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What do we know about non-clinical interventions for preventable and treatable childhood diseases in developing countries?

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Abstract

Preventable and treatable childhood diseases, notably acute respiratory infections and diarrhoeal diseases are the first and second leading causes of death and morbidity among young children in developing countries. The fact that a large proportion of child deaths are caused by these diseases is symptomatic of dysfunctional policy strategies and health systems in the developing world. Though clinical interventions against such diseases have been thoroughly studied, non-clinical interventions have received much less attention. This paper contributes to the existing literature on child wellbeing in two important respects: first, it presents a theory of change-based typology that emerges from a systematic review conducted on non-clinical interventions against preventable and treatable childhood diseases. Second, it pays particular attention to policies that have been tested in a developing country context, …/

Keywords: health policy; respiratory infections, diarrhoeal diseases, children, developing countries, systematic review

JEL classification: I15, I18, O15, O57

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… and which focus on children as the primary target population. Overall, we find that improved water supply and quality, sanitation and hygiene, as well as the provision of medical equipment that detect symptoms of childhood diseases, along with training and education for medical workers, are effective policy instruments to tackle diarrhoeal diseases and acute respiratory infections in developing countries.

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1 Introduction

Children have been at the centre of recent global efforts to improve well-being conditions in developing countries. Since 1990, the year when the Millennium Development Goal 4 (MDG4) began to be monitored, developing countries have made important strides towards reducing child mortality.[1] Over the last 20 years, child mortality rates have fallen considerably, from 87 [85, 89] deaths per 1,000 live births to 51 [51, 55].[2] In absolute terms, this means a reduction from 12 to 6.9 million in the number of children dying every year (UNICEF 2012). However, despite the progress in this front, more than 19,000 children still die every day, most of them of preventable and treatable infectious diseases.

Indeed, child mortality rates remain high in developing countries, with rates about eight times as high as those observed in developed countries. Recent estimates suggest that nearly 80 per cent of under-five deaths occur in sub-Saharan Africa and Southern Asia, and about half of the deaths in one of five countries: India, Nigeria, Democratic Republic of the Congo, Pakistan, and China (Black et al. 2010). India and Nigeria alone account for more than one-third of the child deaths worldwide. The fact that a large proportion of child deaths are caused by preventable and treatable infectious diseases is symptomatic of dysfunctional policy strategies and health systems in the developing world. In that context, assessing 'what works' in tackling the main cause of child morbidity and mortality becomes critical for future policy actions.

Acute respiratory infections, notably pneumonia, and diarrhoeal diseases are the first and second leading causes of death among young children, respectively. Pneumonia and diarrhoea alone lead to 1.6 and 1.3 million child deaths per year respectively, amounting to almost 3 million deaths in total (Black et al. 2010). Young children are particularly vulnerable to the negative health implications of diarrhoeal infections such as poor nutritional absorption, dehydration, and susceptibility to infection. Prolonged periods of diarrhoea can cause malnutrition and micronutrient deficiencies that increase the risk of contracting pneumonia while impairing growth and development of children (World Health Organization 2003; EPH et al. 2004). Early malnutrition is also linked to poor cognitive functioning and learning capacity (Scrimshaw 1998; Worobey et al. 2006), which in the longer term leads to lower labour productivity, and poverty (Wagstaff and Watanabe 2000; Hoddinott et al. 2008; Grosse and Roy 2008).

There is recent evidence of a decline in incidence and mortality rates due to diarrhoea and pneumonia among young children in developing countries (Fischer Walker et al. 2012; EPH et al. 2004), with much attention on clinical interventions devoted to increasing the distribution of rotavirus vaccines, zinc supplements and oral rehydration salts (ORS) solutions to tackle the former disease, whereas antibiotics and immunization against haemophilus influenza type B, pneumococcus, measles and whooping cough (pertussis) to prevent the latter illness (Desai et al. 2011; Todd et al. 2010; Gilani et al. 2012).

Clinical interventions for diarrhoea and respiratory infections such as antibiotics, probiotics, and zinc have been implemented and assessed under various environmental settings (Theodoratou et al. 2010; Traa et al. 2010; Dennehy 2012; Soares-Weiser et al. 2010;

[1] The MDG 4 called for a two-thirds reduction in the under-five mortality rates by 2015.

[2] Values in brackets indicate 90 per cent uncertainly intervals,

Dinleyici et al. 2012; Das et al. 2010; Das et al. 2012; Lazzerini and Ronfani 2011). In contrast, the effectiveness of non-clinical interventions characterized by education and training programmes, and/or improved sanitation, water supply, water quality, and hospital equipment is comparatively under-studied. A recent review of training programmes for health professionals to improve care of seriously ill newborns in developing countries identified only two studies for inclusion (Opiyo and English 2010). Existing reviews tend to focus on all age groups rather than young children specifically (Esrey et al. 1985; Esrey et al. 1991; Fewtrell et al. 2005), or those residing outside of developing countries (Rabie and Curtis 2006).

The focus on small children, notably neonatal, and the health interventions that target that population sub-group is of particular significance, as the share of under-five mortality rates occurring at a very early age is increasing worldwide (UNICEF 2012). To our knowledge, there are no systematic reviews that focus on non-clinical policy interventions aimed to reduce morbidity and mortality due to treatable diseases among young children in developing countries, despite the fact that there has been considerable attention to interventions that aim at enhancing the supply of resources and/or social infrastructure that benefit the poor, and promoting changes in individual behaviour.

This paper contributes to the existing literature on child wellbeing in two important respects: first, it presents a theory of change analytical framework that emerges from a systematic review conducted on *non-clinical* policy interventions against preventable and treatable childhood diseases, namely diarrhoeal and acute respiratory diseases. Second, the paper pays particular attention to policies that have been tested in a developing country context, and which focus on children as the primary target population. Overall, we find that public investment in sanitation and hygiene, water supply and quality, and the provision of medical equipment that detect symptoms of childhood diseases, along with training and education for medical workers, are effective instruments to reduce diarrhoeal diseases and acute respiratory infections.

We find a wide range in terms of impact size, which reflects the various types of policy designs as well as the heterogeneity of socio-economic environments in which these interventions have been implemented. There is no clear evidence to suggest that multi-faceted policy designs are more effective than single-focus interventions, particularly when focusing on young children. And although age seems to influence the degree of policy effectiveness, additional age-disaggregated research is needed to determine more precisely the impact of specific and combined interventions.

The remaining of the paper is organized as follows: Section 2 presents the analytical framework based on a theory of change model, which is derived from the existing literature on non-clinical policy interventions for treatable childhood diseases in developing countries. Section 3 discusses the methodology and searching strategy adopted to conduct the systematic review, whereas Section 4 presents a synthesis of the evidence. Section 5 concludes with some reflections on the policy implications of our findings.

2 A theory of change-based typology

Theory of change is a tool for developing solutions to complex social problems (Anderson 2005). It is a participatory process involving the identification of conditions necessary for long-term goals to be achieved (The Center for Theory of Change Inc. 2013). We focus on

non-clinical interventions that both complement and serve as channels through which *preventive* clinical devices (e.g. vaccine immunizations) and *treatment* innovations (e.g. zinc supplements, oral rehydration salts, and antibiotic treatment of pneumonia) are enhanced.

We have identified two main drivers of change with regard to non-clinical interventions against diarrhoeal and respiratory diseases: first, policies that aim at *enhancing supply-side capabilities* in the area of material resources and/or infrastructure and second, policies that aim at *promoting behavioural change*, primarily through information and education. We briefly describe below these types of policy approaches.

2.1 Enhancing supply-side capabilities

We identify a number of interventions that aim at improving the allocation of resources and/or infrastructure. Major types of policies for resource enhancement included sanitation and hospital upgrades, and improving water supply, its distribution, and/or its quality. These types of non-clinical interventions are depicted in the first column on the left-hand side of Figure 1, and are often enhanced by intersecting with each other. Examples of improved water distribution include the installation of a hand pump in a community or connecting households to municipal water sources (Kolahi et al. 2009; Tonglet et al. 1992; Semenza et al. 1998).

Water quality interventions aim to improve water treatments to remove microbial contaminants, either at the source or in the household. Such interventions were frequently paired with the provision of improved water storage vessels. Graf et al. (2010) assessed a water quality improvement intervention via solar disinfection while others measured the impact of safe water storage containers, ceramic water filters and chlorine or other water disinfectants on the outcome (Clasen et al. 2004; Jensen et al. 2003; Sobsey et al. 2003; Reller et al. 2003; Semenza et al. 1998). Interventions featuring sanitation improvements include Daniels et al. (1990)'s assessment of the impact of latrine ownership on diarrhoeal morbidity and Oberhelman et al. (2006)'s study on the health impact of corralling free-range household chickens.

A large cluster of interventions involve sanitation enhancements combined with hygiene education or promotion aspects. For instance, Sircar et al. (1987) evaluated the impact of a project which combined handwashing, hygiene education, and soap provision, while an intervention assessed by Han and Hlaing (1989) included the provision of soap and instructions for mothers and children to wash their hands after defecation, and before preparing and eating their three main meals per day. Similarly, Shahid et al. (1996) and Luby et al. (2004) assessed the impact of a handwashing initiative consisting of the provision of soap along with regular surveillance and reinforcement of health messages of the benefits of handwashing. Additional multi-pronged interventions are assessed by Garrett et al. (2008); Aziz et al. (1990); Hoque et al. (1996); Rana (2009); Quick et al. (1999); Luby et al. (2006); Alam et al. (1989); and Lockwood et al. (2001).

2.2 Promoting behavioural change

The promotion of behavioural change represents another major driver to reduce child mortality and morbidity. These types of non-clinical interventions are depicted in the second column, or cluster of policies, located on the left-hand side of Figure 1. The intended target of

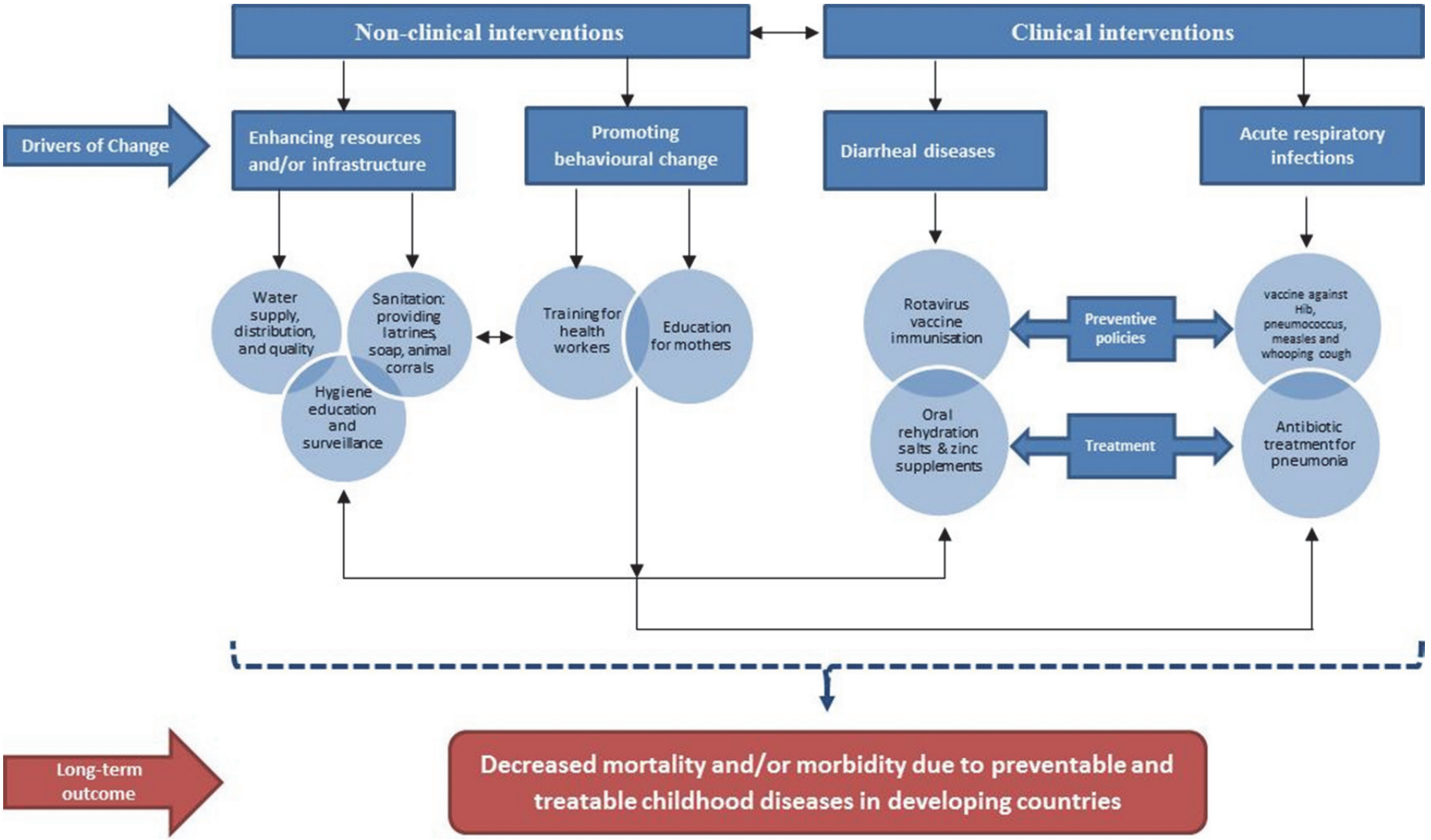


Figure 1: Theory of change flow diagram

Source: Authors.

such interventions is related to disease type. Interventions focused on diarrhoeal-related morbidity and/or mortality are commonly aimed at mothers of young children, while those focused on respiratory infection often contained health worker training and education components.

The impact of educational hygiene messages on behaviours such as handwashing and breastfeeding was assessed by Froozani et al. (1999), who introduced an educational programme promoting breastfeeding among Iranian mothers to lessen the risk of infant ingestion of contaminated water and Ahmed et al. (1993), who evaluate an intervention consisting of educational messages and household surveillance to improve hygiene practices.

Several studies combined handwashing promotion along with instructions regarding animal and child faeces. For instance, Haggerty et al. (1994) assessed an intervention in Zaire (today Democratic Republic of the Congo) consisting of educational messages instructing the disposal of animal faeces, handwashing after defecation and before meal preparation and disposal of children's faeces. Similarly, Stanton and Clemens (1987) observed a significant difference in the rate of diarrhea between control and intervention groups after implementation of a hygiene education programme.

Bateman et al. (1995) measured the impact of two intervention 'models' against diarrhoeal incidence: Model 1 was a more conventional model, based on courtyard education sessions with the tubewell caretakers, their spouses, and tubewell users. The second—more innovative—model adds additional outreach activities: school programmes, child to child activities, and activities with key influencers in the community. Outreach methodologies varied by target group, but included group discussion, demonstrations, participatory action learning exercises, flash card displays, folk songs, role playing, a comic story session, and games.

Interventions focused on respiratory infection morbidity and mortality typically included a health worker training component in addition to health education for mothers. Examples include Lye et al. (1996), who implemented a training programme targeting health workers and mothers of children under the age of five, and Khan et al. (1990), who oversaw an intervention consisting of maternal education and health worker training components. Community-based health workers were trained to recognize signs such as increased respiratory rate and chest retractions to detect pneumonia requiring treatment with antibiotics at home or referral to hospital. The programme also included efforts to educate mothers to recognize pneumonia and to provide appropriate supportive measures, and emphasized the importance of timely immunization and good nutrition. Fauveau et al. (1992) report on the impact of two successive interventions, the first consisting of a community-based family planning and health services project and the second consisting of case detection and management by community health workers, backed by medical support. Other interventions aimed at behavioural change focused solely on the training of health workers (Bang et al. 1994; Pandey et al. 1991).

Non-clinical interventions are fundamental, and complementary to recent global and national efforts to scale up preventive and treatment clinical interventions such as vaccination campaigns and the distribution of oral rehydration salts and zinc supplements, and antibiotics (see the right-hand side of Figure 1). In this paper, we mostly focus on non-clinical interventions although both types of policies, i.e. clinical and non-clinical should be seen as an integral part of public health strategies to tackle preventable and treatable childhood

diseases and hence, decrease child mortality and morbidity in developing countries. In the following section we discuss the systematic review methodology adopted in this study.

3 Review methodology

We conducted a systematic review based on the Cochrane review methodology in terms of selection criteria, searching strategy for the identification of studies, data extraction and data management. In the sections below, we briefly describe the review protocol.

3.1 Selection criteria

Ecological, case-controlled, retrospective cohort, non-blind randomized and non-randomized quasi-experimental studies, including interrupted time series, were included. Studies were excluded on the following grounds: unclear methodologies and/or samples, methodologies which involved mathematical modelling but lacked empirical analysis. The review focused in particular on children and child hospital cases in developing countries. Slightly different definitions of 'children' were used during the search, as dictated by existing age categories in search databases. Studies which presented data on individual children aged five or younger were included. Other units of analysis, such as households or neighbourhoods in cluster trials, were also included if they presented data on children specifically.

Policy interventions in the review included educational or training programmes regarding hygiene, sanitation, nutrition, and case management, and infrastructure enhancements regarding water quality and supply, latrine access, and the provision of hospital equipment. Selected studies described and evaluated one or more of the above interventions. The main outcome measures were childhood mortality and morbidity due to diarrhoeal and respiratory diseases, although studies frequently contained additional outcomes such as quality of treatment provided, admissions to hospital, and hygiene behaviours.

3.2 Search strategy for the identification of studies

The following terms were included in an abstract search carried out through a number of databases and repositories of bibliographic resources that included Medline, Embase, Global Health, IBSS, and Econlit databases:

No. 1 = DEVELOP* COUNTR* OR LOW MIDDLE INCOME

No. 22 = MEASLES OR MORBILLI OR RUBEOLA OR POLIO* OR INFANTILE PARALYSIS OR PNEUMON* OR DIARRHOEA* OR DIARRHEA* OR ROTAVIRUS OR ESCHERICHIA COLI OR GASTROENTERITIS OR PERTUSSIS OR WHOOPING COUGH

No. 3 = CHILD* OR ADOLESCEN* OR TEEN* OR YOUTH OR YOUNG

No. 4 = PROGRAM* or PROJECT or VACCIN* or POLICY or STRATEGY or INTERVENTION or IMMUNIZ* or IMMUNIS* or CAMPAIGN* or REHYDRAT* SOLUTION* or ANTIBIOTIC* or TREATMENT* or MEDICAT* or ZINC THERAP*

For searches in Medline, Embase, and Global Health, No. 1 was supplemented by a medical subject headings (MeSH) query which excluded all high income countries. Identical terms

were entered into the Web of Science database. However, these were topical searches rather than abstract searches, since the latter is not an available option in Web of Science. The resulting articles were refined by excluding editorials and biographies, and those set in developed countries. Where available, filters on age range, language, and document type were applied to exclude articles in languages other than English and those focused on adults. Following the database search, bibliographic lists of relevant studies were examined for additional references.

3.3 Data extraction and management

Articles were transferred from each database into an Endnote file. Duplicates were downloaded into a separate file. An Endnote file containing 4,017 unique articles was generated, along with 1,935 duplicate articles. Of the 4,017, 3,752 were excluded for the following reasons: specific focus on adults or populations in high-income countries, no intervention or policy tested, and/or not focused on a treatable childhood disease (see Figure 2). The texts of 265 articles were reviewed, of which 246 were excluded due to not meeting inclusion criteria.

Selection criteria included a description and evaluation of a non-clinical policy intervention, and a relevant outcome such as morbidity or mortality due to a treatable childhood disease. Published studies and grey literature were included in order to avoid publication bias. In cases of studies yielding two or more articles based on the same sample or intervention, the main or latest article was included and all secondary articles excluded.

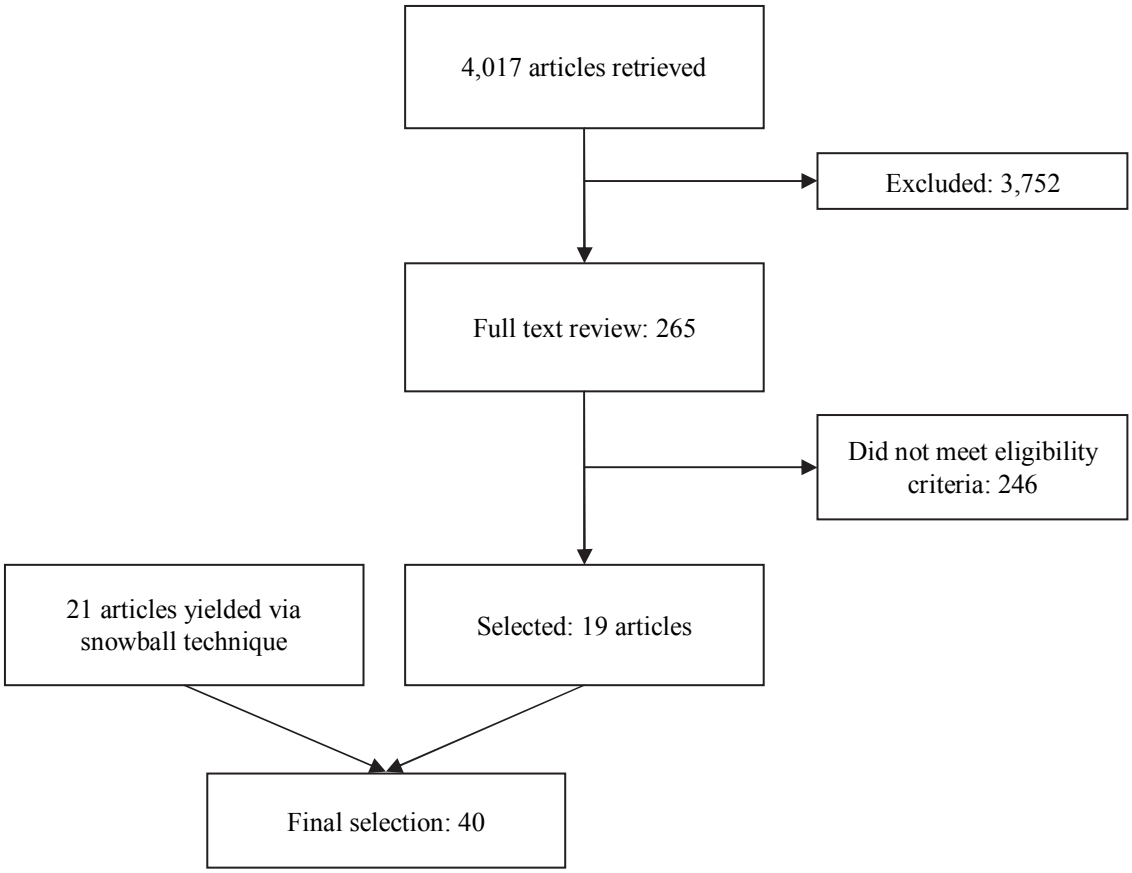
Nineteen articles were selected for inclusion, along with 21 articles yielded through a search of reference lists of included articles and relevant review papers. Thus, the final sample included 40 studies. The following data was extracted from each study: author(s), title of paper, year of publication, year(s) of data collection, type of intervention, country, methodology used, sample size, outcome measures, impact size, summary of main findings, and URL.

Regarding diarrhoeal diseases, 31 studies met the inclusion criteria, whereas only seven studies met the inclusion criteria for acute respiratory infections. Of the 31 included studies for diarrhoea policy intervention, the majority (n = 20) were non-blind randomized control trials, four were cluster randomized control studies, two used quasi-experimental interrupted time series research designs, and the remaining five included a prospective case-control study, a concurrent cohort study, a cross-sectional follow-up survey on a non-blind control trial, a case-control study, and a non-blind control trial. Of the seven studies on acute respiratory infection, four were cluster non-blind randomized control trials, with one also incorporating a quasi-experimental interrupted time series component as phase II of the main study. One study was a non-blind control trial which implemented two consecutive interventions. The remaining two studies followed a quasi-experimental interrupted time series design (see Table A1 in the Appendix).

A variety of sample unit types were observed among the studies. Units included individuals, mother-child pairs, diagnostic cases, households, and communities or neighbourhoods. Of those studies where the exact number of children could be ascertained, sample sizes varied from 51 children to 17,101 children younger than five years in the case of diarrhoeal diseases, whereas from 11,291 to 83,233 children under age five for studies looking at acute respiratory infections.

Out of the 31 studies analysing non-clinical policies against diarrhoeal diseases, 19 were set in Asia and the middle east, six in Africa, five in Latin America and one in two settings (Latin America and Asia). Fifteen studies were set in rural areas, ten in urban, four in peri-urban, one in an unknown setting, and one in a refugee camp not described as either rural or urban. With regard to policy innovations against acute respiratory diseases, six out of seven studies were situated in Asia and the Middle East. The remaining study was set in Africa. Five were set in rural locations, and two did not report locality (Duke et al. 2008; Lye et al. 1996). In the following section, we present a synthesis of the evidence, following the theory of change-based typology described in Section 2.

Figure 2: Methodological steps and selection process



Source: Authors.

4 Synthesis of evidence

This section presents a synthesis of the included articles, according to the theory of change model described in Section 2. The policy interventions are divided into two drivers of change: enhancing resources/infrastructure and promoting behavioural change. The majority of studies (28) described and assessed the efficacy of interventions primarily focused on enhancing resources or infrastructure, while 12 focused on interventions promoting behavioural change among child caregivers and/or health workers. In the next sections we discuss the findings more thoroughly.

4.1 Interventions aimed at enhancing supply-side capabilities

Studies classified as interventions aimed at enhancing supplied side capabilities of governments via resources and/or infrastructure includes those improving water supply or quality, soap access, hospital equipment, or sanitation. Water quality interventions involve the removal of microbial contaminants, either at the source or at the household level. Such interventions were frequently paired with the provision of improved water storage vessels. For instance, Graf et al. (2010) assessed an intervention aimed to improve water quality through solar disinfection, while others focused on the provision of safe water storage containers (Roberts et al. 2001), ceramic water filters and chlorine or other water disinfectants (Semenza et al. 1998; Clasen et al. 2004; Jensen et al. 2003; Sobsey et al. 2003; Reller et al. 2003).

Studies observing the effects of hospital enhancements were rare, with only one study examining the impact of oxygen concentrators and pulse oximeters in hospitals on morbidity of children with pneumonia (Duke et al. 2008). The case fatality rate of the pre-intervention group was 4.97 per cent (95 per cent CI: 4.5-5.5) compared to the post-intervention group rate of 3.22 per cent (95 per cent CI: 2.5-3.8). The risk of death for a child with pneumonia was 35 per cent lower than was before the equipment was implemented (RR 0.65 [0.52-0.78], $p<0.0001$).

Sanitation interventions were those that provided some means of excreta disposal, usually latrines. For instance, Daniels et al. (1990) assessed the impact of latrine ownership on diarrhoeal morbidity. They found that children from households with a latrine may experience 24 per cent fewer episodes of diarrhoea than such children from households without a latrine (OR = 0.76, 95 per cent CI = 0.58 - 1.01), and the impact of latrines was greater in households that used more water, practiced better personal hygiene, and where mothers had a higher level of education or worked outside the home.

Water supply interventions included the provision of a new or improved water supply, or improved distribution. Improved distribution included the installation of a hand pump or household connection to municipal water sources. One study assessed the impact of peri-urban access to a metropolitan sewerage system (Kolahi et al. 2009), while another described a water improvement intervention involving the installation of a piped water network (Tonglet et al., 1992). Semenza et al. (1998) compared diarrhoeal incidence between a group who had access to a piped municipal water system to a group without access, further dividing the latter into a control and intervention group (Semenza et al. 1998). The intervention group received chlorination and safe water equipment. The diarrhoeal rates for children were as follows: 84.4 per 1,000 per month for those in households with piped water, 127.7 per 1,000 children per month in households without piped water and the intervention, and 42.2 per 1,000 children per month in children without piped water but received the intervention. The relative risk of diarrhea among children in the intervention rather than control (no access to piped water, received no intervention) was 0.33 (95 per cent CI = 0.19-0.57). The relative risk of children who received the intervention versus those who received piped water was 0.50 (95 per cent CI = 0.29-0.84). The relative risk of children in the control group versus those who received piped water was 1.5 (95 per cent CI = 1.05-2.13).

Aziz et al. (1990) and Tonglet et al. (1992) each found that the success of water supply interventions which involve the provision of handpumps partially depends on proximity of households to the pumps. Aziz et al. (1990) found that diarrhoea incidence increased as distance from the household to the handpump increased. However, a follow-up study

completed approximately six years after the original revealed that the point prevalence of diarrhoeal morbidity was significantly lower among the population in the intervention area than that in the control area, which suggests health benefits at the community level overall (Hoque et al., 1996). Six years after the intervention, children under the age of five living in the control area had a relative risk of diarrhoea of 2.25 compared to those in the intervention area, but the difference was not statistically significant.

Tonglet et al. (1992) found that children living in villages with a piped water source experienced a significantly reduced incidence of diarrhoea compared to children in a control village, children in intervention villages who lived less than a five minute walk from the water source, and those in households which used more than 50 litres of water per day, experienced half the incidence of diarrhoea than that experienced by other children in the intervention village. These findings demonstrate the impact of relative accessibility *within* communities with improved water supply facilities.

Studies which explored differences within their intervention groups, or contained two intervention groups, add nuance to these findings (Azurin and Alvero 1974; Nanan et al. 2003; Aziz et al. 1990; Bateman et al. 1995). For instance, Azurin and Alvero (1974) found that the rate of incidence (measured by rate per 1,000) was markedly less in the intervention group which received both improved waste disposal and improved water supply (193 per 1,000) than intervention groups which received only improved water supply or only improved waste disposal (213.7 and 321.1 per 1,000 respectively), and a control group which received neither provision (542.2 per 1,000).

A number of multi-pronged interventions were identified, which supplemented resource improvements with an educational component targeting child caregivers (typically mothers) (Garrett et al. 2008; Azurin and Alvero 1974; Nanan et al. 2003; Aziz et al. 1990; Hoque et al. 1996; Quick et al. 1999; Khan 1982; Alam et al. 1989). For instance, Han and Hlaing (1989) provided mothers and children with soap and instructions to wash their hands after defecation and before handling and eating their three main meals per day. The intervention yielded a 30 per cent reduction of diarrhoeal incidence among 0-4 year olds, 31 per cent among those younger than two, and 33 per cent among those aged two or older.

A more extensive intervention assessed by Alam et al. (1989) introduced an augmented water supply through handpumps, as well as health education for mother to an intervention group. Results show that, in both areas, use of handpump water for drinking and washing, removal of child's faeces from the yard, and maternal handwashing before handling food and after defecation of self and child, observed together, decreased yearly diarrhoea incidence in children by more than 40 per cent compared to children living in households where none or only one of these practices was observed. Finally, the Rural Sanitation Pilot Project (RSPP) assessed by Daniels et al. (1990) found that children from households with a latrine may experience 24 per cent fewer episodes of diarrhoea than such children from households without a latrine (OR = 0.76, 95 per cent CI = 0.58 - 1.01), and the impact of latrines was greater in households that used more water, had better personal hygiene, and where mothers had a higher level of education or worked outside the home.

Particularly extensive interventions are assessed by Lockwood et al. (2001); Quick et al. (1999); Rana (2009); Shahid et al. (1996); Nanan et al. (2003); Luby et al. (2006); and Luby et al. (2004). The latter authors found that infants living in households that received handwashing promotion and plain soap had 39 per cent fewer days with diarrhoea versus infants living in control neighbourhoods, and severely malnourished children younger than

five years living in households that received handwashing promotion and plain soap had 42 per cent fewer days with diarrhoea versus severely malnourished children in the control group.

Luby et al. (2006) evaluated an intervention in which households received one of the following: diluted bleach and a water vessel, soap and handwashing promotion messages, flocculent-disinfectant water treatment and a water vessel, disinfectant water treatment and soap and handwashing promotion, or no intervention. Overall, persons living in neighbourhoods that received any of the interventions had markedly less diarrhoea compared to persons living in control neighbourhoods. Diarrhoea prevalence was consistently lower among infants and children aged 1–2 years who lived in intervention neighbourhoods compared to control neighbourhoods. However, the differences in prevalence were not statistically significant and yielded extremely large confidence intervals.

The impact of the Water and Sanitation Extension Programme (WASEP) project, aimed at improving potable water supply, sanitation facilities, and awareness and practices about hygiene behaviour, was assessed by Nanan et al. (2003). They found that children in control villages had a 33 per cent higher adjusted odds ratio for having diarrhoea than children living in intervention villages (adjusted odds ratio, 1.331; $p<0.049$). Within their intervention group, boys had 25 per cent lower odds of having diarrhoea than girls (adjusted odds ratio, 0.748; $p<0.049$).

Lockwood et al. (2001) provide an evaluation of the Nicaragua Rural Water Supply, Sanitation, and Environmental Health Programme. The programme took an integrated approach to improving health and addressed three key areas: (1) water supply and sanitation infrastructure (improving people's access to safe sources of drinking water and excreta disposal facilities); (2) hygiene promotion (promoting knowledge about hygiene and achieving sustainable changes in key high-risk behaviours to reduce the incidence of diarrhoea among the beneficiary population); and (3) enabling environment (conducting capacity-building interventions to support project sustainability at community, institutional, and national levels). The programme was associated with a 7 per cent decrease in households reporting childhood diarrhoea between the baseline and final follow-up survey.

Another large-scale project was assessed by Quick et al. (1999). The intervention was comprised of three elements: point-of-use treatment of contaminated source water with disinfectant produced locally using appropriate technology, safe storage of treated water, and community education. Households in the intervention area had 44 per cent fewer diarrhoea episodes than those in the control area ($p = 0.002$), with significantly less diarrhoea among infants less than one year old and children aged 5-14 years in the former compared to the latter ($p = 0.05$ and 0.01 respectively). In intervention areas, diarrhoea incidence was reduced 53 per cent among infants and 59 per cent among children 5-14.

Rana (2009) assesses a combined sanitation, hygiene, education, and water supply intervention in Bangladesh. The intervention package included promotional activities for installation of sanitary latrines and tube wells, along with health education. The education component was particularly extensive, promoting the following behaviours: washing hands with soap, ash, or soil after defecation, washing hands with soap before eating and before serving food to the household members and children, using safe water for cooking, washing and bathing, keeping surroundings of the households, kitchen, tube wells and latrines tidy, constructing a platform for tube wells with solid materials, disposing of domestic waste, excreta of poultry and livestock in fixed place and disposal of children faeces in sanitary

latrine, and preserving foods with appropriate cover. A significant reduction in point prevalence of waterborne diseases (including diarrhoea, dysentery, jaundice, worm infections and typhoid fever) among under-five children was observed following the intervention, from 22 per cent to 13 per cent ($p<0.001$).

Rasella et al. (2010) reported outcomes associated with The Family Health Programme (FHP) strategy, which reorganized primary health care in Brazil. The outcome was mortality of children younger than five years, particularly due to diarrhoeal diseases and lower respiratory tract infections. Mortality rates due to diarrhoeal diseases for children younger than five years decreased from 0.81 to 0.46 per 1,000 live births (a 43 per cent reduction), as did mortality from lower respiratory infections (from 1.39 to 0.96 per 1,000 live births, a 31 per cent reduction). Reductions of 31 per cent (95 per cent CI: 20 per cent-40 per cent) and 19 per cent (95 per cent CI: 8 per cent-28 per cent) in mortality rates due to diarrhoeal diseases and lower respiratory infections respectively were observed in municipalities with the highest FHP coverage.

Though most studies described above found improved outcomes associated with an intervention, a few did not. For instance, Jensen et al. (2003) found that the incidence of diarrhoea among children in their intervention village (which received water through a chlorinated water supply scheme) did not differ statistically from a neighbouring village where most children used water from a non-chlorinated water supply. Luby et al. (2006) found that children in intervention areas experienced a reduced incidence of diarrhea than those in the control area, but this difference was not statistically significant. In their intervention which corralled free-range chickens, Oberhelman et al. (2006) found a higher rate of diarrhoea in children in their intervention than control group.

Mixed findings were obtained by Reller et al. (2003), who found that their intervention group which received a disinfectant for drinking water plus a storage vessel was the only group to experience a significant decline in diarrhoeal episodes among children aged one or younger. Other intervention groups, including those who received water disinfectant only, bleach only, or bleach plus a storage vessel did not experience a significant reduction of diarrhoeal episodes among children compared to the control group. However, these findings are of questionable validity due to low compliance among the intervention groups.

Some studies obtained divergent findings based on age. In their evaluation of an intervention which promoted handwashing through the provision of soap and education, Sircar et al. (1987) observed no difference in the rates of diarrhoea or dysentery among those younger than five years of age. However, rates of dysentery were lower in the intervention group among those aged five and older. Conversely, Han and Hlaing (1989) found that their intervention (which instructed mothers and children to wash their hands after defecation and before handling and eating their three main meals per day) had no impact on dysentery rates among older children. Luby et al. (2006) found that their multi-faceted intervention had a much greater impact among the 5-15 year-old age group than among young children and infants. Quick et al. (1999) found that infants aged less than one year experienced a 53 per cent reduction in diarrhoeal episodes than their control group counterparts, yet no significant effect was observed for children aged one through four years. Diarrhoea incidence was reduced 61 per cent among those aged 0-11 months, 47 per cent among those aged 12-23 months, and 56 per cent among those aged 24-59 months in an intervention involving handwashing promotion and education assessed by Shahid et al. (1996).

4.2 Interventions promoting behavioural change

The promotion of behavioural change represents another major driver of change. Interventions focused on diarrhoeal-related morbidity and/or mortality are commonly aimed mothers of young children, while those focused on respiratory infection often contained health worker training and education components.

Haggerty et al. (1994) assessed an intervention targeted at diarrhoeal incidence, which featured educational messages instructing the disposal of animal faeces, handwashing after defecation and before meal preparation and disposal of children's faeces. A follow-up survey revealed an 11 per cent reduction in reported diarrhoea among children in the intervention group, compared to controls ($p<0.025$). Stanton and Clemens (1987) similarly observed a significant difference between control and intervention groups after implementation of a hygiene education programme. The rate of diarrhoea in children under the age of five was 4.3 versus 5.8 per 100 in the intervention group and control groups respectively, yielding a protective efficacy of 26 per cent ($p<0.0001$).

A particularly extensive intervention is provided by Bateman et al. (1995), in their assessment of two intervention 'models:' Model 1 was based on education sessions with the tubewell caretakers, their spouses, and tubewell users, while Model 2 added additional outreach activities: school programmes, child to child activities, and activities with key community members. They found that while caretaker sessions alone (Model 1) are worthwhile and have important benefits, Model 2 (with multiple channels of communication) was a better intervention. The dramatic differences between intervention and control areas, together with the smaller differences between the two intervention areas, suggests that the key elements of a successful hygiene behaviour change programme may be those that are similar in both models. The programme resulted in a two-third reduction of diarrhoea in the intervention areas versus control.

Bang et al. (1994) observed a 44 per cent decline ($p<0.01$) in the neonatal mortality rate due to pneumonia following the implementation of a training programme for paramedical workers, village health workers, and traditional birth attendants. Similarly, a training programme implemented by Pandey et al. (1991) led to a 28 per cent reduction in the risk of death from all causes by the third year of implementation (relative risk: 0.72, 95 per cent CI: 0.63-0.82). Reductions were observed not only in deaths due to pneumonia, but also to diarrhoea and measles.

Lye et al. (1996) implemented a training programme targeting mothers of children under the age of five in addition to health staff. The reduction in the incidence of severe acute respiratory infection cases over a 62 week period in the intervention area was significantly greater than in the control area ($p<0.05$). In a similar vein, Mtango and Neuvians (1986) implemented a health service outreach programme featuring regular home visits by health workers aimed at educating mothers and providing treatment to sick children. Within a two-year period the total under-five mortality was reduced by 27.2 per cent from 40.1 to 29.2 per 1,000 children.

A maternal education and health worker training intervention was assessed by Khan et al. (1990). Community-based health workers were trained to recognize signs of pneumonia, and differentiate between cases requiring treatment with antibiotics at home or referral to hospital. After the programme was implemented, the Acute Lower Respiratory Infection (ALRI)-specific mortality rate among children <5 years old in 31 intervention villages was

6.3 deaths per 1,000 children per year, compared with 14.4 in seven control villages ($p = 0.0001$), a difference of 56 per cent. Within one year of the interventions being extended to the control villages, the ALRI specific mortality rate in these villages dropped by 55 per cent to 6.5 per 1,000 children per year ($p = 0.06$).

A dual-pronged intervention was also assessed by Fauveau et al. (1992). They report on the impact of two successive interventions, the first consisting of a community-based family planning and health services project and the second consisting of case detection and management by community health workers, backed by medical support. During the first phase (1986-87), the ALRI mortality among under-5-year-olds was 28 per cent lower in the intervention than in the comparison area ($p<0.01$). During the second phase (1988-89), the ALRI-specific mortality rate among under-5-year-olds was 48 per cent lower in the intervention than in the comparison area ($p<0.001$). The ALRI mortality was 32 per cent lower in the intervention area than during the preceding phase, while there was no significant difference for the comparison area.

English et al. (1997) implemented a nutrition improvement programme and observed the impact on child morbidity due to respiratory and diarrhoeal diseases. The intervention group showed a significant reduction ($p<0.00001$) in the incidence of respiratory infections (from 49.5 per cent to 11.2 per cent) and diarrhoeal infections (18.3 per cent to 5.1 per cent), as well as reduced incidence of pneumonia and severe pneumonia ($p<0.0001$). There was no significant change in the incidence and severity of respiratory or diarrhoeal disease in the control group. Froozani et al. (1999) assessed an educational programme promoting breastfeeding among new mothers in Iran, as a method of lessening the risk of infant ingestion of contaminated water. The mean number of days of diarrhoea among infants in the intervention group was significantly lower ($p\leq0.004$) than in the control group.

Ambiguous results were obtained by Ahmed et al. (1993). Though children in their intervention group experienced fewer episodes of diarrhoeal than their control-group counterparts during the wet season in Bangladesh, rates were similar before and after the wet season. Moreover, significant differences between the control and intervention areas at baseline, along with a lack of significance testing, weaken the validity of these results.

5 Conclusion and policy implications

The evidence support the assumption that enhancing resources and/or infrastructure, and promoting behavioural change, are effective in reducing child morbidity and mortality due to diarrhoeal disease and acute respiratory infections in developing countries. Interventions targeting diarrhoeal incidence generally demonstrated a reduction, ranging from 18.3 per cent (Roberts et al. 2001) to 61 per cent (Rana 2009).

This wide range of impact seems to reflect the diverse types of interventions tested, along with the diverse settings in which these interventions have been implemented. The findings regarding the impact of water sanitation initiatives is well-supported by previous reviews, albeit focused on general populations rather than on children in developing countries (Esrey et al. 1985; Esrey et al. 1991).

This review identified a number of studies, especially those concerned with reducing diarrhoeal disease, which feature a multi-faceted approach (for instance, a sanitation initiative coupled with water quality improvement measures). Though there is some evidence to

suggest that interventions which include several aspects yield more successful outcomes than single-pronged interventions (EPH et al. 2004; Azurin and Alvero 1974; Bateman et al. 1995; Reller et al. 2003), a recent systematic review and meta-analysis on interventions to reduce diarrhoea among all age groups concluded that multiple interventions were not more effective than interventions with a single focus (Fewtrell et al., 2005). Additional age-disaggregated research may clarify whether multi-faceted are more effective than single-focus interventions, as applied to samples consisting of young children.

Several interventions proved more or less effective according to age. Whilst some studies showed greater impacts among infants and very young children (Quick et al. 1999) , others demonstrated a greater effect for older children (Aziz et al. 1990; Sircar et al. 1987; Luby et al. 2006). One study showed a U-shaped impact, with infants and children aged 2-5 benefitting more than those aged 1-2 (Shahid et al. 1996). Another found a strong relationship between the intervention and age category for dysentery, yet not for non-dysentery diarrhoea (Han and Hlaing 1989).

Some interventions, including sanitation promotion among households, may have a greater protective impact for infants since they may come into more frequent contact with surfaces including faeces-contaminated floors in and around dwellings than adults and older children. Infants and very young children also rely on others to wash their hands for them, which certainly influences the efficacy of handwashing promotion interventions. Further research to determine the impact of intervention type by age is justified.

Though almost half of deaths globally among young children occur in India, Nigeria, Democratic Republic of the Congo, Pakistan, and China (Black et al. 2010), only a third of the articles in this review were based in one of these countries. Pakistan was fairly well represented, as the setting of five articles (Jensen et al. 2003; Khan et al. 1990; Luby et al. 2006; Luby et al. 2004; Nanan et al. 2003). Two studies each were set in India (Bang et al. 1994; Sircar et al. 1987) and Zaire (Tonglet et al. 1992; Haggerty et al. 1994). However, there were no studies set in Nigeria or China.

As articles in languages other than English were excluded, we may have missed out in the review some evidence. However, given the fact that most relevant studies have been published in English, we believe the magnitude of the bias is contained. The results of this review show a relative dearth of intervention studies on respiratory infections, compared to those on diarrhoeal diseases: while over 30 studies were identified on diarrhoea diseases, only seven were identified for respiratory infections. This seems to reflect the fact that the bulk of intervention studies on respiratory infections as focused on clinical interventions such as vaccines and antibiotics. The near absence of studies on non-clinical interventions, including handwashing initiatives, on reducing respiratory infections is surprising considering the effectiveness of handwashing initiatives on respiratory infections in other settings (Rabie and Curtis 2006).

This review has identified 40 articles on non-clinical interventions for diarrhoeal diseases and respiratory infections, which together kill approximately three million children in developing countries every year (Black et al. 2010). Investments in implementing initiatives featuring improvements to sanitation, hygiene, water supply and quality, and medical equipment to detect symptoms of childhood diseases, along with training and education for medical workers and the general population have been shown to be effective in reducing the burden of disease among children in developing countries.

Greater attention is warranted in under-studied areas with high disease burdens including Nigeria, China, India, and Democratic Republic of the Congo. There are comparatively few studies assessing the impact of non-clinical interventions on respiratory infections, compared to those focusing on diarrhoeal disease. Future studies should continue to disaggregate their results based on age, since many interventions have different impacts depending on the age of the child.

Appendix
Table A1: Study characteristics of included articles

Study	Setting	Study design	Study size	Intervention	Outcome
a) Enhancing resources and/or infrastructure					
Alam et al. (1989)	Bangladesh (rural)	Non-blind RCT	623 children aged 6-23 months.	Enhanced water supply and quality through handpumps, and health education for mothers.	The use of handpump water for drinking and washing, removal of child's faeces from the yard, and maternal handwashing before handling food and after defecation of self and child, observed together, decreased yearly diarrhoea incidence in children by more than 40 per cent compared to children living in households where none or only one of these practices was observed. On average, a child in the intervention area had 3.4 diarrhoea episodes in a year while a child in the control area had 4.1 episodes. The difference was statistically significant ($p<0.01$). The impact of the educational intervention on maternal hygiene behaviour could be assessed only indirectly by comparing distributions of hygiene practices in two areas. Significant differences have been found ($X2 = 113.3$, $p<0.001$) which may indicate success of the health education programme in promoting hygiene among the non-educated mothers of young children.
Aziz et al. (1990)	Bangladesh (rural)	Non-blind RCT	The sample of children ranged from a low of 6,922 to a high of 8,527 from 1984 to 1987 respectively in the intervention group, and from a low of 6,603 to a high of 8,210 from 1984 to 1985 respectively in the control group.	Water, sanitation, and hygiene education.	Children in the intervention area experienced 25 per cent fewer episodes of diarrhoea than those in the control area. An impact on diarrhoea was seen in each age group except for those aged 0-5 months. The incidence density ratios showed that the impact appeared to increase with age, with the greatest effect in the 36-59 months age group.

					Within the intervention area diarrhoea increased as distance from the household to the handpump increased. The use of a pit latrine, either directly by the child or for disposal of its faeces, was associated with lower diarrhoea incidence.
Azurin and Alvero (1974)	Philippines (peri-urban)	Non-blind RCT	527 children aged 0-4.	Safe water and sanitary facilities for human waste disposal.	Improvement of either water supply or toilet facilities or both was effective in significantly reducing the incidence of cholera in the corresponding study communities as compared with the control. The greatest improvement was observed in the community in which both water supply and toilets were improved than in the communities in which either water or toilets were improved. The rate of cholera infection among those aged 0-4 was 193.1 per 1,000 in the group which received toilets and water, 213.7 per 1,000 in the group which received improved water, 321.1 per 1,000 in the group which received toilets, and 542.2 per 1,000 in the group which received no intervention.

Clasen et al. (2004)	Bolivia (rural)	Non-blind RCT	50 households comprised of 280 persons, of which 32 were children less than five years of age.	Household-based ceramic water filters	Risk of diarrhoea for children less than five years old, controlled for clustering within households, was reduced by 83 per cent (estimated OR 0.17, 95 per cent CI 0.06, 0.49, p 0.001). The risk of diarrhoea decreased by 0.97 (95 per cent CI 0.96, 0.99, p<0.02) for each year of life. The mean reduction in diarrhoea prevalence during the six-month trial was 64 per cent (p<0.0001). The reduction was highest among children less than five years old (72 per cent) and lowest among adults (57 per cent). Prevalence of diarrhoea in the intervention group showed a statistically significant upward trend over the course of the study (p<0.02).
Daniels et al. (1990)	Lesotho (rural)	Case-control	The sample consisted of children less than five years of age presenting at a participating health facility. A total of 803 cases of diarrhoea and 810 controls were recruited.	The Rural Sanitation Pilot Project (RSPP), which promoted and constructed ventilated improved pit latrines and on provided health education directed at improving standards of personal and domestic hygiene practices.	Cases were significantly less likely than controls to come from latrine-owning houses (p<0.01, OR = 0.76, 95 per cent CI = 0.62- 0.93). Children under the age of five from households with a latrine may experience 24 per cent fewer episodes of diarrhoea than such children from households without a latrine (OR = 0.76, 95 per cent CI = 0.58 - 1.01). The impact of latrines on diarrhoea was greater in those households that used more water, practiced better personal hygiene, and where mothers had a higher level of education or worked outside the home.

Duke et al. (2008)	Papua New Guinea (unknown)	Quasi-experimental interrupted time series design	A total sample of 11,291 children, consisting of 7,161 children in the pre-intervention group, and 4,130 in the post intervention group.	Introduction of oxygen concentrators and pulse oximeters into hospitals.	The case fatality rate of the pre-intervention group was 4.97 per cent (95 per cent CI: 4.5-5.5) compared to the post-intervention group case fatality rate of 3.22 per cent (95 per cent CI: 2.5-3.8). After the system was introduced, the risk of death for a child with pneumonia was 35 per cent lower than was before the project began (RR 0.65 [0.52-0.78], p<0.0001).
Garrett et al. (2008)	Kenya (rural)	Quasi-experimental non-blind RCT	960 children under the age of five in 556 households in 12 randomly selected intervention villages and six randomly selected control villages.	The Safe Water System: point-of-use chlorination, safe water storage, sanitation, and rainwater harvesting.	Chlorinating stored water (RR: 0.44, 95 per cent CI: 0.28-0.69), latrine presence (RR: 0.71, 95 per cent CI 0.54-0.92), rainwater use (RR 0.70, 95 per cent CI: 0.52-0.95), and living in an intervention village (RR: 0.31, 95 per cent CI: 0.23-0.41), were independently associated with lower diarrhoea risk. Diarrhoea risk was higher among shallow well users (RR 1.78, 95 per cent CI: 1.12-2.38).
Graf et al. (2010)	Cameroon (urban)	Non-blind RCT	738 and 2,193 randomly selected households.	Solar water disinfection.	A decrease in diarrhoea prevalence among children under the age of five was observed in the intervention group, from 34.4 per cent prior to the intervention to 22.8 per cent after the intervention (x2 = 19.18, p = 0.001, OR = 1.77). The prevalence in the control group remained stable, at 34.4 per cent and 31.8 per cent before and after the intervention respectively.
Han and Hlaing (1989)	Myanmar/Burma (urban)	Non-blind RCT	494 children aged less than five years in 350 households.	Handwashing promotion	The diarrhoeal incidence among children in the handwashing households was significantly lower than that among those in the control households (IDR = 0.70, 95 per cent CI = 0.54-0.92). The percentage reductions in diarrhoea incidence for the 0-4, younger than 2, and 2 or greater than 2 age groups were 30 per cent, 31 per cent, and 33 per cent respectively. Though there was a 40 reduction in dysentery incidence

					(IDR = 0.58, 95 per cent CI = 0.22-1.55) in children under 2 years, there was no impact in older children (IDR = 1.2, 95 per cent CI = 0.52-2.80).
Hoque et al. (1996)	Bangladesh (rural)	Cross sectional survey follow-up of non-blind control trial	500 randomly selected households drawn from intervention and control groups of a previous intervention study. A total of 645 children under the age of five were included, 375 in the intervention area and 270 in the control area.	Water, sanitation, and hygiene education.	In the original intervention study, children in the intervention area experienced 25 per cent fewer episodes of diarrhoea than those in the control area.
Jensen et al. (2003)	Pakistan (rural)	Non-blind RCT	226 children aged less than five years.	Chlorination of drinking-water.	The intervention was not associated with a decrease in the incidence diarrhoea.
Khan (1982)	Bangladesh (unknown)	Non-blind RCT	The study group (who received both the soap and water) contained 65 children aged four and younger, and the control contained 79 children.	Handwashing with soap intervention. Individuals were provided with soap and water pitchers, only water pitchers, only soap, or neither.	Just over 10 per cent of children in the control group subsequently became infected with shigellosis after a family member was diagnosed, compared to over 50 per cent of children in the control group (those who received no soap or water).
Kolahi et al. Sohrabi (2009)	Iran (urban)	Nonrandomized control trial	4,179 children 60 months or younger.	Household access to an urban sewerage system.	The incidence of diarrhoea among children decreased.
Lockwood et al. (2001)	Nicaragua (rural)	Quasi-experimental interrupted time series design	Eight departments of the country and 37 individual municipalities. The hygiene promotion aspect of the programme was carried on a subsample comprised of 169 communities that	Nicaragua Rural Water Supply, Sanitation, and Environmental Health Programme, which improved people's access to safe sources of drinking water and excreta disposal facilities, promoted	The percentage of households where children aged four or under have had diarrhoea during the two weeks prior to the survey was 20 per cent at baseline, 20 per cent at the first follow-up survey, and then dropped to 15 per cent and then 13 per cent in the second and third follow-up surveys respectively.

			included 1,183 individual households, with sample sizes ranging from 10 per cent to 15 per cent, depending upon the absolute size of the community.	hygiene, and conducted capacity-building activities.	
Luby et al. (2004)	Pakistan (urban)	Cluster RCT	The intervention group was comprised of 300 households (1523 children), one control group of 300 households (1640 children), and a second control group of 306 households (1528 children).	The Karachi Soap Health Study, a handwashing promotion intervention.	Infants living in households that received handwashing promotion and plain soap had 39 per cent fewer days with diarrhoea (95 per cent CI, –61 per cent to –16 per cent) versus infants living in control neighbourhoods. Severely malnourished children (weight for age z score, –3.0) younger than five years living in households that received handwashing promotion and plain soap had 42 per cent fewer days with diarrhoea (95 per cent CI, –69 per cent to –16 per cent) versus severely malnourished children in the control group. Similar reductions in diarrhoea were observed among children in households receiving antibacterial soap.
Luby et al. (2006)	Pakistan (urban)	Cluster RCT	47 households consisting of 1,340 individuals.	Point of use water disinfectant treatment, along with handwashing with soap promotion.	Diarrhoea prevalence was consistently lower among infants and children one year–two years who lived in intervention neighbourhoods compared to control neighbourhoods. However, the magnitude of the reductions were less than the overall reduction for all ages, and many of the individual age and intervention specific reductions were not statistically significant. Infants less than one year old in the ‘bleach water treatment’ experienced a diarrhoea prevalence of 8.30 per cent (20 per cent less than control), ‘soap and handwashing promotion’ a prevalence of 7.86 per cent (24 per cent less than control), ‘flocculent-disinfectant water treatment’ a prevalence of 6.20 per cent (40 per cent less than control), and ‘flocculent-disinfectant plus

					soap' 6.48 per cent (38 per cent less than control). However, none of these differences are statistically significant and yielded extremely large confidence intervals.
Nanan et al. (2003)	Pakistan (rural)	Case control study	803 children aged five and younger.	Water and sanitation extension programme (WASEP) project, aimed at improving potable water supply, sanitation facilities, and awareness and practices about hygiene behaviour.	Children in control villages had a 33 per cent higher adjusted odds ratio for having diarrhoea than children living in intervention villages (adjusted odds ratio, 1.331; $p<0.049$). Boys had 25 per cent lower odds of having diarrhoea than girls (adjusted odds ratio, 0.748; $p<0.049$).
Oberhelman et al. (2006)	Peru (peri-urban)	Non-blind RCT	137 children aged five or younger with diarrhoea episodes.	Corralling free-range chickens	For children aged three and under, the intervention group experienced 3.16 episodes per person per year, compared to 2.61 episodes per person per year in the control group. The difference was not significant in a student's t-test. The intervention had little impact, which suggests that diarrhoea incidence among this sample is due to infections acquired outside the home.
Quick et al. (1999)	Bolivia (peri-urban)	Non-blind RCT	127 households consisting of 791 persons divided into intervention and control groups. The intervention group consisted of 64 households with 400 persons, and the control of 63 households with 391 persons. The intervention group included 16 infants aged less than one year, and 53 children aged one to four years. The control group included 27 infants and 64 children	Point-of-use treatment of contaminated water with disinfectant, safe storage of treated water, and community education.	Intervention households had 44 per cent fewer diarrhoea episodes than control households ($p = 0.002$). Infants less than one year old and children aged 5-14 years in intervention households had significantly less diarrhoea than control children ($p = 0.05$ and 0.01 respectively). Diarrhoeal incidence was reduced 53 per cent among infants and 59 per cent among children 5-14. However, the intervention had an insignificant effect on diarrhoeal episodes for children aged one through four.

			aged 1 through four years.		
Rana (2009)	Bangladesh (rural)	Interrupted time-series experimental study	17,101 children aged four or younger.	Promotional activities including the installation of tube wells and sanitary latrines, and health education for improving hygienic behaviour.	Among under-five children the incidence of waterborne diseases was reduced from 22 per cent to 13 per cent ($p<0.001$).
Rasella et al. (2010)	Brazil (unknown)	Ecological study	2,601 Brazilian municipalities.	The Family Health Programme (FHP), a strategy for reorganization of primary health care in Brazil.	Mortality rates for diarrhoeal diseases decreased from 0.81 to 0.46 per 1,000 live births (a 43 per cent reduction), as did mortality from lower respiratory infections (from 1.39 to 0.96 per 1,000 live births, a 31 per cent reduction). Reductions of 31 per cent (95 per cent CI: 20 per cent-40 per cent) and 19 per cent (95 per cent CI: 8 per cent-28 per cent) in mortality rates due to diarrhoeal diseases and lower respiratory infections, respectively, were observed in municipalities with the highest FHP coverage.
Reller et al. (2003)	Guatemala (rural)	Non-blind RCT	12 villages consisting of 492 households, totalling 2,982 persons of which 522 were children one year or younger.	Household-based drinking water disinfectant and a storage vessel.	Children in households which received flocculant disinfectant and a storage vessel experienced significantly fewer episodes of diarrhoea than the control group (adjusted odds ratio = 0.69, 95 per cent confidence interval = 0.50-0.95). Infants in households who received flocculant disinfectant plus a storage vessel had 30 per cent fewer episodes of diarrhoea compared to infants who received flocculant disinfectant alone. Children less than five years of age who lived in households with water treatment had fewer episodes of severe diarrhoea than controls, but they did not have fewer episodes of prolonged diarrhoea.

Roberts et al. (2001)	Malawi (refugee camp)	Non-blind RCT	500 Mozambican refugee households (100 intervention, 400 control).	Water storage improvement programme.	There was 31 per cent less diarrhoeal disease (p = 0.06) in children under five years of age among the group who received the intervention.
Semenza et al. (1998)	Uzbekistan (urban)	Cluster randomized intervention study	344 children under the age of five.	Home chlorination of drinking water for a sample lacking access to piped water.	The home chlorination intervention group had the lowest diarrhoeal rate (28.8 per 1,000 subjects per month), compared to those with piped water and those receiving no intervention. The relative risk of diarrhoea among children in the intervention rather than control (no access to piped water, received no intervention) was 0.33 (95 per cent CI = 0.19-0.57). The relative risk of children who received the intervention versus those who received piped water was 0.50 (95 per cent CI = 0.29-0.84). The relative risk of children in the control group versus those who received piped water was 1.5 (95 per cent CI = 1.05-2.13).
Shahid et al. (1996)	Bangladesh (peri-urban)	Non-blind RCT	The intervention area had 44 children aged 0-11 months, 19 aged 12-23 months, and 68 aged 24-59 months. The control group had 33 children aged 0-11 months, 27 aged 12-23 months, and 79 aged 24-59 months.	Handwashing and education programme	Diarrhoea incidence was reduced 61 per cent among those aged 0-11 months, 47 per cent among those aged 12-23 months, and 56 per cent among those aged 24-59 months.
Sircar et al. (1987)	India (urban)	Non-blind RCT	340 children younger than the age of five.	Handwashing promotion and education programme	The difference in the incidence of diarrhoea and between those younger than the age of five in study and control groups was not significantly different. This was due to the inability to enforce handwashing practices in this younger age group.

Sobsey et al. (2003)	Bangladesh and Bolivia (peri-urban)	Non-blind RCT	Approximately 140 households in Bolivia and about 275 households in Bangladesh.	Chlorination and safe storage of household drinking water	In Bangladesh, the mean diarrhoea incidence rates for children <5 years of age were significantly lower (p = 0.029, t-test) in intervention households (20.8 episodes/1,000 days) than in control households (24.3 episodes/1,000 days). However, in Bolivia, the mean rates in children <5 years of age were only slightly lower in the intervention group (0.77) than in the control group (0.81).
Tonglet et al. (1992)	Zaire (rural)	Non-blind concurrent cohort study	906 children under the age of four at the commencement of the study	Installation of a piped water network.	Median diarrhoea incidence per two weeks proved to be significantly lower in the two intervention villages (0.084 and 0.088) than in the control village (0.091) ($p<0.05$). Within intervention villages, the median diarrhoea incidence per two weeks was halved in children who lived in households located less than a five-minute walk from the public standpipe, or in households using more than 50 litres of water a day.
b) Promoting behavioural change					
Ahmed et al. (1993)	Bangladesh (rural)	Non-blind control trial	Intervention and control groups were each composed of 185 households with children aged 0-18 months.	Educational messages to improve hygiene practices, surveillance of households in the intervention areas to assess household cleanliness and adherence to hygiene messages.	At the time of the first of three surveys, diarrhoea was more prevalent in the intervention site. Mid-way through the intervention the prevalence in the intervention site was consistently lower than that of the control site. At the end of the intervention, the difference between the sites in diarrhoeal rates disappeared. Diarrhoea prevalence was correlated with mother's understanding and knowledge ($r = -0.25$, $p = 0.001$), food hygiene score ($r = -0.56$, $p = 0.001$), all adoption score ($r = -0.64$, $p = 0.0001$), and cleanliness score ($r = -0.78$, $p = 0.0001$).
Bang et al. (1994)	India (rural)	Non-blind RCT	An intervention sample of 58 villages and a control sample of 44 villages with populations of 48,377 and 34,856	Educational intervention training 30 paramedical workers, 25 village health workers and 86 traditional birth	Neonatal mortality due to pneumonia was reduced by 44 per cent in the intervention versus control area ($p<0.001$). Post-intervention, the total neonatal mortality rates were

			respectively.	attendants to diagnose and treat childhood pneumonia.	78.7 and 62.8 per 1,000 in the control and intervention areas respectively ($p<0.01$).
Bateman et al. (1995)	Bangladesh (rural)	Non-blind cluster trial	400 children under the age of five.	Model 1: Education sessions with the tubewell caretakers, their spouses, and tubewell users Model 2: Model one intervention plus outreach activities including school programmes, child to child activities, and activities with key influencers in the community.	In both Models, there is a dramatic reduction in the intervention areas compared to control areas, with an overall reduction of about two thirds in the former. The per cent of children with diarrhoea within the two weeks before the survey are 23 per cent versus 65 per cent for Model 1 intervention and control, and 20 per cent versus 57 per cent for Model 2 intervention and control groups respectively.
English et al. (1997)	Vietnam (unknown)	Non-blind RCT	Preschool children aged five and under in the project commune (average 469 children) and the control commune (average 251 children).	Nutrition improvement programme based on household food production and nutrition education.	The project commune showed a significant reduction ($p<0.00001$) in the incidence of respiratory infections (from 49.5 per cent to 11.2 per cent) and diarrhoeal infections (18.3 per cent to 5.1 per cent). The incidence of pneumonia and severe pneumonia was also significantly reduced in the intervention commune ($p<0.0001$). There was no significant change in the incidence and severity of respiratory disease or the incidence of diarrhoeal disease in the control commune. No significant differences were identified between boys and girls either for the incidence or severity of respiratory infections or the incidence of diarrhoeal disease.
Fauveau et al. (1992)	Bangladesh (rural)	Non-blind RCT consisting of two interventions		Two consecutive interventions.	During the second phase, the ALRI mortality was 32 per cent lower in the intervention area than during the preceding phase, while there was no significant

		implemented consecutively.		The first consisted of a community-based family planning and health services project which involved village community health workers administering vaccines for childhood diseases, promoting oral rehydration therapy for diarrhoea, distributing vitamin A capsules, providing nutritional information, and detecting and referring seriously ill or malnourished children. The second targeted ALRI-related mortality, through case detection and management by community health workers, backed by medical support.	difference for the comparison area (a reduction of 6 per cent). During the first phase, the ALRI-specific death rate in the intervention area was half that in the comparison area for children aged 1-4 years. Although it was halved again during the second phase, the reductions in the ALRI-specific death rates in the two areas were not significantly different between the two phases (X2 test for heterogeneity = 0.6). Among infants aged 1-11 months, the ALRI-specific death rate during the first phase was not significantly lower in the intervention than in the comparison area, but in the intervention area was 30 per cent lower during the second phase than during the first ($p<0.05$). The difference in the reduction between the two areas was of border-line statistical significance (X2 test for heterogeneity = 3.4, $p = 0.06$).
Froozani et al. (1999)	Iran (urban)	Quasi-experimental non-blind RCT	120 pairs of mothers and infants.	Educational intervention to promote breastfeeding.	The mean number of days of diarrhoea among infants in the study group was significantly lower ($P\leq0.004$) than in the control group.
Haggerty et al. (1994)	Zaire (rural)	Non-blind RCT	Baseline information on diarrhoeal morbidity of 2,082 children was obtained. Structured observations were made on a subset of 300 families. At follow-up, a new subsample of 293 families was randomly	Hygiene education.	During the post-intervention period, diarrhoeal morbidity was greatly reduced relative to the previous year among all children in both study groups. Diarrhoeal incidence rates declined by approximately 50 per cent in each group, and the reductions were highly significant within each age category in both groups (SND tests, $p<0.0001$ in every case). One year after baseline, overall, children in intervention

			selected.		sites had a reported mean of 0.85 episodes of diarrhoea, while children in control sites had 0.90 episodes (NS). There was no discernible evidence of a trend towards fewer episodes of diarrhoea in intervention compared to control children after the intervention. Nevertheless, proportionately fewer children in intervention sites were reported to have diarrhoea than at control sites.
Khan et al. (1990)	Pakistan (rural)	Cluster non-blind RCT followed by a time-interrupted series study.	Children aged five years or younger residing in 38 villages (population, 37 245) in three distinct clusters.	Case management by village-level community health workers, backed up by local health centre staff. The intervention consisted of active case-finding and maternal health education. The programme also includes maternal health education.	The ALRI-specific mortality rate among children <5 years old in intervention villages was 6.3 deaths per 1,000 children per year, compared with 14.4 in seven control villages ($p = 0.0001$), a difference of 56 per cent. Within one year of the interventions being extended to the control villages, the ALRI specific mortality rate in these villages dropped by 55 per cent to 6.5 per 1,000 children per year ($p = 0.06$). The ALRI-specific infant (less than one year old) mortality rate in the intervention villages was 15.5 per 1,000 live births per year in 1985-86, compared with 32.5 per 1,000 per year in the control villages, a 52 per cent difference ($p = 0.006$). After interventions began in the control villages in 1987, the ALRI-specific infant mortality rate dropped to 15.0 per 1,000 per year ($p = 0.12$).
Lye et al. (1996)	Malaysia (unspecified)	Non-blind RCT	An intervention sample of n = 1,315 to 1,458 and a control sample of 1,042 to 1,205 children under the age of five.	Health education and training.	The reduction in the incidence of severe acute respiratory infection cases in the intervention area was significantly greater than in the control area ($p<0.05$).
Mtango and Neuvians (1986)	Tanzania (rural)	Cluster non-blind RCT	8,028 and 0,099 children in the intervention area and 8,098 and 9,915 in the control area in the	Health service outreach programme consisting of Village Health Workers visiting households and	The total under five mortality was reduced by 27.2 per cent from 40.1 to 29.2 per 1,000 children. The disease-specific mortality rate for pneumonia was

			first and second year surveys respectively.	providing education and treatment for acute respiratory infections.	reduced by 30.1 per cent from 14.3 to 10.0 per 1,000 children per year, contributing 40 per cent to the overall mortality reduction.
Pandey et al. (1991)	Nepal (rural)	Quasi-experimental interrupted time series design.	13,404 children under the age of five.	Indigenous community health workers in Jumla district were trained to detect and treat pneumonia.	The programme led to a 28 per cent reduction in the risk of death from all causes by the third year since implementation (relative risk: 0.72, 95 per cent CI: 0.63-0.82). There was a significant trend toward lower mortality with the greater duration of the programme (Mantel-Haenszel chi-square for trend = 5.4, $p<0.02$).
Stanton and Clemens (1987)	Bangladesh (urban)	Non-blind RCT	51 communities each comprising 38 families were randomized to either receive (n = 25) or not receive (n = 26) the intervention.	Educational intervention promoting hygienic behavior.	During the six months after the intervention, the rate of diarrhoea in children aged five and under was 4.3 per 100 in the intervention communities and 5.8 in the control communities, yielding a protective efficacy of 26 per cent ($p<0.0001$).

Source: Authors.

References

Alam, N., B. Wojtyniak, F.J. Henry, and M.M. Rahaman (1989). 'Mothers Personal and Domestic Hygiene and Diarrhea Incidence in Young-Children in Rural Bangladesh'. *International Journal of Epidemiology*, 18, 242-7.

Ahmed, M.U., M. Rashid, and S. Begum (1993). 'A Longitudinal Study of the impact of behavioural change intervention on cleanliness, diarrhoeal morbidity and growth of children in rural Bangladesh', *Social Science & Medicine,* 37 (2), 159-71.

Anderson, A. (2005). 'An Introduction to Theory of Change'. *Harvard Family Research Project, Harvard Graduate School of Education*, XI**,** 12 and 19.

Aziz, K.M.A., B.A. Hoque, K.Z. Hasan, M.Y. Patwary, S.R.A. Huttly, M.M. Rahaman, and R.G. Feachem (1990). 'Reduction in Diarrhoeal Diseases in Children in Rural Bangladesh By Environmental and Behavioural Modifications'. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 84, 433-8.

Azurin, J.C. and M. Alvero (1974). 'Field Evaluation of Environmental Sanitation Measures Against Cholera'. *Bulletin of the World Health Organization*, 51, 19-29.

Bang, A.T., R.A. Bang, and P.G. Sontakke (1994). 'Management of Childhood Pneumonia By Traditional Birth Attendants'. *Bulletin of the World Health Organization*, 72: 897-905.

Bateman, O.M., R.A. Jahan, S. Brahman, S. Zeitlyn, and S.L. Laston (1995). 'Prevention of Diarrhea Through Improving Hygiene Behaviors: the Sanitation and Family Education (SAFE) Pilot Project Experience' (42; Washington, DC: CARE–ICDDR,B–EHP Joint Publication).

Black, R.E., S. Cousens, H.L. Johnson, J.E. Lawn, I. Rudan, D.G. Bassani, P. Jha, H. Campbell, C.F. Walker, R. Cibulskis, T. Eisele, L. Liu, and C. Mathers (2010). 'Global, Regional, and National Causes of Child Mortality in 2008: A Systematic Analysis'. *The Lancet*, 375, 1969-87.

Clasen, T.F., J. Brown, S. Collin, O. Suntura, and S. Cairncross (2004). 'Reducing Diarrhea Through the Use of Household-Based Ceramic Water Filters: A Randomized, Controlled Trial in Rural Bolivia'. *American Journal of Tropical Medicine and Hygiene*, 70, 651-7.

Daniels, D.L., S.N. Cousens, L.N. Makoae, and R.G. Feachem (1990). 'A Case-Control Study of the Impact of Improved Sanitation on Diarrhoea Morbidity in Lesotho'. *Bulletin of the World Health Organization*, 68, 455-63.

Das, R.R., M. Singh, and N. Shafiq (2010). 'Zinc in Treatment of Acute Lower Respiratory Tract Infection in Children: Pooled Result from Randomized Controlled Trials'. *Chest Conference: Chest*, 138.

Das, R.R., M. Singh, and N. Shafiq (2012). 'Short-Term Therapeutic Role of Zinc in Children < 5 Years of Age Hospitalised for Severe Acute Lower Respiratory Tract Infection'. *Paediatric Respiratory Reviews*, 13, 184-91.

Dennehy, P.H. (2012). 'Effects of Vaccine on Rotavirus Disease in the Pediatric Population'. *Current Opinion in Pediatrics*, 24, 76-84.

Desai, R., L.H. De Oliveira, U.D. Parashar, B. Lopman, J.E. Tate, and M.M. Patel (2011). 'Reduction in Morbidity and Mortality from Childhood Diarrhoeal Disease after Species

a Rotavirus Vaccine Introduction in Latin America – A Review'. *Memorias Do Instituto Oswaldo Cruz*, 106, 907-11.

Dinleyici, E.C., M. Eren, M. Ozen, Z.A. Yargic, and Y. Vandenplas (2012). 'Effectiveness and Safety of Saccharomyces Boulardii for Acute Infectious Diarrhea'. *Expert Opinion on Biological Therapy*, 12, 395-410.

Duke, T., F. Wandi, M. Jonathan, S. Matai, M. Kaupa, M. Saavu, R. Subhi, and D. Peel (2008). 'Improved Oxygen Systems for Childhood Pneumonia: A Multihospital Effectiveness Study in Papua New Guinea'. *The Lancet*, 372, 1328-33.

English, R.M., J.C. Badcock, T. Giay, T. Ngu, A.M. Waters, and S.A. Bennett (1997). 'Effect of Nutrition Improvement Project on Morbidity from Infectious Diseases in Preschool Children in Vietnam: Comparison with Control Commune'. *British Medical Journal*, 315(7116), 1122-25.

EPH, UNICEF/WES, USAID, World Bank/WSP and WSSCC (2004). Joint Publication 8: The Hygiene Improvement Framework – A Comprehensive Approach for Preventing Childhood Diarrhea. Washington, DC: Environmental Health Project.

Esrey, S.A., R.G. Feachem, and J.M. Hughes (1985). 'Interventions for the Control of Diarrheal Diseases Among Young-Children – Improving Water-Supplies and Excreta Disposal Facilities'. *Bulletin of the World Health Organization*, 63, 757-72.

Esrey, S.A., J.B. Potash, L. Roberts, and C. Shiff (1991). 'Effects of Improved Water-Supply and Sanitation on Ascariasis, Diarrhea, Dracunculiasis, Hookworm Infection, Schistosomiasis, and Trachoma'. *Bulletin of the World Health Organization*, 69, 609-21.

Fauveau, V., M.K. Stewart, J. Chakraborty, and S.A. Khan (1992). 'Impact on Mortality of a Community-based Programme to Control Acute Lower Respiratory Tract Infections'. *Bulletin of the World Health Organization*, 70(1), 109-16.

Fewtrell, L., R.B. Kaufmann, D. Kay, W. Enanoria, L. Haller, and J.M. Colford (2005). 'Water, Sanitation, and Hygiene Interventions To Reduce Diarrhoea in Less Developed Countries: A Systematic Review and Meta-Analysis'. *Lancet Infectious Diseases*, 5, 42-52.

Fischer Walker, C.L., J. Perin, M.J. Aryee, C. Boschi-Pinto, and R.E. Black (2012). 'Diarrhea Incidence in Low- and Middle-Income Countries in 1990 and 2010: A Systematic Review'. *BMC Public Health*, 12**,** 220.

Froozani, M.D., K. Permehzadeh, A.R.D. Motlagh, and B. Golestan (1999). 'Effect of Breastfeeding Education on the Feeding Pattern and Health of Infants in their First 4 Months in the Islamic Republic of Iran'. *Bulletin of the World Health Organization*, 77, 381-85.

Garrett, V., P. Ogutu, P. Mabonga, S. Ombeki, A. Mwaki, G. Aluoch, M. Phelan, and R.E. Quick (2008). 'Diarrhoea Prevention in a High-Risk Rural Kenyan Population Through Point-of-Use Chlorination, Safe Water Storage, Sanitation, and Rainwater Harvesting'. *Epidemiology and Infection*, 136, 1463-71.

Gilani, Z., Y.D. Kwong, O.S. Levine, M. Deloria-Knoll, J.A.G. Scott, K.L. O'Brien, and D.R. Feikin (2012). 'A Literature Review and Survey of Childhood Pneumonia Etiology Studies: 2000-2010'. *Clinical Infectious Diseases*, 54, S102-S108.

Graf, J., S. Zebaze Togouet, N. Kemka, D. Niyitegeka, R. Meierhofer, and J. Gangoue Pieboji (2010). 'Health Gains from Solar Water Disinfection (Sodis): Evaluation of a

Water Quality Intervention in Yaounde, Cameroon'. *Journal of Water and Health*, 8, 779-96.

Grosse, S.D. and K. Roy (2008). 'Long-Term Economic Effect of Early Childhood Nutrition'. *The Lancet*, 371, 365-66.

Haggerty, P.A., K. Muladi, B.R. Kirkwood, A. Ashworth, and M. Manunebo (1994). 'Community-Based Hygiene Education to Reduce Diarrheal Disease in Rural Zaire – Impact of the Intervention on Diarrheal Morbidity'. *International Journal of Epidemiology*, 23, 1050-59.

Han, A.M. and T. Hlaing (1989). 'Prevention of Diarrhoea and Dysentery by Hand Washing'. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 83, 128-31.

Hoddinott, J., J.A. Maluccio, J.R. Behrman, R. Flores, and R. Martorell (2008). 'Effect of a Nutrition Intervention during Early Childhood on Economic Productivity Inguatemalan Adults'. *The Lancet*, 371, 411-16.

Hoque, B.A., T. Juncker, R.B. Sack, M. Ali, and K.M. Aziz (1996). 'Sustainability of a Water, Sanitation and Hygiene Education Project in Rural Bangladesh: A 5-Year Follow-up'. *Bulletin of the World Health Organization*, 74, 431-37.

Jensen, P.K., J.H.J. Ensink, G. Jayasinghe, W. Van Der Hoek, S. Cairncross, and A. Dalsgaard (2003). 'Effect of Chlorination of Drinking-Water on Water Quality and Childhood Diarrhoea in A Village in Pakistan'. *Journal of Health Population and Nutrition*, 21, 26-31.

Khan, A.J., J.A. Khan, M. Akbar, and D.G. Addiss (1990). 'Acute Respiratory Infections in Children: A Case Management Intervention in Abbottabad District, Pakistan'. *Bulletin of the World Health Organization*, 68, 577-85.

Khan, M.U. (1982). 'Interruption of Shigellosis by Hand Washing'. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 76, 164-69.

Kolahi, A.-A., A. Rastegarpour, and M.-R. Sohrabi (2009). 'The Impact of an Urban Sewerage System on Childhood Diarrhoea in Tehran, Iran: A Concurrent Control Field Trial'. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 103, 500-5.

Lazzerini, M. and L. Ronfani (2011). 'Oral Zinc for Treating Diarrhoea in Children'. *Sao Paulo Medical Journal*, 129, 118-19.

Lockwood, H., G.M. Morales, and J.O. Altamirano (2001). 'Nicaragua: Rural Water Supply, Sanitation, and Environmental Health Program'. Washington: U.S. Agency for International Development.

Luby, S.P., M. Agboatwalla, J. Painter, A. Altaf, W. Billhimer, B. Keswick, and R.M. Hoekstra (2006). 'Combining Drinking Water Treatment and Hand Washing for Diarrhoea Prevention, a Cluster Randomised Controlled Trial'. *Tropical Medicine and International Health*, 11, 479-89.

Luby, S.P., M. Agboatwalla, J. Painter, A. Altaf, W.L. Billhimer, and R.M. Hoekstra (2004). 'Effect of Intensive Handwashing Promotion on Childhood Diarrhea in High-Risk Communities in Pakistan: A Randomized Controlled Trial'. *Jama*, 291, 2547-54.

Lye, M.S. et al. (1996). 'Acute Respiratory Tract Infection: A Community-based Intervention Study in Malaysia'. *Journal of Tropical Pediatrics*, 42(3): 138-43.

Mtango, F.D.E. and D. Neuvians (1986). 'Acute Respiratory-Infections in Children under 5 Years - Control Project in Bagamoyo District, Tanzania'. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, 80(6): 851-58.

Nanan, D., F. White, I. Azam, H. Afsar, and S. Hozhabri (2003). 'Evaluation of a Water, Sanitation, and Hygiene Education Intervention on Diarrhoea in Northern Pakistan'. *Bulletin of the World Health Organization*, 81, 160-65.

Oberhelman, R.A. et al. (2006). 'An Intervention-control Study of Corralling of Free-ranging Chickens to Control Campylobacter Infections among Children in a Peruvian Periurban Shantytown'. *American Journal of Tropical Medicine and Hygiene*, 74(6): 1054-9.

Opiyo, N. and M. English (2010). 'In-Service Training for Health Professionals to Improve Care of the Seriously Ill Newborn or Child in Low and Middle-Income Countries' (Review). *Cochrane Database of Systematic Reviews*.

Pandey, M.R., N.M.P. Daulaire, E.S. Starbuck, R.M. Houston, and K. McPherson (1991). 'Reduction in Total Under-Five Mortality in Western Nepal Through Community-Based Antimicrobial Treatment of Pneumonia'. *Lancet*, 338, 993-7.

Quick, R.E., L.V. Venczel, E.D. Mintz, L. Soleto, J. Aparicio, M. Gironaz, L. Hutwagner, K. Greene, C. Bopp, K. Maloney, D. Chavez, M. Sobsey, and R.V. Tauxe (1999). 'Diarrhoea Prevention in Bolivia Through Point-of-Use Water Treatment and Safe Storage: A Promising New Strategy'. *Epidemiology and Infection*, 122, 83-90.

Rabie, T. and V. Curtis (2006). 'Handwashing and Risk of Respiratory Infections: A Quantitative Systematic Review'. *Tropical Medicine and International Health*, 11, 258-67.

Rana, M. (2009). 'Effect of Water, Sanitation and Hygiene Intervention in Reducing Self-Reported Waterborne Diseases in Rural Bangladesh'. Bangladesh: Brac.

Rasella, D., R. Aquino, and M.L. Barreto (2010). 'Reducing Childhood Mortality from Diarrhea and Lower Respiratory Tract Infections in Brazil'. *Pediatrics*, 126(3), E534-E40.

Reller, M.E., C.E. Mendoza, M.B. Lopez, M. Alvarez, R.M. Hoekstra, C.A. Olson, K.G. Baier, B.H. Keswick, and S.P. Luby (2003). 'A Randomized Controlled Trial of Household-Based Flocculant-Disinfectant Drinking Water Treatment for Diarrhea Prevention in Rural Guatemala'. *American Journal of Tropical Medicine and Hygiene*, 69, 411-9.

Roberts, L., Y. Chartier, O. Chartier, G. Malenga, M. Toole, and H. Rodka (2001). 'Keeping Clean Water Clean in a Malawi Refugee Camp: A Randomized Intervention Trial'. *Bulletin of the World Health Organization*, 79, 280-87.

Scrimshaw, N.S. (1998). 'Malnutrition, Brain Development, Learning, and Behavior'. *Nutrition Research*, 18, 351-79.

Semenza, J.C., L. Roberts, A. Henderson, J. Bogan, and C.H. Rubin (1998). 'Water Distribution System and Diarrheal Disease Transmission: A Case Study in Uzbekistan'. *American Journal of Tropical Medicine and Hygiene*, 59, 941-46.

Shahid, N.S., W.B. Greenough Iii, A.R. Samadi, M.I. Huq, and N. Rahman (1996). 'Hand Washing with Soap Reduces Diarhhoea and Spread of Bacterial Pathogens in a Bangladesh Village'. Journal of Diarrhoeal Diseases Research, 14, 85-9.

Sircar, B.K., P.G. Sengupta, S.K. Mondal, D.N. Gupta, N.C. Saha, S. Ghosh, B.C. Deb, and S.C. Pal (1987). 'Effect of Handwashing on the Incidence of Diarrhoea in a Calcutta Slum'. Journal of Diarrhoeal Diseases Research, 5, 112-4.

Soares-Weiser, K., H. Maclehose, I. Ben-Aharon, E. Goldberg, F. Pitan, and N. Cunliffe (2010). 'Vaccines for Preventing Rotavirus Diarrhoea: Vaccines in Use'. Cochrane Database of Systematic Reviews (Online), Cd008521.

Sobsey, M.D., T. Handzel, and L. Venczel (2003). 'Chlorination and Safe Storage of Household Drinking Water in Developing Countries to Reduce Waterborne Disease'. Water Science and Technology, 47, 221-8.

Stanton, B.F., and J.D. Clemens (1987). 'An Educational Intervention for Altering Water-Sanitation Behaviors to Reduce Childhood Diarrhea in Urban Bangladesh. II. A Randomized Trial to Assess the Impact of the Intervention on Hygienic Behaviors and Rates of Diarrhea'. American Journal of Epidemiology, 125(2): 292-301.

The Center for Theory of Change Inc. (2013). TOC Background [Online]. Available: Http://Www.Theoryofchange.Org/What-Is-Theory-Of-Change/Toc-Background/#1 [Accessed 28 May 2013].

Theodoratou, E., S. Johnson, A. Jhass, S.A. Madhi, A. Clark, C. Boschi-Pinto, S. Bhopal, I. Rudan, and H. Campbell (2010). 'The Effect of Haemophilus Influenzae Type B and Pneumococcal Conjugate Vaccines on Childhood Pneumonia Incidence, Severe Morbidity and Mortality'. *International Journal of Epidemiology*, 39 Suppl 1, I172-85.

Todd, S., N.A. Page, A.D. Steele, I. Peenze, and N.A. Cunliffe (2010). 'Rotavirus Strain Types Circulating in Africa: Review of Studies Published During 1997-2006'. (Special Issue: Rotavirus Infection in Africa: Epidemiology, Burden of Disease, and Strain Diversity.) *Journal of Infectious Diseases*, 202.

Tonglet, R., K. Isu, M. Mpese, M. Dramaix, and P. Hennart (1992). 'Can Improvements in Water Supply Reduce Childhood Diarrhoea?' *Health Policy and Planning*, 7, 260-8.

Traa, B.S., C.L.F. Walker, M. Munos, and R.E. Black (2010). 'Antibiotics for the Treatment of Dysentery in Children'. *International Journal of Epidemiology*, 39 Suppl 1**,** I70-4.

UNICEF (2012). 'Levels and Trends in Child Mortality'. New York: United Nations Children's Fund.

Wagstaff, A. and N. Watanabe (2000). 'Socioeconomic Inequalities in Child Malnutrition in Developing World'. *Policy Research Working Paper 2434*. Washington, DC: World Bank.

World Health Organization (2003). 'Treatment of Diarrhoea: A Manual for Physicians and Other Senior Health Workers'. Geneva: World Health Organization.

Worobey, J., B.J. Tepper, and R. Kanarek (2006). *Nutrition and Behavior. A Multidisciplinary Approach*. Cambridge, MA: CABI Publishing.