Hand washing for preventing diarrhoea (Review)

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TABLE OF CONTENTS

HEADER 1
ABSTRACT 1
PLAIN LANGUAGE SUMMARY 2
BACKGROUND 2
OBJECTIVES 3
METHODS 3
RESULTS 7
DISCUSSION 21
AUTHORS' CONCLUSIONS 22
ACKNOWLEDGEMENTS 23
REFERENCES 23
CHARACTERISTICS OF STUDIES 27
DATA AND ANALYSES 37
WHAT'S NEW 37
HISTORY 38
CONTRIBUTIONS OF AUTHORS 38
DECLARATIONS OF INTEREST 38
SOURCES OF SUPPORT 38
DIFFERENCES BETWEEN PROTOCOL AND REVIEW 38
INDEX TERMS 38

[Intervention Review]

Hand washing for preventing diarrhoea

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Editorial group: Cochrane Infectious Diseases Group.
Publication status and date: Edited (no change to conclusions), published in Issue 3, 2009.
Review content assessed as up-to-date: 4 November 2007.

Citation: Ejemot RI, Ehiri JE, Meremikwu MM, Critchley JA. Hand washing for preventing diarrhoea. *Cochrane Database of Systematic Reviews* 2008, Issue 1. Art. No.: CD004265. DOI: 10.1002/14651858.CD004265.pub2.

ABSTRACT

Background

Diarrhoea is a common cause of morbidity and a leading cause of death among children aged less than five years, particularly in low- and middle-income countries. It is transmitted by ingesting contaminated food or drink, by direct person-to-person contact, or from contaminated hands. Hand washing is one of a range of hygiene promotion interventions that can interrupt the transmission of diarrhoea-causing pathogens.

Objectives

To evaluate the effects of interventions to promote hand washing on diarrhoeal episodes in children and adults.

Search strategy

In May 2007, we searched the Cochrane Infectious Diseases Group Specialized Register, CENTRAL (*The Cochrane Library* 2007, Issue 2), MEDLINE, EMBASE, LILACS, PsycINFO, Science Citation Index and Social Science Citation Index, ERIC, SPECTR, Bibliomap, RoRe, The Grey Literature, and reference lists of articles. We also contacted researchers and organizations in the field.

Selection criteria

Randomized controlled trials, where the unit of randomization is an institution (eg day-care centre), household, or community, that compared interventions to promote hand washing or a hygiene promotion that included hand washing with no intervention to promote hand washing.

Data collection and analysis

Two authors independently assessed trial eligibility and risk of bias. We stratified the analyses for cluster adjusted and non-adjusted trials. Where appropriate, incidence rate ratios (IRR) were pooled using the generic inverse variance method and random-effects model with 95% confidence intervals (CI).

Main results

Fourteen randomized controlled trials met the inclusion criteria. Eight trials were institution-based in high-income countries, five were community-based in low or middle-income countries, and one was in a high-risk group (people with acquired immune deficiency syndrome (AIDS)). Considering only trial results that adjusted for cluster randomization, interventions promoting hand washing resulted in a 39% reduction in diarrhoea episodes in children in institutions in high-income countries (IRR 0.61, 95% CI 0.40 to 0.92; 2 trials) and a 32% reduction in such episodes in children living in communities in low- or middle-income countries (IRR 0.68, 95% CI 0.52 to 0.90; 4 trials).

Authors' conclusions

Interventions that promote hand washing can reduce diarrhoea episodes by about one-third. This significant reduction is comparable to the effect of providing clean water in low-income areas. However, trials with longer follow up and that test different methods of promoting hand washing are needed.

PLAIN LANGUAGE SUMMARY

Strategies to encourage hand washing can reduce the incidence of diarrhoea by about one third

Diarrhoea is a serious global public health problem, particularly in low-income and middle-income countries. The World Health Organization estimates that over three million episodes occur each year, with many people dying, especially children aged less than five years in low- and middle-income countries. Persistent diarrhoea can also contribute to malnutrition, reduced resistance to infections, and sometimes impaired growth and development. The organisms causing diarrhoea can be transmitted from infected faeces to people through food and water, person-to-person contact, or direct contact. Hand washing after defecation and handling faeces, and before preparing and eating food can reduce the risk of diarrhoea. This review looked at trials of interventions to increase the use of hand washing in institutions in high-income countries and in communities in low- or middle-income countries, and found many of the interventions like educational programmes, leaflets, and discussions to be effective.

BACKGROUND

Diarrhoea is a serious global public health problem. The World Health Organization (WHO) estimates that over 2.2 million deaths due to diarrhoeal infections occur annually, especially among children less than five years of age (Bern 1992; WHO 2002). The yearly global diarrhoeal disease burden is estimated at 99.2 million disability adjusted life years (DALYs) lost through incapacitation and premature deaths, mainly in low- and middle-income countries (Murray 1996). It is an important cause of malnutrition in children in resource-poor countries. The synergistic relationship between malnutrition and infection is clearly exacerbated in diarrhoeal episodes as children tend to eat less during episodes and their ability to absorb nutrients is reduced (WHO 2003). Thus, each episode contributes to malnutrition, reduced resistance to infections, and, when prolonged, to impaired growth and development (Martines 1993).

Diarrhoeal disease pathogens are usually transmitted through the faeco-oral route (Curtis 2000). The modes of transmission include ingestion of food and water contaminated by faecal matter, person-to-person contact, or direct contact with infected faeces (Black 1989). Some studies estimate that over 70% of all cases of diarrhoea can be attributed to contaminated food and water (Esrey 1989; Motarjemi 1993; Curtis 2000).

Epidemiological evidence shows that the most important risk factors are behaviours that encourage human contact with faecal matter, including improper disposal of faeces and lack of hand washing after defecation, after handling faeces (including children's faeces), and before handling food (LeBaron 1990; Traore 1994; Curtis 1995; Lanata 1998). In particular, hand contact with ready-to-eat food (ie food consumed without further washing, cooking, or processing/preparation by the consumer) represents a potentially important mechanism by which diarrhoea-causing pathogens con-

taminate food and water (PHS 1999). Also important are exposure of food to flies and consumption of contaminated water (Motarjemi 1993; Schmitt 1997).

In many resource-poor countries, households may lack facilities for proper disposal of excreta, and, even where available, these may not be adapted for children's use (Lanata 1998; Yeager 1999). This often leads not only to indiscriminate defecation in and around the premises, but also to increased risk of excreta handling by mothers, caregivers, and children themselves (Curtis 1995). In some cultures children's faeces are regarded as innocuous and adults may not wash their hands after handling them (Traore 1994). However, evidence suggests that children's faeces are equally hazardous and may contain even higher concentrations of pathogens than those of adults owing to their increased interactions with contaminated materials in their surroundings (Benneh 1993; Lanata 1998).

The WHO has identified a number of strategies to control diarrhoea (Feachem 1983). These include improvement of water supply at the household or community level (Clasen 2006) as well as hygiene promotion interventions (Curtis 1997). The latter constitute a range of activities aimed at encouraging individuals and communities to adopt safer practices within domestic and community settings to prevent hygiene-related diseases that lead to diarrhoea (WELL 1999); hand washing is one such intervention.

Hand washing aims to decontaminate the hands and prevent cross transmission (Kaltenthaler 1991; Larson 1995; Rotter 1999). The practice of hand washing and the factors that influence hand washing behaviour among individuals in communities are complex (Hoque 1995a; Hoque 1995b); for example, washing hands with water only or with soap may be influenced by both knowledge of best practice and availability of water and soap. Washing with soap and water not only removes pathogens mechanically, but may also chemically kill contaminating and colonizing flora making hand washing more effective (Han 1989; Shahid 1996; Rotter 1999). Washing hands with soap under running water or large quantities of water with vigorous rubbing was found to be more effective than several members of a household dipping their hands in the same bowl of water (often without soap) (Kaltenthaler 1991), which is common practice in many resource-poor countries, especially before eating (Ehiri 2001). This may contribute to, rather than prevent, food contamination as pathogens present on hands of infected household members can be transferred to those who subsequently dip their hands in the same bowl of water (Schmitt 1997).

Hand washing may require infrastructural, cultural, and behavioural changes, which take time to develop, as well as substantial resources (eg trained personnel, community organization, provision of water supply and soap) (Cave 1999; Yeager 1999; Luby 2001a). Given the many possible ways to reduce diarrhoeal disease, it is important to assess the effectiveness of hand washing interventions compared to other interventions, such as the provision of clean water at the household or community level and improvement of sanitation (disposal of faeces). Clasen 2006 found a 27% protection from diarrhoea related to providing clean water. Two recent meta-analyses of hand washing have been published. Curtis 2003 specifically examined the effectiveness of hand washing with soap in community-based studies and estimated that it could reduce diarrhoea risk by up to 47%. Fewtrell 2005 examined a range of water, sanitation, and hygiene interventions in low- and middle-income countries. Most of the different types of interventions had a similar degree of impact. The effect of hygiene interventions on diarrhoea incidence was estimated by Fewtrell 2005 at 44%. However both reviews included nonrandomized intervention studies. Curtis 2003 included case-control and cross-sectional studies as well as prospective interventions. Fewtrell 2005 presented evidence of publication bias in the hygiene studies. In this Cochrane Review, we assess whether the estimate of effect observed only in randomized controlled intervention trials is of similar magnitude to those seen in previous reviews. We also include both institution-based and community-based studies in countries of any income level.

OBJECTIVES

To evaluate the effects of interventions to promote hand washing on diarrhoeal episodes in children and adults.

METHODS

Criteria for considering studies for this review

Types of studies

Randomized controlled trials, including cluster-randomized trials, where the unit of randomization is an institution (eg day-care centre), household, or community.

Types of participants

Individuals (adults and children) in institutional settings (eg day-care centres, patients in hospitals), communities, or households.

Types of interventions

Intervention

Activities that promote hand washing after defecation or after disposal of children's faeces and before preparing or handling foods;

for example, small group discussions and larger meetings, multimedia communication campaigns with posters, radio/TV campaigns, leaflets, comic books, songs, slide shows, use of T-shirts and badges, pictorial stories, dramas, and games. Trials that focus exclusively on hand washing and those that promote hand washing as part of a broader package of hygiene promotion interventions are eligible if they undertook analyses of effects of hand washing on diarrhoea.

Control

No hand washing promotion.

Types of outcome measures

Primary

- Episodes of diarrhoea (self-reports collected through home visits; hospital/health centre/clinic records including admissions for diarrhoea-related dehydration).

Diarrhoea is defined as:

- Acute/primary diarrhoea: passage of three or more loose or watery stools in a 24-hour period, a loose stool being one that would take the shape of a container; or definitions used by authors consistent with this standard definition.
- Persistent diarrhoea: diarrhoea lasting 14 or more days.
- Dysentery: stool with blood.

Secondary

- Diarrhoea-related death among children or adults.
- Behavioural changes such as changes in the proportion of people who reported or are observed washing their hands after defecation, disposal of children's faeces, or before preparing or handling foods.
- Changes in knowledge, attitudes, and beliefs about hand washing.

Search methods for identification of studies

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

Databases

We searched the following databases using the search terms and strategy described in Table 1: Cochrane Infectious Diseases Group Specialized Register (May 2007); Cochrane Central Register of Controlled Trials (CENTRAL), published in *The Cochrane Library* (2007, Issue 2); MEDLINE (1966 to May 2007); EMBASE (1974 to May 2007); and LILACS (1982 to May 2007).

Table 1. Detailed search strategies

Search set	CIDG SR[a]	CENTRAL	MEDLINE[b]	EMBASE[b]	LILACS[b]
1	handwashing	handwashing	hand wash*	hand wash$	handwashing
2	diarrhea	hand washing	hand disinfec*	hand disinfec*	diarrhea
3	diarrhoea diseases	hand cleansing	hand clean*	hand clean$	1 and 2
4	-	hand hygiene	hand hygiene	hand hygiene	-
5	-	1 or 2 or 3 or 4	hand sterility	hand sterility	-
6	-	diarrhea	HANDWASHING	HANDWASHING	-
7	-	5 and 6	1 or 2 or 3 or 4 or 5 or 6	1 or 2 or 3 or 4 or 5 or 6	-
8	-	-	diarrhoea	diarrhoea	-
9	-	-	diarrhoea	diarrhoea	-

Table 1. Detailed search strategies (*Continued*)

10	-	-	8 or 9	8 or 9	-
11	-	-	7 and 10	7 and 10	-

[a] Cochrane Infectious Diseases Group Specialized Register.
[b] Search terms used in combination with the search strategy for retrieving trials developed by The Cochrane Collaboration (Higgins 2006); upper case: MeSH or EMTREE heading; lower case: free text term.

We also searched the following databases using diarrhea, diarrhoea, and handwashing as search terms: PsycINFO (1967 to May 2007); Science Citation Index and Social Sciences Citation Index (1981 to May 2007); ERIC (Educational Resources Information Center; 1966 to May 2007); SPECTR (The Campbell Collaboration's Social, Psychological, Educational, and Criminological Trials Register; 2000 to May 2007); Bibliomap and RoRe (Register of Review of Effectiveness in Health Promotion) maintained by the Evidence for Policy and Practice Information and Co-ordinating Centre (www.eppi.ioe.ac.uk) (1990 to May 2007); and The Grey Literature (www.nyam.org/library/grey.shtml; 2002 to May 2007).

Researchers and organizations contacted

To obtain information on published, unpublished, and ongoing studies, we contacted relevant experts and international organizations: World Bank (October 2006); Public-Private Partnership for Handwashing (October 2006); WHO (October 2006); UNICEF (October 2006); ICDDR,B (October 2006); IRC International Water & Sanitation Centre, The Netherlands (October 2006); and Child & Adolescent Health and Development, WHO (October 2006).

Reference lists

We also examined reference lists of articles for relevant studies.

Data collection and analysis

Selection of studies

Two authors (Ejemot and Critchley) independently screened titles and abstracts of relevant articles to assess their eligibility for inclusion in the review. Hard copies of trials that were potentially relevant to the review were retrieved for further assessment. Decision on inclusion was reached by consensus among all authors. We scrutinized each trial report to ensure that multiple publications from the same trial were included only once. We listed the excluded studies and the reasons for their exclusion.

Data extraction and management

Two authors (Ejemot and Critchley) independently extracted data on methods, types of participants, interventions, and outcomes from the selected trials using a standard form. Disagreements were resolved by discussion and consensus among authors in consultation with a Cochrane Infectious Diseases Group Editor. We requested unpublished data and additional information from published trials from relevant contact individuals, groups, and organizations.

We extracted data on each study site, including any measures of the availability of water, soap, and literacy level of the communities. Where data were available, we extracted the socioeconomic status of study participants since resources for effective hand washing (eg running water and soap) may be more accessible to higher income households. We carefully summarized details of the intervention including: type of promotional activity; whether soap and water provision was part of the intervention; method of hand washing promoted (washing in a bowl or under running water); and procedure of hand washing.

We had intended to analyse episodes of diarrhoea as a dichotomous outcome, but the data reported by the trials did not permit this type of analysis. We analysed the outcome as count data, when either the incidence rate ratio and 95% confidence intervals (CI), or the number of episodes of diarrhoea and the person-time at risk was reported; or as continuous data when the mean number of diarrhoea episodes and standard deviation were presented.

For individually randomized trials, when continuous outcomes

data were summarized as arithmetic means, we extracted the arithmetic means, standard deviations, and numbers of participants for the treatment and control groups. For count (rate) outcome data we extracted the number of episodes, the number of person-years at risk, and the number of participants for each intervention group, or we extracted a rate ratio and measure of variation (eg CI) directly from the publication.

Cluster-randomized trials require the use of different data extraction methods and analysis methods because trials with a cluster design require more complex analysis than trials that randomize individuals. Observations on participants in the same cluster tend to be correlated; therefore the intra-cluster variation must be accounted for during the analysis of the trial. If this correlation is ignored in the analysis and the same techniques are employed as for individually randomized trials the resulting measure of effect remains a valid estimate, but the associated variance of the estimate will be underestimated leading to unduly narrow CIs. For meta-analysis this means that trials analysed without allowing for this design effect will receive too much weight.

For the cluster-randomized trials, we extracted information on the number of clusters, average size of clusters, unit of randomization, whether the trials adjusted for clustering, and the statistical method used to analyse cluster trials. When a trial's analysis had adjusted for clustering we extracted the point estimate and 95% CI. For count data we extracted the incidence rate ratio. If a trial had not adjusted for clustering we extracted the same data as for the individually randomized trials.

Assessment of risk of bias in included studies

Two authors (Ejemot and Critchley) independently assessed the risk of bias in eligible studies using standard criteria. We classified the method used to generate a randomization sequence and the method used to conceal the sequence as adequate, inadequate, or unclear (Jüni 2001). Double blinding is not possible in studies of hand washing interventions since there is no obvious placebo. However, outcome assessors could be blinded, and we assessed whether or not this had occurred. It is very difficult to assess losses to follow up in open cluster-randomized trials. Some children may leave the study, but others are born or enter the study during the follow-up period; hence participant numbers are in constant flux. Inclusion of all randomized participants in the analysis is thus most clearly represented as the person-time at risk accrued as a percentage of maximum possible person-time at risk in each study arm. We therefore reported on this measure and also on any loss to follow up of both clusters and participants, and assessed this as adequate if at least 90%. We also assessed whether the baseline characteristics were comparable across the intervention groups and assessed whether data was collected at similar time points for the intervention and control sites.

Data synthesis

We analysed the data using Review Manager 5. All results were presented with 95% CI. We stratified the analysis into three categories of studies - institution-based interventions (day-care centres or primary schools), community-based interventions, and intervention in people at high risk of diarrhoea (people with acquired immune deficiency syndrome (AIDS)). We also stratified the analyses for the unit of randomization and whether the cluster trials adjusted for clustering (individual, cluster (adjusted), or cluster (unadjusted)). Since the outcomes and methods of measuring behaviour changes were too variable to make meta-analysis meaningful, we tabulated the results.

Individually randomized trials

Continuous outcome data from individually randomized trials were summarized using the mean difference. Meta-analysis of individually randomized trials was not undertaken due to the limited number of individually randomized trials.

Cluster-randomized trials that adjusted for clustering

For count outcomes, we pooled incidence rate ratios (IRR) in Review Manager 5 using the generic inverse variance method with the random-effects model. We used standard techniques for calculating standard errors from 95% CI (Higgins 2008). When the outcomes and methods of measuring outcomes were too variable to make meta-analysis meaningful (for changes in hand washing behaviour) we tabulated the results. One trial performed child and site-level analyses (Haggerty 1994); the 95% CIs were not provided for the site-level analysis. We therefore estimated the denominator from the number of children by trial arm by assuming that all those who had remained in the trial for at least nine weeks had a total of 12 weeks of follow up. The numerator (average number of episodes per child) was provided at the cluster level. We classified this trial as cluster adjusted.

Cluster-randomized trials that did not adjust for clustering

For trials that did not report on or were unclear on the method used to adjust for clustering, we either extracted information on the rate ratio and unadjusted 95% or, wherever possible, estimated the unadjusted rate ratios and 95% CI from the total number of diarrhoea episodes and person-time at risk in each arm of the trial. Where data on person-time at risk were not directly provided by the authors, we estimated this as accurately as possible from the follow-up duration multiplied by the total number of children as the denominator for both intervention and control groups respectively. The measures of effect and confidence intervals were presented in tables. The confidence intervals have not been adjusted for clustering and are therefore artificially narrow. One trial adjusted for clustering by comparing the mean incidence rate of

intervention and non-intervention classrooms (Kotch 1994), but only a cluster-adjusted 95% CI for a difference outcome (excess mean episodes) and not a rate ratio was presented. We took the cluster-adjusted estimate of the numerator (the mean incidence rate across the clusters) from the published data and estimated the person-time at risk crudely by multiplying the number of bi-weekly contacts by the number of children and assuming this was equally distributed between the intervention and control groups. We classified this trial as not having adjustment for clustering.

Heterogeneity and sensitivity analyses

We anticipated that the trials would be heterogeneous and therefore checked for heterogeneity by visually inspecting the forest plots, applying the chi-squared test with a P value of 0.10 indicating statistical significance, and also implementing the I^2 test statistic with a value of 50% used to denote moderate levels of heterogeneity. We used the random-effects model to pool data if we detected heterogeneity and it was still considered clinically meaningful to combine the trials. We were unable to explore potential sources of heterogeneity in depth because of the limited number of trials in each setting. We explored and attempted to explain heterogeneity where possible using a pre-defined study characteristic (provision of hand washing material (soap) as part of intervention, and type of promotional activity employed).

RESULTS

Description of studies

See: Characteristics of included studies; Characteristics of excluded studies.

Trial selection

Our search yielded 37 potentially relevant studies: 14 met the inclusion criteria and are described in the 'Characteristics of included studies'; one was in Danish (Ladegaard 1999), and the rest were written in English. Eight trials were institution-based, five were community-based, and one was in a high-risk group. The reasons for excluding 23 studies are given in the 'Characteristics of excluded studies'.

Institution-based trials (8 trials)

All eight trials in this group were randomized by cluster using primary schools (Bowen 2007), day-care centres (Black 1981; Bartlett 1988; Butz 1990; Carabin 1999; Ladegaard 1999; Roberts 2000), or classrooms in day-care centres (Kotch 1994) as the unit of randomization. These trials were all conducted in high-income countries except for Bowen 2007, which took place in Fujian province in China. The others were carried out in Australia (Roberts 2000), Europe (Ladegaard 1999), and North America (Black 1981; Bartlett 1988; Butz 1990; Kotch 1994; Carabin 1999), where resources and materials for hand washing are relatively available and accessible.

Interventions

Multiple hygiene interventions were used in all trials except in Black 1981 and Bowen 2007, which used only a hand washing intervention. The interventions are described in more detail in Table 2.

Table 2. Intervention details

Trial	Promotional activity	Classification [a]	Message content	Hand washing method	Hand washing style[b]	Material provision	Water availability
Institution-based							
Bartlett 1988	1. Large group meetings (directors and caregivers) 2. Provision of posters and hand-outs depicting the procedures taught	1. Hygiene education 2. Participatory learning*	Staff and child hand washing, diapering, food handling, and environmental cleaning	Unclear	Not specified	Not specified	Adequate

Table 2. Intervention details (*Continued*)

Black 1981	Large group education	Hygiene education	Staff and child hand washing before handling food and after defecation	Water with bar soap and paper towels	Unclear	By the day-care centres' management	Adequate
Bowen 2007	1. Large group training 2. Posters, videotape, wall charts, games 3. Soap 4. Take home packs 5. Peer trainers and peer-monitoring	1. Hygiene education 2. Behaviour modification	Hand washing before eating and after toileting	Water with soap	Under running water	Supplies of soap to schools in "Expanded Intervention"; 1 bar of soap to homes in both expanded and standard intervention	Adequate (criteria for taking part in trial)
Butz 1990	Large group training (in-home instruction to day-care providers)	1. Hygiene education 2. Provision of soap/hand rinse material	1. Modes of transmission of pathogens in the home 2. Indications of hand washing 3. Use of vinyl gloves and disposable diaper changing pad 4. Use of an alcohol-based hand rinse (if unable to wash hand with water plus soap)	Water with soap	Not specified	All supplies provided by researchers	Adequate
Carabin 1999	1. Large group hygiene training (educators) 2. Handouts	Hygiene education	1. Wash hands before lunch and after using the toilets 2. Clean toys with bleach 3. Use of reminder	Unclear	Not specified	Unclear	Adequate

Table 2. Intervention details (*Continued*)

			cues for hand washing 4. Clean the sand box with bleach 5. Open windows at least 30 min every day				
Kotch 1994	1. Large group training 2. Curriculum for caregivers	Hygiene education	1. Hand washing of children and staff 2. Disinfection of diapering areas and toilet 3. Physical separation of diapering areas from food preparation and serving areas 4. Hygienic diaper disposal	Water with soap plus disposable towel	Under running water	Unclear	Adequate
Ladegaard 1999	Small group practical demonstration	1. Hygiene education 2. Participatory learning[c]	1. Hand washing after stool contact 2. Information on disease spread and when to wash hands to prevent diarrhoea	Water with soap	Under running water	Unclear	Adequate
Roberts 2000	1. Large group training 2. Booklets/ newsletters 3. Songs about hand washing for children	1. Hygiene education 2. Behaviour modification	1. Hand washing before eating and after toileting or changing a diaper (staff and child) 2. Wash toys daily in dishwashers	Water with soap	Under running water	Unclear	Adequate

Table 2. Intervention details (*Continued*)

Community-based							
Haggerty 1994	Large group training	Hygiene education	1. Hand washing before meal preparation and eating 2. Hand washing after defecation (wash both hand and buttocks for children) 3. Proper disposal of children's faeces 4. Disposal of animal faeces from yard	Unclear	Not specified	Unclear	Unknown
Han 1989	Small group education (households)	1. Hygiene education 2. Provision of hand washing material	Hand washing: 1. After defecation 2. Before preparing or eating food	Water with bar soap	Not specified	Plain bar soap provided by researcher	Unknown
Luby 2004a	1. Large group training using slide shows, pamphlets, and video tapes; education at weekly field visits 2. Education at weekly field visits	Hygiene education	Hand washing: 1. Before preparing food 2. Before eating food	Water with plain or antibacterial soap	Water from a pitcher (though not clearly stated)	Soap provided by researchers	Unknown
Luby 2006	1. Large group training using slide shows, pamphlets, and video tapes 2. Education at twice-weekly visits	1. Hygiene education 2. Provision of hand washing material	Hand washing: 1. After stool contact/ defecation 2. Before food preparation/ handling/	Water with antibacterial soap	Not specified	Soap provided by researchers	Unknown

Table 2. Intervention details (*Continued*)

			eating 3. Before feeding infants				
Stanton 1987	1. Small group discussion (only women or children) 2. Larger demonstrations (mixed audience) 3. Posters, games, pictorial stories, and 'flexiflans' for illustrations	Hygiene education	1. Hand washing before food preparation 2. Defecation away from the house and in a proper site 3. Suitable disposal of waste and faeces	Unclear	Not specified	Unclear	Inadequate
High-risk group (AIDS patients)							
Huang 2007	Demonstration by nurses and patients	Hygiene education	1. Hand washing after toileting, before food preparation/handling, eating 2. After cleaning infants who had defecated 3. Before and after sex	Water with soap	Under running water	Unclear (probably not relevant in this population)	Adequate

[a] Message classification.
[b] Whether done under running water; in a bowl by an individual or by several people.
[c] Participatory learning involves a process that helps engage learners in an active role of inquiry in which they share experiences and reflect critically on practice in a context that many group members find stimulating and relatively safe (Martin 1997).

All but one of the institution-based trials had intervention and control arms (monitoring only). Bowen 2007 had three arms, for the standard intervention, expanded intervention (which included the standard intervention and peer-monitoring of hand-washing), and control. It is important to note that the control group in most cases received quite frequent monitoring (estimating diarrhoea illness episodes on typically a fortnightly basis). This monitoring may itself have influenced hand washing behaviour. The Carabin 1999 trial attempted to tease out the effects of the intervention alone from 'monitoring'. The 'monitoring' effect in this trial was estimated as the difference in diarrhoea incidence rates within each arm over one year of the trial (autumn 1996 to autumn 1997). The crude effectiveness of intervention was estimated as the difference between the monitoring effect in the intervention group.

Participants

About 7711 participants were included. Participants were mainly day-care providers or educators, and young children. Five of the trials involved children aged less than three years, one was in children under six years (Ladegaard 1999), and one was with children aged less than seven years (Butz 1990). Bowen 2007 involved children in the first grade at school in China.

The number of clusters ranged from four (Black 1981) to 87 (Bowen 2007). Primary outcome measures were assessed across 161 day-care centres and 87 schools. Participants were exposed to large group training sessions that employed multiple promotional techniques (eg audio and video tapes, pamphlets, practical demonstrations, drama, posters, games, peer monitoring). The aim was to provide education about personal hygiene, diarrhoea transmission, treatment, and prevention, and the importance of and techniques for hand washing. Intervention and control groups were generally comparable in important characteristics at baseline (Table 2).

Outcome measures

Episodes of diarrhoea were measured by all included trials, but none of the trials reported diarrhoea-related deaths (one of our secondary outcome measures). Two trials reported changes in knowledge, attitude, and practice about hand washing (Kotch 1994; Roberts 2000). No trial reported the proportion of people washing their hands. Follow-up periods ranged from four months to 12 months.

Adjustment for clustering

Four trials did not appear to have accounted for clustering in the analysis for any outcome measure (Black 1981; Bartlett 1988; Butz 1990; Ladegaard 1999). Kotch 1994 adjusted for clustering by comparing the mean incidence rate of intervention and non-intervention classrooms, but only a cluster adjusted 95% CI for a difference outcome (excess mean episodes) and not a rate ratio was presented. In the three other cluster-adjusted trials, Bowen 2007 presented only the school level analysis (mean illness and absence rates by school); Carabin 1999 adjusted for clustering using a Bayesian hierarchical model, and Roberts 2000 estimated robust standard errors in a Poisson regression model.

Community-based trials (5 trials)

We included five cluster-randomized controlled trials that used entire communities (generally villages or neighbourhoods, except Han 1989, which used households) as units of randomization. These trials were conducted in low- and middle-income countries in Africa (Haggerty 1994) and Asia (Stanton 1987; Han 1989; Luby 2004a; Luby 2006).

Three trials evaluated hand washing only interventions (Han 1989; Luby 2004a; Luby 2006). Luby 2004a had two hand washing arms, one with plain soap and one with antibacterial soap. These two arms had similar results and are combined in this review. Han 1989 used plain soap. Luby 2006 was a five-arm trial that investigated water quality interventions, hand washing, and a combination of the two; only the arm with antibacterial soap and hand washing education is considered in this review.

The other two trials, Haggerty 1994 and Stanton 1987, used multiple hygiene interventions that included hand washing with soap (the type of soap used is not described). The interventions are described in more detail in Table 2.

Participants

About 8055 participants were included. Participants were mainly mothers or caregivers as well as children. In the community-based trials, only one, Haggerty 1994, was with very young children (< 3 years); two others were with children aged less than five years (Han 1989) or less than six years (Stanton 1987); and two involved older children up to 15 years of age (Luby 2004a; Luby 2006). Changes in knowledge, attitude, and practice on hygiene were assessed in the mothers, while the primary outcome measures were assessed in the children.

The number of clusters varied from 18 (Haggerty 1994) to 1923 (Stanton 1987). The participants were provided with hand washing materials and were involved in large-group hygiene education training. The intervention and control groups were socioeconomically comparable at baseline.

Outcome measures

Diarrhoea episodes were measured by all included trials; some also assessed different types of diarrhoea. Han 1989 measured dysentery rates, and Luby 2004a and Luby 2006 also assessed the rate of persistent diarrhoea. None of the trials reported on diarrhoea-related deaths or the proportion of people washing their hands. Only one of the trials reported on changes in hand washing behaviour (Stanton 1987). Length of follow up ranged from four months to 12 months.

Adjustment for clustering

All trials adjusted for clustering in some way, except for Han 1989. Luby 2004a and Stanton 1987 adjusted for clustering by estimating rates at the group level; Luby 2006 adjusted for clustering by

calculating an intra-class correlation coefficient based on an analysis of variance level and design effect. Luby 2006 reported estimates of the intra-cluster correlation coefficient (ICC). Haggerty 1994 performed child and site level analyses; the 95% CIs were not provided for the site-level analysis. The numerator (average number of episodes per child) was provided at the cluster level.

Trial in a high-risk group

We identified only one trial in a high-risk group. It individually randomized 148 adults with AIDS from one human immunodeficiency virus (HIV) clinic in the USA to receive intensive hand washing promotion delivered by specialist nurses (Huang 2007). The intervention included hygiene education, hand washing demonstrations by nurses and participants, and weekly telephone calls to reinforce hand washing messages. The major outcomes reported were mean episodes of diarrhoea in each group and number of hand washing episodes per day.

Risk of bias in included studies

See Table 3 *for a summary of the risk of bias assessment for all trials.*

Table 3. Methodological quality assessment

Trial	Sequence generation	Allocation concealment	Blinding	Inclusion[a]	Comparability[b]	Time of collection[c]
Institution-based						
Bartlett 1988	Unclear	Unclear	Assessor	Unclear	Adequate	Adequate
Black 1981	Unclear	Unclear	None	Unclear	Adequate	Adequate
Bowen 2007	Adequate	Unclear	None	Adequate	Adequate	Adequate
Butz 1990	Unclear	Unclear	None	Unclear	Adequate	Adequate
Carabin 1999	Adequate	Unclear	None	Unclear	Unclear	Adequate
Kotch 1994	Unclear	Unclear	Assessor	Unclear	Unclear	Adequate
Ladegaard 1999	Unclear	Unclear	None	Unclear	Adequate	Adequate
Roberts 2000	Adequate	Unclear	Assessors	Unclear	Unclear	Adequate
Community-based						
Haggerty 1994	Unclear	Unclear	Assessor	Unclear	Inadequate	Adequate
Han 1989	Unclear	Unclear	None	Unclear	Adequate	Adequate
Luby 2004a	Adequate	Adequate	None	Unclear	Adequate	Adequate

Table 3. Methodological quality assessment (*Continued*)

Luby 2006	Adequate	Unclear	None	Unclear	Adequate	Adequate
Stanton 1987	Adequate	Unclear	None	Unclear	Adequate	Adequate
High-risk group (AIDS patients)						
Huang 2007	Unclear	Unclear	None	Adequate	Adequate	Adequate

[a] Inclusion of randomized participants in the analysis was reported at different levels of analysis (cluster, child, person-at-risk levels).
[b] Comparability between intervention and control groups with respect to baseline characteristics (see methods).
[c] Data collected at similar time periods for intervention and control sites.

Institution-based trials (8 trials)

Three of the eight trials used an adequate method to generate the allocation sequence (Carabin 1999; Roberts 2000; Bowen 2007); the method was unclear in the others. The method used to conceal allocation was unclear in all trials. Three trials reported blinding of the outcome assessors (Bartlett 1988; Kotch 1994; Roberts 2000); the rest were open trials. It was difficult to assess the number of randomized participants included in the analysis as this was reported at different levels (cluster, child, person time-at-risk). However, all trials were able to account for the number of randomized clusters included in the analysis.

Five trials reported adequate comparability between the intervention and control groups with respect to diarrhoea incidence and sociodemographic characteristics (including mean total enrolment, percentage of drop outs, sex, age, and race composition of children enrolled, diapering, and toilet facilities) at baseline (Black 1981; Bartlett 1988; Butz 1990; Ladegaard 1999; Bowen 2007). Investigators in Bowen 2007 were forced to over- or under-sample certain regions to obtain more 'control' schools after the original control schools were sent intervention packs by mistake and thus excluded. This trial reported small differences in household sanitation and piped water at baseline, but no differences between schools in number of students, class size, or hygiene infrastructure. Comparability at baseline was unclear in the other trials. All trials reported collecting data at the same point in time for both the intervention and control groups.

Community-based trials (5 trials)

Luby 2004a, Luby 2006, and Stanton 1987 reported adequate methods for generating allocation sequence. Only Luby 2004a reported adequate allocation concealment; it was unclear in the other trials. All were open trials, except for Haggerty 1994, which reported blinding of the outcome assessor. Inclusion of all randomized participants in the analysis was unclear as it was reported at different levels of analysis (cluster, household, child).

Four trials reported baseline similarity of diarrhoea morbidity and socioeconomic characteristics (including population/household size, socioeconomic status, hand washing and sanitary facilities, and sources of water supply) between the intervention and control groups (Stanton 1987; Han 1989; Luby 2004a; Luby 2006). There were some differences at baseline in Haggerty 1994 (controls had diarrhoea episodes of longer duration than the intervention group). All the trials reported collecting data at the same period for intervention and control groups.

Trial in a high-risk group

Huang 2007 did not clearly report the method of randomization or allocation concealment and did not use blinding. All 148 randomized participants were followed for the trial's one-year duration. Participants were similar at the start of the trial in terms of age, sex, ethnicity, hand washing episodes per day, CD4 count, HIV load, and prophylaxis for opportunistic infections. The results were presented as a continuous outcome only (mean and standard deviation of number of diarrhoea episodes in each arm over the year). This should be viewed with caution as it is likely that the distribution of diarrhoea episodes may be highly skewed (the mean of 1.24 and standard deviation of 0.9 episodes in the

intervention arm imply a non-normal distribution of diarrhoea episodes). If so, the mean may not be the most appropriate measure of the 'average number' of episodes per participant. The trial reported collecting data at the same period for intervention and control groups.

Effects of interventions

The results as reported by each trial are shown in Table 4 (incidence of diarrhoea) and Table 5 (behavioural change). For trials with cluster-adjusted results or where trials have been individually randomized, the data are summarized in forest plots. For trials where this is not possible, the data are summarized in tables in the 'Data and analyses' section.

1. Institution-based trials (8 trials)

1.1. Incidence of diarrhoea

The incidence of diarrhoea was assessed in 7711 children aged less than seven years in 161 day-care centres and 87 schools in the eight trials. We separated the trials into two groups. The two trials that adjusted for clustering and confounders, Carabin 1999 and Roberts 2000, showed a reduction in the incidence of diarrhoea of 39% (IRR 0.61, 95% CI 0.40 to 0.92; Analysis 1.1). The five trials with rate ratios that did not adjust for clustering are shown in Analysis 1.2 (Black 1981; Bartlett 1988; Butz 1990; Kotch 1994; Ladegaard 1999).

All trials showed a benefit from the intervention, except for Bowen 2007, which showed no difference between each arm and for which it was not possible to calculate a rate ratio (the median episodes of diarrhoea were 0 per 100 student-weeks in the control group, standard intervention group, and expanded intervention). Roberts 2000 showed greater risk reduction than other trials, possibly due to a more specific method of hand washing (an approximate "count to 10" to wash and "count to 10" to rinse).

All participants were monitored at least fortnightly to collect data on diarrhoea episodes. This monitoring itself may have helped to improve compliance with hand washing. Only Carabin 1999 attempted to investigate this effect by assessing rates in both groups compared to the pre-intervention period. They found that monitoring alone appeared to reduce the incidence of diarrhoea (IRR 0.73, 95% CI 0.54 to 0.97; Table 4), and that the intervention effect did not appear to have any benefits over and above this monitoring effect when adjusted for age and gender (IRR 0.77, 95% CI 0.51 to 1.18; Table 4) or when adjusted for age, gender, season, and baseline incidence rate in each cluster (IRR 1.10, 95% CI 0.81 to 1.50; Table 4). However, monitoring was particularly frequent (daily) in this trial. In the Bowen 2007 trial among first grade students in schools in China, monitoring may have been less intensive as in-class monitoring was carried out on only one day a week by teachers; reasons for absenteeism were noted when recorded. As the trial was school-based, no illness information was collected during weekends or school holidays. This design reduced the burden of data collection of teachers, but it may also have reduced the ability of the trial to detect differences in the incidence of diarrhoea between each arm of the trial.

Table 4. Incidence of diarrhoea

Trial	Cluster adjusted?	Outcome and result	Method of assessment	Sample size
Institution-based				
Bartlett 1988	No	Diarrhoea rate per child-year of observation Intervention: 0.71 (95% CI 0.65 to 0.77) Control: 0.81 (95% CI 0.75 to 0.87)	1. Active day-care centre-based surveillance (weekly visits plus daily telephone calls to identify diarrhoeal illness 2. Family-based surveys (questionnaire every 2 weeks)	26 day-care centres with 374 children (196 intervention, 178 control) aged 0 to 3 years
Black 1981	No	Diarrhoea incidence/100/child-weeks of observation Intervention: 4.2/100/child-week Control: 8.1/100/child-week	Daily record of attendance plus diarrhoea occurrence for each child by day-care personnel	4 day-care centres (2 intervention, 2 control) with 116 children < 3 years

Table 4. Incidence of diarrhoea (*Continued*)

Bowen 2007	Yes	Median episodes of diarrhoea per 100 student weeks Expanded intervention: 0 per 100 student-weeks Standard intervention: 0 per 100 student-weeks Control: 0 per 100 student-weeks	Teachers trained using standardized case definitions to identify 10 symptoms or signs of illness and record these among students in class, 1 day per week; if parent's reported infection as cause of absence, teachers recorded name of syndrome and asked parent if child suffered any of 10 individual symptoms; verified verbally that reports of diarrhoea met case definition	3962 children within 87 primary schools
Butz 1990	No	Proportion of diarrhoea days per month Diarrhoea episodes/child-days Intervention: 93/10,159 Control: 133/10,424	Daily symptom record for each child by care providers	24 family day-care homes with 108 children (58 intervention, 50 control) aged 1 month to 7 years
Carabin 1999	Yes	Diarrhoea incidence: episodes/100 child-days at risk Incidence rate ratio (95% Bayesian credible interval) 1.10 (0.81 to 1.50), adjusted for age and gender Intervention alone: 0.77 (0.51 to 1.18) Monitoring alone: 0.73 (0.54 to 0.97)	Daily record of diarrhoea episodes on calendar by educators	52 day-care centres with 1729 children aged 18 months to 3 years
Kotch 1994	Yes	Diarrhoea rates: incidence density (episodes/child-year) Intervention (< 2 years): 4.54 Intervention (> 2 years): 2.85 Control (< 2 years): 5.12 Control (> 2 years): 2.79 All: risk ratio 1.19, 95% CI - 0.48 to 1.96	Telephone interview methodology (biweekly calls to families) 5 week interval visits to day-care centres	24 day-care centres with 389 children < 3 years
Ladegaard 1999	No	Diarrhoea episodes/child-month Intervention: 33/848 Control: 61/1052 (34% reduction from 3.25 days per child in favour of children 3 years or more)	Information on absenteeism recorded on a form by child-care provider	8 day-care centres with 475 children (212 intervention, 263 control) aged 6 years and below

Table 4. Incidence of diarrhoea (*Continued*)

Roberts 2000	Yes	Diarrhoeal rates: episodes/child-year Intervention: 1.9 episodes/child-year Control: 2.7 episodes/child-year All: risk ratio 0.50 (95% CI 0.36 to 0.68) < 2 years: risk ratio 0.90 (95% CI, 0.67 to 1.19) > 2 years: risk ratio 0.48 (95% CI 029 to 0.78) (Adjusted for clustering by centre, confounding variables (age, sex, weight at birth, breastfeeding status, child care history, and home factors), and interactions between age and intervention status, and between having a sibling who attends child care and intervention status)	1. Biweekly telephone interviews (parents reports of symptoms) 2. Observation for compliance of recommended practices every 6 weeks	23 day-care centres (11 intervention, 12 control) with 558 children under 3 years
Community-based				
Haggerty 1994	Yes	Diarrhoea rates (mean episodes of diarrhoea) Intervention site: 0.071 Control site: risk ratio 0.075 (risk ratio 0.94, 95% CI 0.85 to 1.05; P = 0.3)	1. Observation recording form 2. Diarrhoeal morbidity form	18 sites (9 intervention, 9 control) with 1954 children aged 3 months to 35 months
Han 1989	No	Incidence density ratio 1. Diarrhoea < 2 years: 0.69 (95% CI 0.48 to 1.10) > 2 years: 0.67 (95% CI 0.45 to 0.98) All: 0.70 (95% CI 0.54 to 0.92) 2. Dysentery < 2 years: 0.59 (95% CI 0.22 to 1.55) > 2 years: 1.21 (95% CI 0.52 to 2.80) All: 0.93 (95% CI 0.39 to 2.23)	Daily surveillance (24 h recall) for diarrhoea and dysentery	350 households (162 intervention, 188 control) with 494 children (236 intervention; 258 control) under 5 years

Table 4. Incidence of diarrhoea (*Continued*)

Luby 2004a	Yes	Incidence density of diarrhoea (number of new episodes of diarrhoea divided by the at-risk person-weeks of observation) Mean incidence 1. Primary diarrhoea Intervention: Antibacterial soap: 2.02 Plain soap: 1.91 Control: 4.06 2. Persistent diarrhoea Intervention: Antibacterial soap: 0.14 Plain soap: 0.12 Control: 0.17	Weekly observational visits to households	36 neighbourhoods (25 intervention, 11 control) with 4691 children (3163 intervention, 1528 control) aged < 15 years
Luby 2006	Yes	Diarrhoea episodes/100 child-weeks: for diarrhoea and persistent diarrhoea 1. Risk ratio: 0.57 (95% CI 0.35 to 0.86) 2. Diarrhoea, mean incidence: 3.71 3. Persistent diarrhoea, mean incidence: 0.09 -52% (-100% to 100%)	Weekly observational visits to households	18 clusters (544 households; 262 intervention; 282 control) with children < 15 years
Stanton 1987	Yes	Rate of diarrhoea per 100 person-weeks Incidence density ratio 0.75 (95% CI 0.66 to 0.84; P < 0.0001) < 2 years: 0.54 (95% CI 0.43 to 0.66) > 2 years: 0.68 (95% CI 0.54 to 0.85)	1. Biweekly histories of diarrhoea for children of all households 2. Single prolonged on-site visit to each sentinel family for hand washing-related behaviour observation	1923 families (937 intervention, 986 control) with children aged < 6 years
High-risk group (AIDS patients)				
Huang 2007	Not applicable	Mean episodes of diarrhoea over study period (1 year) Intervention group: 1.24 (+/- 0.9) Control group: 2.92 (+/- 0.6)	Daily hand washing diary to record number of hand washing episodes per day and diarrhoea diary to record stool frequency and characteristics; weekly telephone calls from study nurse to ascertain episodes of these outcomes	75 in hand washing group, 73 controls

CI: confidence interval.

1.2. Behavioural changes

Two trials reported behavioural changes (Kotch 1994; Roberts 2000). As described in Table 5, Kotch 1994 reported that hand washing behaviour based on 'event sampling scores' improved in the intervention classrooms compared with control classrooms. Roberts 2000 reported that the intervention improved compliance with infection control procedures in three day-care centres. This was associated with a lower illness incidence in children aged greater than or equal to two years (RR 0.34, 95% CI 0.17 to 0.65), reflecting a two-third reduction in diarrhoeal episodes.

Table 5. Behavioural change

Trial	Cluster adjusted?	KAP[a] changes	Detail	Intervention		Control		P
				n	N	n	N	
Institution-based								
Kotch 1994	Yes	Hand washing behaviour, based on event sampling scores[b]	After changing a diaper	-	0.75	0.37	-	-
			After contact with child's mucus, saliva, vomit, etc	-	0.66	0.21	-	-
Roberts 2000	Yes	Compliance for hand washing by children in 11 intervention centres by a score [c]; measured as risk ratio of diarrhoeal episodes (relative to control centres) with 95% confidence intervals	1 (4 centres)	-	0.52 (0.37 to 0.75)	-	-	-

Table 5. Behavioural change (*Continued*)

			2 (4 centres)	-	0.53 (0.37 to 0.76)	-	-	-
			3 (3 centres)	-	0.43 (0.27 to 0.70)	-	-	-
			Children ≥ 2 years	-	0.34 (0.17 to 0.65)	-	-	-
Community-based								
Stanton 1987	Yes	Comparison of hygienic practices after intervention (risk ratio 1.48, confidence interval 1.01 to 2.21)	-	39	79 (39/79 = 49%)	25	75 (25/75 = 33%)	-
High-risk group (AIDS patients)								
Huang 2007	Not applicable	Frequency of hand washing per day	At baseline and at the end of study	-	3.3 (+/- 0.98) 7 times daily	-	3.4 (+/- 1.1) 4 times daily	< 0.05

[a] KAP: knowledge, attitude, and practice.
[b] Event sampling scores (0 = none; 0.5 = partially correct; 1.0 = as recommended in the training).
[c] Compliance score: 1 = lowest compliance rate (53% to 69%); 2 = moderate compliance rate (70% to 79%); 3 = high compliance rate (≥ 80%).

2. Community-based trials (5 trials)

2.1. Incidence of diarrhoea

The intervention reduced the incidence of diarrhoea by 32% (IRR 0.68, 95% CI 0.52 to 0.90; 4 trials, Analysis 2.1) in trials that adjusted for clustering and confounders (Haggerty 1994; Luby 2004a; Luby 2006; Stanton 1987). For Han 1989, which did not account for clustering effects, the reduction was 30% (IRR 0.70, 95% CI 0.54 to 0.92; Analysis 2.2).

Three trials assessed the effect of intervention on the incidence rate of different categories of diarrhoea (Han 1989; Luby 2004a; Luby 2006). Although they reported reductions in the risk of diarrhoea with the interventions (Han 1989 reported on dysentery, and Luby 2004a and Luby 2006 reported on persistent diarrhoea), none of the results were statistically significant (Table 4). Some trials reported the results by participant age (Stanton 1987; Han 1989; Luby 2004a; Luby 2006), with no discernible trend of which age group intervention had greater diarrhoeal reductions (Table 4). Han 1989 and Stanton 1987 reported greater diarrhoeal reduction for children aged less than two years, while Luby 2004a and Luby 2006 reported greater reductions for older children.

Only Haggerty 1994, a cluster-adjusted trial, used blinding (of outcome assessors) and the benefit of hand washing seemed to be less in this trial than in the others (IRR 0.94, 95% CI 0.85 to 1.05; Table 4).

Three trials both provided soap and promoted hand washing only (Han 1989; Luby 2004a; Luby 2006). Luby 2004a and Luby 2006 gave cluster-adjusted estimates and were therefore included in the subgroup analysis. The reduction in the risk of diarrhoea was greater in these two trials (IRR 0.49, 95% CI 0.39 to 0.62; Analysis 2.3) than in the two cluster-adjusted trials that did not provide soap and promoted multiple hygiene interventions (IRR 0.84, 95% CI 0.67 to1.05; Analysis 2.3). With only a small number of trials, these differences may be due to chance or, even if real, it is impossible to discern which components (providing soap or focusing on one message only) may be most effective.

2.2. Behavioural changes

Stanton 1987 adjusted for clustering and reported that the intervention group exhibited a greater increase in hygiene practices (IRR 1.48, 95% CI 1.01 to 2.21), though this increase is of borderline statistical significance (P = 0.056) (Table 5).

3. Trial in a high-risk group

3.1. Episodes of diarrhoea

In Huang 2007, the intensive hand washing intervention reduced the mean number of episodes of diarrhoea over the one-year period of study (2.92 in control group; 1.24 in intervention group; a reduction of 1.68 episodes, 95% CI -1.93 to -1.43; Analysis 2.3).

3.2. Behavioural changes

At the beginning of the trial there was no difference in daily hand washing frequency between intervention and control groups (3.4 ± 1.1 in control group; 3.3 ± 0.98 in intervention group), but at the end of the trial the intervention group reported hand washing seven times a day compared with four times daily in the control group (P < 0.05).

DISCUSSION

The included trials demonstrated distinct benefits from the promotion of hand washing for reducing the incidence of diarrhoea in different settings. However, the risk of bias in the included trials limits a clear interpretation of the evidence presented. Of the 14 trials, only six reported using an adequate method to generate the allocation sequence (Stanton 1987; Carabin 1999; Roberts 2000; Luby 2004a; Luby 2006; Bowen 2007). The method was unclear in the other trials, and, thus, selection bias may have been introduced. Only one trial, Luby 2004a, clearly reported adequately concealed allocation; this is difficult to achieve in trials of this nature since cross-contamination is recognized as a problem (Hayes 2000). Blinding can also be difficult to achieve in these trials, and only four trials attempted blinding of outcome assessors (Bartlett 1988; Haggerty 1994; Kotch 1994; Roberts 2000). The inclusion of all randomized participants in the analysis was reported at different levels of analysis (eg cluster, child, household, person-time at risk), which made it difficult to assess. Also, people tended to enter and leave naturally over the course of a study since most trials were conducted in communities and institutions, and not closed populations. However, all the institutional-based trials reported adequate inclusion of all the randomized clusters, while in most of the community-based trials this was not explicitly reported.

One trial reported differences at baseline between the intervention and control groups (Haggerty 1994), while three trials did not report on this clearly (Kotch 1994; Carabin 1999; Roberts 2000). This might be a problem if there were few clusters. All the included trials reported collecting data over the same period in both trial arms.

There was wide variation in the benefits of hand washing promotion on the incidence of diarrhoea reported by individual trials. This heterogeneity is not surprising as the trials differed greatly in terms of setting, population, and hand washing intervention. However, the pooled estimates from the included trials show a 39% risk reduction for the institution-based trials that adjusted for cluster randomization and 32% for the community-based trials. There was also an important reduction in mean episodes (1.68 fewer episodes in the intervention group) in a high-risk population (AIDS patients), but this is based on one trial with 148 participants and requires confirmation. In most trials, the interventions were based on hygiene promotion (providing education about diarrhoea transmission and treatment, and hand washing behaviours).

Most trials did not appear to have used any explicit 'behavioural change' model, though two trials applied 'participatory learning processes' (Bartlett 1988; Ladegaard 1999). It is not clear whether interventions based on any such models would be more or less effective. Hygiene education may have a 'herd effect' in cluster-randomized trials (hand washing by some community members will benefit others indirectly by reducing the number of pathogens in the local environment) and may have other benefits beyond reductions in diarrhoea such as saving mothers' time (looking after sick children). Generally, the included trials did not assess such outcome measures, and nor did this review.

Many trials promoted a whole range of hygiene interventions in addition to hand washing. There did not appear to be any greater risk reduction for those promoting several hygiene interventions compared with those promoting hand washing only, though this

is difficult to assess with only a limited number of trials. The contribution of the different hygiene education components in achieving the benefits is also unclear.

It is possible that bias was introduced by the intensive monitoring of outcomes in both intervention and control groups in these trials. Carabin 1999 attempted to explore this by assessing the effects of the intervention itself from that of monitoring. The effect of monitoring on diarrhoeal episodes was significant, but the intervention itself had no statistically significant effect. Monitoring of hand washing may therefore be more important than other facets of the intervention on compliance and effectiveness. This is known as the Hawthorne effect (Feachem 1983) whereby the mere fact of being under observation leads to improvement in a trial outcome (in this case, increased frequency of hand washing and reduction of diarrhoea). Carabin 1999 used particularly frequent monitoring (daily); less frequent monitoring may have reduced the importance of this effect.

Provision of hand washing materials by the investigators may increase hand washing effectiveness (although there were too few trials to make strong conclusions) as these trials showed slightly greater risk reductions in diarrhoea episodes than ones that did not.

Although this review shows that hand washing can be effective, most of the trials should be regarded as 'efficacy' trials in the sense that they include intense follow up and monitoring (all contacted intervention communities at least fortnightly, some more often to ascertain diarrhoea episodes and reinforce the hygiene promotion messages); many also provided hand washing materials and replenished supplies regularly. One large-scale trial from Burkina Faso, which is not included in this review, suggested that changes in hand washing behaviour could be maintained in the longer term (three years) in a large community (a city of approximately 300,000 residents) (Curtis 2001) and may be cost-effective (Borghi 2002), but this trial did not assess trends in hospitalization for diarrhoea and requires replicating in other communities. Bowen 2007, included in this review, was larger and had less intensive monitoring (carried out by teachers), but it was not able to detect any difference between either of the intervention and control groups in terms of diarrhoea episodes (there was a median of 0 episodes per 100 student-weeks in all groups). However, Bowen 2007 did find a statistically significant reduction in overall illness (mostly accounted for by differences in rates of upper respiratory tract infections) of 35% and 71% in the standard and expanded intervention groups respectively, and reductions in absenteeism of 44% and 42% respectively compared with controls. This highlights the difficulties in the design of effectiveness studies with more limited monitoring but with sufficient power and sensitivity to detect differences in diarrhoea episodes. Most trials in this review were relatively small with short-term follow up, and it is unclear if their level of effectiveness would be maintained if they were scaled up to larger regions with less intensive monitoring over a longer time period.

All institution- and community-based trials in this review were conducted in children aged less than 15 years, and mostly in children aged less than seven years. Therefore results cannot be generalized to all ages. In future studies, comparison of effects in young (less than three years) and older children may inform decisions of whom to target and optimal message delivery mode suitable for the two settings (institutions in high-income settings; communities in low- and middle-income countries). Older children are able to make their own decisions about hand washing, while toddlers will always be dependent on adults to help them.

The approximate one-third reduction (32% to 39%) in diarrhoea morbidity observed in our review suggests less benefit than was reported by previous reviews of hand washing and hygiene interventions (Curtis 2003; Fewtrell 2004; Fewtrell 2005), which estimated reductions of 47% and 44% respectively. However, it is higher than the estimated 27% diarrhoea reduction of providing clean water (Clasen 2006). In this review, we included only randomized controlled trials where specific hand washing interventions were tested with or without additional hygiene promotion. We excluded observational, case-control, and controlled before-and-after studies, some of which were included in previous reviews. Unlike one previous review (Curtis 2003), we also avoided double-counting of studies since this may overestimate the intervention effect, tends to breakdown the assumption of study independence, and narrows the 95% CIs. Also, we combined incidence rate ratios for diarrhoea as a primary outcome and attempted to extract or estimate these from the paper if they were not reported. Guevara 2004 supports the use of rate ratios in meta-analyses of studies of this nature as it improves the clinical interpretability of findings. Some trials reported odds ratios, but these may overestimate the risk reduction for a common outcome such as diarrhoea episodes if they are combined with rate ratios in a meta-analysis, as in one previous review (Curtis 2003).

Thus the stringent inclusion criteria for this Cochrane Review and the methods of analysis may be responsible for the lower magnitude of effect observed than in the earlier meta-analyses. Nonetheless this review provides strong evidence that hand washing interventions reduce diarrhoeal morbidity by about one-third.

AUTHORS' CONCLUSIONS

Implications for practice

Interventions that promote hand washing are efficacious in reducing diarrhoeal episodes by about one-third and should be encouraged. The challenge is to find effective ways of getting people to wash their hands appropriately.

Implications for research

This review shows that interventions that promote hand washing can be efficacious, but in communities in low-income and middle-

income countries there is a need for large-scale trials with less intensive monitoring and long-term follow up. Although some monitoring is inevitable to completely ascertain diarrhoea episodes, this should be reduced to a minimum and should be supported by community-level outcome measures for severe diarrhoea (hospitalizations or consultations with a doctor for diarrhoea). Data collectors should be blinded to the outcome measure where possible. There is also a need for investigators to collect data on the effects of the intervention on types of diarrhoea (acute, persistent, and dysentery) as risk of diarrhoeal mortality is different for each type.

ACKNOWLEDGEMENTS

We thank all the authors that assisted us with information on their trials. We are particularly grateful to Dr S Luby of the Centers for Disease Control and Prevention (CDC). We thank Karin Schiöler for assisting with translation of the Danish study.

This document is an output from a project funded by the UK Department for International Development (DFID) for the benefit of low-income and middle-income countries. The views expressed are not necessarily those of DFID.

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* *Indicates the major publication for the study*

CHARACTERISTICS OF STUDIES

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

Bartlett 1988

Methods	Cluster-randomized trial Method of allocation sequence: unclear Allocation concealment: unclear Blinding: assessor Inclusion of participants in the analysis: unclear Length of follow up: 12 months Cluster-adjustment method: not adjusted
Participants	Number: 26 day-care centres, with 374 children Inclusion criteria: not stated Exclusion criteria: not stated Age: < 3 years
Interventions	Intervention (see Table 2 for detailed description): 1. Large group meetings (directors and caregivers) 2. Provision of posters and handouts depicting the procedures taught Control: 3. Visited to review surveillance procedures, but no instruction in disease prevention or management provided
Outcomes	Diarrhoea rates
Notes	Location: Maricopa County, Arizona, USA Duration: October 1981 to September 1984

Black 1981

Methods	Cluster-randomized trial Method of allocation sequence: unclear Allocation concealment: unclear Blinding: none Inclusion of participants in the analysis: unclear Length of follow up: 6 months Cluster-adjustment method: not adjusted
Participants	Number: 4 day-care centres, with 116 children Inclusion criteria: not stated Exclusion criteria: not stated Age: < 3 years
Interventions	Intervention (see Table 2 for detailed description): 1. Large group education Control: 2. No intervention

Black 1981 (*Continued*)

Outcomes	1. Diarrhoea rates Not used in this review: 2. Estimate of load of diarrhoea causative agent
Notes	Location: suburban Atlanta, Georgia, USA Duration: June 1976 to April 1977

Bowen 2007

Methods	Cluster-randomized trial Method of allocation sequence: random-number table Allocation concealment: unclear Blinding: none Inclusion of all participants in the analysis: 93% (3962/4256) agreed to participate Length of follow up: 2003 to 2004 school year Cluster-adjustment method: adjusted
Participants	Number: 87 schools (57 intervention; 30 Control); with 3962 children (2670 intervention; 1292 control) Inclusion criteria: public primary schools; at least 20 students in first grade year in 2003 to 2004; no overnight boarders; at least 1 running water tap for every 30 first grade students Exclusion criteria: no compulsory hand washing or provision of hand-cleaning products before school lunch; no commercial hand washing promotion programmes at school during previous 5 years
Interventions	Intervention (see Table 2 for detailed description): 1. Expanded programme: as standard programme plus continuous supply of Safeguard soap for school sinks; 1 student from each class recruited to assist peers with hand washing techniques, and remind them of key hand washing opportunities; teachers asked to encourage this student weekly but not instructed to enforce hand washing behaviour 2. Standard programme: Proctor and Gamble's 'Safeguard' promotion programme delivered in Chinese schools since 1999; teachers deliver programme to first grade children during single 40 minute classroom session; also single 2 h training session for each first grade teacher delivered by Proctor and Gamble staff; teacher's pack contains guidebook outlining hand washing, basic information on infectious disease transmission, 5 posters describing hand washing procedure, videotape, and 5 wall charts for classroom hygiene competition; student take-home pack includes hygiene board game, parent booklet on hand washing, and 50 g bar Safeguard soap Control: 3. All 3 groups received government hygiene educational programme consisting of a cursory statement manual about hand washing after using toilet and before eating
Outcomes	1. Diarrhoea rates Not used in this review: 2. School absences 3. Rates of other common illnesses
Notes	Location: 3 counties in Fujian province, South-East China

Butz 1990

Methods	Cluster-randomized trial Method of allocation sequence: unclear Allocation concealment: unclear Blinding: none Inclusion of participants in the analysis: unclear Length of follow up: 12 months Cluster-adjustment method: not adjusted
Participants	Number: 24 family day-care centres, with 108 children Inclusion criteria: not stated Exclusion criteria: unclear Age: 1 month to 7 years
Interventions	Intervention (see Table 2 for detailed description): 1. Large group training (in-home instruction to day-care providers) Control: 2. No intervention
Outcomes	Incidence of infectious disease symptoms (diarrhoea)
Notes	Location: Baltimore, Maryland, USA Duration: 12 months

Carabin 1999

Methods	Cluster-randomized trial Allocation sequence: day-care centres were stratified by incidence of respiratory infections and block randomized by geographical areas Allocation concealment: unclear Blinding: none Inclusion of participants in the analysis: unclear Length of follow up: 6 months Cluster-adjustment method: adjusted
Participants	Number: 52 day-care centres, with 1729 children Inclusion criteria: presence of at least 1 sandbox and 1 play area; at least 12 available toddler places Exclusion criteria: not stated Age: 18 months to 3 years
Interventions	Intervention (see Table 2 for detailed description): 1. Large group hygiene training (educators) 2. Handouts Control: 3. No intervention
Outcomes	Diarrhoea rates

Carabin 1999 (*Continued*)

Notes	Location: Quebec, Canada Duration: September 1996 to November 1997

Haggerty 1994

Methods	Cluster-randomized trial Allocation sequence: unclear Allocation concealment: unclear Blinding: assessor Inclusion of participants in the analysis: unclear Length of follow up: 6 months Cluster-adjustment method: adjusted and unadjusted results given
Participants	Number: 18 sites, with 1954 children Inclusion criteria: not stated Exclusion criteria: not stated Age: 3 months to 35 months
Interventions	Intervention (see Table 2 for detailed description): 1. Large group training Control: 2. No intervention
Outcomes	Diarrhoeal rates
Notes	Location: Kikwit, Bandundu Province, Zaire (Democratic Republic of Congo) Duration: October 1987 to December 1988

Han 1989

Methods	Cluster-randomized trial Allocation sequence: unclear Allocation concealment: unclear Blinding: none Inclusion of participants in the analysis: unclear Length of follow up: 4 months Cluster-adjustment method: not adjusted
Participants	Number: 350 households (162 intervention and 188 control) with 494 children Inclusion criteria: households with 1 or more children between 6 and 59 months; those in which regular follow up was possible; not allergic to soap; gave informed consent Exclusion criteria: not stated Age: < 5 years
Interventions	Intervention (see Table 2 for detailed description): 1. Small group education (households) Control:

Han 1989 (*Continued*)

	2. No intervention
Outcomes	1. Incidence of diarrhoea 2. Incidence of dysentery
Notes	Location: Nga-Kha ward of Thin-Gun-Kyun township, Rangoon, Burma (now Myanmar) Duration: June to November 1985

Huang 2007

Methods	Individually randomized trial Allocation sequence: unclear Allocation concealment: unclear Blinding: none Inclusion of participants in the analysis: 100% Length of follow up: 1 year
Participants	Number: 73 intervention, 75 control Inclusion criteria: patients with acquired immune deficiency syndrome (AIDS) at local human immunodeficiency virus (HIV) clinic; HIV-1 infection verified by both ELISA and Western Blot; AIDS by CD4 counts and plasma HIV RNA; been on highly active anti-retroviral therapy (HAART) for at least 6 weeks and without diarrhoea for at least 3 months
Interventions	Both groups: 3 dedicated study nurses educated participants on health problem associated with contaminated hands and provided specific hand washing instructions at enrolment; hand washing technique demonstrated by nurses, including wetting hands, lathering completely with soap, running together for at least 15 seconds, and drying hands with towels; all 148 participants then demonstrated adequate hand washing technique Intervention (see Table 2 for detailed description): 1. Weekly telephone call from nurses to determine number of hand washing episodes per day, ensure compliance, answer questions, re-educate participants on importance, and go over instructions Control: 2. Weekly telephone calls but only to ascertain diarrhoea episodes
Outcomes	1. Incidence of diarrhoea 2. Hand washing behaviour Not used in this review: 3. Microbiological diagnosis of diarrhoea episodes
Notes	Location: USA (location unclear) Duration: 1 year (exact dates unclear)

Kotch 1994

Methods	Cluster-randomized trial Allocation sequence: unclear Allocation concealment unclear Blinding: assessor Inclusion of participants in the analysis: unclear Length of follow up: 7 months Cluster-adjustment method: adjusted
Participants	Number: 24 day-care centres, with 389 classrooms Inclusion criteria: children < 3 years; present in the day care at least 20 h per week; absence of chronic illness or medication that would predispose to infection; youngest of potentially eligible children in the same family; consenting English-speaking parents with access a telephone; intending to remain in day-care centre throughout study Exclusion criteria: not stated Age: < 3 years
Interventions	Intervention (see Table 2 for detailed description): 1. Large group training 2. Curriculum for caregivers Control: 3. No intervention
Outcomes	Diarrhoeal rates
Notes	Location: Cumberland County, North Carolina, USA Duration: October 1988 to May 1989

Ladegaard 1999

Methods	Cluster-randomized trial Allocation sequence: unclear Allocation concealment: unclear Blinding: none Inclusion of participants in the analysis: unclear Length of follow up: 4 months Cluster-adjustment method: not adjusted
Participants	Number: 8 day-care centres, with 475 children (212 intervention, 263 control) Inclusion criteria: not stated Exclusion criteria: not stated Age: < 6 years
Interventions	Intervention (see Table 2 for detailed description): 1. Small group practical demonstration Control: 2. No intervention
Outcomes	Diarrhoeal rates

Ladegaard 1999 (*Continued*)

Notes	Location: Odense, Denmark Duration: 6 months

Luby 2004a

Methods	Cluster-randomized trial Allocation sequence: computer-generated Allocation concealment: serially numbered Blinding: none Inclusion of participants in the analysis: unclear Length of follow up: 12 months Cluster-adjustment method: adjusted
Participants	Number: 36 neighbourhoods (25 intervention, 11 control), with 4691 children Inclusion criteria: household located in the study area; have at least 2 children < 5 years; intention to reside in the house for the duration of study Exclusion criteria: not stated Age: < 15 years
Interventions	Intervention (see Table 2 for detailed description): 1. Large group training using slide shows, pamphlets, and video tapes Control: 2. No intervention
Outcomes	Diarrhoeal rates
Notes	Location: low-income squatter settlements, Karachi, Pakistan Duration: April 2002 to April 2003

Luby 2006

Methods	Cluster-randomized trial Allocation sequence: computer generated Allocation concealment: unclear Blinding: none Inclusion of participants in the analysis: unclear Length of follow up: 9 months Cluster-adjustment method: adjusted
Participants	Number: 18 clusters, with 544 households (262 intervention, 282 control) Inclusion criteria: households with at least 1 child < 5 years; provided informed consent Exclusion criteria: not stated Age range: < 15 years
Interventions	Intervention (see Table 2 for detailed description): 1. Large group training using slide shows, pamphlets, and video tapes Control:

Luby 2006 (*Continued*)

	2. No receipt of products expected to change risk of diarrhoea but provided them with regular supply of children's books, note books, etc
Outcomes	1. Primary diarrhoea rates 2. Persistent diarrhoea rates
Notes	Location: multi-ethnic squatter settlements in Central Karachi, Pakistan Duration: April 2003 to December 2003

Roberts 2000

Methods	Cluster-randomized trial Allocation sequence: computer generated Allocation concealment: unclear Blinding: assessors Inclusion of participants in the analysis: unclear Length of follow up: 9 months Cluster-adjustment method: adjusted
Participants	Number: 23 day-care centres, with 558 children Inclusion criteria: day-care centres licensed in the Australian Capital Territory; children < 3 years as at January 1996; attendance for at least 3 days per week; have no underlying chronic illness that predisposes to infection Exclusion criteria: not stated Age: < 3 years
Interventions	Intervention (see Table 2 for detailed description): 1. Large group training 2. Booklets/newsletters 3. Songs about hand washing for children Control: 4. No intervention
Outcomes	1. Diarrhoeal rate 2. Knowledge, attitude, and practice of hand washing
Notes	Location: Australian Capital Territory, Australia Duration: March to November 1996

Stanton 1987

Methods	Cluster-randomized trial Allocation sequence: table of random numbers Allocation concealment: unclear Blinding: none Inclusion of participants in the analysis: unclear Length of follow up: 6 months Cluster-adjustment method: adjusted
Participants	Number: 1923 families (937 intervention, 986 control) Inclusion criteria: not stated Exclusion criteria: not stated Age: < 6 years
Interventions	Intervention (see Table 2 for detailed description): 1. Small group discussion (only women or children) 2. Larger demonstrations (mixed audience) 3. Posters, games, pictorial stories, and 'flexiflans' for illustrations Control: 4. No intervention
Outcomes	1. Diarrhoeal rates 2. Change in knowledge, attitude, and practice of water sanitation behaviours
Notes	Location: Urban Dhaka, Bangladesh Duration: October 1984 to May 1985

[a] See Table 2 for a detailed description of the interventions.

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

Ahmed 1993	Observational study examining risk factors for diarrhoeal infections
Alam 1989	Main intervention was provision of water supply through hand pumps
Barros 1999	Observational study examining risk factors for diarrhoeal infections
Clemens 1987	Observational study examining risk factors for diarrhoeal infections
Curtis 2001	No concurrent control
Doebbeling 1992	Outcome measure (incidence of nosocomial infection)not specific to diarrhoea episodes but to incidence of gastrointestinal infections in general

(*Continued*)

Dyer 2000	Intervention was instant hand sanitizer
Guinan 2002	Observational study
Hammond 2000	Intervention did not involve hand washing
Khan 1982	Case-control study
Larson 2003	No relevant outcome measures (measured colony-forming units of bacteria)
Larson 2004	Outcome measure not specific to incidence of diarrhoea
Lee 1991	Controlled before-and-after study
Luby 2001	Observational study
Luby 2004b	Nonrandomized study
Master 1997	Outcome measure not specific on diarrhoeal episodes
Morton 2004	Outcome measure not specific on diarrhoeal episodes
Peterson 1998	Observational study examining risk factors for diarrhoeal infections
Pinfold 1996	No comparable baseline information on diarrhoeal episodes provided
Shahid 1996	No comparable baseline information provided
Sircar 1987	No comparable baseline information on diarrhoea episodes provided
White 2003	Outcome measure not specific to diarrhoeal morbidity
Wilson 1991	Controlled before-and-after study

DATA AND ANALYSES

Comparison 1. Institutional-based trials: hand washing promotion vs no intervention

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Incidence of diarrhoea: cluster-adjusted rate ratios	2		Incidence rate ratio (Random, 95% CI)	0.61 [0.40, 0.92]
2 Incidence of diarrhoea: not cluster-adjusted rate ratios			Other data	No numeric data

Comparison 2. Community-based trials: hand washing promotion vs no intervention

Outcome or subgroup title	No. of studies	No. of participants	Statistical method	Effect size
1 Incidence of diarrhoea: cluster-adjusted rate ratios	4		Incidence rate ratio (Random, 95% CI)	0.68 [0.52, 0.90]
2 Incidence of diarrhoea: not cluster-adjusted rate ratios			Other data	No numeric data
3 Incidence of diarrhoea: stratified by soap provision and type of intervention	4		Incidence rate ratio (Random, 95% CI)	Subtotals only
3.1 Soap provided and focus on hand washing	2		Incidence rate ratio (Random, 95% CI)	0.49 [0.39, 0.62]
3.2 No soap provided and multiple hygiene interventions	2		Incidence rate ratio (Random, 95% CI)	0.84 [0.67, 1.05]
4 Episodes	1	148	Mean Difference (IV, Random, 95% CI)	-1.68 [-1.93, -1.43]

WHAT'S NEW

Last assessed as up-to-date: 4 November 2007.

8 August 2008	Amended	Converted to new review format with minor editing.
2 July 2008	Amended	Trials that did not adjust for clustering were removed from the meta-analysis and presented the data in tables. Trials that did not adjust for clustering are clearly labelled in the results, tables, and 'Characteristics of included studies'. The methods and results were amended to reflect these changes.

HISTORY

Protocol first published: Issue 2, 2003

Review first published: Issue 1, 2008

CONTRIBUTIONS OF AUTHORS

Regina Ejemot extracted and analysed data, and drafted the review. John Ehiri developed the protocol and commented on the review. Julia Critchley extracted and analysed data, and edited the review. Martin Meremikwu helped finalize the data extraction form and commented on the review.

DECLARATIONS OF INTEREST

None known.

SOURCES OF SUPPORT

Internal sources

- University of Calabar, Nigeria.
- Institute of Tropical Diseases Research and Prevention (ITDR&P), Calabar, Nigeria.
- University of Alabama at Birmingham, USA.
- International Health Group, Liverpool School of Tropical Medicine, UK.

External sources

- Department for International Development (DFID), UK.

DIFFERENCES BETWEEN PROTOCOL AND REVIEW

We added methods for assessing blinding, changed our primary outcome measure from the risk ratio of at least one diarrhoea episode to the incidence rate ratio for diarrhoea episodes, pooled rate ratios in our analyses rather than risk ratios since all studies presented diarrhoea as episodes, and removed "or standard hygiene promotion" as a control because it is included in the "no hand washing promotion" control group. Henry Ejere, a co-author on the protocol, did not participate in preparation of the review.

INDEX TERMS

Medical Subject Headings (MeSH)

*Handwashing; Child Day Care Centers; Diarrhea [*prevention & control]; Randomized Controlled Trials as Topic; Schools

MeSH check words

Child; Humans