categories amongst RCTs	14		Odds Ratio (IV, Random, 95% CI)	0.86 [0.77, 0.97]
1.12.1 Community water	2		Odds Ratio (IV, Random, 95% CI)	0.88 [0.68, 1.14]
1.12.3 Community sanitation	5		Odds Ratio (IV, Random, 95% CI)	0.93 [0.75, 1.14]
1.12.4 Community hygiene	3		Odds Ratio (IV, Random, 95% CI)	0.83 [0.57, 1.19]
1.12.5 Community sanitation and hygiene	1		Odds Ratio (IV, Random, 95% CI)	1.04 [0.41, 2.60]
1.12.6 Community water, sanitation, and hygiene	2		Odds Ratio (IV, Random, 95% CI)	0.78 [0.63, 0.96]
1.12.7 School hygiene	4		Odds Ratio (IV, Random, 95% CI)	0.69 [0.37, 1.28]
1.12.8 School water, sanitation, and hygiene	3		Odds Ratio (IV, Random, 95% CI)	1.06 [0.82, 1.38]
1.13 *Ascaris lumbricoides* prevalence amongst RCTs	12		Odds Ratio (IV, Random, 95% CI)	0.87 [0.73, 1.03]
1.14 *Ascaris lumbricoides* prevalence amongst RCTs - low risk of bias studies only	5		Odds Ratio (IV, Random, 95% CI)	0.88 [0.78, 1.00]
1.15 *Ascaris lumbricoides* prevalence amongst non-RCTs	9		Odds Ratio (IV, Random, 95% CI)	0.76 [0.51, 1.15]
1.16 *Ascaris lumbricoides* prevalence - narrow WASH categories amongst non-RCTs	9		Odds Ratio (IV, Random, 95% CI)	0.76 [0.51, 1.15]
1.16.1 Community sanitation	1		Odds Ratio (IV, Random, 95% CI)	0.45 [0.13, 1.58]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1.16.2 Community hygiene	3		Odds Ratio (IV, Random, 95% CI)	0.93 [0.36, 2.36]
1.16.3 Community sanitation and hygiene	1		Odds Ratio (IV, Random, 95% CI)	0.50 [0.06, 4.00]
1.16.4 Community water, sanitation, and hygiene	1		Odds Ratio (IV, Random, 95% CI)	0.76 [0.42, 1.37]
1.16.5 School hygiene	3		Odds Ratio (IV, Random, 95% CI)	0.94 [0.36, 2.45]
1.17 *Ascaris lumbricoides* prevalence amongst RCTs (intervention type subgroup)	12		Odds Ratio (IV, Random, 95% CI)	0.87 [0.73, 1.03]
1.17.1 Primarily education	4		Odds Ratio (IV, Random, 95% CI)	0.88 [0.37, 2.10]
1.17.2 Single WASH aspect	4		Odds Ratio (IV, Random, 95% CI)	0.92 [0.78, 1.09]
1.17.3 Broad multiple	6		Odds Ratio (IV, Random, 95% CI)	0.81 [0.64, 1.02]
1.18 *Ascaris lumbricoides* prevalence amongst RCTs (age subgroup)	12		Odds Ratio (IV, Random, 95% CI)	0.87 [0.73, 1.03]
1.18.1 Children	9		Odds Ratio (IV, Random, 95% CI)	0.85 [0.73, 0.99]
1.18.2 All ages	3		Odds Ratio (IV, Random, 95% CI)	3.20 [0.92, 11.11]
1.19 *Ascaris lumbricoides* prevalence amongst RCTs (school village subgroup)	12		Odds Ratio (IV, Random, 95% CI)	0.87 [0.73, 1.03]
1.19.1 School	4		Odds Ratio (IV, Random, 95% CI)	0.68 [0.37, 1.26]
1.19.2 Village	8		Odds Ratio (IV, Random, 95% CI)	0.89 [0.77, 1.04]
1.20 *Ascaris lumbricoides* prevalence amongst RCTs (MDA subgroup)	12		Odds Ratio (IV, Random, 95% CI)	0.87 [0.73, 1.03]
1.20.1 Underpinned with drug treatment	9		Odds Ratio (IV, Random, 95% CI)	0.86 [0.71, 1.05]
1.20.2 No drug treatment	3		Odds Ratio (IV, Random, 95% CI)	0.91 [0.49, 1.69]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1.21 *Ascaris lumbricoides* prevalence amongst RCTs (rural urban subgroup)	12		Odds Ratio (IV, Random, 95% CI)	0.87 [0.73, 1.03]
1.21.1 Rural	9		Odds Ratio (IV, Random, 95% CI)	0.87 [0.74, 1.03]
1.21.2 Urban	2		Odds Ratio (IV, Random, 95% CI)	0.41 [0.07, 2.51]
1.21.3 Rural and urban	1		Odds Ratio (IV, Random, 95% CI)	1.24 [0.59, 2.61]
1.22 *Ascaris lumbricoides* prevalence amongst RCTs (world region subgroup)	12		Odds Ratio (IV, Random, 95% CI)	0.87 [0.73, 1.03]
1.22.1 Africa	6		Odds Ratio (IV, Random, 95% CI)	0.73 [0.51, 1.06]
1.22.2 Asia	5		Odds Ratio (IV, Random, 95% CI)	0.98 [0.82, 1.17]
1.22.3 South America	1		Odds Ratio (IV, Random, 95% CI)	0.88 [0.57, 1.36]
1.23 *Ascaris lumbricoides* prevalence - narrow WASH categories amongst RCTs	12		Odds Ratio (IV, Random, 95% CI)	0.89 [0.78, 1.02]
1.23.1 Community water	2		Odds Ratio (IV, Random, 95% CI)	0.87 [0.67, 1.13]
1.23.2 Community sanitation	5		Odds Ratio (IV, Random, 95% CI)	0.95 [0.75, 1.22]
1.23.3 Community hygiene	4		Odds Ratio (IV, Random, 95% CI)	0.99 [0.77, 1.28]
1.23.4 Community water, sanitation, and hygiene	3		Odds Ratio (IV, Random, 95% CI)	0.82 [0.61, 1.11]
1.23.5 School hygiene	3		Odds Ratio (IV, Random, 95% CI)	0.74 [0.34, 1.63]
1.23.6 School water, sanitation, and hygiene	1		Odds Ratio (IV, Random, 95% CI)	0.48 [0.22, 1.05]
1.24 *Trichuris trichiura* prevalence amongst RCTs	9		Odds Ratio (IV, Random, 95% CI)	0.94 [0.77, 1.14]
1.25 *Trichuris trichiura* prevalence amongst RCTs - low risk of bias studies only	4		Odds Ratio (IV, Random, 95% CI)	0.90 [0.73, 1.11]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1.26 *Trichuris trichiura* prevalence amongst non-RCTs	8		Odds Ratio (IV, Random, 95% CI)	0.81 [0.54, 1.20]
1.27 *Trichuris trichiura* prevalence - narrow WASH categories amongst non-RCTs	8		Odds Ratio (IV, Random, 95% CI)	0.81 [0.54, 1.20]
1.27.1 Community water and sanitation	1		Odds Ratio (IV, Random, 95% CI)	3.16 [0.13, 77.87]
1.27.2 Community hygiene	3		Odds Ratio (IV, Random, 95% CI)	1.53 [0.68, 3.44]
1.27.3 Community sanitation and hygiene	1		Odds Ratio (IV, Random, 95% CI)	0.48 [0.09, 2.63]
1.27.4 Community water, sanitation, and hygiene	1		Odds Ratio (IV, Random, 95% CI)	0.64 [0.38, 1.06]
1.27.5 School hygiene	2		Odds Ratio (IV, Random, 95% CI)	0.78 [0.18, 3.41]
1.28 *Trichuris trichiura* prevalence amongst RCTs (intervention type subgroup)	9		Odds Ratio (IV, Random, 95% CI)	0.94 [0.77, 1.14]
1.28.1 Primarily education	4		Odds Ratio (IV, Random, 95% CI)	0.99 [0.75, 1.31]
1.28.2 Single WASH aspect	2		Odds Ratio (IV, Random, 95% CI)	0.84 [0.56, 1.28]
1.28.3 Broad multiple	5		Odds Ratio (IV, Random, 95% CI)	0.98 [0.55, 1.77]
1.29 *Trichuris trichiura* prevalence amongst RCTs (age subgroup)	9		Odds Ratio (IV, Random, 95% CI)	0.94 [0.77, 1.14]
1.29.1 Children	6		Odds Ratio (IV, Random, 95% CI)	0.90 [0.73, 1.10]
1.29.2 All ages	3		Odds Ratio (IV, Random, 95% CI)	3.23 [1.09, 9.53]
1.30 *Trichuris trichiura* prevalence amongst RCTs (school village subgroup)	9		Odds Ratio (IV, Random, 95% CI)	0.94 [0.77, 1.15]
1.30.1 School	4		Odds Ratio (IV, Random, 95% CI)	0.96 [0.74, 1.24]
1.30.2 Village	5		Odds Ratio (IV, Random, 95% CI)	0.97 [0.64, 1.48]

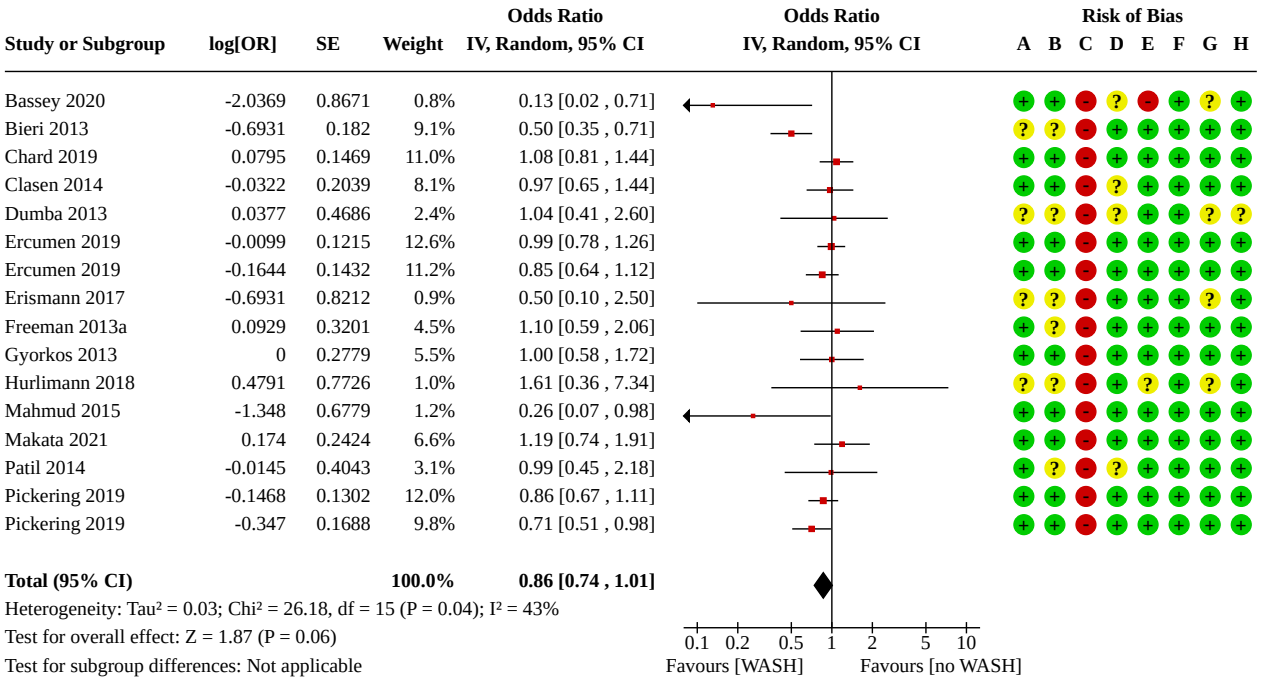
Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1.31 *Trichuris trichiura* prevalence amongst RCTs (MDA subgroup)	9		Odds Ratio (IV, Random, 95% CI)	0.94 [0.77, 1.14]
1.31.1 Underpinned with drug treatment	9		Odds Ratio (IV, Random, 95% CI)	0.94 [0.77, 1.14]
1.32 *Trichuris trichiura* prevalence amongst RCTs (rural urban subgroup)	9		Odds Ratio (IV, Random, 95% CI)	0.94 [0.77, 1.14]
1.32.1 Rural	6		Odds Ratio (IV, Random, 95% CI)	0.91 [0.67, 1.24]
1.32.2 Urban	2		Odds Ratio (IV, Random, 95% CI)	0.89 [0.63, 1.26]
1.32.3 Urban and rural	1		Odds Ratio (IV, Random, 95% CI)	1.17 [0.73, 1.88]
1.33 *Trichuris trichiura* prevalence amongst RCTs (world region subgroup)	9		Odds Ratio (IV, Random, 95% CI)	0.94 [0.77, 1.14]
1.33.1 Africa	5		Odds Ratio (IV, Random, 95% CI)	1.00 [0.72, 1.39]
1.33.2 Asia	3		Odds Ratio (IV, Random, 95% CI)	1.07 [0.59, 1.97]
1.33.3 South America	1		Odds Ratio (IV, Random, 95% CI)	0.88 [0.62, 1.25]
1.34 *Trichuris trichiura* prevalence - narrow WASH categories amongst RCTs	9		Odds Ratio (IV, Random, 95% CI)	0.94 [0.77, 1.14]
1.34.1 Community water	2		Odds Ratio (IV, Random, 95% CI)	0.95 [0.52, 1.74]
1.34.2 Community sanitation	4		Odds Ratio (IV, Random, 95% CI)	1.26 [0.48, 3.29]
1.34.3 Community hygiene	2		Odds Ratio (IV, Random, 95% CI)	0.92 [0.50, 1.69]
1.34.4 Community water, sanitation, and hygiene	3		Odds Ratio (IV, Random, 95% CI)	0.75 [0.40, 1.41]
1.34.5 School hygiene	3		Odds Ratio (IV, Random, 95% CI)	0.98 [0.74, 1.30]
1.34.6 School water, sanitation, and hygiene	1		Odds Ratio (IV, Random, 95% CI)	0.86 [0.46, 1.61]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1.35 Hookworm prevalence amongst RCTs	10		Odds Ratio (IV, Random, 95% CI)	0.88 [0.75, 1.04]
1.36 Hookworm prevalence amongst RCTs - low risk of bias studies only	5		Odds Ratio (IV, Random, 95% CI)	0.83 [0.67, 1.03]
1.37 Hookworm prevalence amongst non-RCTs	8		Odds Ratio (IV, Random, 95% CI)	0.75 [0.53, 1.06]
1.38 Hookworm prevalence - narrow WASH categories amongst non-RCTs	8		Odds Ratio (IV, Random, 95% CI)	0.75 [0.53, 1.06]
1.38.1 Community water and sanitation	1		Odds Ratio (IV, Random, 95% CI)	0.66 [0.42, 1.03]
1.38.2 Community sanitation	1		Odds Ratio (IV, Random, 95% CI)	0.82 [0.31, 2.16]
1.38.3 Community hygiene	3		Odds Ratio (IV, Random, 95% CI)	1.08 [0.30, 3.87]
1.38.4 Community sanitation and hygiene	1		Odds Ratio (IV, Random, 95% CI)	1.77 [0.25, 12.60]
1.38.5 School hygiene	2		Odds Ratio (IV, Random, 95% CI)	0.49 [0.12, 1.99]
1.39 Hookworm prevalence amongst RCTs (intervention type subgroup)	10		Odds Ratio (IV, Random, 95% CI)	0.88 [0.75, 1.04]
1.39.1 Primarily education	4		Odds Ratio (IV, Random, 95% CI)	1.10 [0.57, 2.12]
1.39.2 Single WASH aspect	3		Odds Ratio (IV, Random, 95% CI)	0.90 [0.54, 1.49]
1.39.3 Broad multiple	5		Odds Ratio (IV, Random, 95% CI)	0.87 [0.70, 1.08]
1.40 Hookworm prevalence amongst RCTs (age subgroup)	10		Odds Ratio (IV, Random, 95% CI)	0.88 [0.75, 1.04]
1.40.1 Children	7		Odds Ratio (IV, Random, 95% CI)	0.87 [0.71, 1.06]
1.40.2 All ages	3		Odds Ratio (IV, Random, 95% CI)	0.91 [0.67, 1.24]
1.41 Hookworm prevalence amongst RCTs (school village subgroup)	10		Odds Ratio (IV, Random, 95% CI)	0.88 [0.75, 1.04]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1.41.1 School	4		Odds Ratio (IV, Random, 95% CI)	1.17 [0.74, 1.84]
1.41.2 Village	6		Odds Ratio (IV, Random, 95% CI)	0.85 [0.71, 1.01]
1.42 Hookworm prevalence amongst RCTs (MDA subgroup)	10		Odds Ratio (IV, Random, 95% CI)	0.88 [0.75, 1.04]
1.42.1 Underpinned with drug treatment	9		Odds Ratio (IV, Random, 95% CI)	0.89 [0.75, 1.05]
1.42.2 No drug treatment	1		Odds Ratio (IV, Random, 95% CI)	0.37 [0.07, 1.95]
1.43 Hookworm prevalence amongst RCTs (rural urban subgroup)	10		Odds Ratio (IV, Random, 95% CI)	0.88 [0.75, 1.04]
1.43.1 Rural	7		Odds Ratio (IV, Random, 95% CI)	0.88 [0.74, 1.04]
1.43.2 Urban	2		Odds Ratio (IV, Random, 95% CI)	1.10 [0.51, 2.37]
1.43.3 Urban and rural	1		Odds Ratio (IV, Random, 95% CI)	0.48 [0.04, 5.41]
1.44 Hookworm prevalence amongst RCTs (world region subgroup)	10		Odds Ratio (IV, Random, 95% CI)	0.88 [0.75, 1.04]
1.44.1 Africa	6		Odds Ratio (IV, Random, 95% CI)	1.11 [0.80, 1.53]
1.44.2 Asia	3		Odds Ratio (IV, Random, 95% CI)	0.80 [0.65, 0.98]
1.44.3 South America	1		Odds Ratio (IV, Random, 95% CI)	1.13 [0.51, 2.50]
1.45 Hookworm prevalence - narrow WASH categories amongst RCTs	10		Odds Ratio (IV, Random, 95% CI)	0.89 [0.75, 1.04]
1.45.1 Community water	2		Odds Ratio (IV, Random, 95% CI)	0.84 [0.46, 1.51]
1.45.2 Community sanitation	4		Odds Ratio (IV, Random, 95% CI)	0.88 [0.69, 1.13]
1.45.3 Community hygiene	3		Odds Ratio (IV, Random, 95% CI)	0.98 [0.59, 1.64]
1.45.4 Community water, sanitation, and hygiene	3		Odds Ratio (IV, Random, 95% CI)	0.70 [0.46, 1.08]

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1.45.5 School hygiene	3		Odds Ratio (IV, Random, 95% CI)	1.02 [0.49, 2.12]
1.45.6 School water, sanitation, and hygiene	1		Odds Ratio (IV, Random, 95% CI)	1.27 [0.71, 2.27]

Analysis 1.1. Comparison 1: WASH intervention versus control, Outcome 1: Any STH prevalence amongst RCTs



Risk of bias legend

(A) Random sequence generation (selection bias)
(B) Allocation concealment (selection bias)
(C) Blinding of participants and personnel (performance bias)
(D) Blinding of outcome assessment (detection bias)
(E) Incomplete outcome data (attrition bias)
(F) Selective reporting (reporting bias)
(G) Other bias
(H) Baseline Characteristics

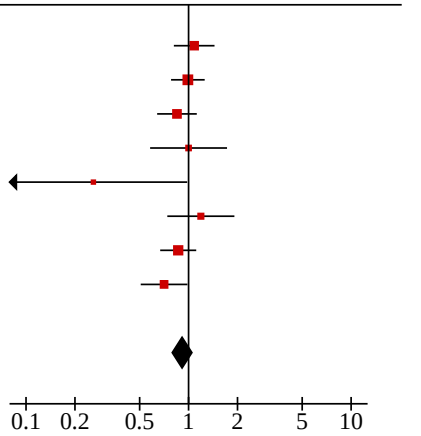
Analysis 1.2. Comparison 1: WASH intervention versus control, Outcome 2: Any STH prevalence amongst RCTs - low risk of bias

Study or Subgroup	log[OR]	SE	Weight	Odds Ratio IV, Random, 95% CI
Chard 2019	0.0795	0.1469	16.2%	1.08 [0.81 , 1.44]
Ercumen 2019	-0.0099	0.1215	20.7%	0.99 [0.78 , 1.26]
Ercumen 2019	-0.1644	0.1432	16.7%	0.85 [0.64 , 1.12]
Gyorkos 2013	0	0.2779	5.8%	1.00 [0.58 , 1.72]
Mahmud 2015	-1.348	0.6779	1.1%	0.26 [0.07 , 0.98]
Makata 2021	0.174	0.2424	7.4%	1.19 [0.74 , 1.91]
Pickering 2019	-0.1468	0.1302	19.0%	0.86 [0.67 , 1.11]
Pickering 2019	-0.347	0.1688	13.2%	0.71 [0.51 , 0.98]
Total (95% CI)			**100.0%**	**0.91 [0.79 , 1.05]**

Heterogeneity: Tau² = 0.01; Chi² = 9.28, df = 7 (P = 0.23); I² = 25%

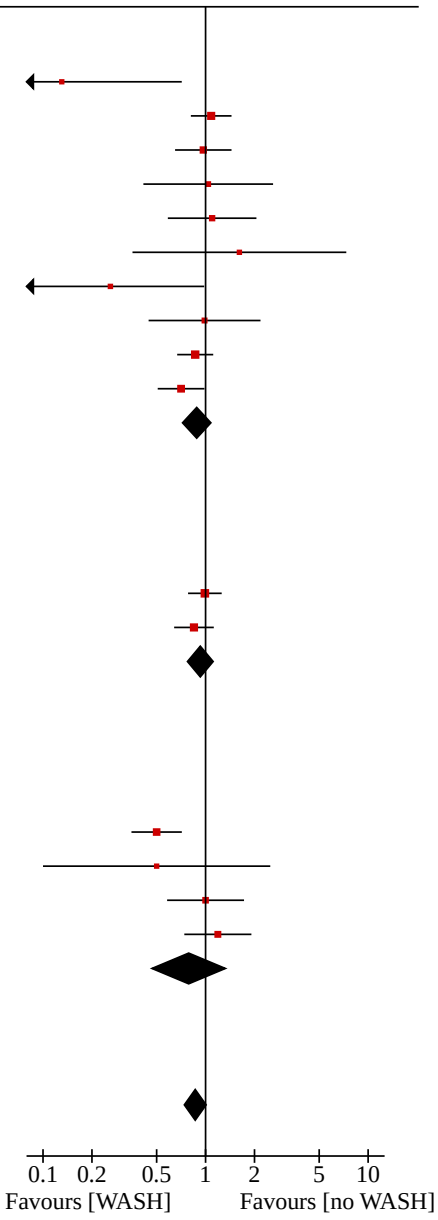
Test for overall effect: Z = 1.30 (P = 0.19)

Test for subgroup differences: Not applicable



Analysis 1.3. Comparison 1: WASH intervention versus control, Outcome 3: Any STH prevalence - ICC

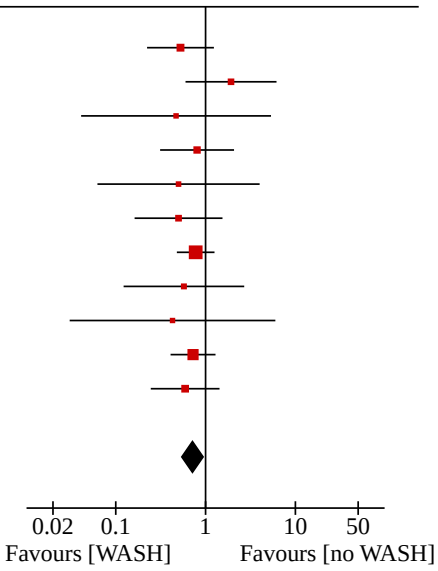
Study or Subgroup	log[OR]	SE	Weight	Odds Ratio IV, Random, 95% CI
1.3.1 Calculated effect estimate using estimated ICC				
Bassey 2020	-2.0369	0.8671	0.8%	0.13 [0.02 , 0.71]
Chard 2019	0.0795	0.1469	11.0%	1.08 [0.81 , 1.44]
Clasen 2014	-0.0322	0.2039	8.1%	0.97 [0.65 , 1.44]
Dumba 2013	0.0377	0.4686	2.4%	1.04 [0.41 , 2.60]
Freeman 2013a	0.0929	0.3201	4.5%	1.10 [0.59 , 2.06]
Hurlimann 2018	0.4791	0.7726	1.0%	1.61 [0.36 , 7.34]
Mahmud 2015	-1.348	0.6779	1.2%	0.26 [0.07 , 0.98]
Patil 2014	-0.0145	0.4043	3.1%	0.99 [0.45 , 2.18]
Pickering 2019	-0.1468	0.1302	12.0%	0.86 [0.67 , 1.11]
Pickering 2019	-0.347	0.1688	9.8%	0.71 [0.51 , 0.98]
Subtotal (95% CI)			**54.0%**	**0.88 [0.72 , 1.08]**
Heterogeneity: Tau² = 0.03; Chi² = 13.27, df = 9 (P = 0.15); I² = 32%				
Test for overall effect: Z = 1.23 (P = 0.22)				
1.3.2 Calculated effect estimate using reported ICC				
Ercumen 2019	-0.0099	0.1215	12.6%	0.99 [0.78 , 1.26]
Ercumen 2019	-0.1644	0.1432	11.2%	0.85 [0.64 , 1.12]
Subtotal (95% CI)			**23.8%**	**0.93 [0.77 , 1.11]**
Heterogeneity: Tau² = 0.00; Chi² = 0.68, df = 1 (P = 0.41); I² = 0%				
Test for overall effect: Z = 0.80 (P = 0.42)				
1.3.3 Study reported cluster-adjusted effect estimate				
Bieri 2013	-0.6931	0.182	9.1%	0.50 [0.35 , 0.71]
Erismann 2017	-0.6931	0.8212	0.9%	0.50 [0.10 , 2.50]
Gyorkos 2013	0	0.2779	5.5%	1.00 [0.58 , 1.72]
Makata 2021	0.174	0.2424	6.6%	1.19 [0.74 , 1.91]
Subtotal (95% CI)			**22.2%**	**0.79 [0.47 , 1.32]**
Heterogeneity: Tau² = 0.17; Chi² = 9.88, df = 3 (P = 0.02); I² = 70%				
Test for overall effect: Z = 0.90 (P = 0.37)				
Total (95% CI)			**100.0%**	**0.86 [0.74 , 1.01]**
Heterogeneity: Tau² = 0.03; Chi² = 26.18, df = 15 (P = 0.04); I² = 43%				
Test for overall effect: Z = 1.87 (P = 0.06)				
Test for subgroup differences: Chi² = 0.40, df = 2 (P = 0.82), I² = 0%				



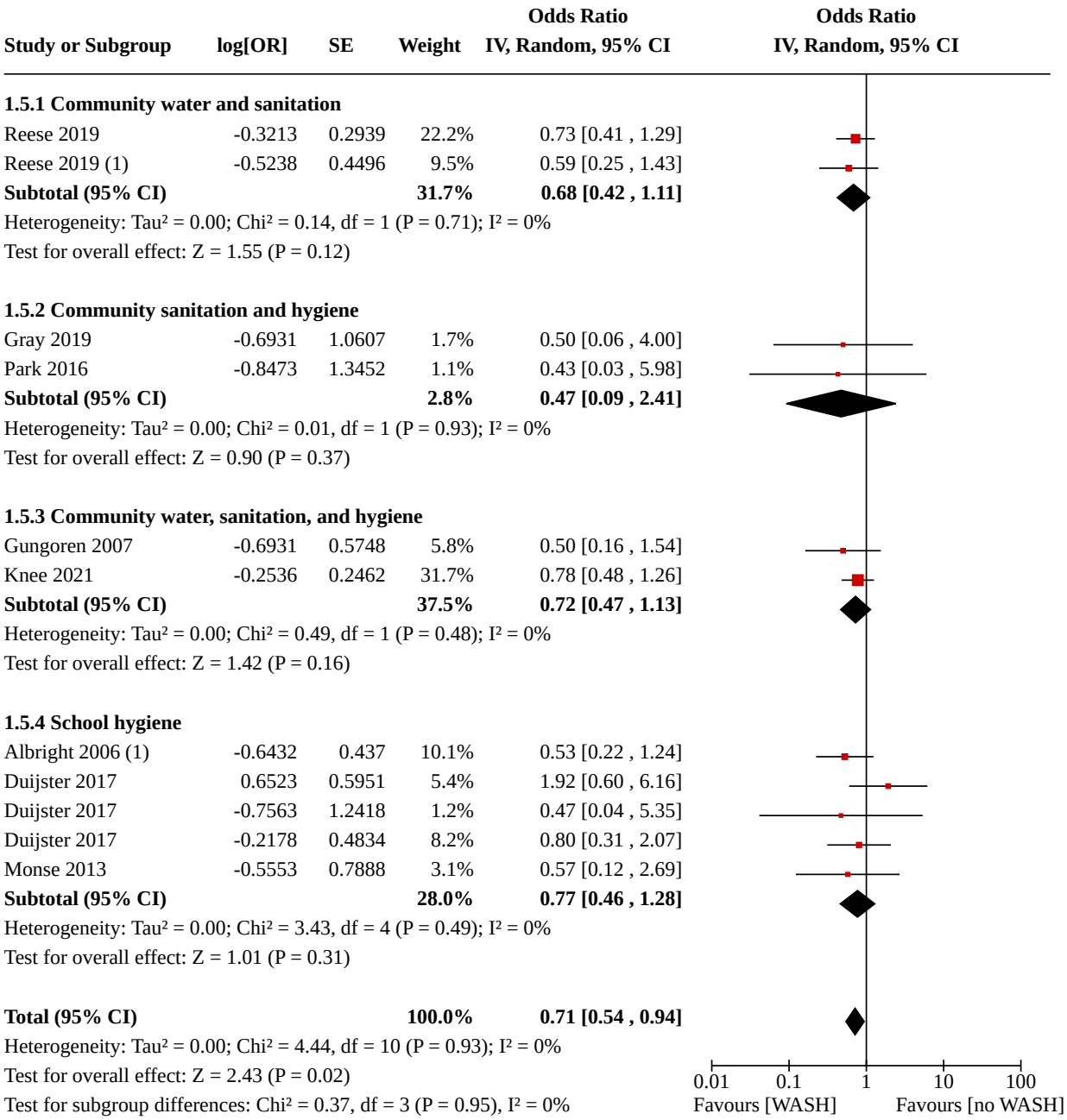
Analysis 1.4. Comparison 1: WASH intervention versus control, Outcome 4: Any STH prevalence amongst non-RCTs

Study or Subgroup	log[OR]	SE	Weight	Odds Ratio IV, Random, 95% CI
Albright 2006	-0.6432	0.437	10.1%	0.53 [0.22 , 1.24]
Duijster 2017	0.6523	0.5951	5.4%	1.92 [0.60 , 6.16]
Duijster 2017	-0.7563	1.2418	1.2%	0.47 [0.04 , 5.35]
Duijster 2017	-0.2178	0.4834	8.2%	0.80 [0.31 , 2.07]
Gray 2019	-0.6931	1.0607	1.7%	0.50 [0.06 , 4.00]
Gungoren 2007	-0.6931	0.5748	5.8%	0.50 [0.16 , 1.54]
Knee 2021	-0.2536	0.2462	31.7%	0.78 [0.48 , 1.26]
Monse 2013	-0.5553	0.7888	3.1%	0.57 [0.12 , 2.69]
Park 2016	-0.8473	1.3452	1.1%	0.43 [0.03 , 5.98]
Reese 2019	-0.3213	0.2939	22.2%	0.73 [0.41 , 1.29]
Reese 2019	-0.5238	0.4496	9.5%	0.59 [0.25 , 1.43]
Total (95% CI)			**100.0%**	**0.71 [0.54 , 0.94]**

Heterogeneity: Tau² = 0.00; Chi² = 4.44, df = 10 (P = 0.93); I² = 0%
Test for overall effect: Z = 2.43 (P = 0.02)
Test for subgroup differences: Not applicable



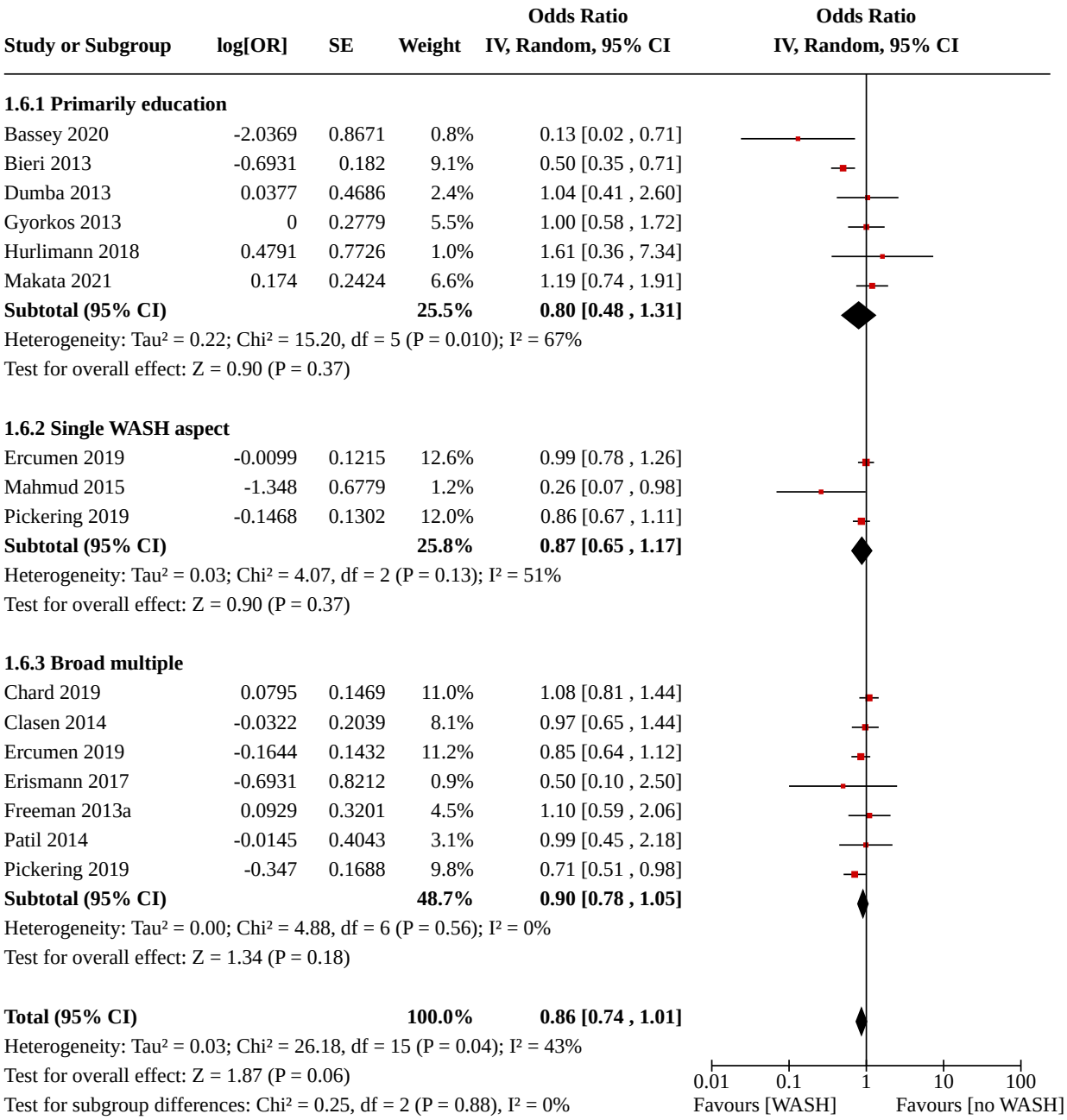
Analysis 1.5. Comparison 1: WASH intervention versus control, Outcome 5: Any STH prevalence - narrow WASH categories amongst non-RCTs



Footnotes

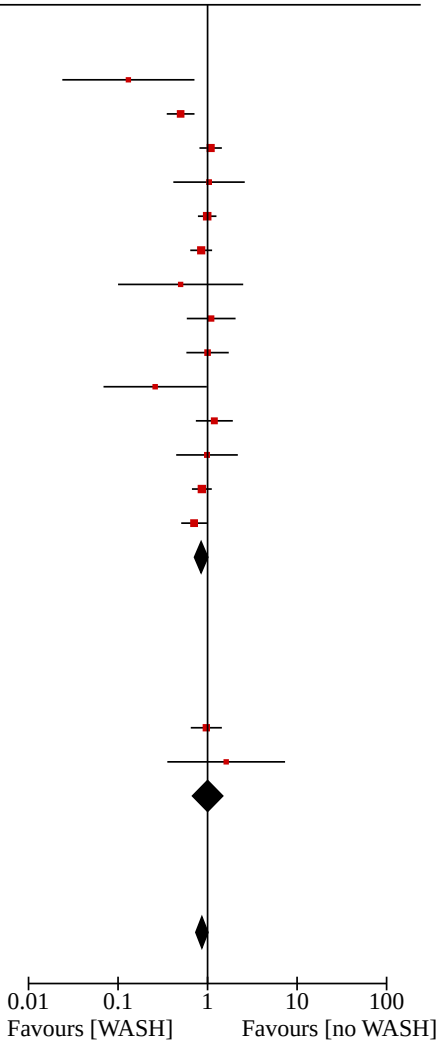
(1) Table notes: We preferentially show the cluster-adjusted odds ratio, as extracted from each paper. If that measure wasn't available

Analysis 1.6. Comparison 1: WASH intervention versus control, Outcome 6: Any STH prevalence amongst RCTs (intervention type subgroup)



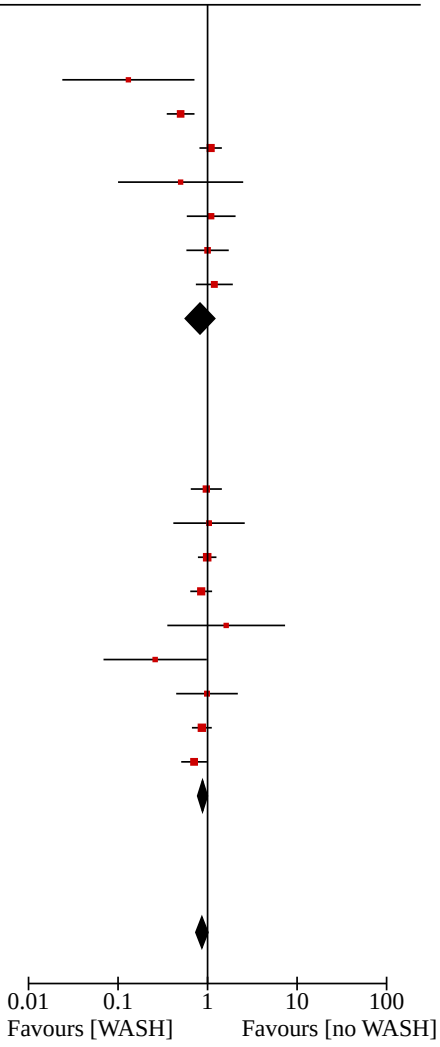
Analysis 1.7. Comparison 1: WASH intervention versus control, Outcome 7: Any STH prevalence amongst RCTs (age subgroup)

Study or Subgroup	log[OR]	SE	Weight	Odds Ratio IV, Random, 95% CI
1.7.1 Children				
Bassey 2020	-2.0369	0.8671	0.8%	0.13 [0.02 , 0.71]
Bieri 2013	-0.6931	0.182	9.1%	0.50 [0.35 , 0.71]
Chard 2019	0.0795	0.1469	11.0%	1.08 [0.81 , 1.44]
Dumba 2013	0.0377	0.4686	2.4%	1.04 [0.41 , 2.60]
Ercumen 2019	-0.0099	0.1215	12.6%	0.99 [0.78 , 1.26]
Ercumen 2019	-0.1644	0.1432	11.2%	0.85 [0.64 , 1.12]
Erismann 2017	-0.6931	0.8212	0.9%	0.50 [0.10 , 2.50]
Freeman 2013a	0.0929	0.3201	4.5%	1.10 [0.59 , 2.06]
Gyorkos 2013	0	0.2779	5.5%	1.00 [0.58 , 1.72]
Mahmud 2015	-1.348	0.6779	1.2%	0.26 [0.07 , 0.98]
Makata 2021	0.174	0.2424	6.6%	1.19 [0.74 , 1.91]
Patil 2014	-0.0145	0.4043	3.1%	0.99 [0.45 , 2.18]
Pickering 2019	-0.1468	0.1302	12.0%	0.86 [0.67 , 1.11]
Pickering 2019	-0.347	0.1688	9.8%	0.71 [0.51 , 0.98]
Subtotal (95% CI)			**90.9%**	**0.85 [0.72 , 1.00]**
Heterogeneity: Tau² = 0.04; Chi² = 25.26, df = 13 (P = 0.02); I² = 49%				
Test for overall effect: Z = 1.92 (P = 0.06)				
1.7.2 All ages				
Clasen 2014	-0.0322	0.2039	8.1%	0.97 [0.65 , 1.44]
Hurlimann 2018	0.4791	0.7726	1.0%	1.61 [0.36 , 7.34]
Subtotal (95% CI)			**9.1%**	**1.00 [0.68 , 1.47]**
Heterogeneity: Tau² = 0.00; Chi² = 0.41, df = 1 (P = 0.52); I² = 0%				
Test for overall effect: Z = 0.01 (P = 1.00)				
Total (95% CI)			**100.0%**	**0.86 [0.74 , 1.01]**
Heterogeneity: Tau² = 0.03; Chi² = 26.18, df = 15 (P = 0.04); I² = 43%				
Test for overall effect: Z = 1.87 (P = 0.06)				
Test for subgroup differences: Chi² = 0.60, df = 1 (P = 0.44), I² = 0%				

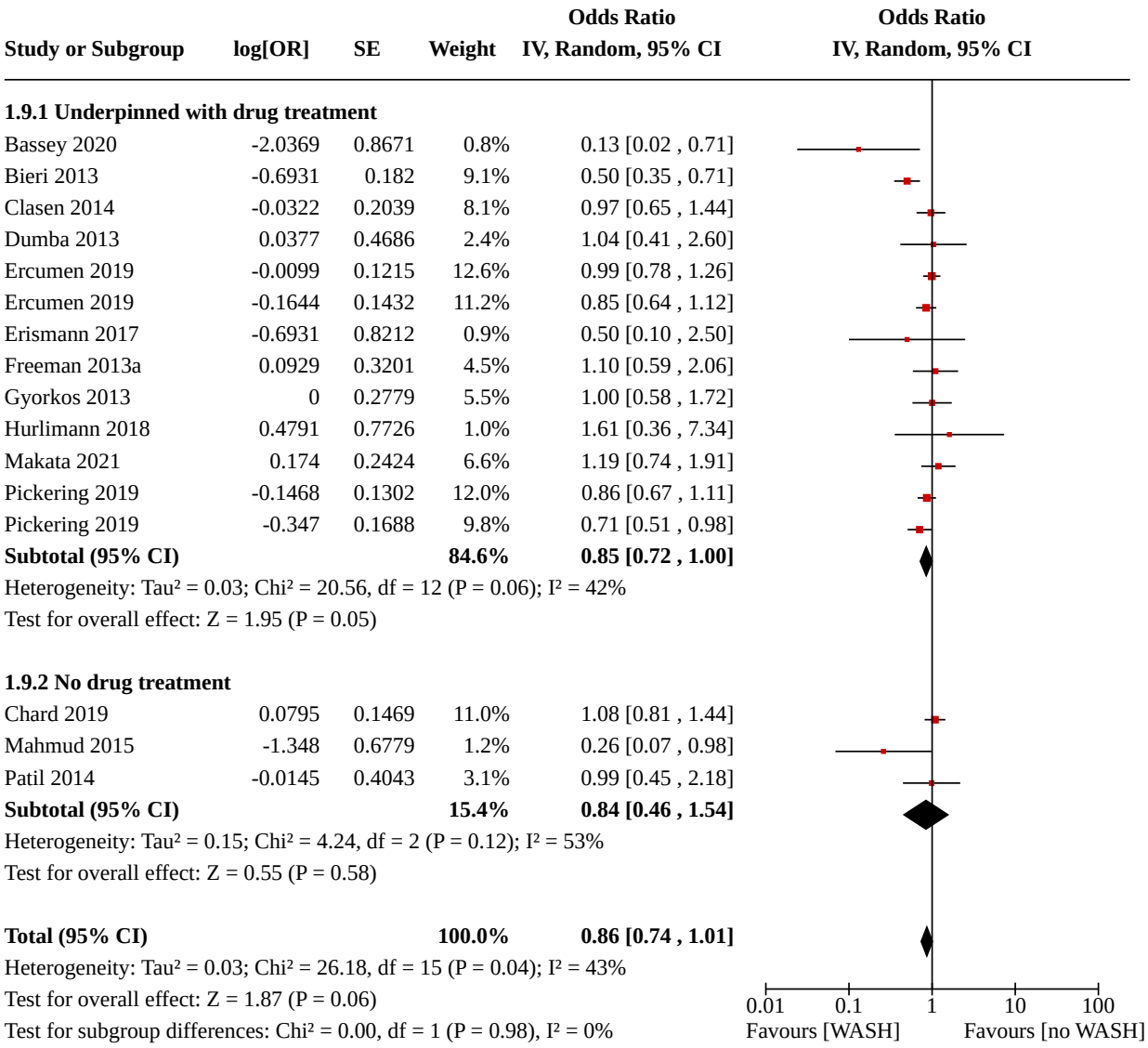


Analysis 1.8. Comparison 1: WASH intervention versus control, Outcome 8: Any STH prevalence amongst RCTs (school village subgroup)

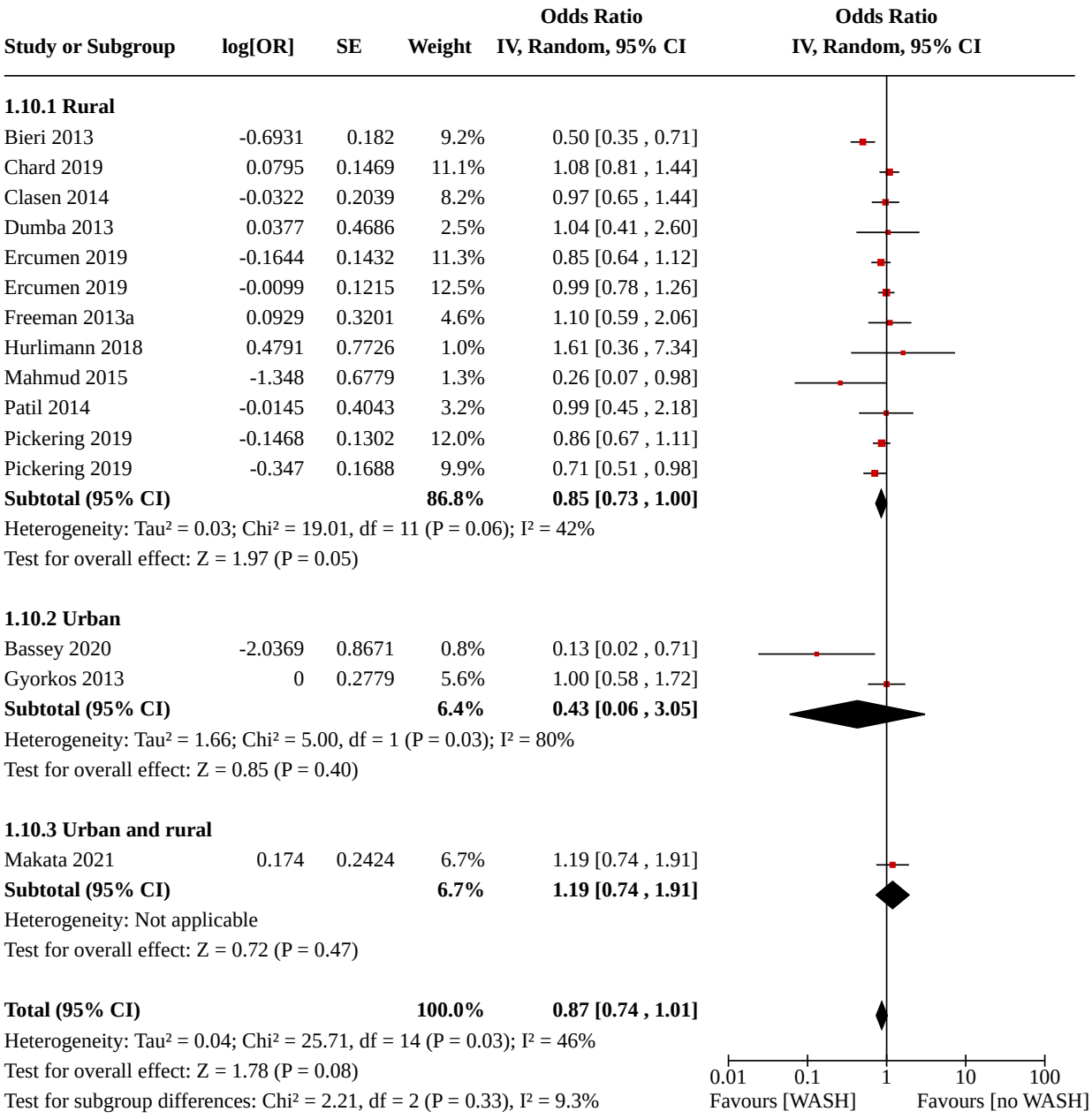
Study or Subgroup	log[OR]	SE	Weight	Odds Ratio IV, Random, 95% CI
1.8.1 School				
Bassey 2020	-2.0369	0.8671	0.8%	0.13 [0.02 , 0.71]
Bieri 2013	-0.6931	0.182	9.1%	0.50 [0.35 , 0.71]
Chard 2019	0.0795	0.1469	11.0%	1.08 [0.81 , 1.44]
Erismann 2017	-0.6931	0.8212	0.9%	0.50 [0.10 , 2.50]
Freeman 2013a	0.0929	0.3201	4.5%	1.10 [0.59 , 2.06]
Gyorkos 2013	0	0.2779	5.5%	1.00 [0.58 , 1.72]
Makata 2021	0.174	0.2424	6.6%	1.19 [0.74 , 1.91]
Subtotal (95% CI)			**38.5%**	**0.82 [0.56 , 1.20]**
Heterogeneity: Tau² = 0.15; Chi² = 19.17, df = 6 (P = 0.004); I² = 69%				
Test for overall effect: Z = 1.01 (P = 0.31)				
1.8.2 Village				
Clasen 2014	-0.0322	0.2039	8.1%	0.97 [0.65 , 1.44]
Dumba 2013	0.0377	0.4686	2.4%	1.04 [0.41 , 2.60]
Ercumen 2019	-0.0099	0.1215	12.6%	0.99 [0.78 , 1.26]
Ercumen 2019	-0.1644	0.1432	11.2%	0.85 [0.64 , 1.12]
Hurlimann 2018	0.4791	0.7726	1.0%	1.61 [0.36 , 7.34]
Mahmud 2015	-1.348	0.6779	1.2%	0.26 [0.07 , 0.98]
Patil 2014	-0.0145	0.4043	3.1%	0.99 [0.45 , 2.18]
Pickering 2019	-0.1468	0.1302	12.0%	0.86 [0.67 , 1.11]
Pickering 2019	-0.347	0.1688	9.8%	0.71 [0.51 , 0.98]
Subtotal (95% CI)			**61.5%**	**0.88 [0.78 , 0.99]**
Heterogeneity: Tau² = 0.00; Chi² = 6.99, df = 8 (P = 0.54); I² = 0%				
Test for overall effect: Z = 2.05 (P = 0.04)				
Total (95% CI)			**100.0%**	**0.86 [0.74 , 1.01]**
Heterogeneity: Tau² = 0.03; Chi² = 26.18, df = 15 (P = 0.04); I² = 43%				
Test for overall effect: Z = 1.87 (P = 0.06)				
Test for subgroup differences: Chi² = 0.10, df = 1 (P = 0.75), I² = 0%				



Analysis 1.9. Comparison 1: WASH intervention versus control, Outcome 9: Any STH prevalence amongst RCTs (MDA subgroup)

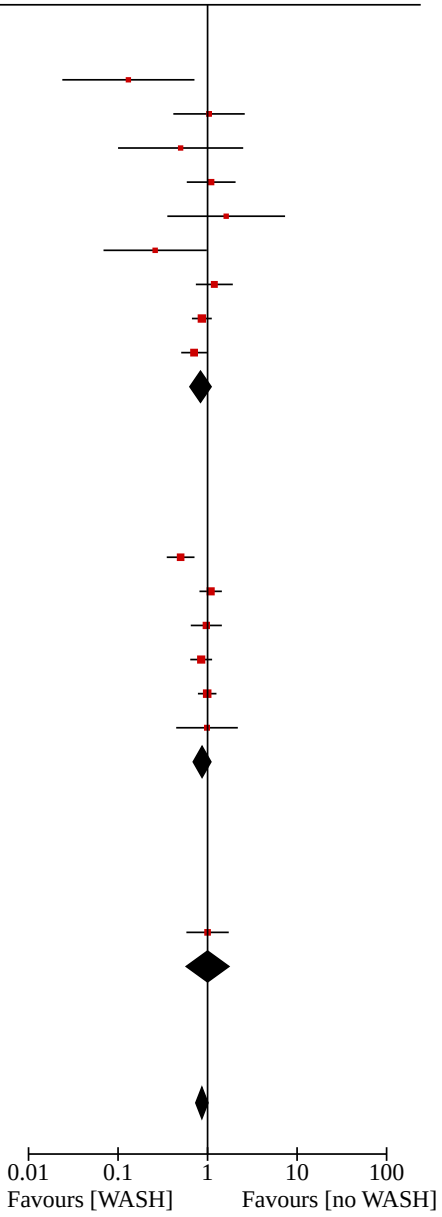


Analysis 1.10. Comparison 1: WASH intervention versus control, Outcome 10: Any STH prevalence amongst RCTs (rural urban subgroup)

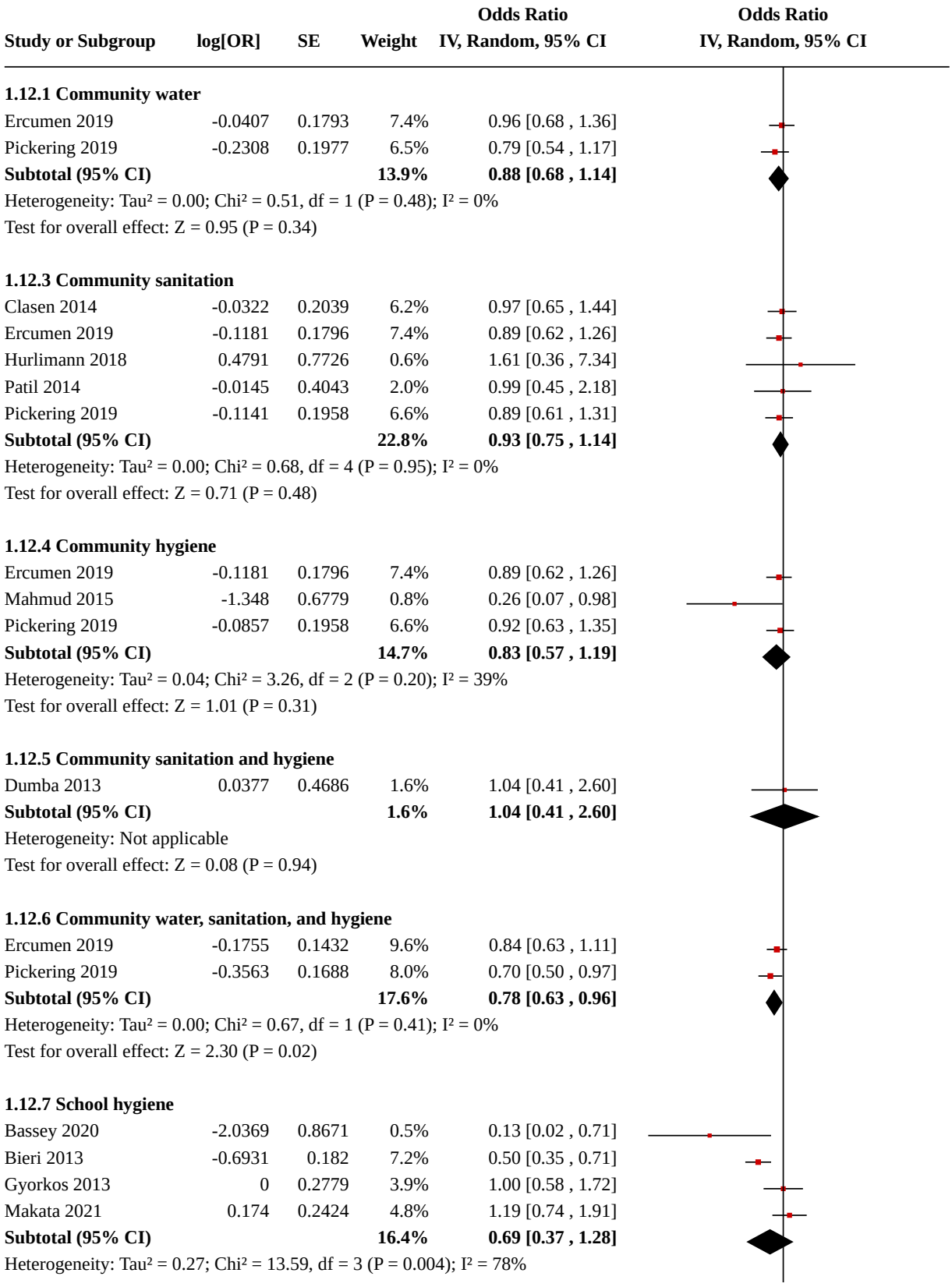


Analysis 1.11. Comparison 1: WASH intervention versus control, Outcome 11: Any STH prevalence amongst RCTs (world region subgroup)

Study or Subgroup	log[OR]	SE	Weight	Odds Ratio IV, Random, 95% CI
1.11.1 Africa				
Bassey 2020	-2.0369	0.8671	0.8%	0.13 [0.02 , 0.71]
Dumba 2013	0.0377	0.4686	2.4%	1.04 [0.41 , 2.60]
Erismann 2017	-0.6931	0.8212	0.9%	0.50 [0.10 , 2.50]
Freeman 2013a	0.0929	0.3201	4.5%	1.10 [0.59 , 2.06]
Hurlimann 2018	0.4791	0.7726	1.0%	1.61 [0.36 , 7.34]
Mahmud 2015	-1.348	0.6779	1.2%	0.26 [0.07 , 0.98]
Makata 2021	0.174	0.2424	6.6%	1.19 [0.74 , 1.91]
Pickering 2019	-0.1468	0.1302	12.0%	0.86 [0.67 , 1.11]
Pickering 2019	-0.347	0.1688	9.8%	0.71 [0.51 , 0.98]
Subtotal (95% CI)			**39.3%**	**0.83 [0.64 , 1.09]**
Heterogeneity: Tau² = 0.05; Chi² = 12.78, df = 8 (P = 0.12); I² = 37%				
Test for overall effect: Z = 1.32 (P = 0.19)				
1.11.2 Asia				
Bieri 2013	-0.6931	0.182	9.1%	0.50 [0.35 , 0.71]
Chard 2019	0.0795	0.1469	11.0%	1.08 [0.81 , 1.44]
Clasen 2014	-0.0322	0.2039	8.1%	0.97 [0.65 , 1.44]
Ercumen 2019	-0.1644	0.1432	11.2%	0.85 [0.64 , 1.12]
Ercumen 2019	-0.0099	0.1215	12.6%	0.99 [0.78 , 1.26]
Patil 2014	-0.0145	0.4043	3.1%	0.99 [0.45 , 2.18]
Subtotal (95% CI)			**55.2%**	**0.87 [0.69 , 1.09]**
Heterogeneity: Tau² = 0.05; Chi² = 12.93, df = 5 (P = 0.02); I² = 61%				
Test for overall effect: Z = 1.24 (P = 0.22)				
1.11.3 South America				
Gyorkos 2013	0	0.2779	5.5%	1.00 [0.58 , 1.72]
Subtotal (95% CI)			**5.5%**	**1.00 [0.58 , 1.72]**
Heterogeneity: Not applicable				
Test for overall effect: Z = 0.00 (P = 1.00)				
Total (95% CI)			**100.0%**	**0.86 [0.74 , 1.01]**
Heterogeneity: Tau² = 0.03; Chi² = 26.18, df = 15 (P = 0.04); I² = 43%				
Test for overall effect: Z = 1.87 (P = 0.06)				
Test for subgroup differences: Chi² = 0.34, df = 2 (P = 0.84), I² = 0%				

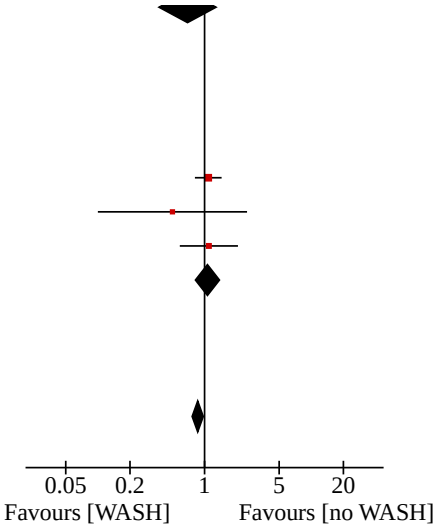


Analysis 1.12. Comparison 1: WASH intervention versus control, Outcome 12: Any STH prevalence - narrow WASH categories amongst RCTs



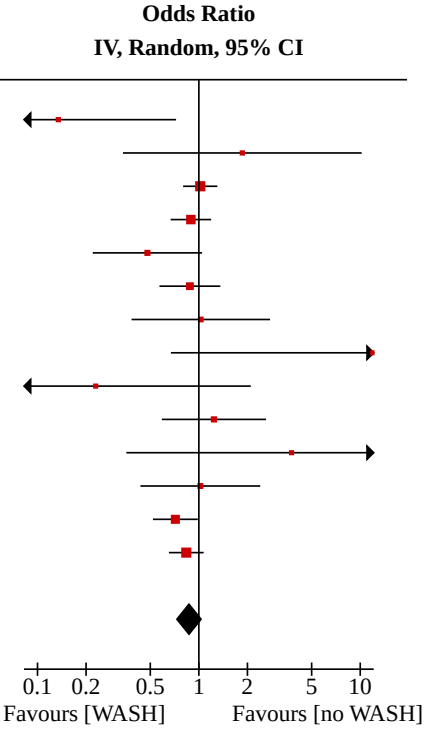
Analysis 1.12. (Continued)

Heterogeneity: Tau² = 0.27; Chi² = 13.59, df = 3 (P = 0.004); I² = 78%				
Test for overall effect: Z = 1.17 (P = 0.24)				
1.12.8 School water, sanitation, and hygiene				
Chard 2019	0.0795	0.1469	9.4%	1.08 [0.81 , 1.44]
Erismann 2017	-0.6931	0.8212	0.5%	0.50 [0.10 , 2.50]
Freeman 2013a	0.0929	0.3201	3.1%	1.10 [0.59 , 2.06]
Subtotal (95% CI)			**13.0%**	**1.06 [0.82 , 1.38]**
Heterogeneity: Tau² = 0.00; Chi² = 0.87, df = 2 (P = 0.65); I² = 0%				
Test for overall effect: Z = 0.47 (P = 0.64)				
Total (95% CI)			**100.0%**	**0.86 [0.77 , 0.97]**
Heterogeneity: Tau² = 0.02; Chi² = 25.83, df = 19 (P = 0.13); I² = 26%				
Test for overall effect: Z = 2.44 (P = 0.01)				
Test for subgroup differences: Chi² = 4.40, df = 6 (P = 0.62), I² = 0%				



Analysis 1.13. Comparison 1: WASH intervention versus control, Outcome 13: *Ascaris lumbricoides* prevalence amongst RCTs

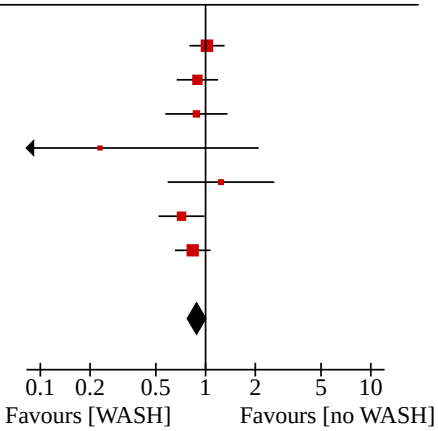
Study or Subgroup	log[OR]	SE	Weight	Odds Ratio IV, Random, 95% CI
Bassey 2020	-2.0053	0.8573	1.0%	0.13 [0.03 , 0.72]
Clasen 2014	0.6203	0.8688	1.0%	1.86 [0.34 , 10.21]
Ercumen 2019	0.0198	0.1246	19.5%	1.02 [0.80 , 1.30]
Ercumen 2019	-0.1138	0.1471	16.9%	0.89 [0.67 , 1.19]
Freeman 2013a	-0.734	0.398	4.2%	0.48 [0.22 , 1.05]
Gyorkos 2013	-0.1278	0.2216	10.5%	0.88 [0.57 , 1.36]
Han 1988	0.0276	0.5041	2.8%	1.03 [0.38 , 2.76]
Hurlimann 2018	2.480427	1.469294	0.4%	11.95 [0.67 , 212.77]
Mahmud 2015	-1.4722	1.129	0.6%	0.23 [0.03 , 2.10]
Makata 2021	0.2151	0.379	4.6%	1.24 [0.59 , 2.61]
Nery 2019a	1.3218	1.2024	0.5%	3.75 [0.36 , 39.59]
Patil 2014	0.0212	0.4362	3.6%	1.02 [0.43 , 2.40]
Pickering 2019	-0.3353	0.1633	15.2%	0.72 [0.52 , 0.98]
Pickering 2019	-0.1795	0.1263	19.3%	0.84 [0.65 , 1.07]
Total (95% CI)			**100.0%**	**0.87 [0.73 , 1.03]**
Heterogeneity: Tau² = 0.02; Chi² = 18.10, df = 13 (P = 0.15); I² = 28%				
Test for overall effect: Z = 1.61 (P = 0.11)				
Test for subgroup differences: Not applicable				



Analysis 1.14. Comparison 1: WASH intervention versus control, Outcome 14: *Ascaris lumbricoides* prevalence amongst RCTs - low risk of bias studies only

Study or Subgroup	log[OR]	SE	Weight	Odds Ratio IV, Random, 95% CI
Ercumen 2019	0.0198	0.1246	27.0%	1.02 [0.80 , 1.30]
Ercumen 2019	-0.1138	0.1471	19.3%	0.89 [0.67 , 1.19]
Gyorkos 2013	-0.1278	0.2216	8.5%	0.88 [0.57 , 1.36]
Mahmud 2015	-1.4722	1.129	0.3%	0.23 [0.03 , 2.10]
Makata 2021	0.2151	0.379	2.9%	1.24 [0.59 , 2.61]
Pickering 2019	-0.3353	0.1633	15.7%	0.72 [0.52 , 0.98]
Pickering 2019	-0.1795	0.1263	26.2%	0.84 [0.65 , 1.07]
Total (95% CI)			**100.0%**	**0.88 [0.78 , 1.00]**

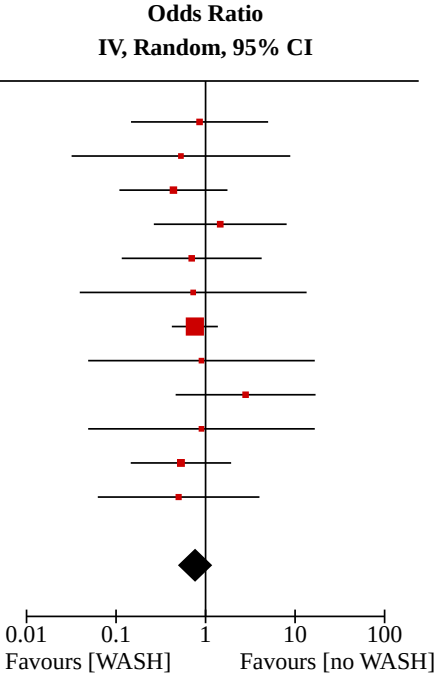
Heterogeneity: Tau² = 0.00; Chi² = 5.43, df = 6 (P = 0.49); I² = 0%
Test for overall effect: Z = 1.95 (P = 0.05)
Test for subgroup differences: Not applicable



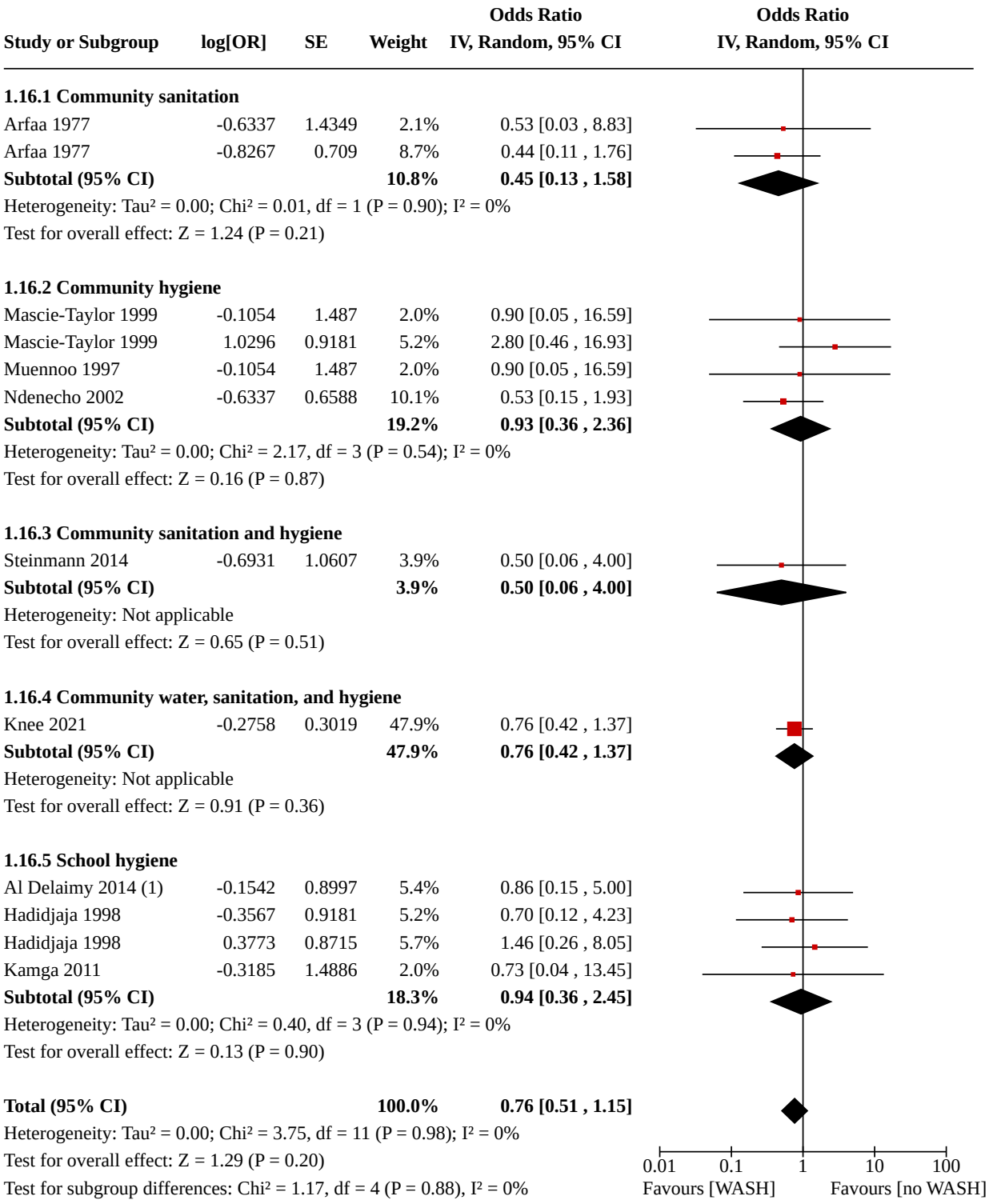
Analysis 1.15. Comparison 1: WASH intervention versus control, Outcome 15: *Ascaris lumbricoides* prevalence amongst non-RCTs

Study or Subgroup	log[OR]	SE	Weight	Odds Ratio IV, Random, 95% CI
Al Delaimy 2014	-0.1542	0.8997	5.4%	0.86 [0.15 , 5.00]
Arfaa 1977	-0.6337	1.4349	2.1%	0.53 [0.03 , 8.83]
Arfaa 1977	-0.8267	0.709	8.7%	0.44 [0.11 , 1.76]
Hadidjaja 1998	0.3773	0.8715	5.7%	1.46 [0.26 , 8.05]
Hadidjaja 1998	-0.3567	0.9181	5.2%	0.70 [0.12 , 4.23]
Kamga 2011	-0.3185	1.4886	2.0%	0.73 [0.04 , 13.45]
Knee 2021	-0.2758	0.3019	47.9%	0.76 [0.42 , 1.37]
Mascie-Taylor 1999	-0.1054	1.487	2.0%	0.90 [0.05 , 16.59]
Mascie-Taylor 1999	1.0296	0.9181	5.2%	2.80 [0.46 , 16.93]
Muennoo 1997	-0.1054	1.487	2.0%	0.90 [0.05 , 16.59]
Ndenecho 2002	-0.6337	0.6588	10.1%	0.53 [0.15 , 1.93]
Steinmann 2014	-0.6931	1.0607	3.9%	0.50 [0.06 , 4.00]
Total (95% CI)			**100.0%**	**0.76 [0.51 , 1.15]**

Heterogeneity: Tau² = 0.00; Chi² = 3.75, df = 11 (P = 0.98); I² = 0%
Test for overall effect: Z = 1.29 (P = 0.20)
Test for subgroup differences: Not applicable



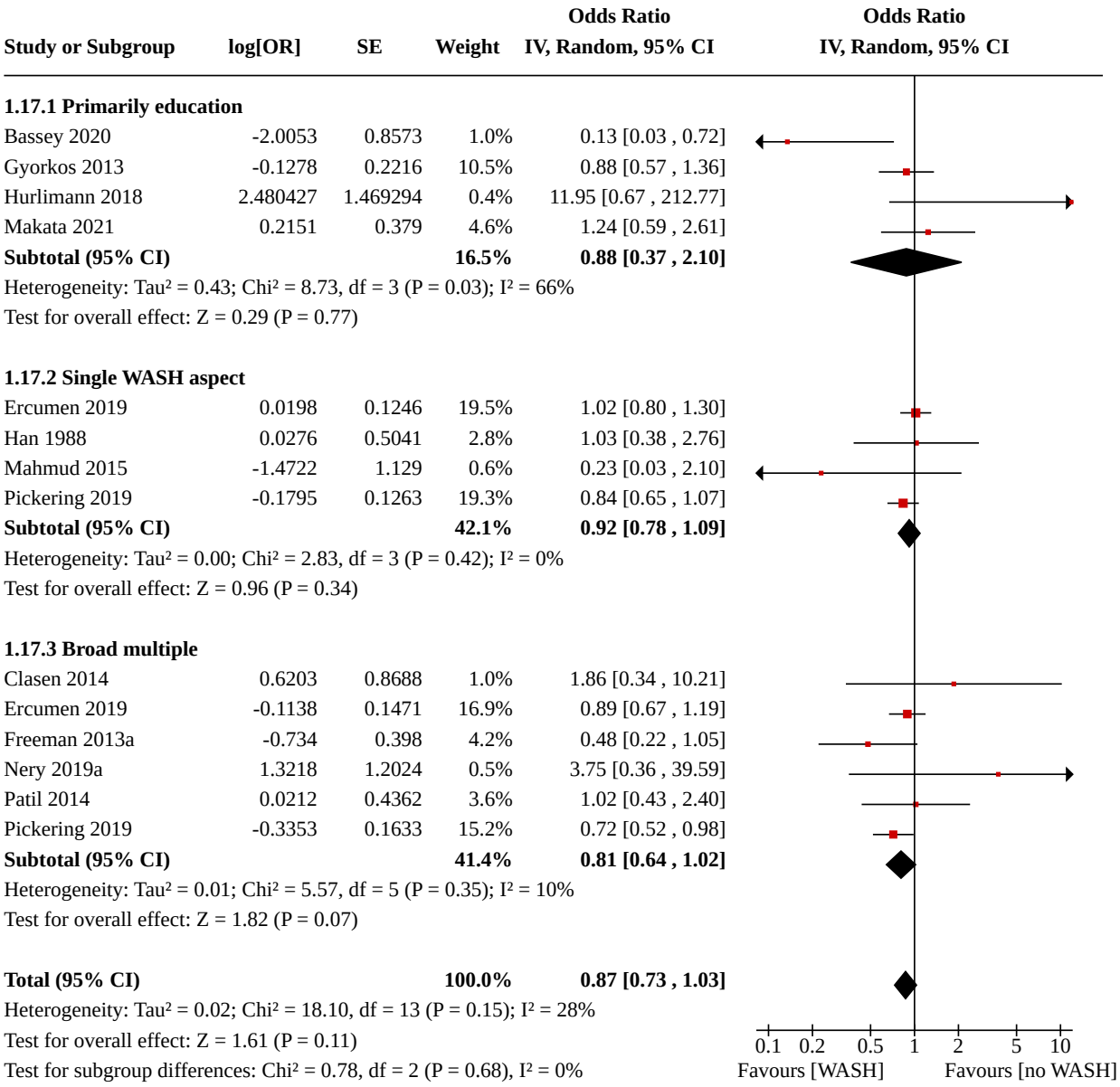
Analysis 1.16. Comparison 1: WASH intervention versus control, Outcome 16: *Ascaris lumbricoides* prevalence - narrow WASH categories amongst non-RCTs



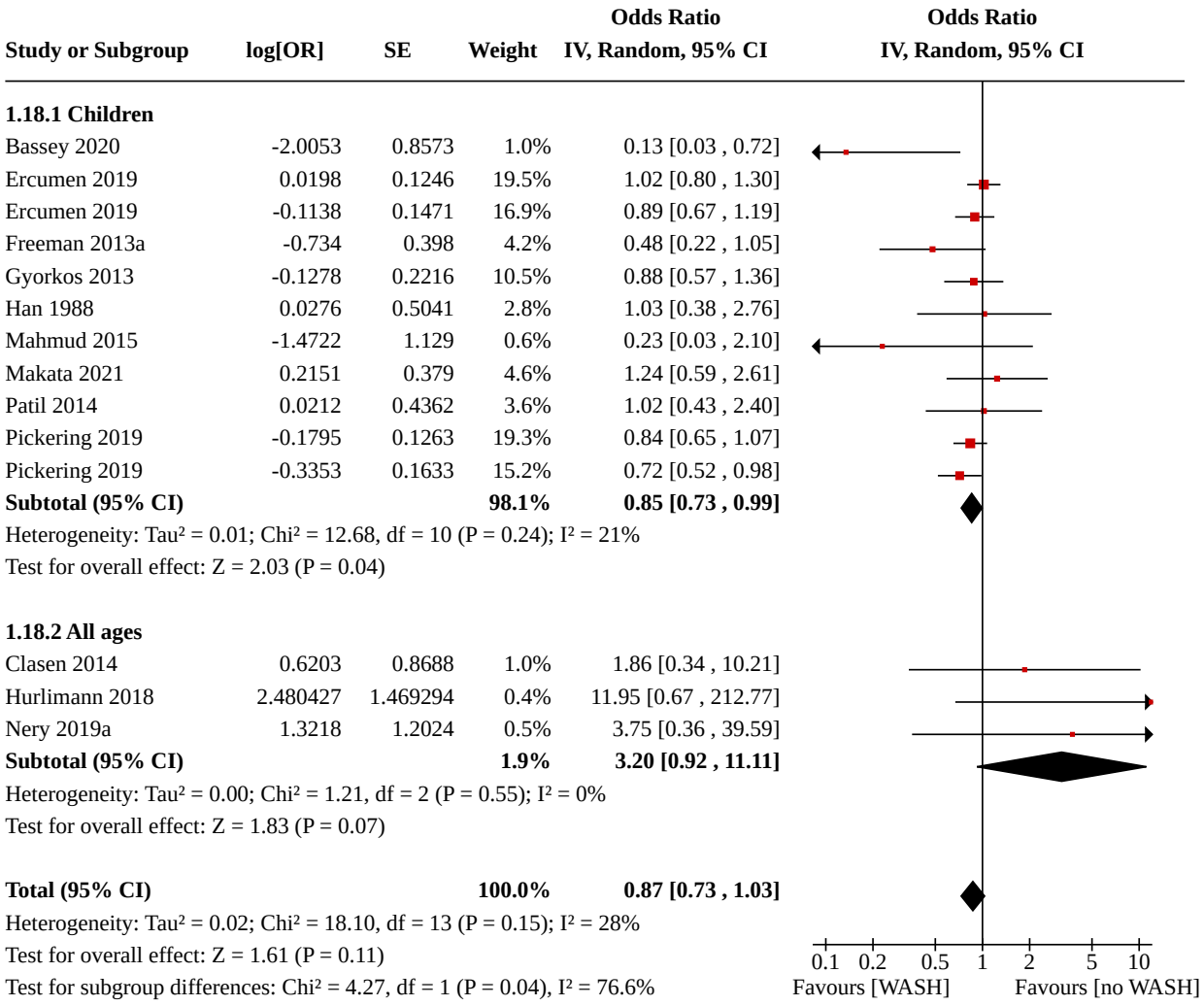
Footnotes

(1) Table notes: We preferentially show the cluster-adjusted odds ratio, as extracted from each paper. If that measure wasn't available

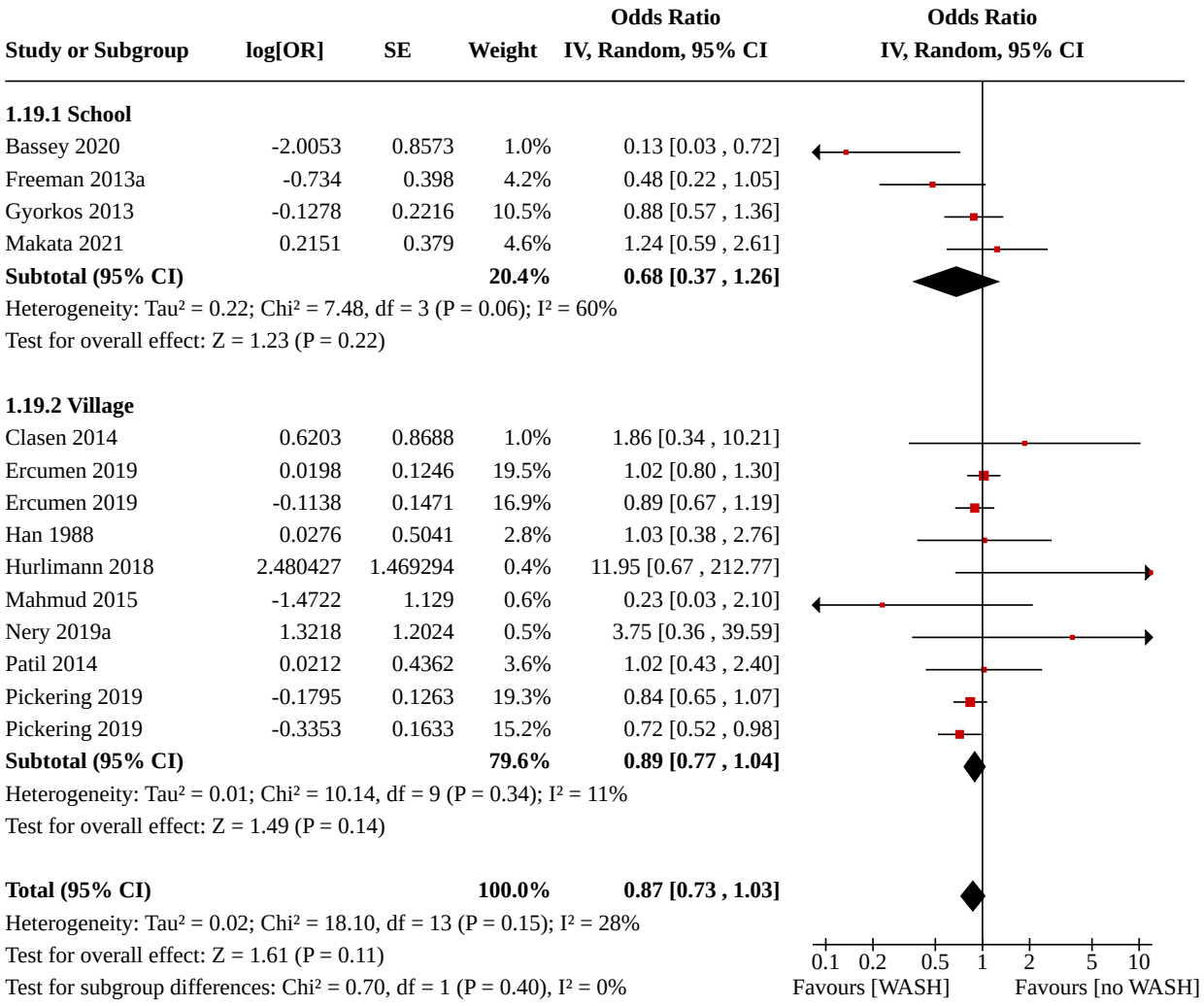
Analysis 1.17. Comparison 1: WASH intervention versus control, Outcome 17: *Ascaris lumbricoides* prevalence amongst RCTs (intervention type subgroup)



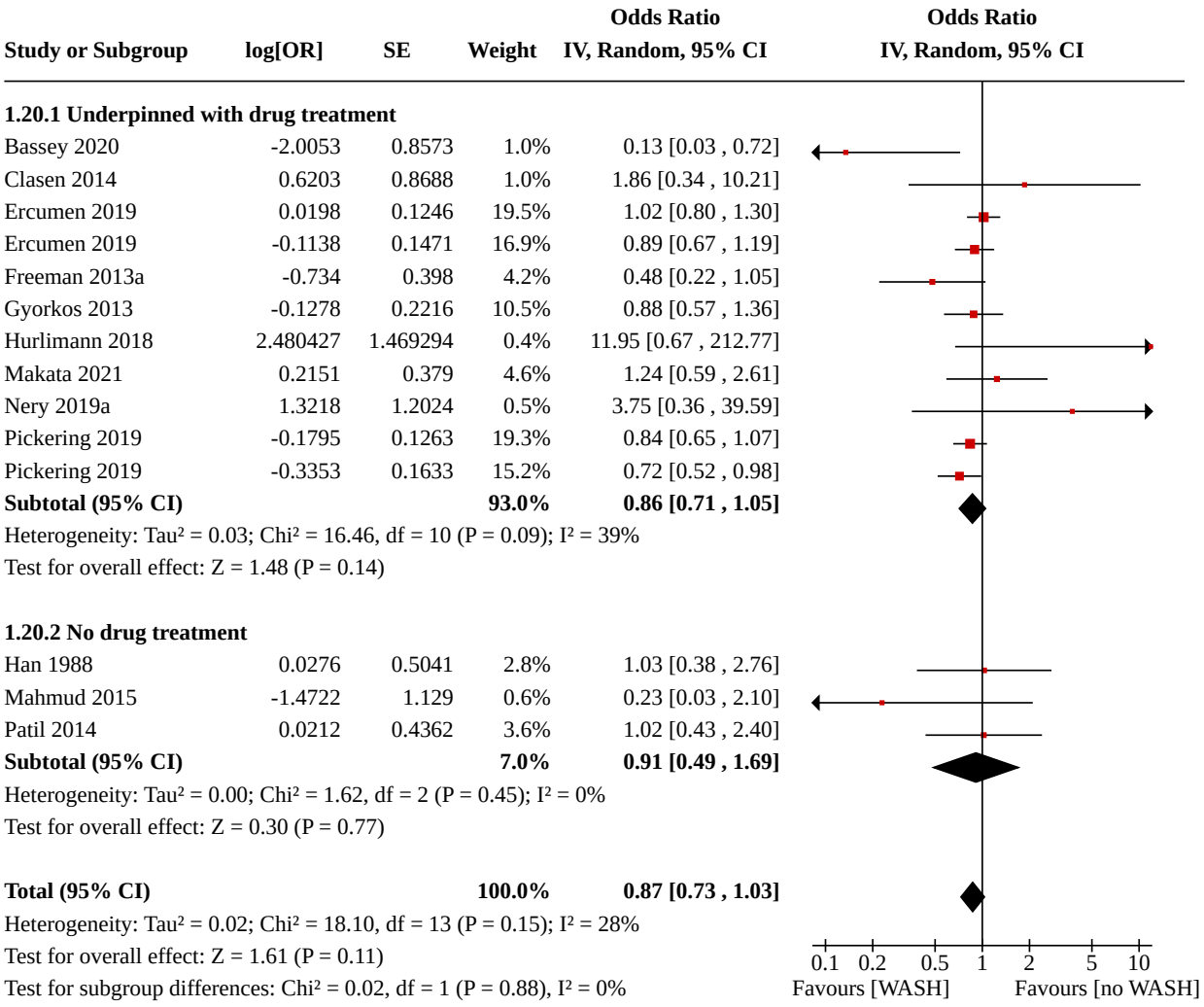
Analysis 1.18. Comparison 1: WASH intervention versus control, Outcome 18: *Ascaris lumbricoides* prevalence amongst RCTs (age subgroup)



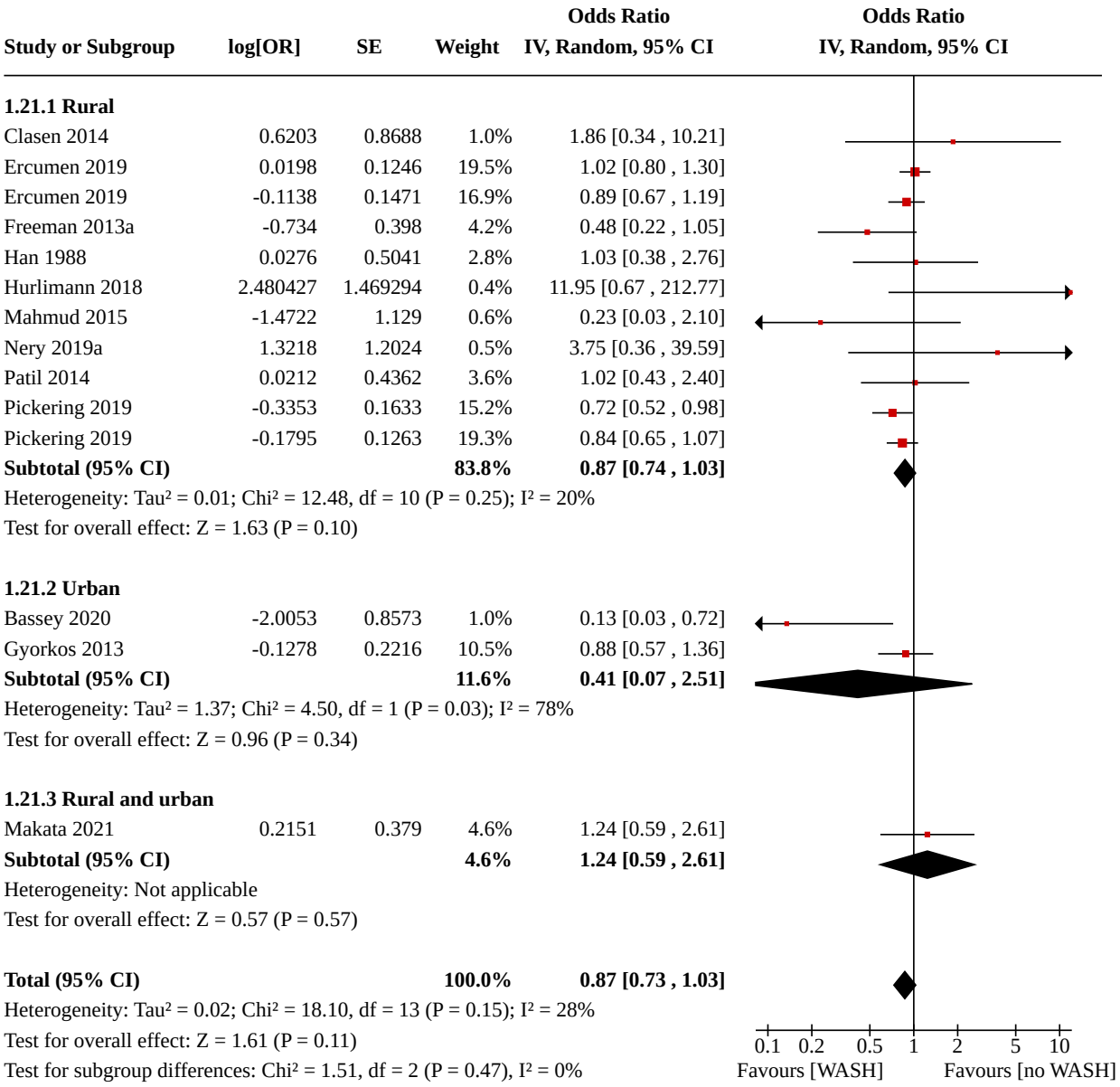
Analysis 1.19. Comparison 1: WASH intervention versus control, Outcome 19: *Ascaris lumbricoides* prevalence amongst RCTs (school village subgroup)



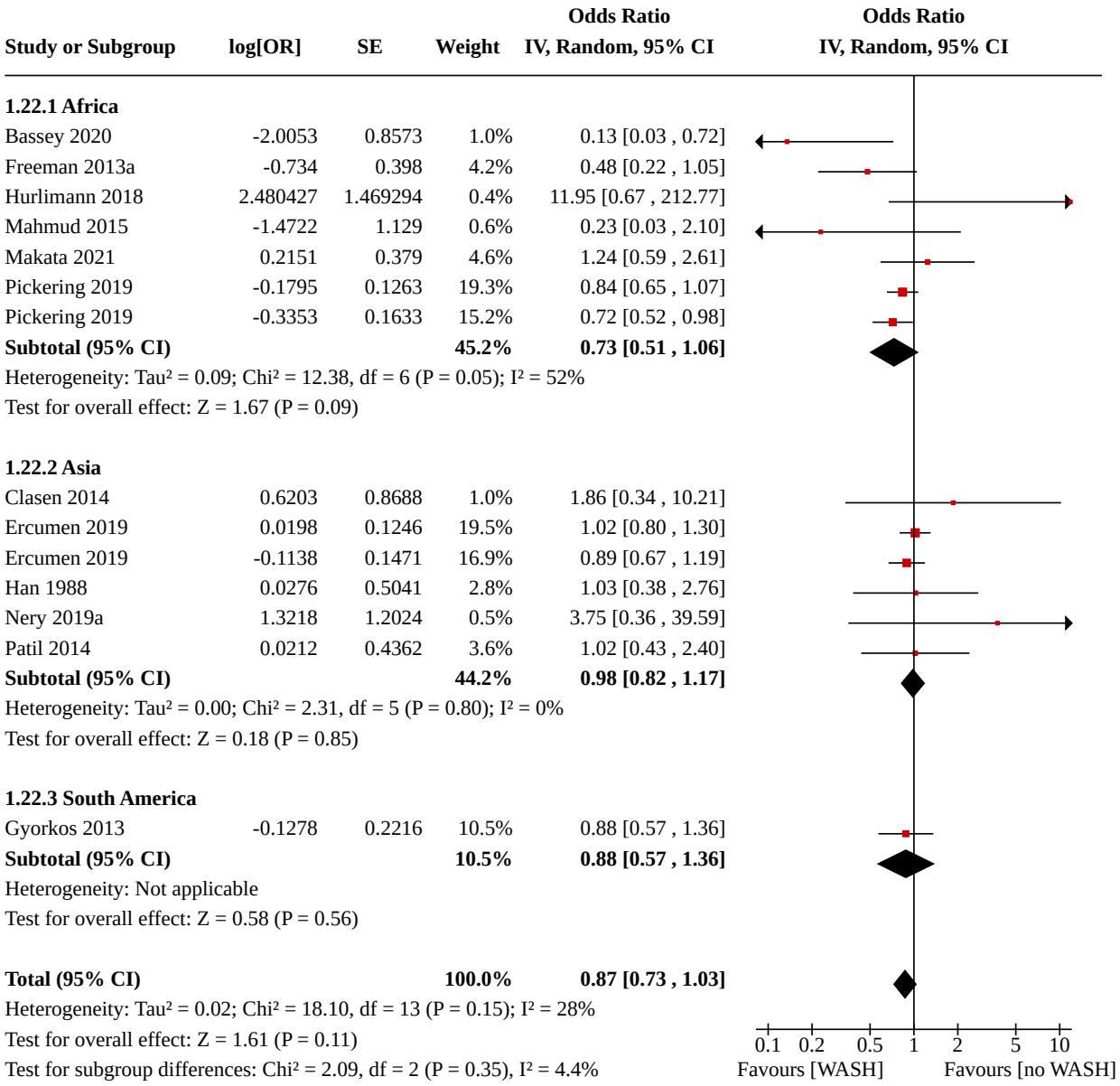
Analysis 1.20. Comparison 1: WASH intervention versus control, Outcome 20: *Ascaris lumbricoides* prevalence amongst RCTs (MDA subgroup)



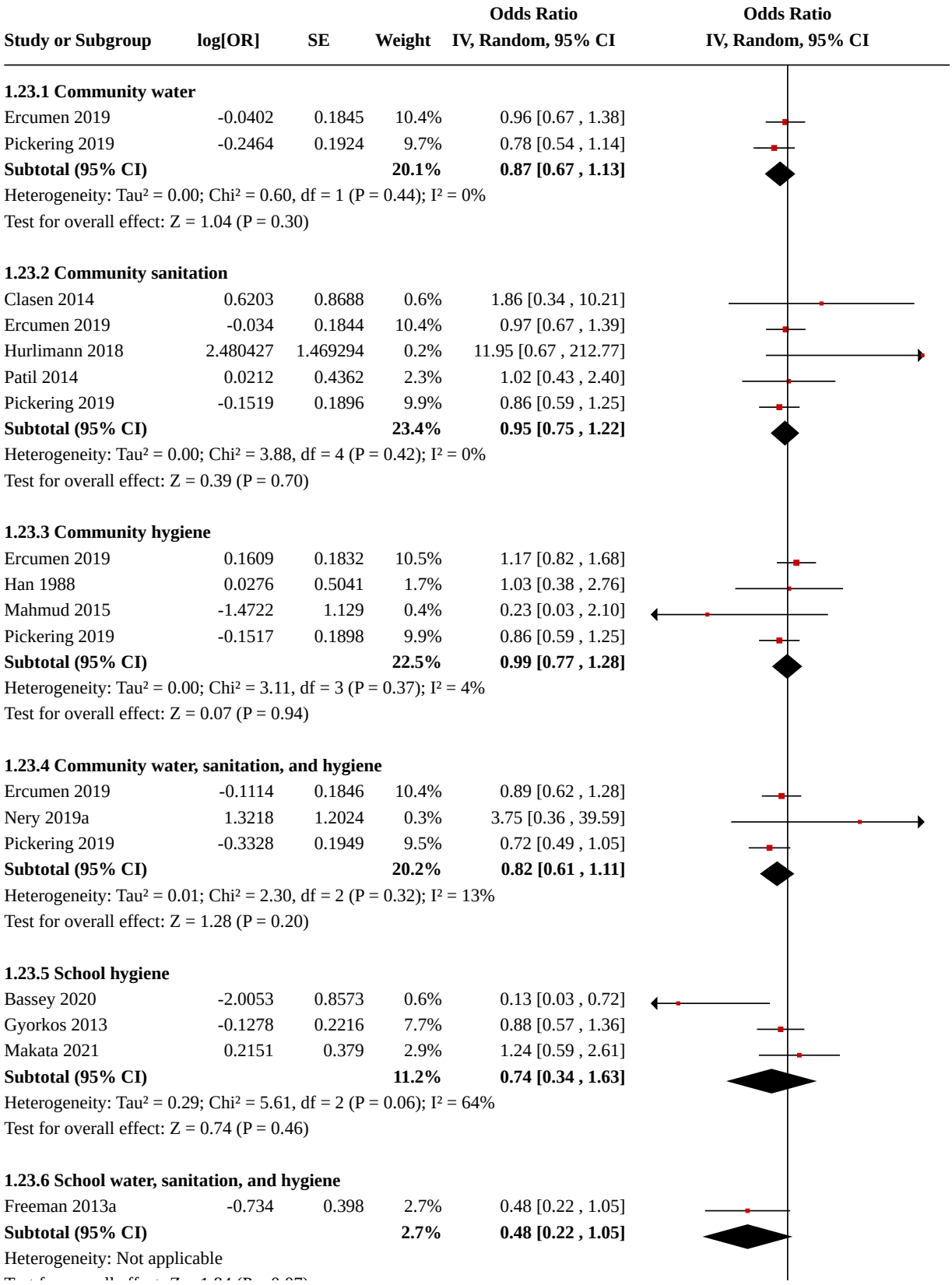
Analysis 1.21. Comparison 1: WASH intervention versus control, Outcome 21: *Ascaris lumbricoides* prevalence amongst RCTs (rural urban subgroup)



Analysis 1.22. Comparison 1: WASH intervention versus control, Outcome 22: *Ascaris lumbricoides* prevalence amongst RCTs (world region subgroup)



Analysis 1.23. Comparison 1: WASH intervention versus control, Outcome 23: *Ascaris lumbricoides* prevalence - narrow WASH categories amongst RCTs

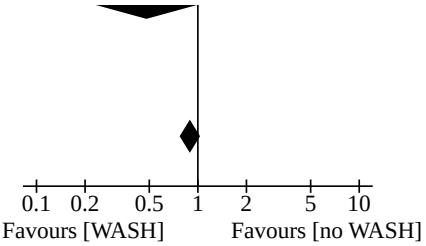


Analysis 1.23. (Continued)

Heterogeneity: Not applicable
Test for overall effect: Z = 1.84 (P = 0.07)

Total (95% CI)	**100.0%**	**0.89 [0.78 , 1.02]**

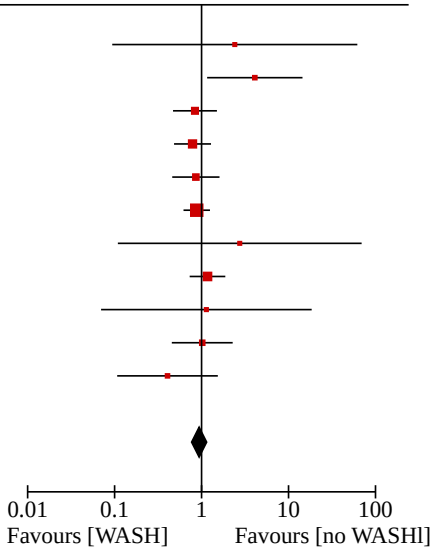
Heterogeneity: Tau² = 0.01; Chi² = 19.34, df = 17 (P = 0.31); I² = 12%
Test for overall effect: Z = 1.71 (P = 0.09)
Test for subgroup differences: Chi² = 3.84, df = 5 (P = 0.57), I² = 0%



Analysis 1.24. Comparison 1: WASH intervention versus control, Outcome 24: *Trichuris trichiura* prevalence amongst RCTs

Study or Subgroup	log[OR]	SE	Weight	Odds Ratio IV, Random, 95% CI
Bassey 2020	0.879559	1.655376	0.4%	2.41 [0.09 , 61.81]
Clasen 2014	1.4098	0.644	2.5%	4.10 [1.16 , 14.47]
Ercumen 2019	-0.1747	0.2964	11.7%	0.84 [0.47 , 1.50]
Ercumen 2019	-0.2392	0.2496	16.5%	0.79 [0.48 , 1.28]
Freeman 2013a	-0.1508	0.3192	10.1%	0.86 [0.46 , 1.61]
Gyorkos 2013	-0.1278	0.1787	32.1%	0.88 [0.62 , 1.25]
Hurlimann 2018	1.010644	1.646423	0.4%	2.75 [0.11 , 69.24]
Makata 2021	0.157	0.2407	17.7%	1.17 [0.73 , 1.88]
Nery 2019a	0.1273	1.4224	0.5%	1.14 [0.07 , 18.45]
Pickering 2019	0.0179	0.4111	6.1%	1.02 [0.45 , 2.28]
Pickering 2019	-0.9016	0.6796	2.2%	0.41 [0.11 , 1.54]
Total (95% CI)			**100.0%**	**0.94 [0.77 , 1.14]**

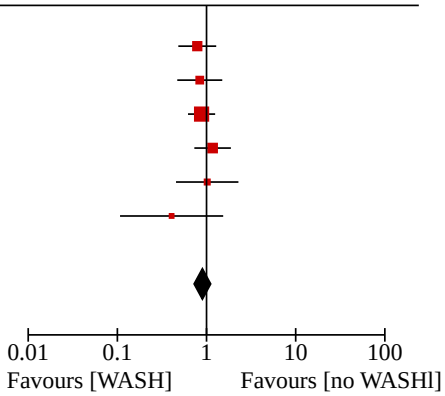
Heterogeneity: Tau² = 0.00; Chi² = 9.24, df = 10 (P = 0.51); I² = 0%
Test for overall effect: Z = 0.64 (P = 0.52)
Test for subgroup differences: Not applicable



Analysis 1.25. Comparison 1: WASH intervention versus control, Outcome 25: *Trichuris trichiura* prevalence amongst RCTs - low risk of bias studies only

Study or Subgroup	log[OR]	SE	Weight	Odds Ratio IV, Random, 95% CI
Ercumen 2019	-0.2392	0.2496	19.1%	0.79 [0.48 , 1.28]
Ercumen 2019	-0.1747	0.2964	13.5%	0.84 [0.47 , 1.50]
Gyorkos 2013	-0.1278	0.1787	37.2%	0.88 [0.62 , 1.25]
Makata 2021	0.157	0.2407	20.5%	1.17 [0.73 , 1.88]
Pickering 2019	0.0179	0.4111	7.0%	1.02 [0.45 , 2.28]
Pickering 2019	-0.9016	0.6796	2.6%	0.41 [0.11 , 1.54]
Total (95% CI)			**100.0%**	**0.90 [0.73 , 1.11]**

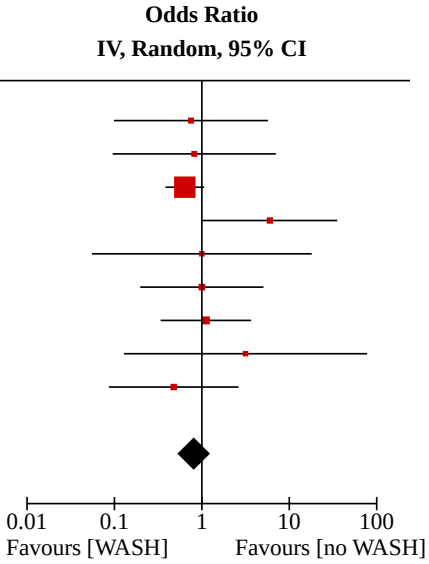
Heterogeneity: Tau² = 0.00; Chi² = 3.01, df = 5 (P = 0.70); I² = 0%
Test for overall effect: Z = 0.98 (P = 0.33)
Test for subgroup differences: Not applicable



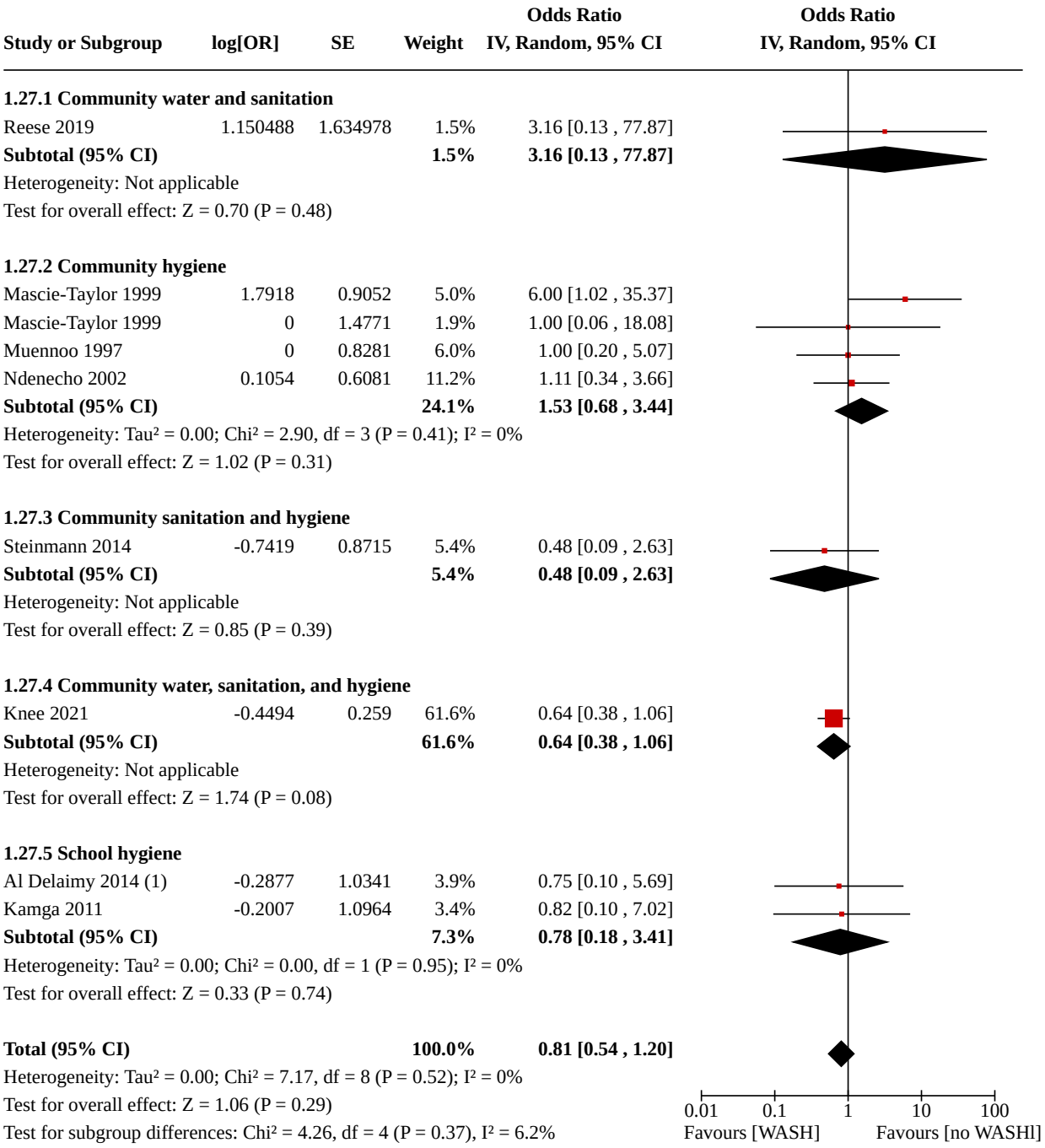
Analysis 1.26. Comparison 1: WASH intervention versus control, Outcome 26: *Trichuris trichiura* prevalence amongst non-RCTs

Study or Subgroup	log[OR]	SE	Weight	Odds Ratio IV, Random, 95% CI
Al Delaimy 2014	-0.2877	1.0341	3.9%	0.75 [0.10 , 5.69]
Kamga 2011	-0.2007	1.0964	3.4%	0.82 [0.10 , 7.02]
Knee 2021	-0.4494	0.259	61.6%	0.64 [0.38 , 1.06]
Mascie-Taylor 1999	1.7918	0.9052	5.0%	6.00 [1.02 , 35.37]
Mascie-Taylor 1999	0	1.4771	1.9%	1.00 [0.06 , 18.08]
Muennoo 1997	0	0.8281	6.0%	1.00 [0.20 , 5.07]
Ndenecho 2002	0.1054	0.6081	11.2%	1.11 [0.34 , 3.66]
Reese 2019	1.150488	1.634978	1.5%	3.16 [0.13 , 77.87]
Steinmann 2014	-0.7419	0.8715	5.4%	0.48 [0.09 , 2.63]
Total (95% CI)			**100.0%**	**0.81 [0.54 , 1.20]**

Heterogeneity: Tau² = 0.00; Chi² = 7.17, df = 8 (P = 0.52); I² = 0%
Test for overall effect: Z = 1.06 (P = 0.29)
Test for subgroup differences: Not applicable



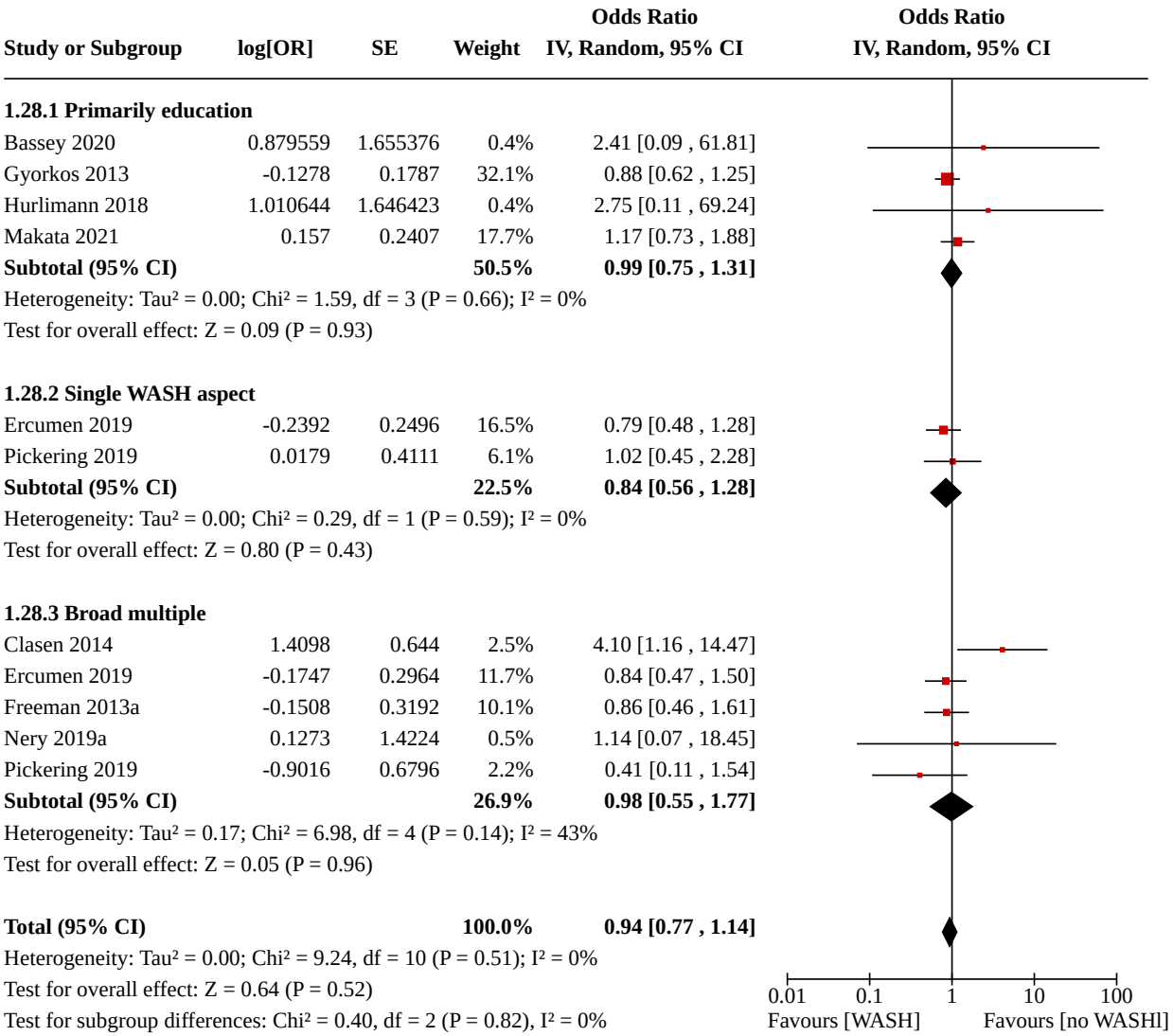
Analysis 1.27. Comparison 1: WASH intervention versus control, Outcome 27: *Trichuris trichiura* prevalence - narrow WASH categories amongst non-RCTs



Footnotes

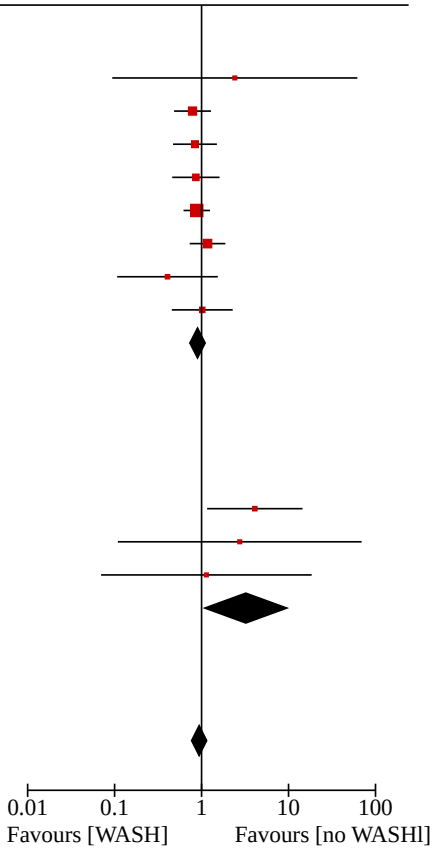
(1) Table notes: We preferentially show the cluster-adjusted odds ratio, as extracted from each paper. If that measure wasn't available, we

Analysis 1.28. Comparison 1: WASH intervention versus control, Outcome 28: *Trichuris trichiura* prevalence amongst RCTs (intervention type subgroup)



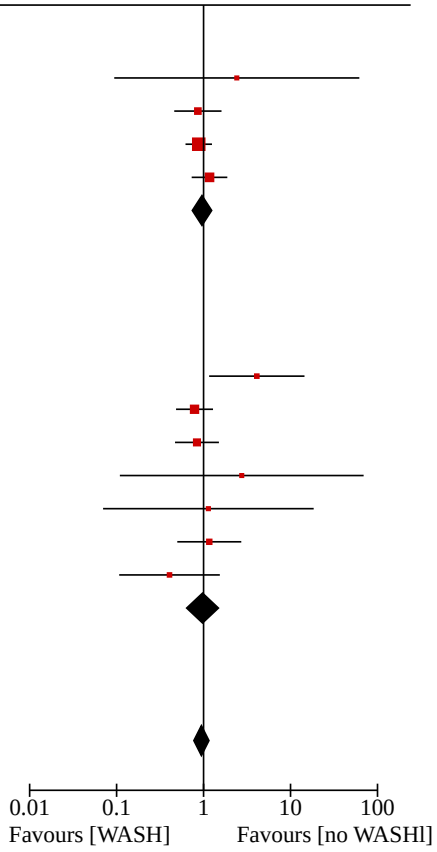
Analysis 1.29. Comparison 1: WASH intervention versus control, Outcome 29: *Trichuris trichiura* prevalence amongst RCTs (age subgroup)

Study or Subgroup	log[OR]	SE	Weight	Odds Ratio IV, Random, 95% CI
1.29.1 Children				
Bassey 2020	0.879559	1.655376	0.4%	2.41 [0.09 , 61.81]
Ercumen 2019	-0.2392	0.2496	16.5%	0.79 [0.48 , 1.28]
Ercumen 2019	-0.1747	0.2964	11.7%	0.84 [0.47 , 1.50]
Freeman 2013a	-0.1508	0.3192	10.1%	0.86 [0.46 , 1.61]
Gyorkos 2013	-0.1278	0.1787	32.1%	0.88 [0.62 , 1.25]
Makata 2021	0.157	0.2407	17.7%	1.17 [0.73 , 1.88]
Pickering 2019	-0.9016	0.6796	2.2%	0.41 [0.11 , 1.54]
Pickering 2019	0.0179	0.4111	6.1%	1.02 [0.45 , 2.28]
Subtotal (95% CI)			**96.6%**	**0.90 [0.73 , 1.10]**
Heterogeneity: Tau² = 0.00; Chi² = 3.38, df = 7 (P = 0.85); I² = 0%				
Test for overall effect: Z = 1.04 (P = 0.30)				
1.29.2 All ages				
Clasen 2014	1.4098	0.644	2.5%	4.10 [1.16 , 14.47]
Hurlimann 2018	1.010644	1.646423	0.4%	2.75 [0.11 , 69.24]
Nery 2019a	0.1273	1.4224	0.5%	1.14 [0.07 , 18.45]
Subtotal (95% CI)			**3.4%**	**3.23 [1.09 , 9.53]**
Heterogeneity: Tau² = 0.00; Chi² = 0.69, df = 2 (P = 0.71); I² = 0%				
Test for overall effect: Z = 2.12 (P = 0.03)				
Total (95% CI)			**100.0%**	**0.94 [0.77 , 1.14]**
Heterogeneity: Tau² = 0.00; Chi² = 9.24, df = 10 (P = 0.51); I² = 0%				
Test for overall effect: Z = 0.64 (P = 0.52)				
Test for subgroup differences: Chi² = 5.17, df = 1 (P = 0.02), I² = 80.7%				



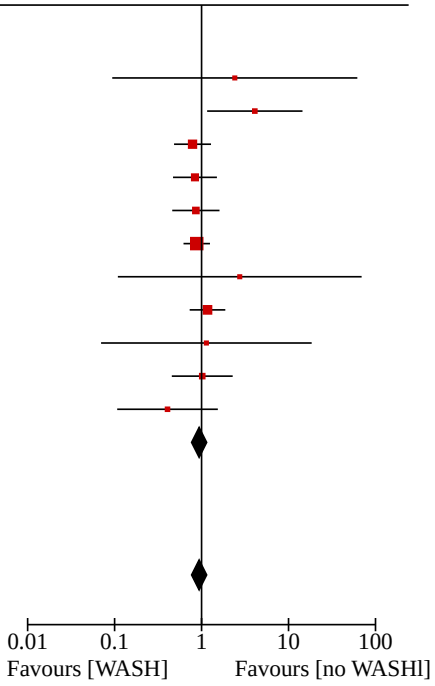
Analysis 1.30. Comparison 1: WASH intervention versus control, Outcome 30: *Trichuris trichiura* prevalence amongst RCTs (school village subgroup)

Study or Subgroup	log[OR]	SE	Weight	Odds Ratio IV, Random, 95% CI
1.30.1 School				
Bassey 2020	0.879559	1.655376	0.4%	2.41 [0.09 , 61.81]
Freeman 2013a	-0.1508	0.3192	10.1%	0.86 [0.46 , 1.61]
Gyorkos 2013	-0.1278	0.1787	32.3%	0.88 [0.62 , 1.25]
Makata 2021	0.157	0.2407	17.8%	1.17 [0.73 , 1.88]
Subtotal (95% CI)			**60.6%**	**0.96 [0.74 , 1.24]**
Heterogeneity: Tau² = 0.00; Chi² = 1.34, df = 3 (P = 0.72); I² = 0%				
Test for overall effect: Z = 0.32 (P = 0.75)				
1.30.2 Village				
Clasen 2014	1.4098	0.644	2.5%	4.10 [1.16 , 14.47]
Ercumen 2019	-0.2392	0.2496	16.6%	0.79 [0.48 , 1.28]
Ercumen 2019	-0.1747	0.2964	11.7%	0.84 [0.47 , 1.50]
Hurlimann 2018	1.010644	1.646423	0.4%	2.75 [0.11 , 69.24]
Nery 2019a	0.1273	1.4224	0.5%	1.14 [0.07 , 18.45]
Pickering 2019	0.1514	0.4322	5.5%	1.16 [0.50 , 2.71]
Pickering 2019	-0.9016	0.6796	2.2%	0.41 [0.11 , 1.54]
Subtotal (95% CI)			**39.4%**	**0.97 [0.64 , 1.48]**
Heterogeneity: Tau² = 0.08; Chi² = 8.07, df = 6 (P = 0.23); I² = 26%				
Test for overall effect: Z = 0.13 (P = 0.90)				
Total (95% CI)			**100.0%**	**0.94 [0.77 , 1.15]**
Heterogeneity: Tau² = 0.00; Chi² = 9.45, df = 10 (P = 0.49); I² = 0%				
Test for overall effect: Z = 0.57 (P = 0.57)				
Test for subgroup differences: Chi² = 0.00, df = 1 (P = 0.95), I² = 0%				

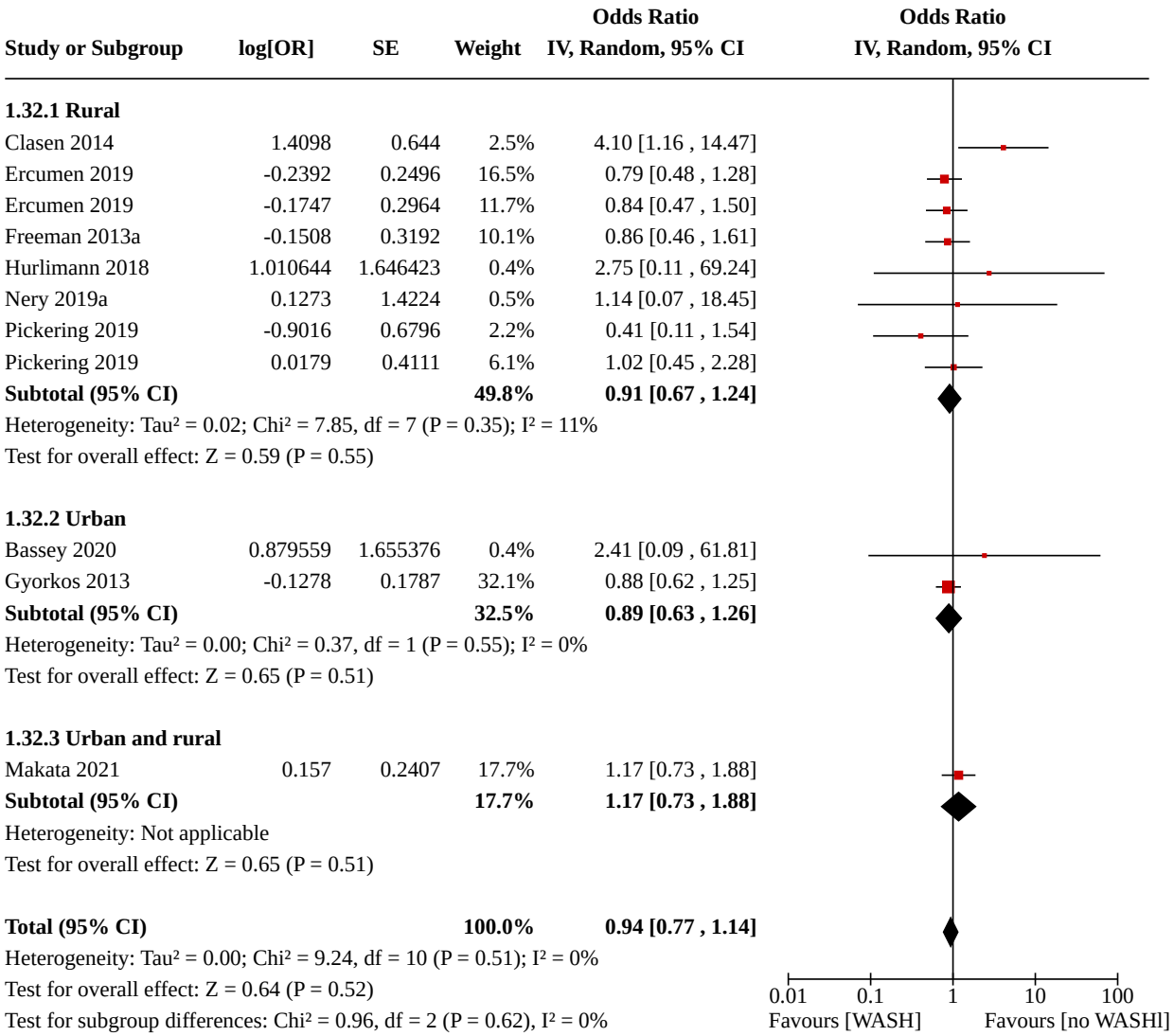


Analysis 1.31. Comparison 1: WASH intervention versus control, Outcome 31: *Trichuris trichiura* prevalence amongst RCTs (MDA subgroup)

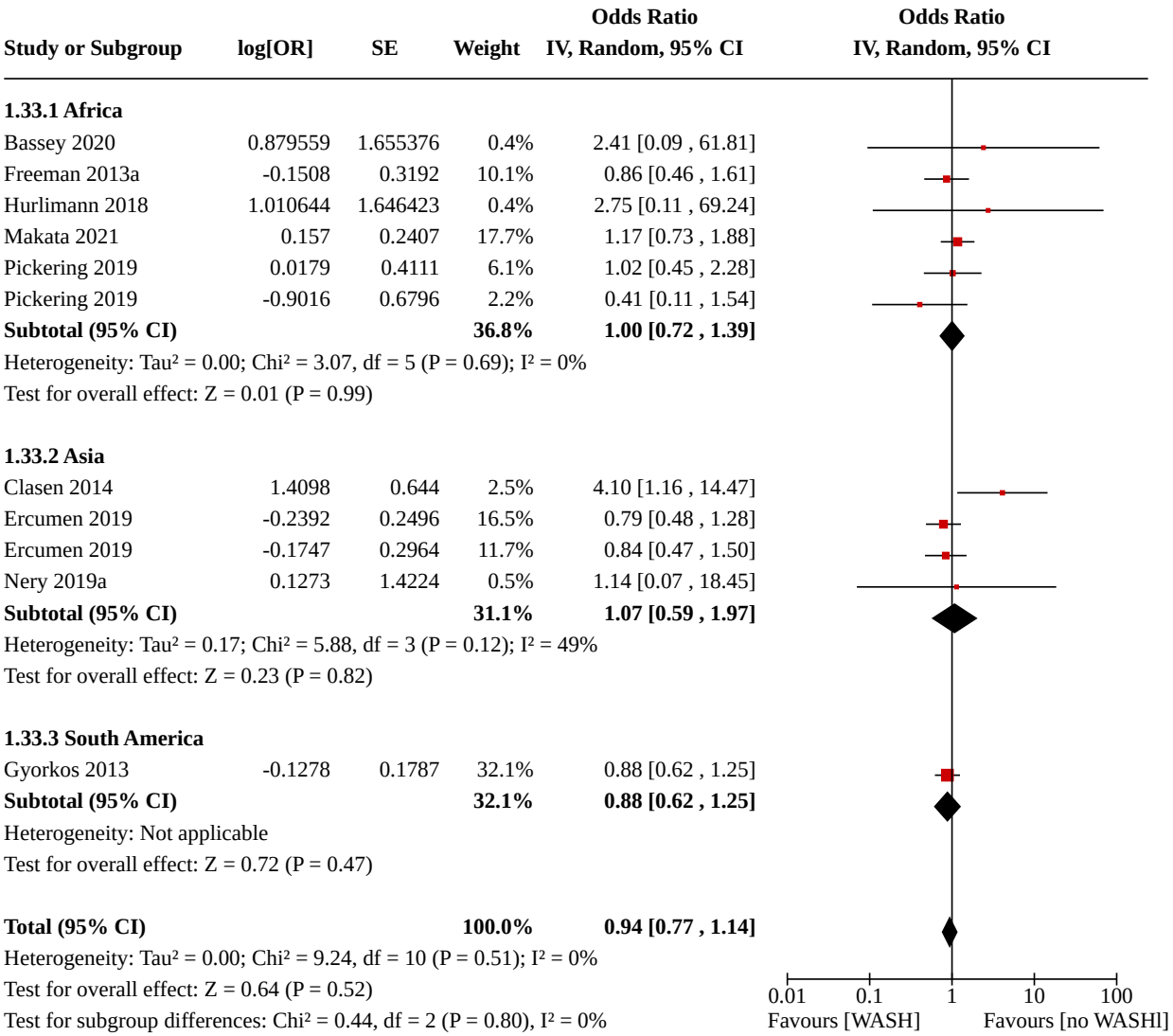
Study or Subgroup	log[OR]	SE	Weight	Odds Ratio IV, Random, 95% CI
1.31.1 Underpinned with drug treatment				
Bassey 2020	0.879559	1.655376	0.4%	2.41 [0.09 , 61.81]
Clasen 2014	1.4098	0.644	2.5%	4.10 [1.16 , 14.47]
Ercumen 2019	-0.2392	0.2496	16.5%	0.79 [0.48 , 1.28]
Ercumen 2019	-0.1747	0.2964	11.7%	0.84 [0.47 , 1.50]
Freeman 2013a	-0.1508	0.3192	10.1%	0.86 [0.46 , 1.61]
Gyorkos 2013	-0.1278	0.1787	32.1%	0.88 [0.62 , 1.25]
Hurlimann 2018	1.010644	1.646423	0.4%	2.75 [0.11 , 69.24]
Makata 2021	0.157	0.2407	17.7%	1.17 [0.73 , 1.88]
Nery 2019a	0.1273	1.4224	0.5%	1.14 [0.07 , 18.45]
Pickering 2019	0.0179	0.4111	6.1%	1.02 [0.45 , 2.28]
Pickering 2019	-0.9016	0.6796	2.2%	0.41 [0.11 , 1.54]
Subtotal (95% CI)			**100.0%**	**0.94 [0.77 , 1.14]**
Heterogeneity: Tau² = 0.00; Chi² = 9.24, df = 10 (P = 0.51); I² = 0%				
Test for overall effect: Z = 0.64 (P = 0.52)				
Total (95% CI)			**100.0%**	**0.94 [0.77 , 1.14]**
Heterogeneity: Tau² = 0.00; Chi² = 9.24, df = 10 (P = 0.51); I² = 0%				
Test for overall effect: Z = 0.64 (P = 0.52)				
Test for subgroup differences: Not applicable				



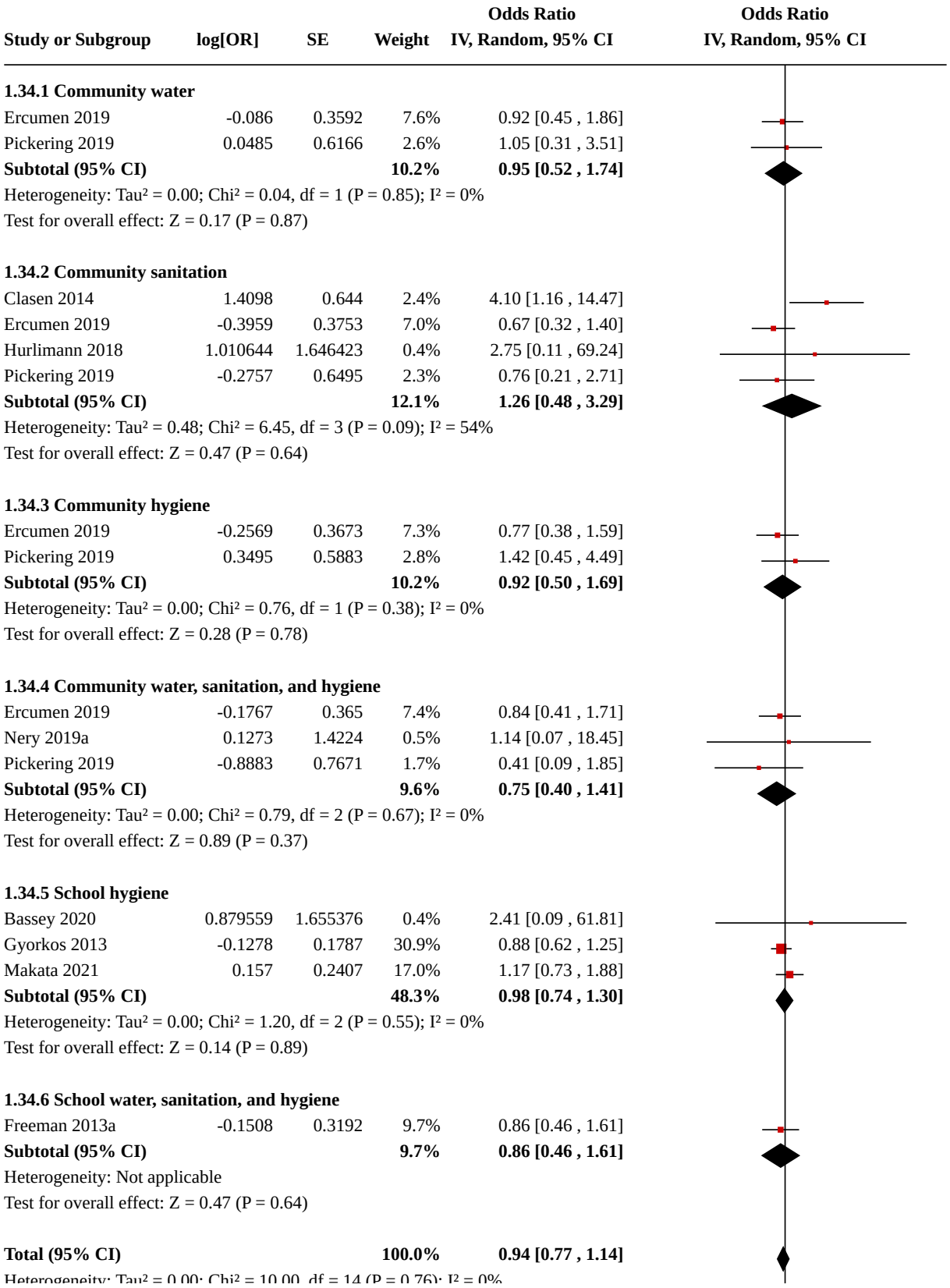
Analysis 1.32. Comparison 1: WASH intervention versus control, Outcome 32: *Trichuris trichiura* prevalence amongst RCTs (rural urban subgroup)



Analysis 1.33. Comparison 1: WASH intervention versus control, Outcome 33: *Trichuris trichiura* prevalence amongst RCTs (world region subgroup)

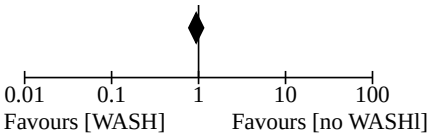


Analysis 1.34. Comparison 1: WASH intervention versus control, Outcome 34: *Trichuris trichiura* prevalence - narrow WASH categories amongst RCTs



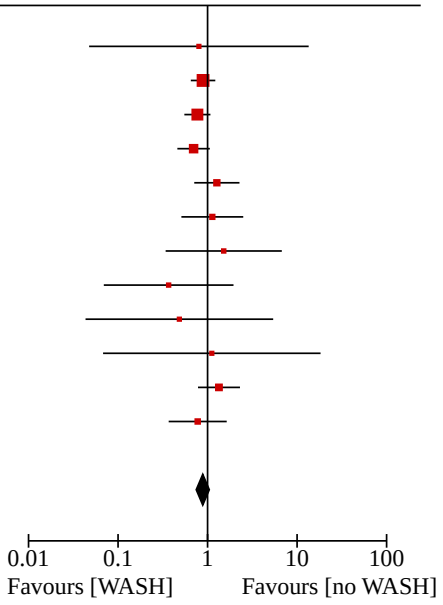
Analysis 1.34. (Continued)

Total (95% CI)	**100.0%**	**0.94 [0.77 , 1.14]**
Heterogeneity: Tau² = 0.00; Chi² = 10.00, df = 14 (P = 0.76); I² = 0%		
Test for overall effect: Z = 0.63 (P = 0.53)		
Test for subgroup differences: Chi² = 1.01, df = 5 (P = 0.96), I² = 0%		



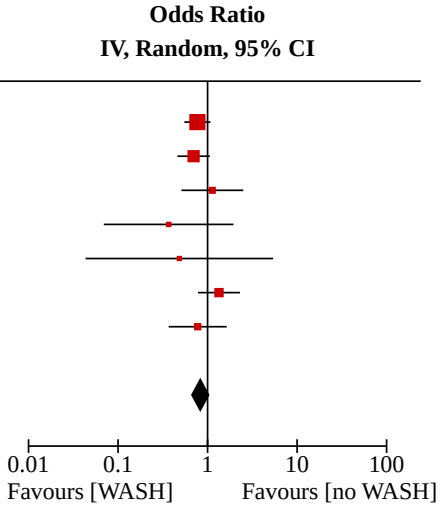
Analysis 1.35. Comparison 1: WASH intervention versus control, Outcome 35: Hookworm prevalence amongst RCTs

Study or Subgroup	log[OR]	SE	Weight	Odds Ratio IV, Random, 95% CI
Bassey 2020	-0.2231	1.4405	0.4%	0.80 [0.05 , 13.47]
Clasen 2014	-0.1162	0.1607	28.2%	0.89 [0.65 , 1.22]
Ercumen 2019	-0.2619	0.171	24.9%	0.77 [0.55 , 1.08]
Ercumen 2019	-0.3594	0.213	16.1%	0.70 [0.46 , 1.06]
Freeman 2013a	0.239	0.2967	8.3%	1.27 [0.71 , 2.27]
Gyorkos 2013	0.1222	0.4059	4.4%	1.13 [0.51 , 2.50]
Hurlimann 2018	0.4155	0.7623	1.3%	1.52 [0.34 , 6.75]
Mahmud 2015	-1.0012	0.8511	1.0%	0.37 [0.07 , 1.95]
Makata 2021	-0.7257	1.2314	0.5%	0.48 [0.04 , 5.41]
Nery 2019a	0.1092	1.4271	0.4%	1.12 [0.07 , 18.29]
Pickering 2019	0.2937	0.2753	9.6%	1.34 [0.78 , 2.30]
Pickering 2019	-0.2541	0.3808	5.0%	0.78 [0.37 , 1.64]
Total (95% CI)			**100.0%**	**0.88 [0.75 , 1.04]**
Heterogeneity: Tau² = 0.00; Chi² = 7.99, df = 11 (P = 0.71); I² = 0%				
Test for overall effect: Z = 1.45 (P = 0.15)				
Test for subgroup differences: Not applicable				



Analysis 1.36. Comparison 1: WASH intervention versus control, Outcome 36: Hookworm prevalence amongst RCTs - low risk of bias studies only

Study or Subgroup	log[OR]	SE	Weight	Odds Ratio IV, Random, 95% CI
Ercumen 2019	-0.2619	0.171	40.5%	0.77 [0.55 , 1.08]
Ercumen 2019	-0.3594	0.213	26.1%	0.70 [0.46 , 1.06]
Gyorkos 2013	0.1222	0.4059	7.2%	1.13 [0.51 , 2.50]
Mahmud 2015	-1.0012	0.8511	1.6%	0.37 [0.07 , 1.95]
Makata 2021	-0.7257	1.2314	0.8%	0.48 [0.04 , 5.41]
Pickering 2019	0.2937	0.2753	15.6%	1.34 [0.78 , 2.30]
Pickering 2019	-0.2541	0.3808	8.2%	0.78 [0.37 , 1.64]
Total (95% CI)			**100.0%**	**0.83 [0.67 , 1.03]**
Heterogeneity: Tau² = 0.00; Chi² = 5.61, df = 6 (P = 0.47); I² = 0%				
Test for overall effect: Z = 1.73 (P = 0.08)				
Test for subgroup differences: Not applicable				



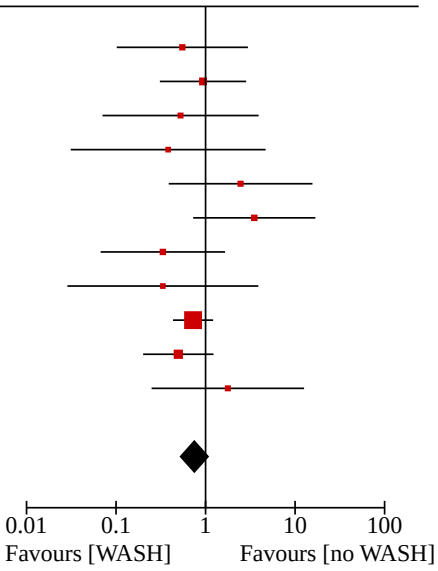
Analysis 1.37. Comparison 1: WASH intervention versus control, Outcome 37: Hookworm prevalence amongst non-RCTs

Study or Subgroup	log[OR]	SE	Weight	Odds Ratio IV, Random, 95% CI
Al Delaimy 2014	-0.5978	0.8608	4.4%	0.55 [0.10 , 2.97]
Arfaa 1977	-0.066	0.5661	10.1%	0.94 [0.31 , 2.84]
Arfaa 1977	-0.6436	1.0243	3.1%	0.53 [0.07 , 3.91]
Kamga 2011	-0.9614	1.279	2.0%	0.38 [0.03 , 4.69]
Mascie-Taylor 1999	0.9008	0.9431	3.6%	2.46 [0.39 , 15.63]
Mascie-Taylor 1999	1.2528	0.8018	5.0%	3.50 [0.73 , 16.85]
Muennoo 1997	-1.0986	0.8165	4.8%	0.33 [0.07 , 1.65]
Ndenecho 2002	-1.0986	1.2528	2.1%	0.33 [0.03 , 3.88]
Reese 2019	-0.3217	0.2629	46.7%	0.72 [0.43 , 1.21]
Reese 2019	-0.701	0.4618	15.1%	0.50 [0.20 , 1.23]
Steinmann 2014	0.5725	1.0006	3.2%	1.77 [0.25 , 12.60]
Total (95% CI)			**100.0%**	**0.75 [0.53 , 1.06]**

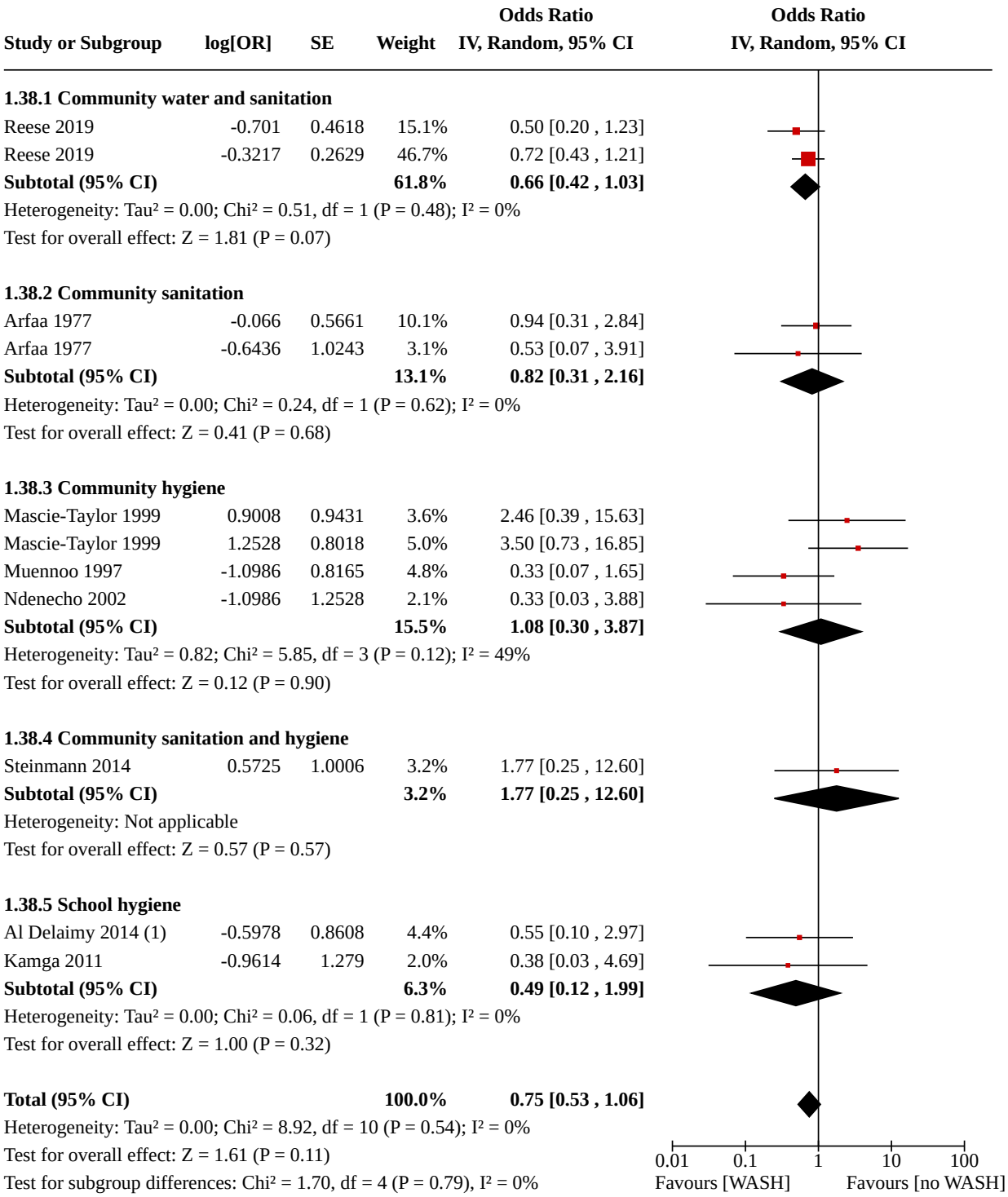
Heterogeneity: Tau² = 0.00; Chi² = 8.92, df = 10 (P = 0.54); I² = 0%

Test for overall effect: Z = 1.61 (P = 0.11)

Test for subgroup differences: Not applicable



Analysis 1.38. Comparison 1: WASH intervention versus control, Outcome 38: Hookworm prevalence - narrow WASH categories amongst non-RCTs

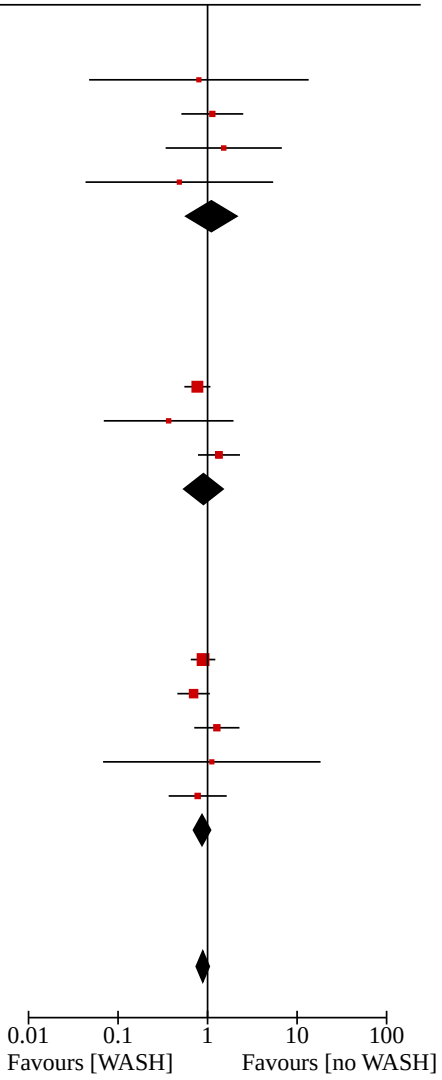


Footnotes

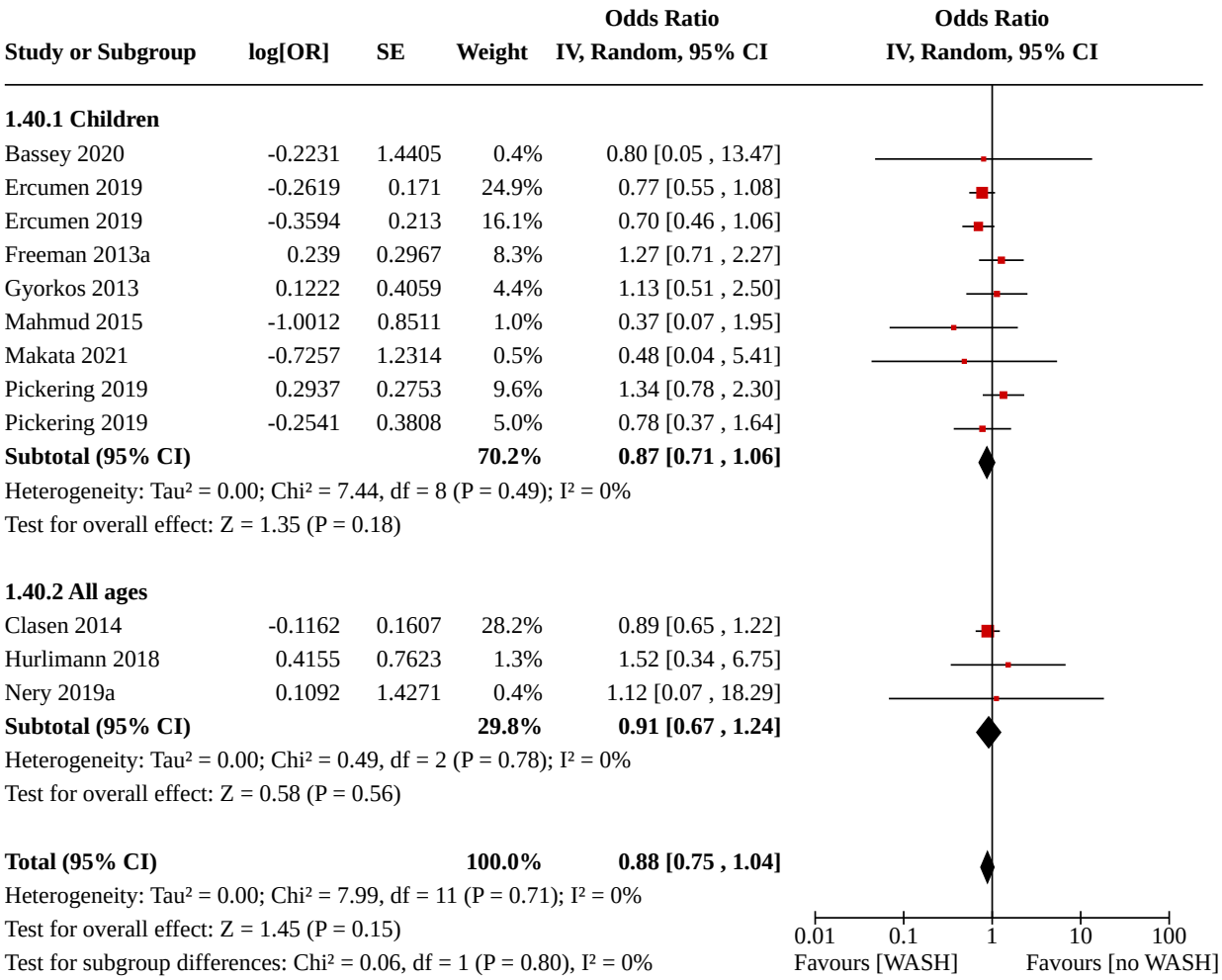
(1) Table notes: We preferentially show the cluster-adjusted odds ratio, as extracted from each paper. If that measure wasn't available

Analysis 1.39. Comparison 1: WASH intervention versus control, Outcome 39: Hookworm prevalence amongst RCTs (intervention type subgroup)

Study or Subgroup	log[OR]	SE	Weight	Odds Ratio IV, Random, 95% CI
1.39.1 Primarily education				
Bassey 2020	-0.2231	1.4405	0.4%	0.80 [0.05 , 13.47]
Gyorkos 2013	0.1222	0.4059	4.4%	1.13 [0.51 , 2.50]
Hurlimann 2018	0.4155	0.7623	1.3%	1.52 [0.34 , 6.75]
Makata 2021	-0.7257	1.2314	0.5%	0.48 [0.04 , 5.41]
Subtotal (95% CI)			**6.5%**	**1.10 [0.57 , 2.12]**
Heterogeneity: Tau² = 0.00; Chi² = 0.67, df = 3 (P = 0.88); I² = 0%				
Test for overall effect: Z = 0.29 (P = 0.77)				
1.39.2 Single WASH aspect				
Ercumen 2019	-0.2619	0.171	24.9%	0.77 [0.55 , 1.08]
Mahmud 2015	-1.0012	0.8511	1.0%	0.37 [0.07 , 1.95]
Pickering 2019	0.2937	0.2753	9.6%	1.34 [0.78 , 2.30]
Subtotal (95% CI)			**35.5%**	**0.90 [0.54 , 1.49]**
Heterogeneity: Tau² = 0.09; Chi² = 4.01, df = 2 (P = 0.13); I² = 50%				
Test for overall effect: Z = 0.41 (P = 0.68)				
1.39.3 Broad multiple				
Clasen 2014	-0.1162	0.1607	28.2%	0.89 [0.65 , 1.22]
Ercumen 2019	-0.3594	0.213	16.1%	0.70 [0.46 , 1.06]
Freeman 2013a	0.239	0.2967	8.3%	1.27 [0.71 , 2.27]
Nery 2019a	0.1092	1.4271	0.4%	1.12 [0.07 , 18.29]
Pickering 2019	-0.2541	0.3808	5.0%	0.78 [0.37 , 1.64]
Subtotal (95% CI)			**57.9%**	**0.87 [0.70 , 1.08]**
Heterogeneity: Tau² = 0.00; Chi² = 2.83, df = 4 (P = 0.59); I² = 0%				
Test for overall effect: Z = 1.28 (P = 0.20)				
Total (95% CI)			**100.0%**	**0.88 [0.75 , 1.04]**
Heterogeneity: Tau² = 0.00; Chi² = 7.99, df = 11 (P = 0.71); I² = 0%				
Test for overall effect: Z = 1.45 (P = 0.15)				
Test for subgroup differences: Chi² = 0.47, df = 2 (P = 0.79), I² = 0%				

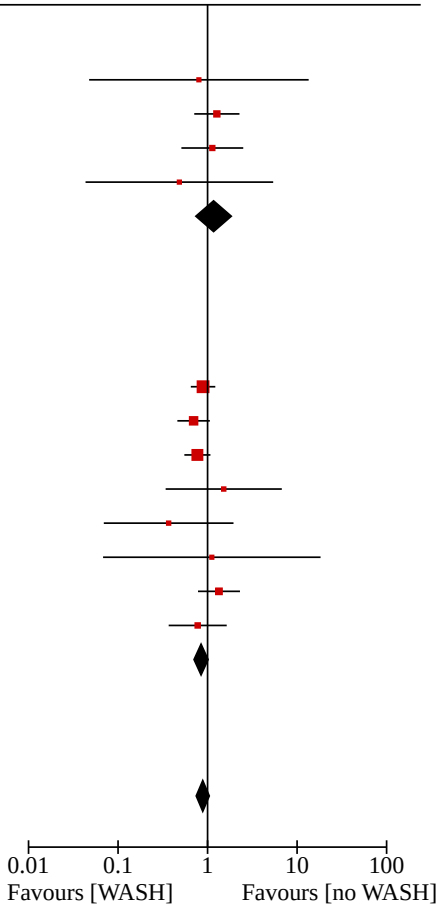


Analysis 1.40. Comparison 1: WASH intervention versus control, Outcome 40: Hookworm prevalence amongst RCTs (age subgroup)

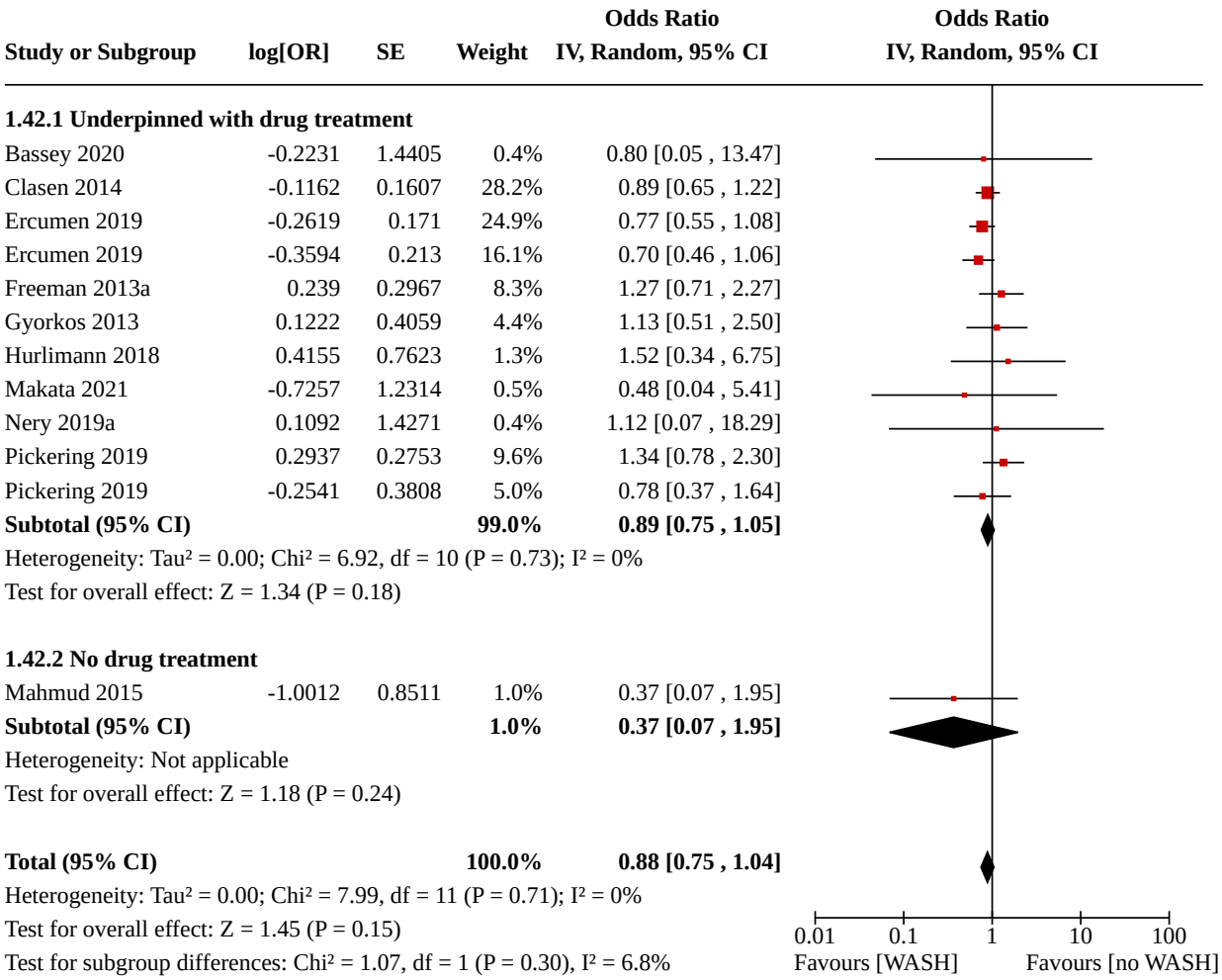


Analysis 1.41. Comparison 1: WASH intervention versus control, Outcome 41: Hookworm prevalence amongst RCTs (school village subgroup)

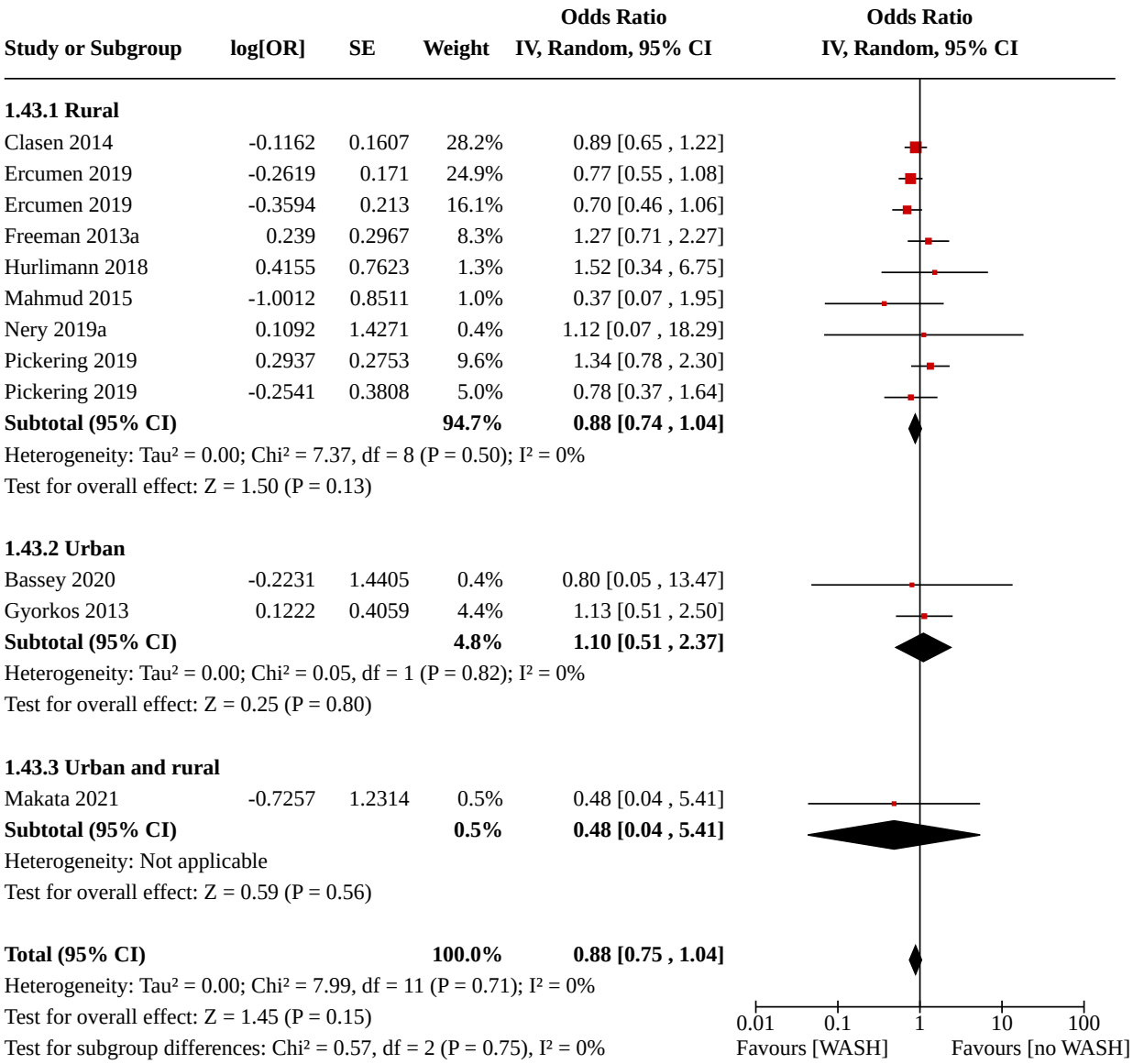
Study or Subgroup	log[OR]	SE	Weight	Odds Ratio IV, Random, 95% CI
1.41.1 School				
Bassey 2020	-0.2231	1.4405	0.4%	0.80 [0.05 , 13.47]
Freeman 2013a	0.239	0.2967	8.3%	1.27 [0.71 , 2.27]
Gyorkos 2013	0.1222	0.4059	4.4%	1.13 [0.51 , 2.50]
Makata 2021	-0.7257	1.2314	0.5%	0.48 [0.04 , 5.41]
Subtotal (95% CI)			**13.5%**	**1.17 [0.74 , 1.84]**
Heterogeneity: Tau² = 0.00; Chi² = 0.67, df = 3 (P = 0.88); I² = 0%				
Test for overall effect: Z = 0.67 (P = 0.51)				
1.41.2 Village				
Clasen 2014	-0.1162	0.1607	28.2%	0.89 [0.65 , 1.22]
Ercumen 2019	-0.3594	0.213	16.1%	0.70 [0.46 , 1.06]
Ercumen 2019	-0.2619	0.171	24.9%	0.77 [0.55 , 1.08]
Hurlimann 2018	0.4155	0.7623	1.3%	1.52 [0.34 , 6.75]
Mahmud 2015	-1.0012	0.8511	1.0%	0.37 [0.07 , 1.95]
Nery 2019a	0.1092	1.4271	0.4%	1.12 [0.07 , 18.29]
Pickering 2019	0.2937	0.2753	9.6%	1.34 [0.78 , 2.30]
Pickering 2019	-0.2541	0.3808	5.0%	0.78 [0.37 , 1.64]
Subtotal (95% CI)			**86.5%**	**0.85 [0.71 , 1.01]**
Heterogeneity: Tau² = 0.00; Chi² = 5.66, df = 7 (P = 0.58); I² = 0%				
Test for overall effect: Z = 1.82 (P = 0.07)				
Total (95% CI)			**100.0%**	**0.88 [0.75 , 1.04]**
Heterogeneity: Tau² = 0.00; Chi² = 7.99, df = 11 (P = 0.71); I² = 0%				
Test for overall effect: Z = 1.45 (P = 0.15)				
Test for subgroup differences: Chi² = 1.67, df = 1 (P = 0.20), I² = 39.9%				



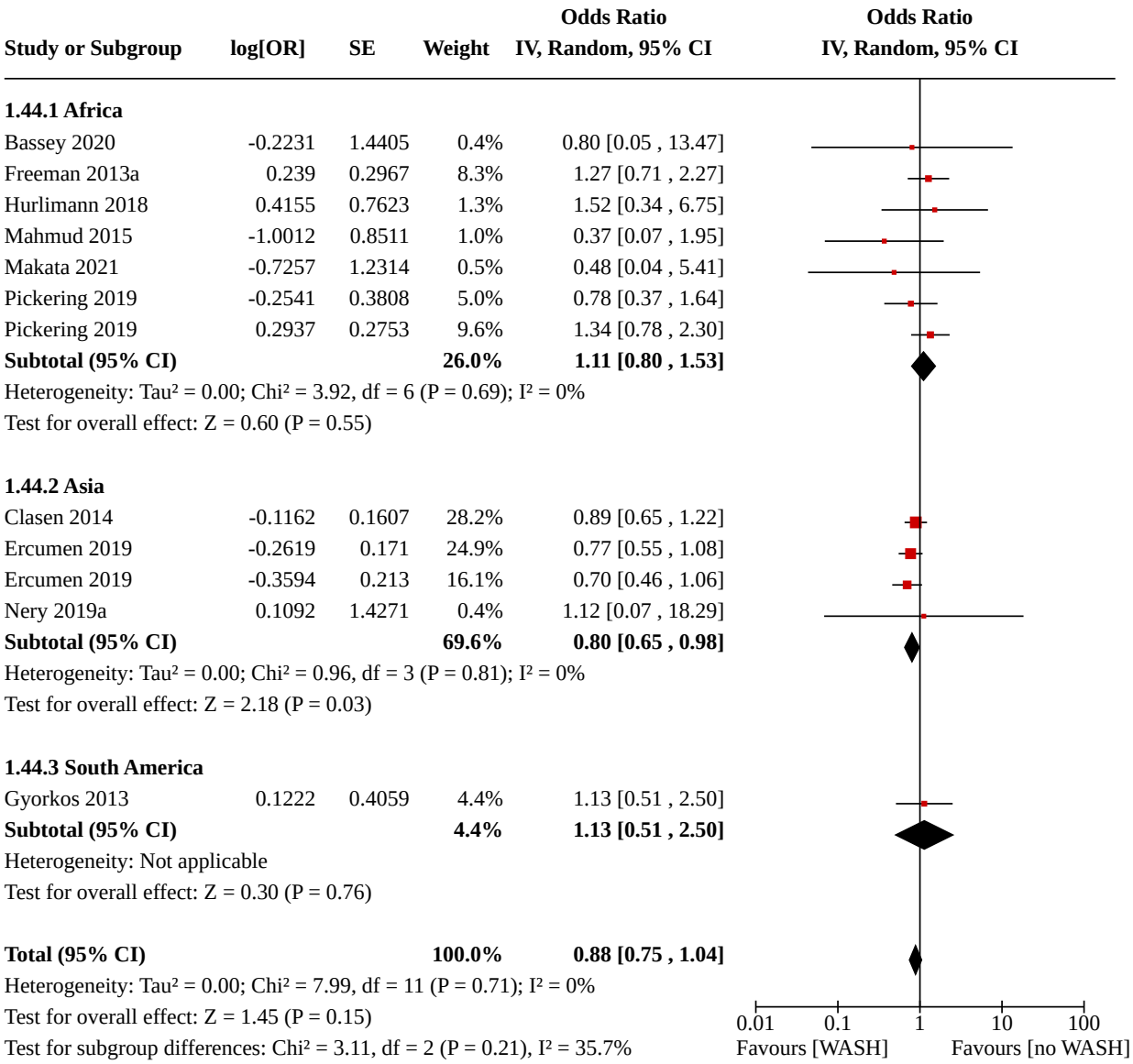
Analysis 1.42. Comparison 1: WASH intervention versus control, Outcome 42: Hookworm prevalence amongst RCTs (MDA subgroup)



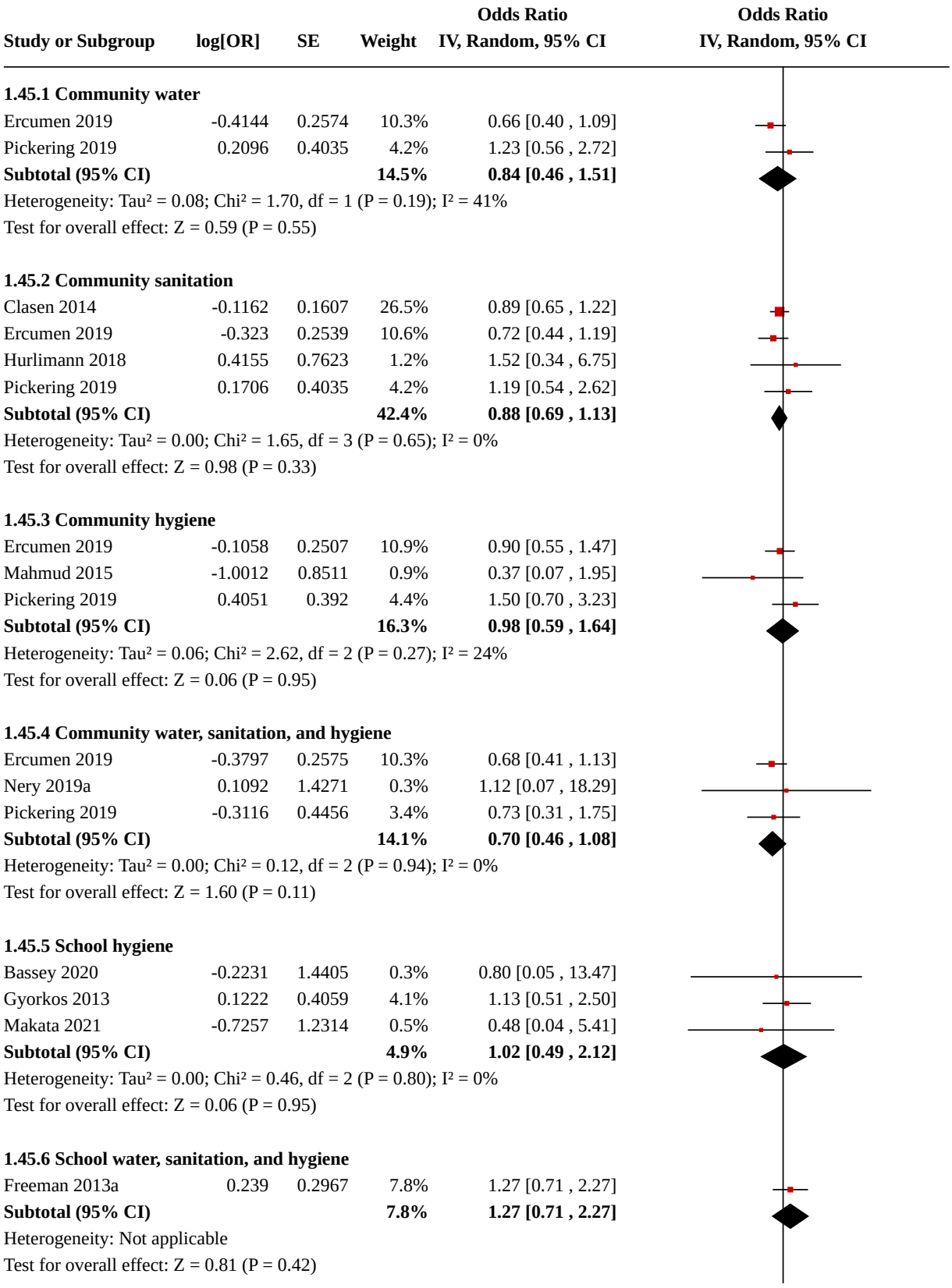
Analysis 1.43. Comparison 1: WASH intervention versus control, Outcome 43: Hookworm prevalence amongst RCTs (rural urban subgroup)



Analysis 1.44. Comparison 1: WASH intervention versus control, Outcome 44: Hookworm prevalence amongst RCTs (world region subgroup)



Analysis 1.45. Comparison 1: WASH intervention versus control, Outcome 45: Hookworm prevalence - narrow WASH categories amongst RCTs

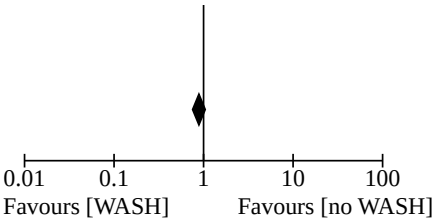


Analysis 1.45. (Continued)

Heterogeneity: Not applicable
Test for overall effect: Z = 0.81 (P = 0.42)

Total (95% CI)	**100.0%**	**0.89 [0.75 , 1.04]**

Heterogeneity: Tau² = 0.00; Chi² = 9.79, df = 15 (P = 0.83); I² = 0%
Test for overall effect: Z = 1.45 (P = 0.15)
Test for subgroup differences: Chi² = 2.90, df = 5 (P = 0.72), I² = 0%



ADDITIONAL TABLES

Table 1. Description of study settings

Study ID	Population	Country	Study design	Urban status	Intervention category	Outcomes assessed	Study duration (months)
Bassey 2020	**Clusters** 6 schools **Individuals** 255 schoolchildren ages 5 to 10	Nigeria	cRCT	Urban	Primarily education	Any STH; *Ascaris lumbricoides*; *Trichuris trichiura*; hookworm	8
Bieri 2013	**Clusters** 38 schools **Individuals** 1718 schoolchildren ages 5 to 14	China	cRCT	Rural	Primarily education	Any STH	10
Chard 2019	**Clusters** 100 schools **Individuals** 9258 primary school-aged children	Lao PDR	cRCT	Rural	Broad multiple	Any STH	33
Clasen 2014	**Clusters** 100 villages **Individuals** 4294 participants of all ages	India	cRCT	Rural	Broad multiple	Any STH; *Ascaris lumbricoides*; *Trichuris trichiura*; hookworm	44
Dumba 2013	**Clusters** 19 villages **Individuals** 558 children ages < 5	Uganda	cRCT	Rural	Primarily education	Any STH	-
Ercumen 2019	**Clusters** 540 geographic clusters assessing WASH **Individuals** 3685 and 1706 children ages 2 to 12	Bangladesh	cRCT	Rural	Single WASH aspect and broad multiple	Any STH; *Ascaris lumbricoides*; *Trichuris trichiura*; hookworm	48
Erismann 2017	**Clusters** 8 schools **Individuals** 360 children ages 8 to 15	Burkina Faso	cRCT	Rural	Broad multiple	Any STH	13

Table 1. Description of study settings *(Continued)*

Freeman 2013a	**Clusters** 39 schools **Individuals** 1113 children ages 7 to 13	Kenya	cRCT	Rural	Broad multiple	Any STH; *Ascaris lumbricoides*; *Trichuris trichiura*; hookworm	23
Gyorkos 2013	**Clusters** 18 schools **Individuals** 1089 children age 10	Peru	cRCT	Urban /peri-urban	Primarily education	Any STH; *Ascaris lumbricoides*	7
Han 1988	**Individuals** 239 children ages 3 to 4	Burma/Myanmar	RCT[a]	Rural	Single WASH aspect	*Ascaris lumbricoides*	-
Hurlimann 2018	**Clusters** 9 villages **Individuals** 810 participants of all ages	Côte d'Ivoire	cRCT	Rural	Primarily education	Any STH; *Ascaris lumbricoides*; *Trichuris trichiura*; hookworm	13
Mahmud 2015	**Clusters** 107 households (household is the cluster) **Individuals** 178 children ages 6 to 15	Ethiopia	cRCT	Rural	Single WASH aspect	Any STH; *Ascaris lumbricoides*; hookworm	8
Makata 2021	**Clusters** 16 schools **Individuals** 3081 school-age children	Tanzania	cRCT	Urban and rural	Primarily education	Any STH; *Ascaris lumbricoides*; *Trichuris trichiura*; hookworm	12
Nery 2019a	**Clusters** 18 villages **Individuals** 1178 participants ages 1+	Timor-Leste	cRCT	Rural	Broad multiple	*Ascaris lumbricoides*; *Trichuris trichiura*; hookworm; hookworm	24
Patil 2014	**Clusters** 80 villages **Individuals** 1150 children ages < 5	India	cRCT	Rural	Broad multiple	Any STH; *Ascaris lumbricoides*	24
Pickering 2019	**Clusters** 465 clusters **Individuals** 4576 and 2226 children ages 2 to 15	Kenya	cRCT	Rural	Single WASH aspect and broad multiple	Any STH; *Ascaris lumbricoides*; hookworm	44

Table 1. Description of study settings *(Continued)*

Albright 2006	**Clusters** 50 schools **Individuals** 3463 children ages 6 to 12	Indonesia	cNON-RCT	Urban and rural	Primarily education	Any STH	10
Al-Delaimy 2014	**Clusters** 2 schools **Individuals** 317 children ages 7 to 11	Malaysia	cNON-RCT	Rural	Primarily education	*Ascaris lumbricoides*; *Trichuris trichiura*; hookworm	11
Arfaa 1977	**Clusters** 8 and 6 villages **Individuals** 1155 and 580 participants of all ages	Iran	cNON-RCT	Rural	Broad multiple	*Ascaris lumbricoides*; hookworm	48
Duijster 2017	**Clusters** 20, 18, and 44 schools **Individuals** 478, 486, and 535 children ages 6 to 7	Cambodia, Indonesia, Lao PDR	cNON-RCT	Urban and rural	Broad multiple	Any STH	24
Gray 2019	**Clusters** 2 villages **Individuals** 527 individuals ages 3 to 70	Indonesia	cNON-RCT[b]	Rural	Broad multiple	Any STH	8
Gungoren 2007	**Clusters** 8 villages **Individuals** 178 children ages 2 to 14	Uzbekistan	cNON-RCT	Rural	Primarily education	Any STH	14
Hadidjaja 1998	**Clusters** 2 and 2 schools **Individuals** 535 and 314 children ages 6 to 8	Indonesia	cNON-RCT[b]	Urban	Primarily education	*Ascaris lumbricoides*	5
Kamga 2011	**Clusters** 2 schools **Individuals** 370 children ages 5 to 15	Cameroon	cNON-RCT[b]	Rural	Primarily education	*Ascaris lumbricoides*; *Trichuris trichiura*; hookworm	-
Knee 2021	**Clusters** 408 compounds **Individuals**	Mozambique	cNON-RCT	Urban	Broad multiple	Any STH; *Ascaris lumbricoides*; *Trichuris trichiura*	24

Table 1. Description of study settings *(Continued)*

	545 children age 1 to 48 months at the beginning of the study						
Mascie-Taylor 1999	**Clusters** 2 and 2 areas **Individuals** 1100 and 1100 children ages 2 to 8	Bangladesh	cNON-RCT[b]	Rural	Primarily education	*Ascaris lumbricoides*; *Trichuris trichiura*; hookworm	18
Monse 2013	**Clusters** 7 schools **Individuals** 341 children ages 6 to 7	Philippines	cNON-RCT	-	Single WASH aspect	Any STH	-
Muennoo 1997	**Clusters** 2 villages **Individuals** 767 participants, ages not reported	Thailand	cNON-RCT	Rural	Primarily education	*Ascaris lumbricoides*; *Trichuris trichiura*; hookworm	-
Ndenecho 2002	**Clusters** 6 schools **Individuals** 148 children ages 8 to 15	Cameroon	cNON-RCT	Urban, suburban, and rural	Primarily education	*Ascaris lumbricoides*; *Trichuris trichiura*; hookworm	-
Park 2016	**Clusters** 2 villages **Individuals** 99 children ages 3 to 13	Indonesia	cNON-RCT	Suburban	Broad multiple	Any STH	-
Reese 2019	**Clusters** 90 villages **Individuals** 775 children ages < 5, 1457 children ages 5+	India	cNON-RCT	Rural	Broad multiple	Any STH; *Trichuris trichiura*; hookworm	17
Steinmann 2014	**Clusters** 2 villages **Individuals** 200 participants ages 2+	China	cNON-RCT	Rural	Broad multiple	*Ascaris lumbricoides*; *Trichuris trichiura*; hookworm; *Strongyloides stercoralis*	65

Abbreviations: cNON-RCT: cluster-non-randomized controlled trial; cRCT: cluster-randomized controlled trial; RCT: randomized controlled trial; STH: soil-transmitted helminth; WASH: water, sanitation, and hygiene

[a]The study states that "children were randomly assigned", but the intervention appears to have been implemented at the household level, and it is not clear if multiple children were included in each household or if the design was a cluster or individual RCT.

[b]This study was classified as a non-RCT. Whilst the study did use a random mechanism to allocate the intervention, there was only one intervention area compared to one control area, so randomization in this case is not likely to reduce confounding or imbalances.

Table 2. Characteristics of interventions

Study ID	Design details	Intervention category	Intervention delivery	Intervention description	Control description	MDA underpinning
Bassey 2020	**Design** cRCT **Total clusters** 6 schools **Allocation of clusters** 3 schools randomized to intervention, 3 to control	*Primarily education* Software	Intervention was designed, implemented, and evaluated by the study team.	A health education board game called "Worms and Ladders" was implemented in intervention schools to communicate health education messages to schoolchildren across 6 schools. The game is based on the concept of reward for good health behaviour by moving up a ladder, and punishment for risky health behaviour by being bitten by the STH worms.	"Snake and Ladder" board game	Yes. Following baseline assessments, the selected schools were dewormed using 400 mg albendazole (single dose).
Bieri 2013	**Design** cRCT **Total clusters** 38 schools **Allocation of clusters** 19 schools randomized to intervention, 19 to control	*Primarily education* Software	The intervention was delivered by colleagues at the at the diagnostic laboratory of the Linxiang Center for Disease Control.	The intervention comprised multiple education components, including a 12-minute cartoon that informed children about the transmission and prevention of STHs, a period for students to ask questions and hold a classroom discussion, a handout pamphlet, a drawing competition, and an essay competition.	Only received the poster and albendazole if infected	Yes. After the baseline assessment, all participants in the intervention and control schools were given a 400 mg single oral dose of albendazole.
Chard 2019	**Design** cRCT **Total clusters** 100 schools **Allocation of clusters** 50 schools randomized to intervention, 50 to control	*Broad multiple* Hardware and software	The intervention was implemented by the Ministry of Health and Ministry of Education and Sports, Government of Lao PDR, with technical support from UNICEF.	A comprehensive school WASH intervention comprising the provision of a school water supply, sanitation facilities, individual and group handwashing, and facilities, drinking water filters, and behaviour change education and promotion	Continued as usual, and received the intervention after research activities ended	No
Clasen 2014	**Design** cRCT	*Broad multiple*	The intervention was delivered by	Latrine promotion and construction in accordance with the Government of India's Total Sanitation Campaign, which combined social mobilization with a post hoc	Villages randomly assigned to control in-	Yes. After baseline stool collection,

Table 2. Characteristics of interventions *(Continued)*

	Total clusters 100 villages **Allocation of clusters** 50 villages randomized to intervention, 50 to control	Hardware and software	WaterAid, an international non-governmental organizations, and their local partners.	subsidy. Each participating below-poverty-line household was provided with a latrine, and households contributed sand, bricks, and labor. The subsidy did not cover the cost of full walls, door, and roof.	tervention carried on with usual WASH behaviours and facilities, given 1-dose albendazole after baseline stool collection.	one 400 mg dose of albendazole (200 mg for children), a broad-spectrum anthelmintic, was given to individuals enrolled for stool sampling (except women in their first trimester of pregnancy).
Dumba 2013	**Design** cRCT **Total clusters** 19 villages **Allocation of clusters** 10 villages randomized to intervention, 9 to control	*Primarily education* Software	The interventions were developed and delivered by the study team.	Participatory Hygiene and Sanitation Transformation (PHAST) health education in 19 villages, a participatory approach developed to encourage people to analyse their own situation and identify key problems, decide what things need to be improved, plan how they are going to do it, and then act. The PHAST intervention was carried out 3 times amongst the parents and guardians in the intervention group. After each training session, the respondents' households were visited to reinforce what had been discussed during the training.	Treated with albendazole and continued as usual	Yes. All the children were treated with a single oral dose (dose depending on age) of albendazole once every 3 months.
Ercumen 2019	**Design** cRCT **Total clusters** 540 geographic clusters **Allocation of clusters** 90 clusters randomized to water, 90 to sanitation, 90 to hygiene; 90 to WASH; 180 to control	*Single WASH aspect and broad multiple* Hardware and software	The interventions were delivered by icddr,b staff.	This trial evaluated the impact (alone and in concert) of multiple study arms; we have focused on those related to WASH. The first arm included water treatment through chlorination with sodium dichloroisocyanurate (NaDCC) tablets coupled with safe storage in a narrow-mouth lidded vessel with a spigot. The second arm included sanitation improvements by upgrading to concrete-lined double-pit latrines and the provision of child potties and sani-scoops for faeces disposal. The third intervention included handwashing promotion by providing handwashing stations with a water reservoir and a bottle of soapy water mixture at the food preparation and latrine areas. The fourth study arm combined the water treatment, sanitation, and handwashing interventions. Other study arms focused on nutrition improvements and combinations of WASH and	No intervention - after the completion of stool collection in a given compound, all compound members were offered a single dose of albendazole	Yes. The Bangladesh Ministry of Health has implemented a school-based MDA programme that offers mebendazole, with preschool-aged children receiving albendazole deworming through the Expanded Programme on Immu-

Table 2. Characteristics of interventions *(Continued)*

				nutrition interventions and are not emphasized in this review.		nization (EPI).
Erismann 2017	**Design** cRCT **Total clusters** 8 schools **Allocation of clusters** 4 schools randomized to intervention, 4 to control	*Broad multiple* Hardware and software	The interventions were developed and delivered by the study team.	Interventions within schools using 4 main components, including agriculture, WASH, education, and treatment amongst 360 randomly selected children aged 8 to 15 years. The first component included providing 12 teachers and 4 school directors seeds and small gardening tools and agricultural trainings for school garden activities. The second WASH component consisted of latrine installation, rehabilitation of water pumps, installation of handwashing stations, toolkits to make soap, and safe drinking water stations in classrooms. The third component, an educational behaviour change strategy, provided teachers and school directors with materials developed for teaching in the classroom 1 to 2 times a week and 16 community representatives with monthly trainings at schools on hygiene and nutrition. The fourth component provided treatments to children in intervention and control schools found anaemic or infected with intestinal parasites (i.e. a triple dose of 400 mg albendazole against STH infections).	Nearby schools that continued WASH behaviours as usual	Yes. Treatments a triple dose of 400 mg albendazole to children found anaemic or infected with intestinal parasites in both intervention and control schools, following national guidelines
Freeman 2013a	**Design** cRCT **Total clusters** 39 schools (1 lost) **Allocation of clusters** 20 schools randomized to intervention, 19 to control (1 lost)	*Broad multiple* Hardware and software	The intervention was delivered by CARE, an international NGO.	Interventions included hygiene promotion, water treatment technology, and sanitation infrastructure, which included commercially manufactured handwashing and drinking water storage containers and a 1-year supply of point-of-use water treatment product distributed by Population Services International. 1 parent and 1 teacher at each school were trained on hygiene behaviour change, health education, and proper maintenance of sanitation and water storage facilities.	Control schools received albendazole; sanitation improvements and hygiene education after the final round of data collection	Yes. All children in study schools (intervention and control) received mass treatment of STH infections using a single 400 mg oral dose of albendazole.
Gyorkos 2013	**Design** cRCT **Total clusters** 18 schools **Allocation of clusters**	*Primarily education* Software	The intervention was delivered by local partners.	A health education intervention in 18 primary schools for schoolchildren following the third baseline visit at each intervention school, consisting of 2 components. First, in each grade 5 classroom, a 1-hour classroom activity was led by a member of the research team to describe STH acquisition, transmission, and prevention. During this activity, a 32-page booklet (in Spanish) was given to each student and teacher. Second, a half-day workshop was	Deworming alone during study, health education after the study	Yes. Following baseline assessment, all grade 5 children in intervention and control schools were given

Table 2. Characteristics of interventions *(Continued)*

	9 schools randomized to intervention, 9 to control			organized for teachers and school principals with the goal of promoting an integrated health curriculum, and teachers' resource booklets were provided and discussed. Albendazole tablets were also provided.		a 400 mg chewable.
Han 1988	**Design** RCT[a] **Allocation of individuals** 114 individuals randomized to intervention, 125 to control	*Single WASH aspect* Hardware and software	The interventions were developed and delivered by the study team.	Provided 2 small bars of plain soap, 1 for use after defecation and the other for use before food handling or eating. The mothers and their children under 5 were asked to wash their hands after defecation and before preparing or eating their 3 main meals. The soaps were replenished as necessary.	Continued as usual	No
Hurlimann 2018	**Design** cRCT **Total clusters** 9 villages **Allocation of clusters** 4 villages randomized to intervention, 5 to control	*Primarily education* Software	The intervention was delivered by the Centre Suisse de Recherches Scientifiques en Côte d'Ivoire and the Unité de Formation et de Recherche Biosciences from the Université Félix Houphouët-Boigny.	Community-led total sanitation intervention and supported specific health education sessions using participatory rural appraisal tools in 9 communities of south-central Côte d'Ivoire. The team evaluated existing knowledge and provided health education to the whole community and individual groups (e.g. men, women, children, and health committees) through focus group discussions led by a social scientist. The intervention also included setting up an action plan for continued provision of health education.	Continued as usual	Yes. Preventive chemotherapy was implemented using albendazole for the control of soil-transmitted helminthiasis.
Mahmud 2015	**Design** cRCT **Total clusters** 107 households (households were clusters) **Allocation of clusters** 54 households randomized to	*Single WASH aspect* Hardware and software	The interventions were delivered by local fieldworkers.	The first intervention encouraged all individuals in the intervention households to wash their hands with water and soap before meals, after defecation, after playing on the ground, before preparing food, after cleaning an infant who had defecated, before feeding infants, and whenever their hands got unclean. Initially, 2 to 4 bars (120 g each) of plain soap were provided per household and were regularly replaced throughout the study period. The second intervention used fieldworkers to clip the fingernails of children assigned to the nail-clipping intervention on a weekly basis. The third intervention assigned individuals and children to both	Fieldworkers provided the control households with a regular monthly supply of sugar to preserve willingness to participate, but they gave no products that would be	No

Table 2. Characteristics of interventions *(Continued)*

	intervention, 53 to control			handwashing with soap and nail-clipping interventions.	expected to affect handwashing and nail-clipping behaviour.	
Makata 2021	**Design** cRCT **Total clusters** 16 primary schools **Allocation of clusters** 8 schools randomized to intervention, 8 to control. Randomization was stratified by district.	*Primarily education* Software	The interventions were developed and implemented by the research team.	The intervention comprised 3 components: health education of children to promote handwashing with water and soap, a one-off engagement meeting with parents at school to obtain their support, and modest modification of the physical environment at schools to facilitate handwashing. Health education was delivered using specifically designed teaching materials in 3 teacher-led sessions given during the course of 1 year. The sessions combined classroom lessons and handwashing demonstrations and games.	Similar schools in the region with similar baseline STH prevalence. They did not receive the intervention, but still received MDA before beginning the study.	Yes, in all study schools a school-wide MDA was conducted using a single 400 mg oral dose of albendazole in line with the national neglected tropical disease programme guidelines 2 weeks before baseline data collection.
Patil 2014	**Design** cRCT **Total clusters** 80 villages **Allocation of clusters** 40 villages randomized to intervention, 40 to control	*Broad multiple* Hardware and software	The intervention was delivered by the village government (Gram Panchayat) with support from district and block administration personnel or consultants.	India's Total Sanitation Campaign (TSC) and the Water and Sanitation Program from the World Bank in 80 rural villages. The intervention provided subsides for and promotion of individual household latrines, school sanitation and hygiene education, preschool toilets, and community sanitation complexes. Additionally, the TSC supported rural sanitary marts and production centres for toilet construction, ongoing mobilization and behaviour change activities, flexible technology options for toilets, and a community award for "open defecation free" communities. The implementers provided capacity building support to 10 districts in Madhya Pradesh to strengthen the implementation of the programme. A concurrent programme called Nirmal Vatika that was implemented along with the intervention provided additional financial and material subsidies to households.	Group that had not yet received TSC carried on as usual.	No
Pickering 2019	**Design** cRCT **Total clusters**	*Single WASH aspect and broad multiple*	The interventions were delivered by local commu-	This trial evaluated the impact (alone and in concert) of multiple study arms; we have focused on those related to WASH. The first arm focused on water treatment by providing a chlorine treatment	Double-sized active control and	Yes. Study coincided with a national school-

Table 2. Characteristics of interventions *(Continued)*

	465 clusters **Allocation of clusters** 77 randomized to water, 77 to sanitation, 77 to hygiene; 76 to WASH; 158 to control	Hardware and software	nity health promoters.	to drinking water. The second arm improved sanitation through the provision of toilets with plastic slabs and hardware to manage child faeces. The third arm focused on handwashing with soap. The fourth arm combined water treatment, improved sanitation, and handwashing with soap. Other study arms focused on nutrition improvements and combinations of WASH and nutrition interventions and are not emphasized in this review.	a passive control	based targeted MDA programme to reduce STH prevalence. 43% of study children reported taking deworming medication in the past 6 months.
Nery 2019a	**Design** cRCT **Total clusters** 18 villages (6 excluded) **Allocation of clusters** 9 clusters randomized to intervention (3 excluded); 9 to control (3 excluded)	*Broad multiple* Hardware and software	The intervention was delivered by the research team, WaterAid, and their partner NGOs.	A 3-component intervention in 18 communities. The first component consisted of improving water supply and working with residents over a period of up to 10 months, usually culminating in the building of several tap stands per community. The second component involved promoting improved household sanitation using a strategy based on the community-led total sanitation process, whereby following a 1- to 2-day "triggering" meeting, residents committed to ending open defecation in their community by constructing and using household latrines. The third component encouraged handwashing with soap at critical times and hygiene promotion activities conducted by community hygiene promoters from local partner NGOs using a variety of information, education, and communication materials such as flip charts, games, songs, and posters.	Everyone received MDA.	Yes. Individuals in clusters in both study arms received the deworming intervention, 400 mg albendazole, delivered to all eligible members of a community (residents older than 1 year of age, excluding pregnant women in their first trimester).
Albright 2006	**Design** cNON-RCT **Total clusters** 50 schools **Allocation of clusters** 5 schools allocated to intervention; 45 to 50 to control (i.e. "9-10 other schools in each of the 5	*Primarily education* Software	The interventions were delivered by the study team.	A campaign was initiated to explain to parents, students, and teachers the findings of the behavioural and personal hygiene studies and to discourage characteristics of behaviour and hygiene that were conducive to acquisition of STH infections ("risk elements"). Concomitant with the deworming process, efforts to teach children how to avoid acquiring STH infections and the concept of living worm-free were strongly emphasized. This was achieved primarily by members of the project team, who spent many hours with the students socializing, singing songs, making posters, all with a worm-free theme. Members of the team also organized community meetings with parents and teachers for the purpose of: (a) describing the objectives and desired	9 to 10 schools per district who received MDA but did not receive behavioural remediation instruction and carried on as usual after deworming	Yes, worm-infected children in all the schools were provided with 2, 100 mg tablets of mebendazole each day for 3 days. All children in the schools also received a package of fried noo-

Table 2. Characteristics of interventions *(Continued)*

	districts")			results of the study; (b) explaining how children can be taught to avoid STH infections; and (c) instilling in them (especially the parents) the realization that the children can be protected from worms without strain on their financial resources or family lives.		dles fortified with iron and zinc and vitamins.
Al-Delaimy 2014	**Design** cNON-RCT **Total clusters** 2 schools **Allocation of clusters** 1 school allocated to intervention, 1 to control	*Primarily education* Software	The interventions were delivered by school staff.	The key messages for prevention created for the study were washing hands with soap before eating, after playing with soil, and after using the toilet; wearing slippers or shoes when going outside, avoiding open (indiscriminate) defecation, washing vegetables and fruits before consumption, drinking clean (boiled) water, covering food from flies, and cutting nails periodically. The key health messages were integrated into a health education learning package that involved a workshop for teachers, teacher's guidebook on STH, posters, a comic book, drawing activities, a sanitary bag, puppet show, 2 nursery song videos, and group discussions. The intervention concepts were provided to the teachers from the intervention school in the form of a half-day workshop, and a teacher's guide to STH booklet was distributed to the teachers, with further training provided to help them understand how to assist in the introduction and follow-ups of the package.	In the control school after baseline screening for the presence of intestinal parasitic infections, infected children were listed accordingly and only received a 3-day course of 400 mg/daily albendazole tablets.	Yes, children from both schools were dewormed before commencement of the intervention portion of the study.
Arfaa 1977	**Design** cNON-RCT **Total clusters** 14 villages **Allocation of clusters** 4 villages allocated to an intervention; 4 to corresponding control; 3 villages allocated to another intervention; 3 to corresponding control	*Broad multiple* Hardware and software	It is not reported who delivered the intervention.	1 intervention arm consisted of 4 villages who were provided with mass treatment and sanitation. The 'sanitation' component included the construction of 1 latrine for each family and the provision of a safe water supply. Another arm of 4 villages received an intervention like that provided to the first group, but with no MDA.	1 control arm consisted of 4 villages and were only provided with mass treatment. Another control arm consisted of 3 villages and received no mass treatment.	Yes, MDA provided to select study arms.

Table 2. Characteristics of interventions *(Continued)*

Duijster 2017	**Design** cNON-RCT **Total clusters** 20 schools (Cambodia), 18 schools (Indonesia), 44 schools (Lao PDR) **Allocation of clusters** 10 schools allocated to intervention, 10 to control (Cambodia); 9 schools allocated to intervention, 9 to control (Indonesia); 22 schools allocated to intervention, 22 to control (Lao PDR)	*Broad multiple* Hardware and software	The interventions were delivered by project field staff who supported the data collection and study logistics.	Fit for School programme amongst 41 public elementary schools (10 schools in Cambodia (Pnomh Penh, and the provinces Kampot, Takeo, Kampong Thom, and Kampong Chhnang), nine schools in Indonesia (Bandung City and Indramayu), and 22 schools in Lao PDR (Vientiane Capital and surroundings)). The intervention included daily handwashing with soap as a group activity, daily toothbrushing with 0.3 mL of toothpaste (containing 1450 parts per million free available fluoride) as a group activity, and biannual deworming with a single dose of albendazole or mebendazole (400 mg tablet) as part of the respective national government-co-ordinated deworming programme.	Public elementary schools nearby of similar size classification implemented the regular government health education curriculum and biannual deworming.	Yes, and all children received biannual deworming with a single dose of albendazole or mebendazole (400 mg tablet) as part of the respective national government-co-ordinated deworming programme.
Kamga 2011	**Design** cNON-RCT[b] **Total clusters** 2 schools **Allocation of clusters** 1 school to intervention, 1 to control, “random selection”	*Primarily education* Software	The interventions were developed and delivered by the study team.	Health education, aimed at promoting and reinforcing health behaviour with particular reference to the need to encourage aspects of personal hygiene relevant to the control of faecal-orally transmitted parasitic infections, was given to the pupils in the experimental village but not in the control village.	Other schools carrying on as usual	No
Gray 2019	**Design** cNON-RCT[b] **Total clusters** 2 villages **Allocation of clusters** 1 village randomized to intervention, 1 to control	*Broad multiple* Hardware and software	Intervention was designed, implemented, and evaluated by the study team and local stakeholders.	Residents were given health education regarding hygiene, sanitation, and prevention of STH infections. This health education component was delivered via community meetings in each village. The content of the health education programme comprised information about the dangers of STH infections and, through the use of illustrated leaflets, how the transmission of STH infections can be prevented by the construction of latrines and with appropriate hygiene-related behaviours. Subsequently, a series of small group workshops took place with the vil-	Continued as usual	No

Table 2. Characteristics of interventions *(Continued)*

				lagers to describe the Budi's Amphibious Latrine (BALatrine) construction in detail and how to plan, construct, use, and maintain their latrines, as well as to discuss STH disease pathways.		
Gungoren 2007	**Design** cNON-RCT **Total clusters** 8 villages (seasonal climate change villages not used) **Allocation of clusters** 4 villages allocated to intervention, 1 to control	*Primarily education* Software	The interventions were implemented by a recruited village member.	Participatory Hygiene and Sanitation Transformation (PHAST) methodology as the key tool in hygiene promotion activities amongst Uzbek villages of the Fergana valley. 3 hygiene behaviours were targeted: handwashing with soap, safe disposal of faeces, and boiling of drinking water. Some sessions were organized for parents only; some sessions were specifically designed for children by adapting PHAST drawings and exercises to their level of understanding.	MDA-only village used as control.	Yes, free medicines and MDA
Hadidjaja 1998	**Design** cNON-RCT[b] **Total clusters** 4 schools **Allocation of clusters** 1 school randomized to intervention and 1 corresponding control; 1 other school randomized to different intervention and 1 corresponding control	*Primarily education* Software	The interventions were developed and delivered by the study team.	1 intervention school had trained teachers to provide health education on the prevention of *Ascaris lumbricoides* infection and nutrition every week for 5 months. Another intervention school was given a single dose of 500 mg mebendazole and health education, but the study does not state whether it is the same health education provided to the other group.	1 control school received a placebo (a tablet containing cassava flour mixed with sugar, but without mebendazole), but no education. Another control school was treated with mebendazole only (a single 500 mg dose), but received no education.	No
Knee 2021	**Design** cNON-RCT **Total clusters** 408 compounds	*Broad multiple* Hardware	The NGO Water and Sanitation for the Urban Poor selected intervention com-	300 intervention facilities – pour-flush toilets discharging to septic tanks, the liquid effluent of which flows to the soil through soakaway pits. There were 2 intervention designs with the same basic sanitation technology: communal sanitation blocks (CSBs) and shared latrines (SLs). The primary dif-	Other compounds in the region selected by the NGO continued as usual without the	Yes, whilst the National Deworming Campaign (NDC) provided al- benda-

Table 2. Characteristics of interventions *(Continued)*

	Allocation of clusters Unclear how many in each arm		pounds and designed and implemented the intervention.	ference between CSBs and SLs was size. CSBs (n = 50) included multiple stalls with toilets and served compounds of 21 or more people, with 1 stall allocated per 20 residents. CSBs also included rainwater harvesting systems, a municipal shared water connection, elevated water tanks for storage of municipal water, a handwashing basin, a laundry facility, and a well-drained area for bathing.	intervention.	zole to all compound members following baseline, during 12-month visitation only 58% of caregivers (56% control, 60% intervention) confirmed during these visits that their child was dewormed.
Mascie-Taylor 1999	**Design** cNON-RCT[b] **Total clusters** 4 areas **Allocation of clusters** 1 area randomized to intervention and 1 corresponding control; 1 other area randomized to different intervention and 1 corresponding control	*Primarily education* Software	"This research was supported by a World Bank Consortium under the 4th Population and Health Project with the World Health Organization as the technical executing agency." The educational package comprised home visits once a month, focus group discussions, and visits to school.	1 intervention area received albendazole chemotherapy at baseline as well as health education. Another intervention area received albendazole chemotherapy at 0, 6, and 12 months and health education.	1 control area received albendazole chemotherapy at 0 months only, but received no health education intervention. Another control area received albendazole chemotherapy at baseline and again at 6 and 12 months, but received no health education intervention.	Yes. In all 4 areas, the index child and all other household members received albendazole chemotherapy at the commencement of the study. In the second and third areas, only the index child from each house was treated at 6 and 12 months.
Monse 2013	**Design** cNON-RCT **Total clusters** 7 schools	*Single WASH aspect* Software	The intervention components were implemented by education staff (teach-	The Essential Health Care Program in the province of Camiguin, Mindanao amongst children in public elementary schools ages 6 to 7 years old. The intervention consisted of daily supervised handwashing with soap and clean water (as a scheduled group activity); daily supervised brushing with a fluoride tooth-	Annual physical examination, biannual deworming carried out by school nurses, the	Yes, biannual deworming with a single 400 mg dose of albendazole

Table 2. Characteristics of interventions *(Continued)*

	Allocation of clusters 4 schools allocated to intervention, 3 to control		ers for daily tasks, school health nurses of the Department of Education for orientation and supervision).	paste (0.3 mL; 1450 ppm free available fluoride, scheduled group activity); and biannual deworming.	distribution of a single (10 mL) commercial toothpaste sachet, a toothbrush, and an oral health message at the beginning of the school year, and health education as part of the regular school curriculum	as an MDA at school
Muennoo 1997	**Design** cNON-RCT **Total clusters** 2 villages **Allocation of clusters** 1 village allocated to intervention, 1 to control	*Primarily education* Software	The interventions were developed and delivered by the study team.	A health education intervention with an emphasis on STH mode of transmission, prevention, and treatment. These messages were delivered through various mass media, including demonstrations, games, posters, videos, and discussion. The concept of self-awareness after health education was also introduced with the aim of decreasing STH transmission.	Albendazole and carry on as usual	Yes, a single 400 mg dose of albendazole was given to all cases infected with *Ascaris lumbricoides* or hookworm, or both. *Trichuris trichiura* patients were treated with the same dose of albendazole for 3 consecutive days.
Ndenecho 2002	**Design** cNON-RCT **Total clusters** 5 schools **Allocation of clusters** 3 schools allocated to intervention, 2 to control	*Primarily education* Software	The interventions were developed and delivered by the study team.	Health instruction intervention repeated once a week in a hygiene class. The study does not report the contents of the health instructions.	MDA only, carry on as usual	Yes, mebendazole (one 100 mg tablet twice a day for 3 days) was administered in a single health district to all participating children who tested positive for 1 or more

Table 2. Characteristics of interventions *(Continued)*

						of the soil-transmitted nematode species after pre-treatment faecal examination.
Park 2016	**Design** cNON-RCT **Total clusters** 2 villages **Allocation of clusters** 1 village allocated to intervention, 1 to control	*Broad multiple* Hardware and software	The interventions were developed and delivered by the study team.	Budi's Amphibious Latrine and health education in 2 villages. There were no details in the report regarding measuring of health education knowledge at baseline or endline, what the health education was comprised of, or when it was given.	Children who were found to have STH infection at baseline were treated with 400 mg of albendazole.	Yes, in both villages, all children who were found to have STH infection at baseline were treated with 400 mg of albendazole.
Reese 2019	**Design** cNON-RCT **Total clusters** 90 villages **Allocation of clusters** 45 villages allocated to intervention, 45 to control	*Broad multiple* Hardware	The interventions were designed and implemented by a local organization, Gram Vikas.	A combined household-level piped water and sanitation intervention that consisted of a household pour-flush toilet (constructed by the participants) with dual soak-away pits, an attached bathing room, and household piped water connections in the toilet, bathing room, and kitchen.	Control villages matched but did not receive the interventions.	No
Steinmann 2014	**Design** cNON-RCT **Total clusters** 2 villages **Allocation of clusters** 1 village allocated to intervention, 1 to control	*Broad multiple* Hardware and software	The interventions were developed and delivered by the study arm and local partners.	Construction of an improved latrine for each interested family, regular health education, and bi-annual administration of albendazole	An initial health education at study inception and bi-annual administration of albendazole	Yes, bi-annual administration of albendazole at a standard dose of 400 mg offered to all inhabitants of the study villages aged 2 years and above.

Abbreviations: cNON-RCT: cluster-non-randomized controlled trial; cRCT: cluster-randomized controlled trial; MDA: mass drug administration; RCT: randomized controlled trial; STH: soil-transmitted helminth; WASH: water, sanitation, and hygiene

[a]The study states that "children were randomly assigned", but the intervention appears to have been implemented at the household level, and it is not clear if multiple children were included in each household, or if the design was a cluster or individual RCT.
[b]This study was classified as a non-RCT. Whilst the study did use a random mechanism to allocate the intervention, there was only 1 intervention area compared to 1 control area, so randomization in this case is not likely to reduce confounding or imbalances.

Table 3. Subgroup meta-analyses, assessing the effectiveness of WASH interventions on any STH prevalence in RCTs

	N[a]	Subgroup estimate (95% CI)	P value for heterogeneity, I^2	P value for subgroup differences, I^2
Intervention subgroup				P = 0.88, I^2 = 0%
Primarily education	6	0.80 (0.48 to 1.31)	P = 0.01, I^2 = 67%	
Single WASH aspect	3	0.87 (0.65 to 1.17)	P = 0.13, I^2 = 51%	
Broad multiple	7	0.90 (0.78 to 1.05)	P = 0.56, I^2 = 0%	
Age subgroup				P = 0.44, I^2 = 0%
Children	14	0.85 (0.72 to 1.00)	P = 0.02, I^2 = 49%	
All ages	2	1.00 (0.68 to 1.47)	P = 0.52, I^2 = 0%	
School-village subgroup				P = 0.75, I^2 = 0%
School	7	0.82 (0.56 to 1.20)	P < 0.01, I^2 = 69%	
Village	9	0.88 (0.78 to 0.99)	P = 0.54, I^2 = 0%	
Drug treatment subgroup				P = 0.98, I^2 = 0%
Underpinned with drug treatment	13	0.85 (0.72 to 1.00)	P = 0.06, I^2 = 42%	
No drug treatment	3	0.84 (0.46 to 1.54)	P = 0.12, I^2 = 53%	
Urban-rural subgroup				P = 0.33, I^2 = 9.3%
Rural	12	0.85 (0.73 to 1.00)	P = 0.06, I^2 = 42%	
Urban	2	0.43 (0.06 to 3.05)	P = 0.03, I^2 = 80%	
Urban and rural	1	1.19 (0.74 to 1.91)	-	
World region subgroup				P = 0.84, I^2 = 0%
Africa	9	0.83 (0.64 to 1.09)	P = 0.12, I^2 = 37%	
Asia	6	0.87 (0.69 to 1.09)	P = 0.02, I^2 = 61%	
South America	1	1.00 (0.58 to 1.72)	-	

Abbreviations: CI: confidence interval; RCT: randomized controlled trial; STH: soil-transmitted helminth; WASH: water, sanitation, and hygiene
[a]Number of estimates.

Table 4. Subgroup meta-analyses, assessing the effectiveness of WASH interventions on *Ascaris lumbricoides* prevalence in RCTs

	N[a]	Subgroup estimate (95% CI)	P value for heterogeneity, I^2	P value for subgroup differences, I^2
Intervention subgroup				P = 0.68, I^2 = 0%
Primarily education	4	0.88 (0.37 to 2.10)	P = 0.03, I^2 = 66%	
Single WASH aspect	4	0.92 (0.78 to 1.09)	P = 0.42, I^2 = 0%	
Broad multiple	6	0.81 (0.64 to 1.02)	P = 0.35, I^2 = 10%	
Age subgroup				P = 0.04, I^2 = 77%
Children	11	0.85 (0.73 to 0.99)	P = 0.24, I^2 = 21%	
All ages	3	3.20 (0.92 to 11.11)	P = 0.55, I^2 = 0%	
School-village subgroup				P = 0.40, I^2 = 0%
School	4	0.68, (0.37 to 1.26)	P = 0.06, I^2 = 60%	
Village	10	0.89 (0.77 to 1.04)	P = 0.34, I^2 = 11%	
Drug treatment subgroup				P = 0.88, I^2 = 0%
Underpinned with drug treatment	11	0.86 (0.71 to 1.05)	P = 0.09, I^2 = 39%	
No drug treatment	3	0.91 (0.49 to 1.69)	P = 0.45, I^2 = 0%	
Urban-rural subgroup				P = 0.47, I^2 = 0%
Rural	11	0.87 (0.74 to 1.03)	P = 0.25, I^2 = 20%	
Urban	2	0.41 (0.07 to 2.51)	P = 0.03, I^2 = 78%	
Rural and urban	1	1.24 (0.59 to 2.61)	-	
World region subgroup				P = 0.35, I^2 = 4%
Africa	7	0.73 (0.51 to 1.06)	P = 0.05, I^2 = 52%	
Asia	6	0.98 (0.82 to 1.17)	P = 0.80, I^2 = 0%	
South America	1	0.88 (0.57 to 1.36)	-	

Abbreviations: CI: confidence interval; RCT: randomized controlled trial; WASH: water, sanitation, and hygiene
[a]Number of estimates.

Table 5. Subgroup meta-analyses, assessing the effectiveness of WASH interventions on *Trichuris trichiura* prevalence in RCTs

	N[a]	Subgroup estimate (95% CI)	P value for heterogeneity, I^2	P value for subgroup differences, I^2
Intervention subgroup				P = 0.82, I^2 = 0%
Primarily education	4	0.99 (0.75 to 1.31)	P = 0.66, I^2 = 0%	
Single WASH aspect	2	0.84 (0.56 to 1.28)	P = 0.59, I^2 = 0%	
Broad multiple	5	0.98 (0.55 to 1.77)	P = 0.14, I^2 = 43%	
Age subgroup				P = 0.02, I^2 = 81%
Children	8	0.90 (0.73 to 1.10)	P = 0.85, I^2 = 0%	
All ages	3	3.23 (1.09 to 9.53)	P = 0.71, I^2 = 0%	
School-village subgroup				P = 0.95, I^2 = 0%
School	4	0.96 (0.74 to 1.24)	P = 0.72, I^2 = 0%	
Village	7	0.97 (0.64 to 1.48)	P = 0.23, I^2 = 26%	
Drug treatment subgroup				-
Underpinned with drug treatment	11	0.94 (0.77 to 1.14)	P = 0.51, I^2 = 0%	
No drug treatment	0	-	-	
Urban-rural subgroup				P = 0.62, I^2 = 0%
Rural	8	0.91 (0.67 to 1.24)	P = 0.35, I^2 = 11%	
Urban	2	0.89 (0.63 to 1.26)	P = 0.55, I^2 = 0%	
Urban and rural	1	1.17 (0.73 to 1.88)	-	
World region subgroup				P = 0.80, I^2 = 0%
Africa	6	1.00 (0.72 to 1.39)	P = 0.69, I^2 = 0%	
Asia	4	1.07 (0.59 to 1.97)	P = 0.12, I^2 = 49%	
South America	1	0.88 (0.62 to 1.25)	-	

Abbreviations: CI: confidence interval; RCT: randomized controlled trial; WASH: water, sanitation, and hygiene
[a]Number of estimates.

Table 6. Subgroup meta-analyses, assessing the effectiveness of WASH interventions on hookworm prevalence in RCTs

	N[a]	Subgroup estimate (95% CI)	P value for heterogeneity, I^2	P value for subgroup differences, I^2
Intervention subgroup				P = 0.79, I^2 = 0%
Primarily education	4	1.10 (0.57 to 2.12)	P = 0.88, I^2 = 0%	
Single WASH aspect	3	0.90 (0.54 to 1.49)	P = 0.13, I^2 = 50%	
Broad multiple	5	0.87 (0.70 to 1.08)	P = 0.59, I^2 = 0%	
Age subgroup				P = 0.80, I^2 = 0%
Children	9	0.87 (0.71 to 1.06)	P = 0.49, I^2 = 0%	
All ages	3	0.91 (0.67 to 1.24)	P = 0.78, I^2 = 0%	
School-village subgroup				P = 0.20, I^2 = 40%
School	4	1.17 (0.74 to 1.84)	P = 0.88, I^2 = 0%	
Village	8	0.85 (0.71 to 1.01)	P = 0.58, I^2 = 0%	
Drug treatment subgroup				P = 0.30, I^2 = 7%
Underpinned with drug treatment	11	0.89 (0.75 to 1.05)	P = 0.73, I^2 = 0%	
No drug treatment	1	0.37 (0.07 to 1.95)	-	
Urban-rural subgroup				P = 0.75, I^2 = 0%
Rural	9	0.88 (0.74 to 1.04)	P = 0.50, I^2 = 0%	
Urban	2	1.10 (0.51 to 2.37)	P = 0.82, I^2 = 0%	
Urban and rural	1	0.48 (0.04 to 5.41)	-	
World region subgroup				P = 0.21, I^2 = 36%
Africa	7	1.11 (0.80 to 1.53)	P = 0.69, I^2 = 0%	
Asia	4	0.80 (0.65 to 0.98)	P = 0.81, I^2 = 0%	
South America	1	1.13 (0.51 to 2.50)	-	

Abbreviations: CI: confidence interval; RCT: randomized controlled trial; WASH: water, sanitation, and hygiene
[a]Number of estimates.

Table 7. RCTs and non-RCTs assessing the effectiveness of WASH interventions on *Ascaris lumbricoides* intensity of infection

Study ID	Study type	Measure of tendency	Intervention			Control			Reported measure of association
			EPG	N	SD or SE	EPG	N	SD or SE	
Bassey 2020	RCT	NR	0.055	142	SE = 0.0234	0.437	113	SE = 0.0612	NR; P < 0.001
Clasen 2014	RCT	NR	0.9	2150	NR	0.5	2000	NR	MD 1.85 (0.07, 48.75)
Ercumen 2019	RCT	GM	4.4	941	NR	5.2	1530	NR	FECR −0.15 (−0.35, 0.05)
Water	RCT	GM	5.0	971	NR	5.2	1530	NR	−0.02 (−0.27, 0.24)
Sanitation	RCT	GM	5.8	972	NR	5.2	1530	NR	−0.06 (−0.26, 0.13)
Handwashing	RCT	GM	7.6	977	NR	5.2	1530	NR	0.40 (0.04, 0.76)
Freeman 2013a	RCT	AM	395	3	SD = 623	796	556	SD = 1337	NR; P = 0.004
Gyorkos 2013	RCT	AM	1392	518	SD = 5927	2147	571	SD = 7206	MD −755 (−1536, 27)
Han 1988	RCT	NR	14.4	114	NR	14.9	125	NR	NR
Hurlimann 2018	RCT	GM	2232	425	NR	0	385	NR	IRR not calculable
Nery 2019a	RCT	NR	NR	553	NR	NR	595	NR	NR; P = 0.49
Makata 2021	RCT	NR	150	1556	+/− 105	305	1515	+/− 350	NR; "no significant differences"
Pickering 2019	RCT	GM[a]	0.4	1058	NR	0.6	2335	NR	FECR −0.19 (−0.33, −0.05)
Water	RCT	GM[a]	0.4	1114	NR	0.6	2335	NR	−0.16 (−0.32, −0.01)
Sanitation	RCT	GM[a]	0.5	1154	NR	0.6	2335	NR	−0.09 (−0.25, 0.07)
Handwashing	RCT	GM[a]	0.5	1140	NR	0.6	2335	NR	−0.08 (−0.25, 0.08)
Al Delaimy 2014	Non-RCT	NR[b]	NR	172	NR	NR	145	NR	NR; P < 0.01
Arfaa 1977	Non-RCT	NR	755	752	NR	510	403	NR	NR

Table 7. RCTs and non-RCTs assessing the effectiveness of WASH interventions on *Ascaris lumbricoides* intensity of infection *(Continued)*

	Non-RCT	NR	3834	384	NR	3408	196	NR	% egg reduction = 60
Hadidjaja 1998	Non-RCT[c]	AM[d]	812	NR	NR	657	NR	NR	NR
		AM[d]	819	NR	NR	657	NR	NR	NR
Mascie-Taylor 1999	Non-RCT[c]	GM	36.8	550	NR	14.8	550	NR	% change = 68
		GM	1.9	550	NR	7.9	550	NR	% change = 63
Steinmann 2014	Non-RCT	Median	768	100	NR	8256	100	NR	NR

Abbreviations: AM: arithmetic mean; EPG: eggs per gram; FECR: faecal egg count reduction, defined as egg ratio (ER) − 1, where ER is the ratio of mean eggs per gram between arms; GM: geometric mean; IRR: incidence ratio rates (i.e. compares egg counts in intervention and control); MD: mean difference; non-RCT: non-randomized controlled trial; NR: not reported; RCT: randomized controlled trial; SD: standard deviation; SE: standard error; WASH: water, sanitation, and hygiene

[a]Value of 0.5 EPG substituted for samples below the detection limit to calculate log-transformed mean.

[b]Paper implies that it was an AM, but is not said explicitly.

[c]This study was classified as a non-RCT. Whilst the study did use a random mechanism to allocate the intervention, there was only 1 intervention area compared to 1 control area, so randomization in this case is not likely to reduce confounding or imbalances.

[d]This study reported the AM amongst only the positive individuals.

Table 8. RCTs and non-RCTs assessing the effectiveness of WASH interventions on *Trichuris trichiura* intensity of infection

Study ID	Study type	Measure of tendency	Intervention			Control			Reported measure of association
			Mean EPG	N	SD or SE	Mean EPG	N	SD or SE	
Bassey 2020	RCT	NR	0.0055	142	SE = 0.0040	0	113	SE = 0.0000	NR; P = 0.013
Clasen 2014	RCT	NR	0.9	2149	NR	0.1	2002	NR	MD 9.90 (1.98, 46.62)
Ercumen 2019	RCT	GM	0.4	941	NR	0.4	1530	NR	FECR −0.03 (−0.16, 0.11)
Water	RCT	GM	0.4	971	NR	0.4	1530	NR	0.01 (−0.11, 0.13)
Sanitation	RCT	GM	0.3	972	NR	0.4	1530	NR	−0.10 (−0.18, −0.01)
Handwashing	RCT	GM	0.3	977	NR	0.4	1530	NR	−0.10 (−0.19, −0.01)

Table 8. RCTs and non-RCTs assessing the effectiveness of WASH interventions on *Trichuris trichiura* intensity of infection *(Continued)*

Freeman 2013a	RCT	AM	23	556	SD = 70.5	33.1	556	SD = 62	NR; P = 0.46
Gyorkos 2013	RCT	AM	450.6	518	SD = 1659	309.8	571	SD = 760	MD 141 (−297, 15)
Hurlimann 2018	RCT	GM	26	425	NR	0	385	NR	IRR = not calculable
Makata 2021	RCT	NR	16	1556	+/− 6	34	1515	+/− 19	NR; "no significant differences"
Pickering 2019	RCT	GM[a]	−0.29	1058	NR	−0.27	2335	NR	FECR −0.02 (−0.04, 0.00)
Water	RCT	GM[a]	−0.27	1114	NR	−0.27	2335	NR	0.00 (−0.03, 0.03)
Sanitation	RCT	GM[a]	−0.27	1154	NR	−0.27	2335	NR	0.00 (−0.03, 0.02)
Handwashing	RCT	GM[a]	−0.26	1140	NR	−0.27	2335	NR	0.01 (−0.02, 0.04)
Al Delaimy 2014	Non-RCT	NR[b]	NR	172	NR	NR	145	NR	NR; P ≥ 0.05
Hadidjaja 1998	Non-RCT[c]	AM[d]	82	NR	NR	58	NR	NR	NR
		AM[d]	37	NR	NR	58	NR	NR	NR
Mascie-Taylor 1999	Non-RCT[c]	GM	16.8	550	NR	5.4	550	NR	% change = 4
		GM	1.1	550	NR	1.4	550	NR	% change = 21
Reese 2019 (< 2)	Non-RCT	NR	0	709	SD = 0.1	0	745	SD = 0	NR; P = 0.318
Steinmann 2014	Non-RCT	Median	48	100	NR	96	100	NR	NR

Abbreviations: AM: arithmetic mean; EPG: eggs per gram; FECR: faecal egg count reduction, defined as egg ratio (ER) − 1, where ER is the ratio of mean eggs per gram between arms; GM: geometric mean; IRR: incidence ratio rates (i.e. compares egg counts in intervention and control); MD: mean difference; non-RCT: non-randomized controlled trial; NR: not reported; RCT: randomized controlled trial; SD: standard deviation; SE: standard error; WASH: water, sanitation, and hygiene

[a]Value of 0.5 EPG substituted for samples below the detection limit to calculate log-transformed mean.

[b]Paper implies that it was an AM, but is not said explicitly.

[c]This study was classified as a non-RCT. Whilst the study did use a random mechanism to allocate the intervention, there was only 1 intervention area compared to 1 control area, so randomization in this case is not likely to reduce confounding or imbalances.

[d]This study reported the AM amongst only the positive individuals.

Table 9. RCTs and non-RCTs assessing the effectiveness of WASH interventions on hookworm intensity of infection

Study ID	Study type	Measure of tendency	Intervention			Control			Reported measure of association
			Mean EPG	N	SD or SE	Mean EPG	N	SD or SE	
Bassey 2020	RCT	NR	0.0021	142	SE = 0.0021	0.0053	113	SE = 0.0038	NR; P = 0.118
Clasen 2014	RCT	NR	8.7	2151	NR	9.1	2002	NR	MD 0.96, (0.54, 1.68)
Ercumen 2019	RCT	GM	0.4	941	NR	0.6	1530	NR	FECR −0.11, (−0.21, −0.00)
Water	RCT	GM	0.4	971	NR	0.6	1530	NR	−0.11, (−0.21, −0.01)
Sanitation	RCT	GM	0.4	972	NR	0.6	1530	NR	−0.08, (−0.19, 0.04)
Handwashing	RCT	GM	0.5	977	NR	0.6	1530	NR	−0.03, (−0.15, 0.09)
Freeman 2013a	RCT	AM	34.4	556	SD = 48.7	31.8	556	SD = 54.1	NR; P = 0.5
Gyorkos 2013	RCT	AM	11.2	518	SD = 70	7.9	571	SD = 73	MD 3.3, (−12, 5.3)
Hurlimann 2018	RCT	GM	55	425	NR	68	385	NR	IRR 0.91, (0.71, 1.18)
Nery 2019a	RCT	NR	NR	553	NR	NR	595	NR	NR; P = 0.55
Pickering 2019	RCT	GM[a]	−0.26	1058	NR	−0.25	2335	NR	FECR −0.02, (−0.04, 0.00)
Water	RCT	GM[a]	−0.23	1114	NR	−0.25	2335	NR	0.02, (−0.02, 0.05)
Sanitation	RCT	GM[a]	−0.24	1154	NR	−0.25	2335	NR	0.01, (−0.02, 0.04)
Handwashing	RCT	GM[a]	−0.21	1140	NR	−0.25	2335	NR	0.03, (0.00, 0.07)
Al Delaimy 2014	Non-RCT	NR[b]	NR	172	NR	NR	145	NR	NR; P < 0.001
Arfaa 1977	Non-RCT	NR	193	752	NR	99	403	NR	NR
		NR	1143	384	NR	702	196	NR	% egg reduction = 26
Mascie-Taylor 1999	Non-RCT[c]	GM	3.1	550	NR	1.8	550	NR	% change = 71

Table 9. RCTs and non-RCTs assessing the effectiveness of WASH interventions on hookworm intensity of infection *(Continued)*

		GM	1.0	550	NR	1.4	550	NR	% change = 81
Reese 2019 (< 2)	Non-RCT	NR	3.7	708	SD = 18.4	5.8	742	SD = 24.2	NR; P = 0.333
(< 5)	Non-RCT	NR	0.4	357	SD = 3.62	1.8	415	SD = 24.04	NR; P = 0.115
Steinmann 2014	Non-RCT	Median	48	100	NR	108	100	NR	NR

Abbreviations: AM: arithmetic mean; EPG: eggs per gram; FECR: faecal egg count reduction, defined as egg ratio (ER) − 1, where ER is the ratio of mean eggs per gram between arms; GM: geometric mean; IRR: incidence ratio rates (i.e. compares egg counts in intervention and control); MD: mean difference; non-RCT: non-randomized controlled trial; NR: not reported; RCT: randomized controlled trial; SD: standard deviation; SE: standard error; WASH: water, sanitation, and hygiene

[a]Value of 0.5 EPG substituted for samples below the detection limit to calculate log-transformed mean.

[b]Paper implies that it was an AM, but is not said explicitly.

[c]This study was classified as a non-RCT. Whilst the study did use a random mechanism to allocate the intervention, there was only 1 intervention area compared to 1 control area, so randomization in this case is not likely to reduce confounding or imbalances.

APPENDICES

Appendix 1. Study design definitions

We adopted the following definitions from the *Cochrane Handbook for Systematic Reviews of Interventions*.

Randomized controlled trial (RCT): an experiment in which two or more interventions, possibly including a control intervention or no intervention, are compared by being randomly allocated to participants. In most trials one intervention is assigned to each individual, but sometimes assignment is to defined groups of individuals (e.g. a household), or interventions are assigned within individuals (e.g. in different orders or to different parts of the body).

We also included non-RCTs in the review, which were all trials with an external control group where participants (or clusters) were allocated to different interventions using a non-random method. This includes the following study designs, as defined in the *Cochrane Handbook for Systematic Reviews of Interventions*.

- **Non-randomized controlled trial:** a study with an experimental design where participants are allocated to different interventions using a non-random method.
- **Controlled before-and-after study:** a study in which observations are made before and after the implementation of an intervention, both in a group that receives the intervention and in a control group that does not.

Appendix 2. Search strategy

PubMed (Medline)

Search number	Query
1	Soil-transmitted helmint*[Text Word]
2	"Strongyloidiasis"[Mesh] OR "Strongyloides"[Mesh] OR strongyloid* [Title/Abstract]
3	"Hookworm Infections"[Mesh] OR hookworm* [Title/Abstract]
4	"Trichuris"[Mesh] OR trichuris [Title/Abstract]
5	"Ascariasis"[Mesh] OR "Ascaris"[Mesh] OR ascari* [Title/Abstract]
6	"Necator americanus"[Mesh] OR necator [title/Abstract]
7	"Ancylostomiasis"[Mesh] OR "Ancylostoma"[Mesh] OR ancylostom* [Title/Abstract]
8	Geohelmin*[Text Word]
9	(((((((Geohelmin*[Text Word]) OR ("Ancylostomiasis"[Mesh] OR "Ancylostoma"[Mesh] OR ancylostom* [Title/Abstract])) OR ("Necator americanus"[Mesh] OR necator [title/Abstract])) OR ("Ascariasis"[Mesh] OR "Ascaris"[Mesh] OR ascari* [Title/Abstract])) OR ("Trichuris"[Mesh] OR trichuris [Title/Abstract])) OR ("Hookworm Infections"[Mesh] OR hookworm* [Title/Abstract])) OR ("Strongyloidiasis"[Mesh] OR "Strongyloides"[Mesh] OR strongyloid* [Title/Abstract])) OR (Soil-transmitted helmint*[Text Word])
10	WASH[Title/Abstract]
11	"Sanitation"[Mesh] OR "Water Supply"[Mesh] OR "Hand Disinfection"[Mesh] OR "Waste Management"[Mesh]
12	"Hand hygiene" [Mesh] OR "Toilet facilities" [Mesh] OR "Health education" [Mesh]
13	"Sanitary engineering "[Title/Abstract]

(Continued)

15	"hand washing" [Title/Abstract] OR handwashing [Title/Abstract] OR hand-washing [Title/Abstract]
16	Latrine*[Title/Abstract] OR toilet*[Title/Abstract] OR sanitation[Title/Abstract]
17	(((((Latrine*[Title/Abstract] OR toilet*[Title/Abstract] OR sanitation[Title/Abstract]) OR ("hand washing" [Title/Abstract] OR handwashing [Title/Abstract] OR hand-washing [Title/Abstract])) OR ("Sanitary engineering "[Title/Abstract])) OR ("Hand hygiene" [Mesh] OR "Toilet facilities" [Mesh] OR "Health education" [Mesh])) OR ("Sanitation"[Mesh] OR "Water Supply"[Mesh] OR "Hand Disinfection"[Mesh] OR "Waste Management"[Mesh])) OR (WASH[Title/Abstract])
18	((((((Latrine*[Title/Abstract] OR toilet*[Title/Abstract] OR sanitation[Title/Abstract]) OR ("hand washing" [Title/Abstract] OR handwashing [Title/Abstract] OR hand-washing [Title/Abstract])) OR ("Sanitary engineering "[Title/Abstract])) OR ("Hand hygiene" [Mesh] OR "Toilet facilities" [Mesh] OR "Health education" [Mesh])) OR ("Sanitation"[Mesh] OR "Water Supply"[Mesh] OR "Hand Disinfection"[Mesh] OR "Waste Management"[Mesh])) OR (WASH[Title/Abstract])) AND (((((((Geohelmin*[Text Word]) OR ("Ancylostomiasis"[Mesh] OR "Ancylostoma"[Mesh] OR ancylostom* [Title/Abstract])) OR ("Necator americanus"[Mesh] OR necator [title/Abstract])) OR ("Ascariasis"[Mesh] OR "Ascaris"[Mesh] OR ascari* [Title/Abstract])) OR ("Trichuris"[Mesh] OR trichuris [Title/Abstract])) OR ("Hookworm Infections"[Mesh] OR hookworm* [Title/Abstract])) OR ("Strongyloidiasis"[Mesh] OR "Strongyloides"[Mesh] OR strongyloid* [Title/Abstract])) OR (Soil-transmitted helmint*[Text Word]))
19	((((((Latrine*[Title/Abstract] OR toilet*[Title/Abstract] OR sanitation[Title/Abstract]) OR ("hand washing" [Title/Abstract] OR handwashing [Title/Abstract] OR hand-washing [Title/Abstract])) OR ("Sanitary engineering "[Title/Abstract])) OR ("Hand hygiene" [Mesh] OR "Toilet facilities" [Mesh] OR "Health education" [Mesh])) OR ("Sanitation"[Mesh] OR "Water Supply"[Mesh] OR "Hand Disinfection"[Mesh] OR "Waste Management"[Mesh])) OR (WASH[Title/Abstract])) AND (((((((Geohelmin*[Text Word]) OR ("Ancylostomiasis"[Mesh] OR "Ancylostoma"[Mesh] OR ancylostom* [Title/Abstract])) OR ("Necator americanus"[Mesh] OR necator [title/Abstract])) OR ("Ascariasis"[Mesh] OR "Ascaris"[Mesh] OR ascari* [Title/Abstract])) OR ("Trichuris"[Mesh] OR trichuris [Title/Abstract])) OR ("Hookworm Infections"[Mesh] OR hookworm* [Title/Abstract])) OR ("Strongyloidiasis"[Mesh] OR "Strongyloides"[Mesh] OR strongyloid* [Title/Abstract])) OR (Soil-transmitted helmint*[Text Word]))

Embase 1947-Present, updated daily

1	"Soil-transmitted helmint* ".mp. or helminthiasis/
2	Geohelmin*.mp.
3	Ancylostoma/ or ancylostomiasis/ or ancylostom*.mp.
4	necator.mp. or Necator americanus/ or Necator/
5	ascariasis/ or Ascaris/ or ascar*.mp.
6	trichuris.mp. or exp Trichuris/
7	hookworm infection/ or hookworm/ or hookworm*.mp.
8	exp Strongyloides/ or strongyloidiasis/ or strongyloid*.mp.
9	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8
10	sanitation/ or environmental sanitation/ or sanitation.mp.

11 water supply.mp. or water supply/

12 waste management.mp. or waste management/

13 soap/ or hand washing.mp. or hand washing/ or detergent/

14 (handwashing or hand-washing).mp.

15 toilet facilities.mp.

16 latrine*.mp.

17 WASH.mp.

18 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17

19 9 and 18

Indexes=SCI-EXPANDED, SSCI, CPCI-S, CPCI-SSH (Web of Science)

1 TOPIC: (helmint* OR Geohelmin* or ancylostom* or Necator or ascar* or Trichuris or hookworm* or Strongyloid*) AND TOPIC: (sanitation or " water supply" or hygiene or handwashing or toilet* OR latrine*)

Database: LILACS

Search on: helmint$ OR Geohelmin$ or ancylostom$ or Necator or ascar$ or Trichuris or hookworm$ or Strongyloid$ [Abstract words] and sanitation or water or hygiene or handwashing or toilet$ [Abstract words] and human [Words]

Cochrane Central Register of Controlled Trials

Issue 10 of 12, October 2021

#1 "soil-transmitted helminth*":ti,ab,kw (Word variations have been searched)

#2 geohelminth*

#3 ancylostom*

#4 MeSH descriptor: [Ancylostomiasis] explode all trees

#5 MeSH descriptor: [Ancylostoma] explode all trees

#6 necator

#7 MeSH descriptor: [Necator] explode all trees

#8 ascari*

#9 MeSH descriptor: [Ascaris] explode all trees

#10 trichuris

#11 MeSH descriptor: [Trichuris] explode all trees

#12 hookworm*

#13 MeSH descriptor: [Ancylostomatoidea] explode all trees

#14 strongyloid*

#15 MeSH descriptor: [Strongyloides] explode all trees

#16 MeSH descriptor: [Strongyloidiasis] explode all trees

#17 #1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11 or #12 or #13 or #14 or #15 or #16

#18 hand washing or handwashing or hand-washing ti, ab Latrine or toilet* or sanitation or handwashing or hand-washing

#19 MeSH descriptor: [Sanitation] explode all trees

#20 MeSH descriptor: [Water Supply] explode all trees

#21 MeSH descriptor: [Hand Disinfection] explode all trees

#22 MeSH descriptor: [Hand Disinfection] explode all trees

#23 MeSH descriptor: [Waste Management] explode all trees

#24 MeSH descriptor: [Hand Hygiene] explode all trees

#25 MeSH descriptor: [Toilet Facilities] explode all trees

#26 MeSH descriptor: [Health Education] explode all trees

#27 "sanitary engineering" or hygiene

#28 #18 or #19 or #20 or #21 or #22 or #23 or #24 or #25 or #26 or #27

#29 #17 and #28

Clinicaltrials.gov, WHO ICTRP, ISRCTN: Helminth* and (hygiene or sanitation)

Appendix 3. Data to be extracted

Fields
Trial description (for example, study design, setting, year)
Allocation of intervention and control group
Sample size (number of clusters, individuals)
Intervention components
Definition and practices of control group
The primary research question
Details on the trial population (for example, age groups)
The selection process (for example, random selection)
WASH factors measured (for example, water access, latrine use)
Diagnostic assay, including information about quality control
Which STH species were measured
Prescribed criteria of methodological quality

(Continued)

Publication status
Age groups and stratification
Baseline characteristics

Abbreviations: STH: soil-transmitted helminth; WASH: water, sanitation, and hygiene

HISTORY

Protocol first published: Issue 5, 2016

CONTRIBUTIONS OF AUTHORS

MCF conceived the review. JVG, MCF, RI, JW, and AM each contributed to the initial draft. JVG performed all quantitative analyses and wrote the quantitative sections of the paper. JW and AM performed the searches and data extraction, and JW, AM, and JVG drafted the bias analysis and qualitative results. LMP, JB, JVG, and MCF performed the GRADE analyses. All authors reviewed and approved the final document.

DECLARATIONS OF INTEREST

JVG was contracted by a nonprofit, The Task Force for Global Health, to perform the analyses and write this review. JVG declares no other conflicts of interest.

JW has no conflicts of interest to declare.

AM has no conflicts of interest to declare.

LMP has no conflicts of interest to declare.

JB has no conflicts of interest to declare.

RI has engaged in activities related to the topic of this review, including work as a co-author on opinion pieces, in global health development, and as the previous director of Children Without Worms (a non-governmental organization leading on soil-transmitted helminth policy and a program of the Task Force for Global Health). RI declares no other conflicts of interest.

MCF serves on the Soil-Transmitted Helminthiasis Advisory Committee (Children Without Worms), which receives funding from Johnson & Johnson and GlaxoSmithKline. MCF received a grant from Johnson & Johnson for work assessing the impact of school-based water, sanitation, and hygiene on soil-transmitted helminth infection, and has consulted as a member of the Global Scientific Expert Community (Reckitt Benckiser Health Limited). MCF declares no other conflicts of interest.

Children Without Worms' relationship with Johnson & Johnson and GlaxoSmithKline was assessed by the Cochrane Funding Panel, who determined that Children Without Worms' financial support did not represent a financial conflict of interest for this review.

SOURCES OF SUPPORT

Internal sources

- Liverpool School of Tropical Medicine, UK

External sources

- Children Without Worms (CWW), USA

  The CWW programme of The Task Force for Global Health provided funding to JVG, JW, and AM to perform the search, data extraction, analyses, and writing
- Foreign, Commonwealth and Development Office (FCDO), UK

  Project number 300342-104

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

There were several changes between our protocol, Freeman 2016, and this review.

Eric Strunz, Jurg Utzinger, and David G Addiss stepped down from the author team. Joshua V Garn, Jen Wilkers, Ashley A Meehan, Lisa M Pfadenhauer, Jacob Burns, and Rubina Imtiaz joined the author team at review stage.

We included non-randomized controlled trials, whereas in the protocol we stated that we would only include randomized and quasi-randomized trials. We had originally planned to do meta-regression, which we did not do because of the small number of studies. We used I^2, and not Cochran's Q, to assess heterogeneity.

The intervention types listed in the protocol were not well-specified. In the review we have assessed both broad categorizations of WASH as well as more narrow categorizations of water, sanitation, or hygiene interventions.

We performed sensitivity analyses to assess some biases, but did not perform sensitivity analyses to assess the effect of estimating the intracluster correlation coefficients in some instances. We did not perform sensitivity analyses to assess the effect of missing data, as there was very little evidence of missing data across nearly all of the included studies.

We originally intended to request additional unpublished research from select organizations and from trial authors who had registrations from 2012 or earlier with no corresponding paper, but did not do this in this review because of discontinuity of study staff after the main extraction, and in part because we felt our searches of the literature were producing sufficient evidence; however, it is possible that this could have led to missed studies.

INDEX TERMS

Medical Subject Headings (MeSH)

Ascaris lumbricoides; Hygiene; Observational Studies as Topic; *Sanitation [methods]; *Soil [parasitology]; Water

MeSH check words

Animals; Humans