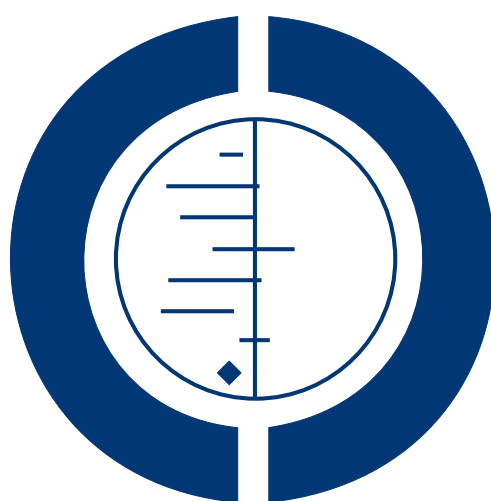# Interventions to improve water quality and supply, sanitation and hygiene practices, and their effects on the nutritional status of children (Protocol)

Dangour AD, Watson L, Cumming O, Boisson S, Velleman Y, Cavill S, Allen E, Uauy R

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Interventions to improve water quality and supply, sanitation and hygiene practices, and their effects on the nutritional status of children

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ABSTRACT

This is the protocol for a review and there is no abstract. The objectives are as follows:

The primary aim of this review is to evaluate the effectiveness of interventions to improve water quality and supply (adequate quantity to maintain hygiene practices), provide adequate sanitation and promote hand-washing with soap, in improving the nutritional status of children under the age of 18 years.

The secondary aim of this review is to identify current research gaps.

BACKGROUND

Water, sanitation and hygiene (WASH) interventions such as provision of clean piped drinking water, enhanced facilities for excreta disposal and the promotion of hand-washing with soap are frequently implemented to improve health (especially with relation to infectious diseases) and children's development outcomes. There are no published systematic reviews investigating the impact of WASH interventions on medium- to long-term markers of health in childhood such as measures of physical growth and nutritional sufficiency. This review will assess the strength of evidence linking WASH interventions with measures of child nutritional status.

Description of the condition

In 2010 it was estimated that approximately 925 million people worldwide were undernourished (insufficient calorie availability) (FAO 2010), and global estimates of people with specific nutrient insufficiencies (for example iron and iodine) are in excess of 2 billion (SCN 2004). A lack of calories, minerals and vitamins is estimated to be the underlying cause of 35% of all child deaths and 11% of the global disease burden (Black, Allen, et al 2008). This figure includes estimates of the negative effects of undernutrition on pregnant women, which can cause poor foetal growth (intra-uterine growth retardation) and low birthweight. The Millennium Development Goal 4 (MDG 4) is to reduce by two thirds the mortality rate of children less than 5 years of age and current evidence suggests that the achievement of good nutritional status is crucial for the attainment of this goal.

In low-income countries over 27% of children under the age of 5 years (147 million) suffer from chronic undernutrition manifested as short height for their age (or stunting) and 23% (126 million) are underweight (low weight for age); by far the largest numbers of undernourished children live in South Asia and Sub-Saharan Africa. The period from conception to 24 months of age is widely recognised as a critical window for the prevention of chronic undernutrition (Black, Allen, et al 2008). The long-term consequences of chronic undernutrition include reduced school attendance and diminished health, economic and gender potential. One target for Millennium Development Goal 1 (MDG 1) is to reduce by half the proportion of people who suffer from hunger, but to date progress towards this goal has been slow (Unicef 2008). There are both direct and indirect causes of undernutrition in children. The two direct immediate causes of undernutrition are inadequate dietary intake and disease, which interact in a complex manner and manifest as either chronic undernutrition (short height or stunting) or in acute situations as severe thinness (or wasting). Underlying these immediate causes are a multitude of indirect factors that contribute to nutritional status such as food security, child-care practices, maternal education, access to health services and water, hygiene and sanitation conditions. Ultimately, these factors are embedded in the larger political, economic, social and cultural environment.

Nutritional status in children is normally evaluated by assessing physical growth performance (via anthropometry) or micro-nutrient status (clinical signs of deficiency or blood measures). Various standardised methods are available for the assessment of nutritional status.

Description of the intervention

The integral role in health of safe water, sanitary disposal of human waste and personal hygiene has long been recognized (Fewtrell, Kaufmann, et al 2005). One target for Millennium Development Goal 7 (MDG 7) is to reduce by half the proportion of people without access to safe drinking water and basic sanitation. Activities linked to this goal aim to reduce the prevalence of infectious diseases and thereby improve nutritional status, especially in children. However, discourse around efforts to reach the MDG 7 targets is often not linked directly to health.

Currently approximately 2.6 billion people do not have access to improved sanitation, that is sanitation which ensures the hygienic separation of human excreta from human contact, and they rely on facilities such as unsafe flush or pour flush (to the street, yard, plot, open sewer, ditch or other location), a pit latrine without a slab or platform, a bucket and hanging latrine. Approximately 1.1 billion people have no sanitation facilities at all and have to practice open defecation (WHO/UNICEF 2010). Approximately 884 million people do not have access to improved drinking water sources (WHO/UNICEF 2010). Progress towards MDG 7 is on track for access to safe water but will fall well short for provision of basic sanitation (WHO/UNICEF 2010) and there are major differences between and within countries and regions.

Water, sanitation and hygiene (WASH) interventions are defined in this review as follows.

Water quality is any intervention to improve the microbiological quality of drinking water, including removing or inactivating microbiological pathogens (via household, community, or water source level water treatment systems involving filtration, sedimentation, chemical treatment, heat treatment or ultraviolet (UV) radiation) and protecting the microbiological quality of water prior to consumption (residual disinfection, protected distribution, improved storage). The effects of chemical contaminants (that is arsenic, fluoride) are not included in this review.

Water quantity or supply is any intervention to provide a new or improved water supply or improved distribution (installation of a new hand pump or household connection), or both.

Sanitation is interventions to introduce or expand the provision or use of facilities for excreta disposal (flush or pour flush to piped sewer system, septic tank or pit latrine; ventilated improved pit (VIP) latrine; pit latrine with slab; or composting toilet).

Hygiene is interventions that promote adoption of or increased practice of hand-washing with soap after defecation and disposal of child faeces prior to preparing and handling food and before

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eating (group discussions, media campaigns, leaflets, songs, pictorial stories, dramas etc.).

How the intervention might work

The causes of poor nutritional status in children are numerous and complicated and are both direct and indirect. The overall conceptual framework of the manner in which poor water supply and quality and also poor sanitation and hygiene might impact on child nutritional status identifies both direct pathways, namely diarrhoea (Briend 1990; Guerrant, Oriá, et al 2008), tropical enteropathy (Humphrey 2009) and nematode infections (Pruss-Ustun and Corvalan 2006); and indirect pathways, namely the time taken to collect water at long distances from the home, the purchase of water from water vendors and contamination of groundwater by poisonous metals (Figure 1). This review will focus on those pathways exemplified in Figure 2.

Figure 1.   Conceptual framework showing how poor water, sanitation and hygiene might impact child nutritional status, directly and indirectly
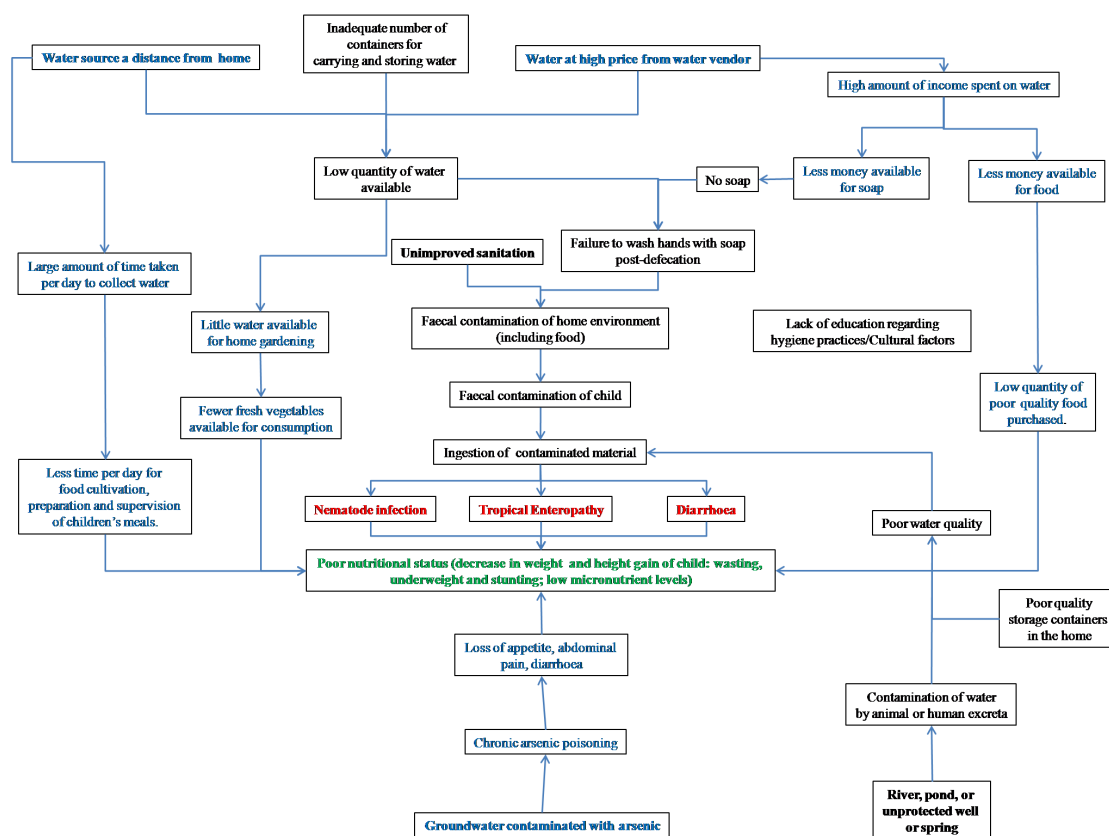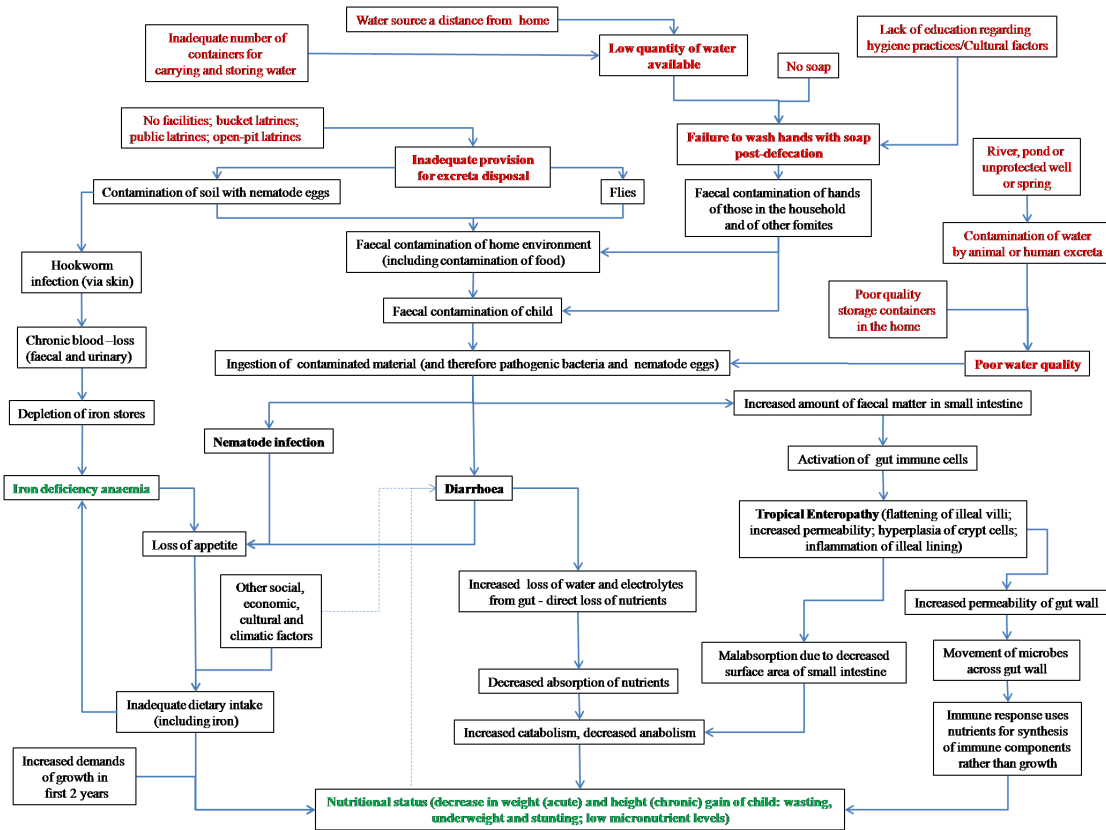
Figure 2.   Conceptual framework showing how poor water, sanitation and hygiene might directly impact child nutritional status

Why it is important to do this review

Several reviews have been published on the impact of sanitation interventions on diarrhoea incidence, the most recent of which is a Cochrane review that reports some evidence for effectiveness (Clasen, Boestoen, et al 2010). A further recent Cochrane review on the impact of hand-washing to prevent diarrhoea (Ejemot, Ehiri, et al 2008) reported that these interventions can reduce diarrhoea by approximately one third. The links between diarrhoea and other enteric infections and child nutritional outcomes are already well established (Pruss-Ustun and Corvalan 2006; Checkley, Buckley, et al 2008; Guerrant, Oriá, et al 2008).

However, work published thus far focuses only on the impact of WASH interventions on the incidence of childhood diarrhoea, and there are no published systematic reviews investigating the effect of WASH interventions on child nutritional status. The current review will therefore evaluate the strength of evidence linking WASH interventions with measures of child nutritional status. Indirect effects of improved nutritional status (such as improved Intelligence Quotient (IQ) levels, school performance, school at-

tendance) will not be included in the review. Linking up the to-date distinct evidence base will help identify the role of WASH interventions in improving child health in efforts to meet the MDG 7 targets and will help establish priorities for future research.

OBJECTIVES

The primary aim of this review is to evaluate the effectiveness of interventions to improve water quality and supply (adequate quantity to maintain hygiene practices), provide adequate sanitation and promote hand-washing with soap, in improving the nutritional status of children under the age of 18 years.

The secondary aim of this review is to identify current research gaps.

METHODS

Criteria for considering studies for this review

Types of studies

We will include randomised (including cluster randomised), quasi-randomised and non-randomised controlled trials, including controlled before and after studies (cohort or cross-sectional), interrupted time series (ITS) and historically controlled studies.

Types of participants

We will include children aged < 18 years from any country in the world.

Types of interventions

We will include the following intervention types.
1. Any intervention aimed at improving the microbiological quality of drinking water, including:
   • removing or inactivating microbiological pathogens (via household, community, or water source level water treatment systems (filtration, sedimentation, chemical treatment, heat treatment, UV radiation)), or both;
   • protecting the microbiological quality of water prior to consumption (residual disinfection, protected distribution, improved storage).

2. Any intervention aimed at introducing a new or improved water supply or improved distribution (installation of a new hand pump or household connection), or both.
3. Interventions aimed at introducing or expanding the coverage and use of facilities designed to improve sanitation, i.e. to reduce direct and indirect contact with human faeces (pour-flush, composting or water sealed flush toilet, piped sewer system, septic tank, simple pit latrines, VIP latrine or use of a potty or scoop for the disposal of child faeces).
4. Interventions aimed at the promotion of hand-washing with soap after defecation, disposal of child faeces and prior to preparing and handling food (group discussions, media campaigns, leaflets, songs, pictorial stories, dramas etc.).
5. We will also include interventions that combine several components from the above list.
Control participants will consist of the following.
1. Water quality: study participants who have continued with usual practice, or a less stringent version of the intervention (i.e. new protected well but no household disinfection on top of this).
2. Water supply: study participants who have continued with usual practice.
3. Sanitation: study participants who have continued to practice open defecation or who continue with usual practice regarding excreta disposal rather than following the prescribed intervention.
4. Hygiene: no hand-washing promotion; study participants who continued with usual practice.
There will be no minimum duration of intervention.

Types of outcome measures

Primary outcomes

• Child nutritional status as measured by anthropometry: weight-for-height (wasting), weight-for-age (underweight), height-for-age (stunting).

Secondary outcomes

• Child nutritional status as measured by anthropometry: weight, height, mid-upper arm circumference, skin fold thickness, per cent body fat, birthweight.
• Child nutritional status as measured by micro-nutrient status: haemoglobin, serum ferritin, soluble transferrin receptor, serum retinol, serum zinc, urinary iodine, clinical signs of deficiency.

Search methods for identification of studies

Electronic searches

We will search the following databases using a keyword search and MeSH terms. Search terms will be adapted according to the requirements or individual databases.
• Cochrane Public Health Group Special Register.
• MEDLINE (general medicine).
• MEDLINE-In-Process.
• Web of Science.
• EMBASE (general medicine).
• Econlit (economics).
• Global Health (public health).
• Greenfile.
• Cababstracts (applied life sciences).
• Trial registers (CENTRAL, *meta*Register of Controlled Trials (*m*RCT)).
• Grey literature (www.nyam.org/library/online-resources/grey-literature-report/; http://indexmedicus.afro.who.int/; http://bases.bvs.br/; www.hellis.org; www.emro.who.int/HIS/VHSL/; http://wprim.wpro.who.int/iah/I/index.htm; 3ie Impact; http://scholar.google.co.uk/).
• Chinese-language databases (Fung 2005) available under the China National Knowledge Infrastructure (CNKI-CAJ).

Our search strategy is shown in Appendix 1. There will be no language restrictions.
Reference lists of key articles will be handsearched for any additional relevant articles.

Searching other resources

We will contact researchers and organizations including the Public-Private Partnership for Handwashing with Soap; IRC International Water and Sanitation Centre; Department of Child and Adolescent Health and Development (WHO); World Bank; World Bank Water and Sanitation Programme; World Health Organization (WHO) and United Nations Children's Fund (UNICEF); International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B); Water, Sanitation and Health Programme (WHO); Environmental Health Project (USAID); Foodborne and Diarrheal Diseases Branch, Centers for Disease Control and Prevention (CDC),;USAID and UK Department for International Development (DFID) for information regarding unpublished and ongoing trials.

We will search the conference proceedings of the following for relevant abstracts:

- Waterlines Journal;
- International Water Association and the Water, Engineering and Development Centre (Loughborough University, UK);
- Public health conferences (e.g. American Public Health Association; European Public Health Association).

Data collection and analysis

Selection of studies

Titles and abstracts retrieved through the search strategy will be reviewed independently by two review authors (LW and SB) to identify and select potentially relevant studies using pre-defined inclusion criteria. The full text of all articles selected by either team member will be retrieved for a full text review. Where there is a difference of opinion, disagreement will be resolved through discussion with a third review author (ADD). All studies which initially appeared to meet the inclusion criteria but upon inspection of the full text do not merit inclusion will be detailed in the 'Excluded studies' table with reasons for exclusion.

Data extraction and management

Data from all relevant articles will be independently extracted by two review authors (LW and SB). The data extraction forms will be based on the data collection form from the Cochrane Effective Practice and Organisation of Care (EPOC) Group and Cochrane Public Health Group, modified for use in this review. Quality criteria questions for the different study designs will be built into this form. If there are any discrepancies between the two review authors, a third author (ADD) will be used to resolve them.

Data will be extracted, and included in the 'Characteristics of included studies', on the following.

- Study design and sample size.
- Method of participant selection.

- Study duration.
- Details of participants.
- Study setting, population characteristics.
- Description of intervention.
- Length of intervention and post-intervention follow-up.
- Unit of randomisation.
- Unit of analysis.
- Primary and secondary outcomes.
- Process and implementation factors.
- Intervention uptake.
- Information on cost of intervention.
- Any reference in the study to additional outcomes of interest, e.g. educational outcomes (however, specific data will not be extracted).

Multiple papers reporting results from one study will be considered as one study. A standard approach will be used where comparisons of multiple reports and publications of the same study will be checked for contradictions and completeness and the data used once.

Assessment of risk of bias in included studies

The risk of bias of included studies will be assessed using the EPOC risk of bias tool for studies with a separate control group. This includes the standard Cochrane risk of bias tool items to assess five domains of bias: selection, performance, attrition, detection and reporting. The EPOC risk of bias tool includes additional items to assess the risk of selection bias and subsequent confounding ("were baseline outcome measurements similar?" and "were baseline characteristics similar?"), as well as an additional item to consider the likelihood of contamination ("was the study adequately protected against contamination?"). We will also supplement the EPOC risk of bias tool with another additional item to address whether the study authors appropriately adjusted for important confounders in their analysis.

The risk of bias for ITS studies will be assessed using the EPOC risk of bias tool for ITS study designs which includes four items from the Cochrane risk of bias tool, to assess performance, attrition, detection and reporting bias, as well as the following additional items relevant for ITS studies: "was the intervention independent of other changes?", "was the shape of the intervention effect pre-specified?" and "was the intervention unlikely to affect data collection?".

Studies will be assessed for each item with answers of 'Low' indicating low risk of bias, 'High' indicating high risk of bias, and 'Unclear' indicating either lack of information or uncertainty over the potential for bias. For some items in the risk of bias tool (for example blinding), the risk of bias may be different for different outcomes within the same study; so, where relevant, the risk of bias will be assessed at the outcome level within each study. For this reason, the overall risk of bias will be summarised for relevant outcomes across studies. Relevant outcomes will be judged overall

as 'Low', 'Medium', or 'High' risk of bias giving overall consideration of the study designs and the potential impact of the identified weaknesses noted in the table for each study that contributed results for that outcome.

We will attempt to contact study authors if there is any ambiguity in their papers regarding the reporting of these risk of bias indicators.

Measures of treatment effect

To express effect size differences between post-intervention values of intervention and control groups we will express effect sizes for binary and categorical outcomes as risk ratios as recommended in the Cochrane Public Health Group guidelines. For continuous outcomes we will use weighted mean difference sand we will report them using the original scale if possible. Standardised mean differences will be reported when different studies have used different scales for the same outcome. All measures of effect will be presented with 95% confidence intervals.

Unit of analysis issues

In the case of a study having more than two arms, the overall effects of the intervention versus control (means and SDs) will be examined by pooling the individual effect of each intervention arm (mean and SD), and weighting the overall values for the numbers within each arm. Cluster-randomised trials will be clearly identified in the review and information regarding data handling will be clearly stated. When necessary, and possible, the results of clustered trials will be re-analysed to take account of the clustered design. If re-analysis is not possible then standard errors may be inflated. Where appropriate, cluster-randomised trials will be combined with individually randomised trials in the same meta-analysis as advised in Chapter 16 of the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011). Appropriate statistical advice will be sought.

Dealing with missing data

Authors will be contacted directly by e-mail if outcome data are unclear or are not fully reported (or variables reported at baseline but not as outcomes). If the information cannot be obtained this will be reflected in the risk of bias table. In addition, we will record the completion rates of both the intervention and outcome and classify them according to completion.

Assessment of heterogeneity

Heterogeneity will be assessed by exploration of the forest plots and estimated using the I^2 statistic. Clinical heterogeneity will be determined by baseline disease rates and adjusted for in the meta-analysis, if appropriate.

Assessment of reporting biases

As recommended in Chapter 8 of the *Cochrane Handbook for Systematic Reviews of Interventions* ('Assessing risk of bias in included studies'), where there are an adequate number of studies bias will be assessed using funnel plots. When there is an inadequate number of studies (< 10) bias will be assessed using the methods recommended in the *Cochrane Handbook for Systematic Reviews of Interventions* (Higgins 2011).

Data synthesis

We will report all statistically significant and non-significant outcomes according to type of study design.

Statistical analysis will be carried out using Review Manager software if data are of sufficient similarity and quality. A random-effects model meta-analysis will be carried out if there are a minimum of two studies of any type of intervention to be combined. A forest plot with appropriate effect sizes and 95% confidence intervals will be provided for each meta-analysis, along with a measure of heterogeneity (I^2 statistic).

In the case of insufficient data, a narrative synthesis will be conducted and in this situation we anticipate that studies will be grouped by either outcome type or intervention type.

We will attempt to include a summary of findings table to provide information about the primary outcomes, effect sizes, process and implementation factors, cost of intervention and quality of the information.

Subgroup analysis and investigation of heterogeneity

Where sufficient data are available we will perform additional subgroup analyses to compare outcomes by the following characteristics.

- Gender.
- Age groups (< 2 years, 2 to 5 years, > 5 years).
- Duration of intervention (< 6 months, > 6 months).
- Community location (urban, rural).
- Country setting (low- or middle-income, high-income).

Where possible, subgroup effects will be assessed using meta-regression.

We will explore the ability to examine issues of equity using the *Cochrane and Campbell Equity Checklist for Review Authors (*Ueffing 2009), working with the Campbell and Cochrane Equity Methods Group.

Sensitivity analysis

We will carry out a sensitivity analysis of studies with a low risk of bias as reported in the Cochrane risk of bias table.

ACKNOWLEDGEMENTS

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* *Indicates the major publication for the study*

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APPENDICES

Appendix 1. MEDLINE search strategy

Database: Ovid MEDLINE(R)
/ - subject heading
* - truncation term
ab - abstract
adj - adjacent to
ti - title
? - optional wildcard term
Appendix: Search strategy

1. Stunt*.ab,ti.
2. Short stature.ab,ti.
3. Growth.ab,ti.
4. Wast*.ab,ti.
5. Thin.ab,ti.
6. Emaciated.ab,ti.
7. Undernourish*.ab,ti.
8. (BMI or body mass index).ab,ti.
9. (Intra-uterine growth retardation or IUGR).ab,ti.
10. Underweight.ab,ti.
11. Weight-for-age.ab,ti.
12. Height-for-age.ab,ti.
13. Length-for-age.ab,ti.
14. Weight-for-height.ab,ti.
15. ((Increas* or improv* or chang*) adj3 height).ab,ti.
16. ((Increas* or improv* or chang*) adj3 weight).ab,ti.
17. Body fat percentage.ab,ti.
18. Development*.ab,ti.
19. Under?nutrition.ab,ti.
20. Malnutrition.ab,ti.
21. Nutritional status.ab,ti.
22. Nutriti*.ab,ti.
23. (GAM or global acute malnutrition).ab,ti.
24. (SAM or severe acute malnutrition).ab,ti.
25. (PEM or Protein energy malnutrition).ab,ti.
26. Nutritional deficiency status.ab,ti.
27. (An?emia or iron deficiency an?emia).ab,ti.
28. Vitamin a deficienc*.ab,ti.
29. Zinc deficienc*.ab,ti.
30. Iodine deficienc*.ab,ti.
31. (MUAC or mid-upper arm circumference).ab,ti.
32. Skinfold thickness.ab,ti.
33. Anthropometry*.ab,ti.
34. Nutrition Disorders/
35. Child Nutrition Disorders/
36. Infant Nutrition Disorders/
37. Malnutrition/
38. Starvation/
39. Wasting Syndrome/

40. or/1-39 (Combines outcome terms)
41. Child*.ab,ti.
42. Infan*.ab,ti.
43. Baby.ab,ti.
44. Toddler.ab,ti.
45. Pre?school*.ab,ti.
46. young person.ab,ti.
47. (Boy or girl).ab,ti.
48. Child/
49. Child, Preschool/
50. Infant/
51. Adolescent/
52. or/41-51 (Combines Child terms)
53. (Hand$1 adj3 (wash* or clean* or disinfect*)).ab,ti.
54. Hand hygiene.ab,ti.
55. Hand hygiene.ab,ti.
56. Hand sterility.ab,ti.
57. Handwashing.ab,ti.
58. (water adj3 (improv$ or sediment$ or radiat$ or irradiat$ or UV)).ti,ab.
59. Sanita*.ab,ti.
60. (Latrine$1 or toilet$1 or water closet$1 or privy or pour flush or sewer system$1 or septic tank$1).ab,ti.
61. ((Faeces or feces or fecal or faecal or defecation or excrement or waste or excreta) adj3 (dispos* or manag* or service*)).ab,ti.
62. Water purification.ab,ti.
63. Water microbiology.ab,ti.
64. (Water adj5 (disinfect* or connect* or quality or handpump$1 or standpipe$1 or piped)).ti,ab.
65. (water adj5 (Purif* or treat* or improv* or decontaminat* or filt* or consum* or supply or drink* or quantity or distribut* or stor* or volume)).ab,ti.
66. (water adj3 (safe or improv* or Clean*)).ab,ti.
67. (water adj3 Hygien*).ab,ti.
68. Water Supply/ or Water Purification/ or Water Pollution/ or Sanitation/
69. or/53-68 (Combines water quality interventions)
70. 40 and 52 and 69 (All concepts combined)

H I S T O R Y

Protocol first published: Issue 10, 2011

Date	Event	Description
12 August 2011	Amended	Protocol FINAL
3 August 2011	Amended	Protocol: Amended according to external peer reviewer feedback.
18 May 2011	Amended	Protocol: Amended according to internal reviewer feedback.

CONTRIBUTIONS OF AUTHORS

The following assignation of tasks has been agreed to by all authors.

Draft the protocol: all.

Study selection: LW, SB.

Extract data from studies: LW, SB.

Enter data into RevMan: LW.

Carry out the analysis: LW, EA.

Interpret the analysis: LW, EA, ADD.

Draft the final review: all.

Disagreement resolution: ADD.

Update the review: ADD.

DECLARATIONS OF INTEREST

No known potential conflict of interest