Cochrane Library

Cochrane Database of Systematic Reviews

Interventions to improve sanitation for preventing diarrhoea (Protocol)

Bauza V, Sclar G, Majorin F, Clasen T

Bauza V, Sclar G, Majorin F, Clasen T.
Interventions to improve sanitation for preventing diarrhoea.
Cochrane Database of Systematic Reviews 2019, Issue 5. Art. No.: CD013328.
DOI: 10.1002/14651858.CD013328.

www.cochranelibrary.com

TABLE OF CONTENTS

HEADER 1
ABSTRACT 1
BACKGROUND 1
OBJECTIVES 3
METHODS 3
ACKNOWLEDGEMENTS 7
REFERENCES 7
APPENDICES 9
CONTRIBUTIONS OF AUTHORS 12
DECLARATIONS OF INTEREST 13
SOURCES OF SUPPORT 13

[Intervention Protocol]

Interventions to improve sanitation for preventing diarrhoea

Valerie Bauza[1], Gloria Sclar[1], Fiona Majorin[2], Thomas Clasen[1]

[1]Department of Environmental Health, Rollins School of Public Health, Emory University, Atlanta, GA, USA. [2]Faculty of Infectious and Tropical Diseases, London School of Hygiene & Tropical Medicine, London, UK

Contact address: Thomas Clasen, Department of Environmental Health, Rollins School of Public Health, Emory University, Atlanta, GA, USA. thomas.f.clasen@emory.edu.

Editorial group: Cochrane Infectious Diseases Group.
Publication status and date: New, published in Issue 5, 2019.

Citation: Bauza V, Sclar G, Majorin F, Clasen T. Interventions to improve sanitation for preventing diarrhoea. *Cochrane Database of Systematic Reviews* 2019, Issue 5. Art. No.: CD013328. DOI: 10.1002/14651858.CD013328.

ABSTRACT

This is a protocol for a Cochrane Review (Intervention). The objectives are as follows:

To assess the effectiveness of sanitation interventions for preventing diarrhoeal disease.

BACKGROUND

Description of the condition

Diarrhoeal disease is the second-leading cause of death in low-income countries (WHO 2018), responsible for approximately 1.7 million deaths globally in 2016 (GBD 2017). Young children are especially vulnerable; diarrhoeal disease is the second-leading cause of death in children under five years old globally, resulting in an estimated 525,000 deaths of children under five each year (WHO 2017). Additionally, as diarrhoeal diseases inhibit normal ingestion of foods and adsorption of nutrients, repeated diarrhoea episodes can lead to malnutrition and stunted growth (Checkley 2008; Guerrant 2012), which could result in reduced resistance to infection as well as impaired cognitive function later in life and lower adult economic productivity (Guerrant 2012). However, although young children are a particularly vulnerable population, diarrhoea can lead to morbidity and mortality amongst all ages, and it is estimated that almost three-quarters of the deaths due to diarrhoea around the globe occur in individuals over five years old, including a high burden in adults over 70 years of age (Troeger 2018).

The infectious enteric pathogens associated with diarrhoeal disease are transmitted primarily through the faecal-oral route, and a wide variety of bacterial, viral, and protozoan pathogens excreted in the faeces of humans and animals are known to cause diarrhoea (Feachem 1983). Some pathogens that may contribute to the greatest burden of diarrhoea include rotavirus, *Cryptosporidium* spp, certain pathogenic strains of *Escherichia coli*, *Shigella*, *Campylobacter* spp, *Vibrio cholerae*, norovirus GII, and astrovirus (Kotloff 2013; Platts-Mills 2015); however, the importance of individual pathogens likely varies between settings, seasons, and conditions. Sanitation facilities are critical in reducing the transmission of enteric pathogens, as these facilities serve as a primary barrier to separate pathogens excreted in human faeces from the environment. However, despite major international efforts such as the Millennium Development Goals (MDGs) to expand sanitation coverage, progress fell far short of the target, and global sanitation coverage remains low. In 2015, an estimated 2.3 billion people (32% of the world's population) lacked access to "basic" sanitation service, the indicator used to measure progress under the Sustainable De-

velopment Goal (SDG) sanitation target, which is defined as a flush or pour-flush facility that flushes to a piped sewer system, septic tank, or pit latrine; a pit latrine with a slab; a ventilated improved pit (VIP) latrine; or a composting toilet not shared with other households (WHO/UNICEF 2017). Sanitation coverage is particularly low in the least developed countries, where only one in three people (32%) have access to basic sanitation services. Regionally, the coverage is lowest in sub-Saharan Africa, where only 28% of the population has access to basic sanitation. Globally, an estimated 892 million people still practice open defecation, of which about 524 million reside in India (WHO/UNICEF 2017). While access to and use of sanitation facilities is essential for containing human excreta, preventing exposure to faecal pathogens also requires attention to the safe management of faecal sludge as part of a comprehensive sanitation solution. Faecal sludge management applies both to on-site facilities such as pit latrines as well as off-site systems where sludge is flushed into sewers. Currently, only 39% of the world's population uses a "safely managed" sanitation service, the highest rung on the WHO/UNICEF sanitation ladder, which requires basic sanitation facilities where the excreta is safely disposed of in situ or is treated off-site (WHO/UNICEF 2017).

Description of the intervention

Sanitation interventions are aimed at introducing, improving, or expanding coverage or use of facilities or systems for human excreta disposal and management. More specifically, sanitation interventions may include steps to reduce open defecation by constructing latrines or toilets, encouraging behaviour change to increase latrine or toilet use, as well as the upgrading of facilities to achieve a higher level of service. They may also include improvements to safely remove, convey, and treat faecal sludge, such as pit emptying and sewerage.

Several definitions for the level of sanitation service are relevant for this review, as interventions are often described in terms of these definitions. The Joint Monitoring Programme for Water Supply, Sanitation and Hygiene (JMP), which monitors progress towards international water, sanitation, and hygiene targets, has several definitions of sanitation that are commonly used in studies. Prior to the SDGs, the JMP defined improved sanitation and unimproved sanitation in terms of the facilities for the disposal of human excreta (WHO/UNICEF 2015), as follows.

- Improved sanitation: a private flush or pour-flush facility (that flushes to a piped sewer system, septic tank, or pit latrine), a pit latrine with a slab, a VIP latrine, or a composting toilet.
- Unimproved sanitation: any other flush or pour-flush facility (that flushes elsewhere), a pit latrine without a slab, a bucket latrine, a hanging latrine, any public or shared facility, or open defecation.

For monitoring the new SDGs that began in 2016, new sanitation service levels have been defined along a sanitation ladder, which users can move up as upgrades to sanitation are made. This ladder includes the five levels of service defined as safely managed, basic, limited, unimproved, and open defecation (WHO/UNICEF 2017), as follows.

- Safely managed: use of improved facilities that are not shared and with excreta safely disposed of in situ or treated off-site.
- Basic service: use of improved facilities that are not shared.
- Limited service: use of improved facilities that are shared with other households.
- Unimproved service: use of pit latrines without a slab or platform, hanging toilets, or bucket toilets.
- Open defecation: disposal of human faeces in fields, surface water, forests, bushes, or with solid waste.

Our systematic review will evaluate the following three separate types of sanitation interventions.

- Interventions that move participants' access to sanitation from no sanitation facility to any sanitation facility.
- Interventions that move participants' access to sanitation from any sanitation facility to a higher level of service (as defined by JMP for SDGs monitoring).
- Interventions that encourage participants to increase or improve the use of existing sanitation facilities.

How the intervention might work

The infectious pathogens excreted in the faeces of humans and animals that cause diarrhoeal disease are transmitted primarily through the faecal-oral route (Feachem 1983), with sanitation facilities acting as a primary barrier to contain faeces and prevent pathogens excreted in human faeces from entering the environment. If not properly contained, these pathogens may be transmitted through the ingestion of contaminated food, water, soil, by person-to-person contact, and by direct or indirect contact with infected faeces. Due to the complexity of multiple pathways, environmental interventions for the prevention of diarrhoeal disease often include steps to improve the proper disposal of human faeces through sanitation interventions, as well as improving water quality (Clasen 2015), water quantity and access (Stelmach 2015), and promoting hand washing and other hygiene practices (collectively referred to as WASH) (Ejemot-Nwadiaro 2015). Although this review will focus only on evaluating sanitation interventions and will not include the evaluation of other individual WASH interventions, the effectiveness of individual sanitation interventions may vary between settings due to exposure to pathogens from other transmission pathways not addressed by a sanitation intervention. However, understanding the effect of sanitation interventions alone compared to other individual or combined WASH interventions assessed in other reviews can help policymakers prioritise interventions.

In addition to diarrhoea, there are other important health risks associated with poor sanitation. These include the infectious diseases of schistosomiasis, soil-transmitted helminth infection (including ascariasis, trichuriasis, and hookworm infection), and trachoma, as well as nutritional status (Freeman 2017). Nutritional status could be affected from repeated diarrhoea episodes or soil-transmitted helminth infection (Bethony 2006; Checkley 2008), as well as environmental enteric dysfunction (also called environmental enteropathy). Environmental enteric dysfunction is a subclinical disorder of the small intestine that leads to chronic gut inflammation and impaired nutrient absorption. Environmental enteric dysfunction is hypothesized to be caused by repeated ingestion of faecal bacteria and associated infection and is thought to lead to impaired growth (Humphrey 2009; Korpe 2012). However, these health risks are outside of the scope of this review.

Why it is important to do this review

This is a new Cochrane Review that supersedes a Cochrane Review completed in 2010 (Clasen 2010). Clasen 2010 concluded that while there was a wide range of effects and the certainty of the evidence was poor, there was some evidence that sanitation interventions to improve excreta disposal were protective against diarrhoea. However, many of the studies combined sanitation with other WASH interventions, thus preventing an estimate of the effect of sanitation alone. The review also found substantial heterogeneity in the interventions and methods of assessment that prevented a comparison of studies or the pooling of results and meta-analysis. It concluded with a recommendation for rigorous studies across multiple settings to provide evidence to better assess the potential effectiveness of sanitation interventions on diarrhoea.
Several new studies have been published since publication of Clasen 2010, including rigorous studies of sanitation interventions. In this review, we will expand the inclusion criteria to include controlled before-and-after and matched cohort studies; update the search terms; extract data from newly identified studies; and repeat data extraction from previously identified studies. We will adopt the Cochrane tool to assess risk of bias and apply the GRADE approach to assess the certainty of the evidence. We will also reconsider if subgroup analyses or meta-analyses are appropriate after the inclusion of new studies.

OBJECTIVES

To assess the effectiveness of sanitation interventions for preventing diarrhoeal disease.

METHODS

Criteria for considering studies for this review

Types of studies

We will include randomized controlled trials (RCTs), quasi-RCTs, non-randomized controlled trials, controlled before-and-after studies (CBAs), and matched cohort studies. For randomized trials, we will include studies with a unit of randomization of individuals, families, households, villages, communities, or other clusters. For cluster-RCTs, we will only include studies that have at least two clusters per arm. For CBAs, we will only include studies that have at least two sites per arm and contemporaneous data collection in the intervention and control arms. For matched cohort studies, we will only include studies that have at least two sites per arm. A matched cohort study is a rigorous observational study method that allows for causal inference to be assessed from a non-randomized pre-existing development intervention implemented at a group or community level (Arnold 2010). A quasi-RCT refers to a controlled trial that uses a method of participant allocation that is not truly random, but that is intended to produce similar groups as randomization (e.g. allocation by date of birth, medical record number, or every other person) (Cochrane Community 2018).

Types of participants

Children and adults in any country or population.

Types of interventions

Interventions

Interventions aimed at introducing or expanding the coverage and use of sanitation facilities designed to reduce direct or indirect contact with human faeces. Our systematic review will evaluate the following three separate types of sanitation interventions.

- Interventions that move participants' access to sanitation from no sanitation facility to any sanitation facility. This may include interventions that encourage the building of new facilities including pit latrines, VIP latrines, bucket latrines, hanging toilets, water-sealed flush or pour-flush toilets (whether or not connected to a vault, septic tank, or sewer), and composting toilets.
- Interventions that move participants' access to sanitation from any sanitation facility to a higher level of service (as defined by JMP for SDGs monitoring). This may include interventions that encourage the building of new facilities including pit latrines, VIP latrines, composting toilets, and water-sealed flush or pour-flush toilets, as long as the facility is at a higher level of service than the existing facility. It may also include interventions to promote the safe management of faecal sludge, such as pit

emptying, sewerage connection, and composting or other treatment that could upgrade the sanitation level of service.

- Interventions that encourage participants to increase or improve the use of existing sanitation facilities.

We will include sanitation interventions whether they are conducted independently or in combination with other interventions, such as interventions to improve water quality, water quantity or access, hygiene practices, and/or child nutrition. We expect that we may encounter studies with multiple intervention groups, such as studies with one arm receiving a sanitation intervention and another arm receiving a sanitation intervention coupled with water and hygiene interventions, with each compared to the same control arm. In such cases, we will extract the data comparing the sanitation-only arm to the control arm to include in our analysis of sanitation-only interventions, and extract the data comparing the combined water, sanitation, and hygiene arm to the control arm to include in our analysis of combined sanitation intervention with water and/or hygiene interventions.

We will exclude interventions aimed solely at the safe disposal of child faeces, such as the promotion of potties, unless safe disposal of child faeces is part of a larger sanitation intervention covering adults and children. We will also exclude interventions aimed solely at the containment of animal faeces. Although faeces from young children and animals may be important sources of exposure to faecal pathogens capable of infecting humans, other reviews focus specifically on the disposal of faeces from children, Majorin 2014, and animals, Penakalapati 2017. Finally, this review does not extend to interventions that are not aimed principally at the sanitary disposal and management of human faeces, thus it does not include efforts to promote the use of human waste in agricultural applications, or efforts to improve drainage, recycling or reuse of wastewater or stormwater, or management of solid waste.

Control

Study participants who practice open defecation or who continue to follow their current practices with respect to excreta disposal or faecal sludge management rather than the prescribed intervention. We will exclude any controls that received a separate intervention to reduce diarrhoea that was not also introduced to the intervention arm. However, we will include controls that received a separate intervention to reduce diarrhoea if that intervention was also introduced into the intervention group alongside the sanitation intervention.

Types of outcome measures

Primary outcomes

- Diarrhoea amongst individuals, whether or not confirmed by microbiological examination.

The World Health Organization (WHO) definition of diarrhoea is three or more loose or fluid stools (that take the shape of the container) in a 24-hour period (WHO 1993). However, we will define diarrhoea and an episode in accordance with the case definitions used in each study. We will exclude studies that have no clinical outcomes, for example studies that report only on microbiological pathogens in the stool. Where data are provided, we will extract and analyse data from the studies describing the method of diarrhoea surveillance and reporting, as well as persistent diarrhoea, the appearance of dysentery or blood in stool, and hospital admission or clinical visits in response to diarrhoea.

Secondary outcomes

- Mortality.
- Persistent diarrhoea (episodes continuing for 14 days or longer).
- Dysentery (bloody diarrhoea).
- Hospital or clinical visits for diarrhoea.
- Adverse events (harmful effects of an intervention).

Search methods for identification of studies

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

Electronic searches

We will search the following databases using the search terms detailed in Appendix 1: Cochrane Infectious Disease Group Specialized Register; Cochrane Central Register of Controlled Trials (CENTRAL) published in the Cochrane Library; MEDLINE; Embase; and LILACS (Latin American and Caribbean Health Science Information database). We will also search Chinese language databases available under the China National Knowledge Infrastructure (CNKI-CAJ) using comparable Chinese language search terms. We will also search the *meta*Register of Controlled Trials (*m*RCT) using 'diarrhoea' and 'sanitation or latrine or toilet or privy or disposal or sewerage' as search terms. Databases will be searched from their inception year to present.

Searching other resources

Conference proceedings

We will search the conference proceedings of the following organizations for relevant abstracts: International Water Association and the Water, Engineering and Development Centre, Loughborough University, UK.

Researchers and organizations

We will contact individual researchers working in the field, as well as the following organizations for ongoing or unpublished studies: the Water, Sanitation and Health Programme of the WHO; World Bank Water and Sanitation Program; UNICEF Water, Sanitation and Hygiene; Environmental Health Project; IRC International Water and Sanitation Centre; Foodborne and Diarrheal Diseases Branch, Division of Bacterial and Mycotic Diseases, Centers for Disease Control and Prevention (CDC); US Agency for International Development (USAID); and the UK Department for International Development (DFID).

Reference lists

We will check the reference lists of all studies identified by the above methods.

Data collection and analysis

Selection of studies

Two review authors will independently review the titles and abstracts identified by the searches and select all potentially relevant studies. After obtaining the full-text articles of these studies, the two review authors will independently assess each trial to determine if it meets the inclusion criteria by completing an eligibility form. For Chinese language search results, one review author fluent in Chinese will undertake the same process individually and summarize the article in English, and the two review authors assessing the English language studies will assess the summaries to independently determine the eligibility of the study.

Review authors TC and FM have been involved in studies that could meet the inclusion criteria of this review. We will assure independence on assessment of eligibility and risk of bias by assigning the review authors who are not involved in any of these included studies to tasks for studies that involve a review author. Furthermore, no author of an included study will perform data extraction on their own study.

We will resolve any disagreements regarding study eligibility by consulting another review author (VB). We will list any studies excluded after full-text assessment and the reasons for their exclusion in the 'Characteristics of excluded studies' tables. We will illustrate the study selection process in a PRISMA diagram.

Data extraction and management

Two review authors will use a pre-piloted form to independently extract and record the data described in Appendix 2. If any discrepancies arise from data extraction, one review author (VB) will assess the item in question, discuss it with the two review authors, and make the final decision. One review author (VB) will enter the extracted data into Review Manager 5 (RevMan 2014).

Assessment of risk of bias in included studies

We will use the Cochrane 'Risk of bias' assessment tool to assess the risk of bias for RCTs (Higgins 2011). Specifically, we will assess risk of bias for the following six criteria for RCTs:

- random sequence generation;
- allocation concealment;
- blinding of participants and personnel;
- blinding of outcome assessment;
- incomplete outcome data; and
- selective reporting.

We will assess each criterion as either at low, high, or unclear risk of bias based on Cochrane 'Risk of bias' tool guidelines. For cluster-RCTs, we will also assess the following five risk of bias criteria recommended for cluster-RCTs in the *Cochrane Handbook for Systematic Reviews of Interventions*:

- recruitment bias;
- baseline imbalance;
- loss of clusters;
- incorrect analysis; and
- comparability with individually randomized trials.

For other study designs (quasi-RCTs, non-randomized controlled trials, CBA studies, and matched cohort studies), we will use the Cochrane Effective Practice and Organisation of Care (EPOC) tool to assess the risk of bias (Cochrane EPOC 2017), which will include an assessment of random sequence generation, allocation concealment, incomplete outcome data, selective reporting, and other biases, criteria that are similar to those assessed for RCTs, as well as the following criteria.

- Baseline outcome measurements similar: we will assign low risk if there were no important differences between groups at baseline for diarrhoea measurement or if adjusted analysis was performed to account for this difference; unclear risk if no baseline measures were taken for these variables; or high risk if important differences were present and not corrected for in analysis.
- Baseline characteristics similar: we will assign low risk if there were no important differences between groups at baseline for age category, socioeconomic status, access to water, hygiene practices, or sanitation facilities or if adjusted analysis was performed to account for this difference; unclear risk if no baseline measures were taken for these variables; or high risk if important differences were present and not corrected for in analysis.
- Protection against contamination: we will assign low risk if allocation was assigned by community or group in a manner such that it is unlikely that the control group received the intervention; unclear risk if it is possible that the control group

received the intervention; and high risk if it is likely that the control group received the intervention.

Two review authors will independently review the risk of bias criteria and resolve any disagreements by discussion amongst each other or by consulting a third review author (TC) if necessary.

Measures of treatment effect

We will record diarrhoea morbidity based on the measure used in the study. We expect that we may encounter studies that measure and report diarrhoea prevalence as a dichotomous outcome, as well as studies that measure and report diarrhoea incidence as a count outcome. We will not pool results based on these different measures of disease frequency. Rather, we will assess which outcome is more commonly used by studies and attempt to convert the effect measures for other studies to a similar form for meta-analysis. For example, if the majority of studies measure diarrhoea prevalence and report a risk ratio (RR), we will attempt to convert the count data reported in studies measuring incidence into a dichotomous outcome to include in our meta-analysis. More broadly, we will attempt to convert the effect measures for each study into a relative risk with 95% confidence interval (CI) for diarrhoea. If the relative risk is not reported in the study, we will attempt to calculate it from the reported data. If the relative risk or the raw data necessary to calculate it are not reported, we will attempt to obtain these data by contacting the study author. If we are unable to obtain these data, then we will use the effect measure reported in the study.

Unit of analysis issues

For cluster-RCTs, we will assess whether the statistical methods used properly accounted for the cluster design, and then will extract the effect measure and confidence interval reported from analysis that accounts for the cluster design in an attempt to avoid unit of analysis errors. In case measures of effect are not adjusted for clustering in a cluster-RCT, we will attempt to adjust the data using an intracluster correlation coefficient (ICC). If an ICC is not reported in the study, will use an external estimate of an ICC from a similar study to adjust the data. We will not include any unadjusted measures of effect from cluster-RCTs in our meta-analyses.

Dealing with missing data

In the case that data needed to assess eligibility criteria or the outcomes are missing, we will attempt to contact study authors to obtain the missing data. We will report the number of participants lost to follow-up. We will also evaluate whether the missing data from participants lost to follow-up are likely to be missing at random or not. If we expect that these data are missing at random, we will ignore the missing data and perform analysis only using available data. If we expect that these data are not missing at random, we will evaluate whether the use of imputations and sensitivity analyses for missing data would be a more appropriate approach.

Assessment of heterogeneity

We will assess heterogeneity amongst studies by visually examining the confidence intervals for overlap on forest plots, using the Chi^2 test, and calculating the I^2 statistic. We will apply the Chi^2 test with an assumption that a $P < 0.10$ is significant and indicates potential heterogeneity. We will use the I^2 statistic to quantify the level of heterogeneity present. We will also explore methodological heterogeneity as a possible explanation for any observed heterogeneity in outcome results, including methodological reasons such as differences in study participants, interventions, and levels of diarrhoea prevalence in controls.

Assessment of reporting biases

If sufficient data are available (10 or more included studies), we will assess potential publication bias by creating funnel plots and visually inspecting the plots for asymmetry. If sufficient data are not available to construct funnel plots, we will assess potential publication bias by plotting the relative risk against the number of clusters in each study, as done in the previous version of this review (Clasen 2010). To assess for potential selective reporting of outcomes, we will compare the outcomes listed in the published protocol or methods sections to the study results outcomes presented.

Data synthesis

We will compile and analyse data using Review Manager 5 (RevMan 2014). We will stratify our primary analysis by study design; whether the sanitation intervention is being assessed individually or in combination with other water, hygiene, or nutrition interventions; and the type of sanitation intervention being evaluated. When appropriate, based on an assessment of methodological heterogeneity amongst studies, we will perform a meta-analysis to estimate a pooled effect measure for outcomes. We will use random-effects models for any meta-analysis to incorporate heterogeneity into the analysis. If a meta-analysis is not appropriate, we will present the results from individual studies on a forest plot and provide a narrative summary of the results.

Assessment of the certainty of the evidence

We will use the GRADE approach to assess the overall certainty of the evidence for each outcome as either high, moderate, low, or very low certainty (Guyatt 2011). We will start with a 'high' certainty rating for outcomes with results from RCTs, quasi-RCTs, non-randomized controlled trials, CBA studies, and matched cohort studies. Following the GRADE approach, we will downgrade the certainty of the evidence by one level for each serious risk and

two levels for each very serious risk of any of the following criteria: (1) risk of bias, (2) inconsistency, (3) indirectness, (4) imprecision, or (5) publication bias (Guyatt 2011). We will report the results of this assessment for each outcome in the 'Summary of findings' table.

Subgroup analysis and investigation of heterogeneity

If we identify sufficient studies, we will assess if subgroup analysis is appropriate for several factors including the following.

- Outcome assessment by age of the participant (such as grouping by: children < 5 years; children 5 to 10 years; adults and children older than 10 years of age).
- Level of diarrhoea prevalence in the control group (such as grouping studies with < 5%; 5% to < 15%; 15% to < 30%; and > 30% diarrhoea prevalence in the control group).
- Case definition of diarrhoea.
- Sanitation level of service (as defined by JMP).
- Sanitation coverage levels (including the change in coverage level due to the intervention and the coverage level at the end of the study).
- Location of the study (e.g. urban versus rural, region of the world, the relative wealth of the setting/participants).

Sensitivity analysis

If we perform any meta-analysis as part of this Cochrane Review, we will conduct a sensitivity analysis to see if using a fixed-effect model instead of a random-effects model would have influenced the results. Additionally, if any other decisions need to be made during the review that could affect the results (such as decisions to resolve disagreements over eligibility criteria or including/excluding studies with high potential bias), we will conduct a sensitivity analysis to determine how these decisions may have influenced the results.

ACKNOWLEDGEMENTS

The Academic Editor is Professor Mical Paul.

We gratefully acknowledge Kristof Bostoen, Wolf-Peter Schmidt, Sophie Boisson, Isaac C-H Fung, Marion W Jenkins, Beth Scott, Steven Sugden, and Sandy Cairncross, co-authors of the Cochrane Review (Clasen 2010), which is superseded by this review.

The editorial base of the Cochrane Infectious Diseases Group is funded by UK aid from the UK government for the benefit of low- and middle-income countries (project number 300342-104). The views expressed do not necessarily reflect the UK government's official policies.

REFERENCES

Additional references

Arnold 2010
Arnold BF, Khush RS, Ramaswamy P, London AG, Rajkumar P, Ramaprabha P, et al. Causal inference methods to study nonrandomized, preexisting development interventions. *Proceedings of the National Academy of Sciences of the United States of America* 2010;**107**(52):22605-10.

Bethony 2006
Bethony J, Brooker S, Albonico M, Geiger SM, Loukas A, Diemert D, et al. Soil-transmitted helminth infections: ascariasis, trichuriasis, and hookworm. *Lancet* 2006;**367** (9521):1521-32.

Checkley 2008
Checkley W, Buckley G, Gilman RH, Assis AM, Guerrant RL, Morris SS, et al. Multi-country analysis of the effects of diarrhoea on childhood stunting. *International Journal of Epidemiology* 2008;**37**(4):816-30.

Clasen 2015
Clasen TF, Alexander KT, Sinclair D, Boisson S, Peletz R, Chang HH, et al. Interventions to improve water quality for preventing diarrhoea. *Cochrane Database of Systematic Reviews* 2015, Issue 10. DOI: 10.1002/14651858.CD004794.pub3

Cochrane Community 2018
Cochrane Community. Glossary. community.cochrane.org/glossary (accessed 10 December 2018).

Cochrane EPOC 2017
Cochrane Effective Practice, Organisation of Care. Suggested risk of bias criteria for EPOC reviews. 2017. epoc.cochrane.org/sites/epoc.cochrane.org/files/public/uploads/Resources-for-authors2017/suggested_risk_of_bias_criteria_for_epoc_reviews.pdf (accessed 10 December 2018).

Ejemot-Nwadiaro 2015
Ejemot-Nwadiaro RI, Ehiri JE, Arikpo D, Meremikwu MM, Critchley JA. Hand washing promotion for preventing diarrhoea. *Cochrane Database of Systematic Reviews* 2015, Issue 9. DOI: 10.1002/14651858.CD004265.pub3

Feachem 1983
Feachem RG, Bradley DJ, Garelick H, Mara DD. *Sanitation and Disease: Health Aspects of Wastewater and Excreta Management, World Bank Studies in Water Supply and Sanitation*. Vol. **3**, John Wiley & Sons, 1983.

Freeman 2017
Freeman MC, Garn JV, Sclar GD, Boisson S, Medlicott K, Alexander KT, et al. The impact of sanitation on infectious

disease and nutritional status: a systematic review and meta-analysis. *International Journal of Hygiene and Environmental Health* 2017;**220**(6):928-49.

GBD 2017
GBD 2016 Causes of Death Collaborators. Global, regional, and national age-sex specific mortality for 264 causes of death, 1980-2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet* 2017;**390** (10100):1151-210.

Guerrant 2012
Guerrant RL, DeBoer MD, Moore SR, Scharf RJ, Lima AAM. The impoverished gut - a triple burden of diarrhoea, stunting and chronic disease. *Nature Reviews Gastroenterology & Hepatology* 2012;**10**(4):220-9.

Guyatt 2011
Guyatt G, Oxman AD, Akl EA, Kunz R, Vist G, Brozek J, et al. GRADE Guidelines: 1. Introduction - GRADE evidence profiles and summary of findings tables. *Journal of Clinical Epidemiology* 2011;**64**(4):383-94.

Higgins 2011
Higgins JP, Altman DG, Gøtzsche PC, Jüni P, Moher D, Oxman AD, et al. The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. *BMJ* 2011;**343**: d5928.

Humphrey 2009
Humphrey JH. Child undernutrition, tropical enteropathy, toilets, and handwashing. *Lancet* 2009;**374**(9694):1032-5.

Korpe 2012
Korpe PS, Petri WA. Environmental enteropathy: critical implications of a poorly understood condition. *Trends in Molecular Medicine* 2012;**18**(6):328-36.

Kotloff 2013
Kotloff KL, Nataro JP, Blackwelder WC, Nasrin D, Farag TH, Panchalingam S, et al. Burden and aetiology of diarrhoeal disease in infants and young children in developing countries (the Global Enteric Multicenter Study, GEMS): a prospective, case-control study. *Lancet* 2013;**382** (9888):209-22.

Lefebvre 2011
Lefebvre C, Manheimer E, Glanville J. Chapter 6: Searching for studies. In: Higgins JP, Green S, editor(s). Cochrane Handbook for Systematic Reviews of Interventions Version 5.1.0 (updated March 2011). The Cochrane Collaboration, 2011. Available from handbook.cochrane.org.

Majorin 2014
Majorin F, Torondel B, Ka Seen Chan G, Clasen TF. Interventions to improve disposal of child faeces for preventing diarrhoea and soil-transmitted helminth infection. *Cochrane Database of Systematic Reviews* 2014, Issue 4. DOI: 10.1002/14651858.CD011055

Penakalapati 2017
Penakalapati G, Swarthout J, Delahoy MJ, McAliley L, Wodnik B, Levy K, et al. Exposure to animal feces and human health: a systematic review and proposed research priorities. *Environmental Science and Technology* 2017;**51** (20):11537–52.

Platts-Mills 2015
Platts-Mills JA, Babji S, Bodhidatta L, Gratz J, Haque R, Havt A, et al. Pathogen-specific burdens of community diarrhoea in developing countries: a multisite birth cohort study (MAL-ED). *Lancet Global Health* 2015;**9**:e564–75.

RevMan 2014 [Computer program]
Nordic Cochrane Centre, The Cochrane Collaboration. Review Manager 5 (RevMan 5). Version 5.3. Copenhagen: Nordic Cochrane Centre, The Cochrane Collaboration, 2014.

Stelmach 2015
Stelmach RD, Clasen T. Household water quantity and health: a systematic review. *International Journal of Environmental Research and Public Health* 2015;**12**(6):5954-74.

Troeger 2018
Troeger C, Blacker BF, Khalil IA, Rao PC, Cao S, Zimsen SRM, et al. Estimates of the global, regional, and national morbidity, mortality, and aetiologies of diarrhoea in 195 countries: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet Infectious Diseases* 2018;**18**(11): 1211–28.

WHO 1993
World Health Organization. The management and prevention of diarrhoea: practical guidelines. 3rd edition. apps.who.int/iris/bitstream/handle/10665/37036/9241544546_eng.pdf?sequence=1&isAllowed=y (accessed 29 March 2018).

WHO 2017
World Health Organization. Diarrhoeal disease fact sheet. www.who.int/mediacentre/factsheets/fs330/en/ (accessed 29 March 2018).

WHO 2018
World Health Organization. The top 10 causes of death. www.who.int/mediacentre/factsheets/fs310/en/ (accessed 02 April 2019).

WHO/UNICEF 2015
World Health Organization/UNICEF. Progress on sanitation and drinking water - 2015 update and MDG assessment. data.unicef.org/wp-content/uploads/2015/12/Progress-on-Sanitation-and-Drinking-Water_234.pdf (accessed 16 August 2018).

WHO/UNICEF 2017
World Health Organization/UNICEF. Progress on drinking water, sanitation and hygiene: 2017 update and SDG baselines. www.who.int/mediacentre/news/releases/2017/launch-version-report-jmp-water-sanitation-hygiene.pdf (accessed 16 August 2018).

References to other published versions of this review

Clasen 2010
Clasen TF, Bostoen K, Schmidt WP, Boisson S, Fung IC, Jenkins MW, et al. Interventions to improve disposal of

human excreta for preventing diarrhoea. *Cochrane Database of Systematic Reviews* 2010, Issue 6. DOI: 10.1002/14651858.CD007180.pub2

* *Indicates the major publication for the study*

APPENDICES

Appendix 1. Detailed search strategy

Search set	CIDG SR[a]	CENTRAL	MEDLINE[b]	Embase[b]	LILACS
1	excreta disposal	"excreta disposal" [ti, ab, kw]	"excreta disposal" [ti, ab]	"excreta disposal" [ti, ab]	excreta disposal
2	sanitation	Sanitation [Mesh terms]	Sanitation [Mesh]	environmental sanitation [Emtree]	sanitation
3	latrine OR toilet OR water closet OR privy OR sewer*	latrine OR toilet OR water closet OR privy OR sewer* [ti, ab, kw]	latrine OR toilet OR water closet OR privy OR sewer* [ti, ab]	Sanitation [Emtree]	latrine OR toilet OR water closet OR privy OR sewer*
4	faeces OR defecation OR excrement OR waste OR sludge	faeces OR defecation OR excrement OR waste OR sludge [ti, ab, kw]	faeces OR defecation OR excrement OR waste OR sludge [ti, ab]	solid waste management [Emtree]	faeces OR defecation OR excrement OR waste OR sludge
5	1 OR 2 OR 3 OR 4	1 OR 2 OR 3 OR 4	1 OR 2 OR 3 OR 4	latrine OR toilet OR water closet OR privy OR sewer* [ti, ab]	1 OR 2 OR 3 OR 4
6	diarrhea	"diarrhea/epidemiology"[Mesh Terms] OR "diarrhea/microbiology"[Mesh Terms] OR "diarrhea/prevention and control"[Mesh Terms]	"diarrhea/epidemiology"[Mesh] OR "diarrhea/microbiology"[Mesh] OR "diarrhea/prevention and control"[Mesh]	faeces OR defecation OR excrement OR Waste OR sludge [ti, ab]	diarrhea OR cholera OR shigell* OR dysenter* OR cryptosporid* or giardia* OR Escherichia OR clostridium
7	waterborne OR foodborne	(waterborne OR foodborne) AND (infection* OR illness*)	(waterborne OR foodborne) AND (infection* OR illness*)	1-6/OR	waterborne OR foodborne

(*Continued*)

8	6 OR 7	cholera OR shigell* OR dysenter* OR cryptosporid* or giardia* OR Escherichia OR clostridium [ti, ab, kw]	cholera OR shigell* OR dysenter* OR cryptosporid* or giardia* OR Escherichia OR clostridium	diarrhea/dm, ep, pc [Disease Management, Epidemiology, Prevention]	6 OR 7
9	5 AND 8	"Enterobacteriaceae Infections"[Mesh]	"Enterobacteriaceae Infections"[Mesh]	(waterborne OR foodborne) AND (infection* OR illness*)	5 AND 8
10	-	6 OR 7 OR 8 OR 9	6 OR 7 OR 8 OR 9	cholera OR shigell* OR dysenter* OR cryptosporid* or giardia* OR Escherichia OR clostridium [ti, ab]	-
11	-	5 AND 10	5 AND 10	Enterobacteriaceae infection [Emtree]	-
12	-	-	Limit 11 to Human	8 OR 9 OR 10 OR 11	-
13	-	-	-	7 AND 12	-
14	-	-	-	Limit 13 to Human	-

[a] Cochrane Infectious Diseases Group Specialized Register.
[b] Search terms used in combination with the search strategy for retrieving trials developed by Cochrane (Lefebvre 2011).

Appendix 2. Data to extract from included studies

Type of data	Fields
General information	Study ID
	Name of data extractor
	Date of data extraction
	Study citation
	Publication type

(*Continued*)

	Publication status
	Funding source
Study eligibility	Type of study - RCT, quasi-RCT, non-randomized controlled trial, CBA, matched cohort
	Participants - children or adults in any country or population
	Type of intervention - sanitation intervention to introduce or upgrade sanitation facilities, or expand the coverage or use of sanitation facilities
	Outcome • Diarrhoea among individuals, whether reported as incidence or prevalence • Mortality • Persistent diarrhoea • Dysentery (bloody diarrhoea) • Hospital or clinical visits for diarrhoea • Adverse events (harmful effects of an intervention)
	If excluded, provide reason for exclusion and stop data extraction
Study data	Country and setting (urban, rural)
	Year of study
	Number of participants/groups/clusters and average number of participants per group/cluster
	Age of participants
	Method of participant recruitment
	Inclusion/exclusion criteria for study participation. Matching criteria used for matched cohort studies
	Unit of randomization and whether measurement of effect adjusts for clustering where randomization is done by groups other than individual
	If participants are blinded and method of blinding participants
	Types and details of the sanitation intervention, including factors that may augment or diminish effectiveness (e.g. location, emptying practices, overflow protection)
	Description of sanitation facilities and practices at baseline in control and intervention groups
	Other components of intervention (e.g. hygiene message, improved water supply, improved water quality, improved storage)
	Duration of intervention and duration of follow-up

(*Continued*)

	Definition of control group and description of sanitation facilities and practices
	Whether water is protected to point of use (i.e. by pipe, residual disinfection, or safe storage)
	Hygiene practices
	Child defecation practices
	Child faeces disposal practices
	Sanitation use levels and open defecation prevalence at baseline, endline, and other time points measured
	Sanitation coverage levels at baseline and postintervention at time of outcome assessment
	Any measurements of environmental contamination measured (e.g. water, hands, soil, flies)
	Description of any missing data with reason for loss
	Prescribed criteria of risk of bias assessments - varies based on study design
Outcomes	Time points measured and reported, including season (wet/dry) of each outcome measurement
	Case definition of outcome
	Method for outcome assessment (self reported, caregiver reported, observed, clinically confirmed, or other surveillance method)
	If self or caregiver reported, what is the recall period used?
	Effect measure and 95% confidence interval for each age group reported. For non-randomized studies, unadjusted and adjusted effect measures and 95% confidence intervals, including a list of factors that were adjusted for. For cluster-RCT, record whether effect measure is adjusted for clustering and the ICC
	Mortality attributed to diarrhoea
	Diarrhoea prevalence (or incidence) in control and intervention groups at baseline, endline, and other time points measured
	Rate of utilisation of intervention and manner of assessing it
	Number or per cent of participants/groups lost to withdrawal or follow-up with reason
	Key conclusions of the study authors

CONTRIBUTIONS OF AUTHORS

TC planned the review.

VB drafted the protocol.

All review authors reviewed, revised, and approved the final protocol.

DECLARATIONS OF INTEREST

VB has no known conflicts of interest.

FM has no known conflicts of interest.

GS has no known conflicts of interest.

TC has no known conflicts of interest.

SOURCES OF SUPPORT

Internal sources

- Liverpool School of Tropical Medicine, UK.

External sources

- Department for International Development (DFID), UK.

Project number 300342-104

- National Institute of Environmental Health Sciences, USA.

This research is supported in part by a grant from the National Institute of Environmental Health Sciences, USA (T32ES012870 to VB).