ABSTRACT

Water Supply and Sanitation Interventions in Developing Countries: The Role of Hygiene Promotion

The World Health Organization's (WHO) *Global Water Supply and Sanitation Assessment 2000 Report*, states that as of the beginning of the year 2000, 2.4 billion people lacked access to proper sanitation facilities while another 1.1 billion lacked access to improved water supplies (WHO, 2000). Given the negative health impacts associated with inadequate water supplies and sanitation, these numbers suggest that there is a great need for interventions designed to increase access to safe and adequate water supply and sanitation. However, the provision of the appropriate technology and infrastructure may be insufficient if people fail to use it or if they lack a basic understanding of the need for hygiene. Based on this assumption this review aims to determine whether properly designed hygiene promotion programs enhance the success of water supply and sanitation interventions.

The findings from the review of the literature are inconclusive in term of whether hygiene promotion enhances the success of water supply and sanitation interventions. However, there is some evidence that hygiene promotion alone can result in a reduction of certain disease outcomes and may therefore be a low-cost alternative where the provision of water supply and sanitation infrastructure is not feasible.

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1. Introduction

Despite the increase in the proportion of the world's population served with improved water supply and access to sanitation facilities in the 1990s, 1.1 billion people still lacked access to a safe water source while 2.4 billion people lacked access to proper sanitation in the year 2000 (WHO, 2000). The majority of the underserved population was in the developing world particularly in Africa and Asia as is shown in Table 1.1. The provision of clean water and sanitation in these parts of the world will be expected to remain a challenge with the projected increase in urban populations (WHO, 2000). The aim of this review is to determine whether water supply and sanitation interventions that include a hygiene promotion component are more successful than interventions that address technical aspects alone, as suggested by Cairncross (1992). Successful interventions, in this review are considered to be those that demonstrate an improvement in the quality of water stored in the home, reduction in adverse health outcomes, or an improvement in other quality of life measures.

Table 1.1: Distribution of the global population not served with improved water supply and sanitation by region (Source WHO, 2000)

Water Supply	
Asia	63 %
Africa	28 %
Latin America and the Caribbean	7 %
Europe	2 %
Total number of people	1.1 Billion
Sanitation	
Asia	80 %
Africa	13 %
Latin America and the Caribbean	5 %
Europe	2 %
Total number of people	2.4 Billion

2. Background

There are many diseases that are associated with inadequate water supply and sanitation. Some of these diseases and their effects are described in Table 2.1. The World Health Organization's (WHO) *Global Water Supply and Sanitation Assessment 2000 Report*, also outlines some of the health problems associated with inadequate water supply and sanitation. These include: -

a) *Diarrheal Diseases* – It is postulated that provision of adequate water supplies, sanitation and health education would reduce the incidence of diarrheal diseases, which are estimated to affect over 2 billion people every year, by a quarter to a third of the current occurrence.

b) *Intestinal Worm Infestations* – Approximately 10% of the population in developing countries may be infected with intestinal worms, which can lead to malnutrition, anemia, and retarded growth.

c) *Trachoma* – It is estimated that 500 million people are at risk of developing this disease, which may be responsible for causing blindness in 6 million people.

d) *Schistosomiasis* – About 200 million people are infected and it is estimated that there would be a median reduction of approximately 80% given properly designed water supply and sanitation interventions.

Table 2.1: Incidence and effects of selected diseases in developing countries (Source: WASH, 1993)

Disease	Incidence	Estimated Deaths/Year
Diarrhea	875 million*	4 600 000
Ascariasis	900 million	20 000
Guinea worm	4 million	**
Schistosomiasis	200 million	**
Hookworm	800 million	**
Trachoma	500 million	***

* Estimated cases per year

** Effect is usually debilitation rather than death

*** Major disability is blindness

To further understand the relationship between water supply, sanitation, and health status, it is convenient to classify water and sanitation-related diseases into categories based on transmission routes. Here, six categories are presented based on classifications by McJunkin (1983) and the WHO (1992).

a) *Waterborne- Microbial Diseases*

These are diseases that result primarily from the ingestion of pathogens present in water mainly as a result of fecal contamination of the water. While ingestion is the main route of exposure, some diseases such as leptospirosis may result from infection following skin contact where the skin is abraded.

b) *Waterborne – Chemical Diseases*

These are diseases that result from ingestion of water containing chemical toxins, which may result from natural, or anthropogenic contamination of water supplies. This class of diseases is mainly restricted to small geographical locations and is more common in industrialized nations.

c) *Water-washed / Water Hygiene Diseases*

Water hygiene diseases are those that result from inadequate hygiene as a result of water scarcity. They include many waterborne – microbial diseases.

Examples of water hygiene diseases include trachoma and skin diseases that are characterized by insect infestations such as scabies (caused by mites) and pediculosis (caused by lice). Interventions to reduce the prevalence of these diseases would include the provision of sufficient quantities of water and educating people on the need to observe hygienic practices.

d) *Water Contact Diseases*

These are diseases resulting from skin contact with infected water. Schistosomiasis is one of the most important water-contact diseases. It occurs when schistosome larvae penetrate human skin. Interventions to reduce the incidence of water-contact diseases may include the reduction of the need for water contact through the provision of piped water. In the case of schistosomiasis control, proper disposal of human wastes, which may bear schistosome eggs is also important.

e) *Water-Vector Habitat Diseases*

These are diseases caused by infectious agents that are transmitted by animal vectors that spend most or part of their lifecycle in water. Malaria and other mosquito-borne diseases are typical examples of this category of diseases. Interventions to reduce the incidence of water-vector habitat diseases include the destruction of breeding grounds, reducing contact with the animal vectors, or by direct attack of the vectors e.g. through the use of insecticides.

f) *Water Dispersed Diseases*

These are infections that result from inhalation exposure to microbial agents that proliferate in water. An example of this type of disease would include

Legionnaires' disease. This class of disease in more prevalent in developed countries.

Many of the diseases included in the categories above have also been classified separately as *Excreta Disposal Diseases* because their transmission can be effectively reduced by proper disposal of human wastes (McJunkin, 1983).

Given the high incidence of infectious diseases in the developing world, the provision of improved water supplies and sanitation facilities has received a lot of attention. It is a general belief that the provision of these facilities will have a profound positive impact on the health status of the recipients. Table 2.2 illustrates the expected reductions in morbidity for some water-related diseases are a result of well-designed water supply and sanitation interventions. In addition to reductions in morbidity and mortality, improvements in water supply and sanitation can be expected to have other indirect effects as illustrated in Figure 2.1. For example, women in many parts of the developing world spend a considerable portion of their time fetching water for domestic use. Thus, improving access to water supplies may decrease the time needed to obtain water; thereby, allowing women to engage in more productive activities (Nadakavukaren, 1995).

Table 2.2: Estimated reductions in selected water-related diseases resulting from water supply improvements in East Africa in 1966 (Source McJunkin, 1983)

Disease	Estimated percent reductions
Guinea Worm	100
Typhoid	80
Urinary Schistosomiasis	80
Scabies	80
Inflammatory Eye Disease	70
Schistosomiasis, unspecified	60
Trachoma	60
Bacillary dysentery	50
Dysentery, Unspecified	50
Gastroenteritis	50
Intestinal Schistosomiasis	40

It is important to note that the benefits of improved water supplies and sanitation may not be realized if the receiving population lacks the necessary understanding of the need for hygiene (Davies-Coles, 1995; Cairncross, 1989). In this technical report it is hypothesized that the success of water supply and sanitation interventions depends on their inclusion of a hygiene promotion component with the underlying assumption that the recipients are not well-informed. While consideration of other social, cultural, economic and political determinants is important in the design of these interventions, a comprehensive review of these factors is beyond the scope of this report. This report reviews a sample of studies that evaluate the effectiveness of water supply and sanitation interventions by looking at changes in disease outcome, water quality, and behavior. Two epidemiological studies are also included.

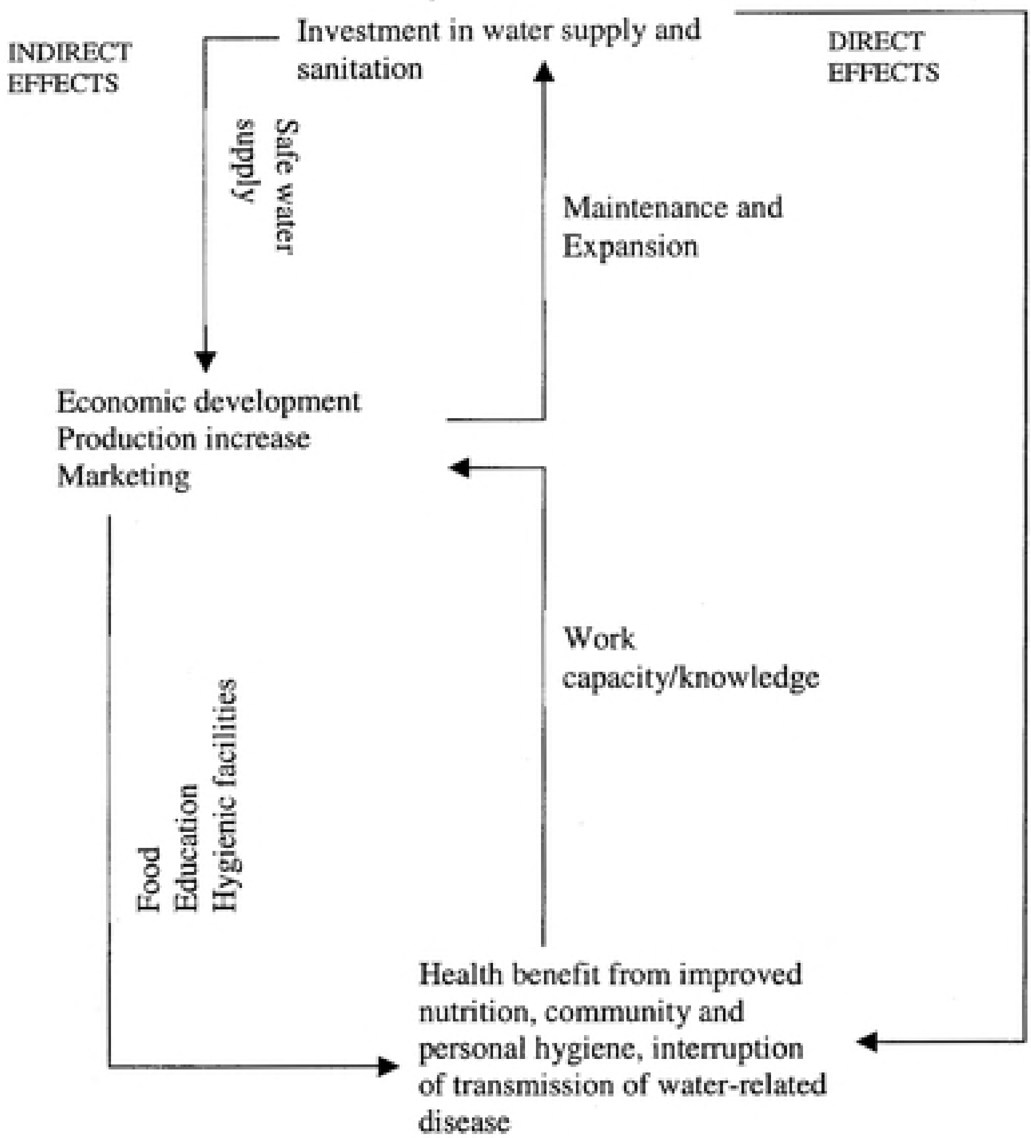

Figure 2.1: Direct and indirect effects of water supply and sanitation on health: A conceptual framework. (Source: Lloyd and Helmer, 1991)

3. Methods

The studies included in this review were selected via a general library search, MEDLINE, and by following up references cited in other studies. For the MEDLINE search, the key words HYGIENE, SANITATION, WATER, WATER SUPPLY, INTERVENTION, and DEVELOPING COUNTRIES were used in different combinations. Out of the hits obtained, approximately 18 studies were selected based on appropriateness to the question at hand. The studies used in this review were either interventional studies or epidemiological studies that determined the risk factors associated with various water-related diseases. Table 3.1 provides a summary of the studies included in this review.

A study was classified as an intervention study if it evaluated the impact of water supply, sanitation or hygiene promotion projects. These studies could either be prospective or retrospective in nature. On the other hand, a study was classified as epidemiological if it was a non–randomized case-control study that looked at risk factors associated with increased incidence of certain disease outcomes.

Table 3.1: Summary of Studies.

Study	Intervention/Study	Classification	Findings
1. Alam *et al.*, 1989	▪ Hand pumps ▪ Health education	Technology and education	▪ On average a child in the intervention group had 3.4 diarrhea episodes per year while a child in the control groups had 4.1 episodes per year ($p<0.01$)
2. Edungbola *et al.*, 1988	▪ Borehole	Technology	▪ Status of guinea worm infection o Pre intervention ▪ Intervention group 59.6 % ▪ Control 52.1% o Post intervention ▪ Intervention group 11.1 % ▪ Control 51.1%
3. Hoque *et al.*, 1996	▪ Intervention o Tara Pumps o Twin Latrines o Hygiene education o Involvement of women	Technology and education	▪ Prevalence of diarrhea morbidity o Percentage of over-5-year-olds reporting a diarrhea attack in previous 24 hours ▪ Intervention 1.3 ▪ Control 3.0 o Percentage of under-5-year-olds reporting a diarrhea attack in previous 24 hours ▪ Intervention 6.0 ▪ Control 10.0 ▪ Higher continued use of sanitation facilities in intervention areas o Use of latrines ▪ Intervention 83% ▪ Control 8%
4. Naholi, 1996	Study population received ▪ Education on waste disposal and recycling ▪ Recycling technology	Technology and education	▪ Change in attitudes ▪ Increased income

Table 3.1 (Continued)

5. Nthuli, 1996	▪ Community owned water vending facility ▪ Cleaning of ditches and drains ▪ Waste recycling	Technology and education	▪ Improvement in health ▪ Empowerment of women ▪ Collection of solid waste by city government as a result of liaisons
6. Pinfold, 1990	▪ Tap – 20-liter translucent plastic container with tap ▪ Education o Hand washing practices o Washing dishes immediately after use	Technology and education	▪ Geometric means of E. coli in stored water/50 mL o Control group ▪ Pre-intervention 14.0 ▪ Post-intervention 19.1 o Education only group ▪ Pre-intervention 17.6 ▪ Post-intervention 14.9 o Education & tap group ▪ Pre-intervention 14.8 ▪ Post-intervention 6.5 ▪ Significant reduction in stored water contamination in the education & tap group (p<0.001) ▪ Group receiving education had 57.3% lower counts of fingertip streptococci
7. Quick *et al.*, 1996	▪ Pilot study ▪ Group A (intervention) o 20-liter, narrow mouthed lidded water vessel o Disinfectant o Education on proper disinfectant, proper use and cleaning of special vessel ▪ Group B o Special vessel o Education on proper use and cleaning of vessel ▪ Group C (Control)	Technology and education	▪ Significant drop in geometric fecal coliform and E. coli count per 100 ml in water samples Study Group / Fecal Coliform Count / E. coli Count / P-Value A / 2 / 2 / Referent B / 63 / 41 / <0.0001 C / 78 / 54 / <0.0001

Table 3.1 (Continued)

8. Quick *et al.*, 1999	▪ Intervention group o Disinfectant o Water storage container o Education about the use of disinfectant and promotion of hygienic practices ▪ Control group o Education on hygienic practices	Technology and education	▪ Median E. coli counts per 100 ml (range) in water stored o Baseline ▪ Control 80000(0-8000000) ▪ Intervention 9200(0-8000000) o After 6 months ▪ Control 6400(0-205000)) ▪ Intervention 0(0-8000000) ▪ Percentage of household samples with no E. coli counts o Baseline ▪ Control 5.4 % ▪ Intervention 5.1 % o After 6 months ▪ Control 13.3 % ▪ Intervention 71.1 %
9. Semenza *et al.*, 1998	▪ Intervention o Disinfectant o Narrow necked water container with a sprout o Education ▪ Use of chlorine ▪ Use of chlorinated water	Technology and education	▪ Home chlorination reduced diarrhea incidence by 85 % relative risk = 0.15, 95% CI (0.07-0.31) ▪ Mean diarrhea rate o Piped Water 75/1000 o No piped water 179.2/1000 ▪ Home chlorination group 28.9/1000
10. Hoare *et al.*, 1999	▪ Intervention - fortnightly talks on hand washing and skin hygiene ▪ Controls – talks on family planning	Education	▪ Mean incidence of skin infections during the rainy season o Intervention 1.07 o Control 1.59 (p = 0.047, independent t-test)

Table 3.1 (Continued)

11. Shahid *et al.*, 1996	▪ Intervention group
	  o Education emphasizing hand washing practices
	  o Soap and pitcher provided
		Education	▪ Lower rates if diarrhea in the intervention population except for diarrhea caused by rotavirus infection

12. Stanton & Clemens, 1987	▪ Education intervention – handwashing, waste disposal, use of latrines for defecation	Education	▪ Reduction in diarrhea episodes
			  o Control 23.9%
			  o Intervention Group 41.2%

13. West *et al.*, 1995	▪ Hygiene intervention
	  o Control group received antibiotic treatment for trachoma
	  o Intervention group received treatment and education that emphasized the importance of face washing
		Education	▪ Baseline values
			  o Control 19%
			  o Intervention 18%
			▪ Percentage of children with sustained clean faces after the 12 month intervention period
			  o Control 26 %
			  o Intervention 35% ($p<0.05$)
			▪ Odds Ratios (95% CI) for children in intervention villages compared to controls
			  o Severe trachoma 0.62 (0.40-0.97)
			  o Any trachoma 0.81 (0.42-1.59)

14. Wilson *et al.*, 1991	▪ Intervention group
	  o Education emphasizing hand washing practices
	  o Soap and soap dishes
	▪ Control group
	  o Information given only in response to specific questions
		Education	▪ Percent reduction in the incidence of water-related diseases in control and intervention villages
			  o Diarrhea
			    ▪ Control 30%
			    ▪ Intervention 89 %
			  o Skin and eye diseases
			    ▪ Control 45%
			    ▪ Intervention 22%

Table 3.1 (Continued)

15. Yuan *et al.*, 2000	▪ Intervention group received educational videos and comics that contained information about the transmission and prevention of schistosomiasis	Education	▪ Change in water contact behavior (swimming) o Once ▪ Intervention –3.2 ▪ Control –3.0 o Twice ▪ Intervention –7.0 ▪ Control –7.2 o > 3 times ▪ Intervention —10.4 ▪ Control –17.9 o Never ▪ Intervention 20.4 ▪ Control 28.0 ▪ Change in choice of water sources o Unsafe ▪ Intervention –7.5 ▪ Control 7.2 o Safe ▪ Intervention 26.2 ▪ Control –16.3 o Safe / unsafe ▪ Intervention –18.7 ▪ Control 9.2
16. Dolin *et al.*, 1997	▪ Review study looking at changes in the prevalence of trachoma in three years	Review study	▪ Reduction in prevalence of trachoma with public health improvements
17. Levin *et al.*, 1976	▪ Epidemiological study looking at the relationship between tube well use and frequency of cholera and other non-cholera diarrhea	Epidemiological study	▪ Disease incidence same for canal and tank users ▪ Tube well users had similar or higher incidences of cholera ▪ Families with high school graduates had a lower incidence of disease

Table 3.1 (Continued)

18. Traore *et al.*, 1994	Epidemiological study	Association between disposal of child stools and admission into hospital for diarrhea or dysentery {odds ratio = 1.50; 95% CI (1.09-2.06) for the cases versus neighborhood controls}{odds ratio = 1.31; 95% CI (0.96-1.79) for the cases versus hospital controls}

4. Results and Discussion

4.1 Findings

The evaluation of the interventions focused on changes in health outcomes; participants' behavior; on changes in the quality of water stored in the home; and on changes in the number of fecal streptococci isolated from fingertip rinses. Table 4.1 provides a summary of the results by the outcome indicators.

Table 4.1: Summary of results by outcome

Outcome	Type of Intervention/study	Results
1. Change in health outcome		
Diarrhea		
Alam *et al.*, 1989	B	17.1% lower diarrheal incidence in the intervention population
Hoque *et al.*, 1996	B	43.3% lower diarrheal incidence in the intervention population
Levin *et al.*, 1976	Retrospective cohort study	Diarrheal incidence similar regardless of water source. Lower incidence in families with high-school graduates regardless of source of water
Quick *et al.*, 1999	B	44% lower diarrheal incidence in the intervention population
Semenza *et al.*, 1998	B	Intervention population had an 85% reduction in the incidence of diarrhea
Shahid *et al.*, 1996	A	17 –69 % lower diarrheal incidence in the intervention population
Stanton & Clemens, 1987	A	Intervention population had a 41.2% reduction in the incidence of diarrhea, compared to 23.9% in the control population
Traore *et al.*, 1994	Case-control study	Association between disposal of child stools and admission into hospital for diarrhea or dysentery {odds ratio = 1.50; 95% CI (1.09-2.06) for the cases versus neighborhood controls}{odds ratio = 1.31; 95% CI (0.96-1.79) for the cases versus hospital controls}
Wilson *et al.*, 1991	A	Intervention population had an 89% reduction in the incidence of diarrhea, compared to 30% in the control population

Table 4.1 (continued)

Skin and eye diseases		
Dolin *et al.*, 1997	Analysis of Surveys	Reduction in prevalence of active trachoma with public health improvements between 1959-1996)
Edungbola *et al.*, 1988	B	Intervention population had an 81% reduction in guinea worm infections compared to 2 % in the control population
Hoare *et al.*, 1999	A	32.7% lower incidence of skin infections in the intervention population
Wilson *et al.*, 1991	A	Intervention population had a 22% reduction in the incidence of skin and eye diseases, compared to 45% in the control population
2. *Behavioral change*		
Naholi, 1996	B	All participants sorting their waste
Nthuli, 1996	B	Collection of solid wastes
West *et al.*, 1995	A	35% of children in the intervention group had sustained clean faces compared to 26 % among the controls
Yuan *et al.*, 2000	A	31.3% of children in the intervention group chose unsafe places to swim compared to 46.4% among the controls
3. *Improvements in water quality*		
Pinfold, 1990	B	Control group increase of 36.4% in geometric mean of E. coli/ 50 ml in stored water samples "Education only" group decrease of 15.3% in geometric mean of E. coli/ 50 ml in stored water samples "Education and tap" group decrease of 56.1% in geometric mean of E. coli/ 50 ml in stored water samples
Quick *et al.*, 1996	B	Intervention group – 93 % of household water samples met WHO microbiological guideline of <1 E. Coli per 100ml
Quick *et al.*, 1999	B	Control group - 13.3% of household water samples had no E. coli Intervention group – 71.1% of household water samples had no E. coli

A = Education alone
B = Education and Technology

4.2 Discussion of results

The results obtained from the selected studies fail to demonstrate whether hygiene promotion enhances positive outcomes in water and sanitation interventions but suggest that the pay-off from hygiene promotion interventions is similar to interventions that provide both the infrastructure and hygiene promotion. For example, in the studies by Wilson *et al.* (1991) and Semenza *et al.* (1998) there was a similar reduction in the incidence of diarrhea episodes (89% and 85%, respectively) despite the fact that the former was an "education only" intervention while the latter was an "education and technology" intervention.

In the study by Pinfold (1990), the study group that received hygiene education emphasizing hand washing practices and a 20-liter water container to reinforce the educational message, had a higher post-intervention reduction in E. coli contamination of stored water and in number of fecal streptococci isolated from fingertip rinses compared to the control group and a study group that received the hygiene education only. This demonstrates that the accessibility of water supplies may encourage hygienic practices.

The reasons why the studies may fail to demonstrate whether hygiene promotion enhances water supply and sanitation interventions may be a reflection of the difference in the selected units of evaluation (disease outcome and changes in water quality). The inconsistency may also be as result of the small sample of studies reviewed such that if more studies were included, a more clear-cut difference may be observed. Based on the results obtained, it appears that education alone can significantly reduce the incidence of water-related diseases. If this is true, then health promotion interventions could be selected as a viable alternative in areas where the provision of water and sanitation infrastructure is not feasible for economic or other reasons.

4.3 Review of literature

Demonstrating a causal link between water supply and sanitation interventions, and positive changes in health, behavioral and other indicators is a challenge (Esrey, 1985). Here an evaluation of the selected literature is provided.

In the project described by Naholi (1996), the selected outcomes were change in attitude towards waste disposal; increase in awareness of health hazards associated with uncollected wastes; generation of income from the sale of recycled products; and improvement in the participants' quality of life. Other than revenues obtained from sales, these measures are largely subjective and though objective measures are described in the paper (for example, number of participants sorting their garbage), it is not clear whether these measures were self-reported or whether they were based on observation. In either case, it is possible that over reporting of positive outcomes may have occurred. This is a general limitation of studies on water supply and sanitation interventions because blinding is often not possible (Shahid, 1996).

In some of the studies especially those with an educational component, reduction in morbidity and improvements in hygienic practices were observed in control groups (Stanton and Clemens, 1987; West, 1995; Wilson, 1991; Yuan, 2000; Quick, 1999; Edungbola, 1988). This may have resulted from information dissemination; the Hawthorne effect, whereby people change their behavior simply because they are being observed; or may reflect the extent of comparability of the intervention and control groups (Lindskog, 1987). A possible impact of this phenomenon would be a masking of the overall impact of the intervention.

In the study by Quick *et al.*, (1999), it was observed that the greatest reductions in diarrhea episodes were in children less than one year and those between the ages of 5 and 14. The reasons given for this are that in the former age group, children are under constant care and have a highly controlled source of water, while the latter age group can learn how to avoid contaminated water sources (Quick, 1999). If this true, positive outcomes in the intervention groups may be masked if disease incidence is aggregated across age groups rather than analyzing the data by age.

A review of the baseline levels of coliform counts in water samples in the study by Quick *et al.* (1996) suggests that one of the control populations (Group B: received a special water storage vessel, but received no disinfectant) had a significantly higher level of contamination. However since there is no correction for this difference in the final analysis of the results, it is difficult to assess to true impact of the intervention.

Other limitations that may make it difficult to assess the impact of water supply, sanitation and health education interventions have been extensively studied and can be found in Blum and Feachem (1983). Some of the problems mentioned in the paper may be applicable to the studies included in this review and include: -

a) *Lack of adequate controls - either a complete absence of a control group or the non-collection of baseline data*

   The lack of a control population prevents the attribution of changes in selected indicators to the intervention. For example, improvements in various health indicators may result from other social, economic, or environmental changes.

b) *One to one comparisons*

   Comparison of one intervention group to one control group is similar to comparing the "differential response between two individuals" to a particular treatment, which limits statistical comparisons. On way to avoid this problem is to evaluate several randomly selected groups (or villages) within the intervention and control populations. Another solution would be to compare the intervention group to several control groups.

c) *Confounding variables*

It is important to control for baseline levels of water supply and sanitation infrastructure coverage, socio-economic status, and education.

d) *Health indicator recall*

Asking people about the rates of disease morbidity may provide unreliable data because:

- The respondent may not know the disease history of family members
- The respondent may be unwilling to provide the information for various reasons
- There is a limited ability to recall disease incidence

There are several ways to deal with this problem including keeping the recall period as short as possible. In addition, isolation of etiologic agents and sero-diagnosis may provide evidence of disease.

e) *Health indicator definitions*

It is important to carefully define outcome indicators such as "diarrhea episodes" and "coliforms."

f) *Failure to record facility usage*

Documentation of the use of provided infrastructure is critical to establish a link between the intervention and changes in outcome indicators.

g) *Seasonality*

Certain infections and diseases show some seasonality in their occurrence. Thus, it is important for planners of interventions to document the season when health indicators are measured, and ensure that the measurements are carried out during the same season in the intervention and control population.

4.4 Hygiene Promotion

4.4.1 Definition

In this report, the definition of hygiene promotion is that used by Ferron *et al.* (2000) – "strategies which aim to prevent water and sanitation related diseases and optimize the short- and long-term effects of water supply and sanitation interventions." Hygiene promotion encompasses hygiene education; social marketing of hygienic practices; and "community management" of water and sanitation technology to enhance their sustainability (Ferron, 2000).

Hygiene education, in the context of water supply and sanitation interventions, addresses knowledge about water-related diseases; the use, storage and disposal of water; personal, domestic and environmental cleanliness (Anonymous, 1996); and the use of new technologies (WASH, 1993). In addition, hygiene education also includes messages that enhance the desirability of the hygienic practices while decreasing that of risky behaviors (Curtis, 1997). As a result of education, communities may suffer less from water-related diseases (Alam, 1989) and may also be more likely to maintain the novel technologies thereby increasing their sustainability.

4.4.2 Importance of hygiene promotion

According to the staff of the Water and Sanitation for Health (WASH) project (WASH, 1993), one of the lessons learned during the project was that "improvements in hygiene-related behavior are an indispensable measure of success for water and sanitation activities." As such, the staff asserts that behavioral change should be accorded the same level of attention as the construction of water supply and sanitation facilities. This is because individuals' and communities' behaviors affect their use of the available infrastructure (WASH, 1993).

Successfully changing human behavior is a difficult task that requires that the planners of water and sanitation projects have a good understanding of personal and community knowledge and attitudes of hygiene (WASH, 1993; Curtis, 1997). Some of the questions that the planners should ask themselves during the formative research process have been outlined by Curtis (1997) and include: -

a) *What practices put children at risk of infection?*

   Some examples of practices that would put children at increased risk of diarrheal diseases might include improper disposal of human excreta, keeping of domestic animals like goats and pigs in the home, and the use of feeding bottles, which should be used under sanitary conditions.

b) *What practices are priorities for intervention?*

   These are generally widespread practices that increase the risk of disease transmission such as inadequate hand washing practices

c) *Which members of the community should be addressed?*

   This may include school children or those in charge of childcare

d) *How can we build on perceptions of hygiene and disease to motivate changes in behavior?*

Curtis *et al.* (1993) found that hygiene was considered a virtue in the population they studied. Thus, intervention messages were tailored to focus on the social desirability of the adoption of certain practices. For example, some of the women reported that the presence of fecal matter on the ground was embarrassing. As such, reduction of embarrassment could motivate participants to adopt proper stool disposal practices.

e) *What channels of communication and what materials are likely to be most effective?*

The selection of the appropriate channel of communication is based on the understanding of "structure and functioning of the society" and of the "reach and acceptability" of available communication channels. For example, Curtis *et al.*, 1997) found that word-of-mouth and the radio were important channels of information thus neighborhood hygiene commissions, micro-programs on radio, and radio interviews were among the selected communication channels selected for a health promotion project.

Based on the insight from the formative research on the baseline data, health promotion programs can then be designed. It is also important that planners ensure that the communities are involved in the planning of the interventions since the projects tend to be more effective when there is a strong community interest (WHO, 1990). The following section describes some of the hygienic practices to be targeted in interventions.

4.4.3 Examples of hygienic practices to be targeted in interventions

As stated in the previous section, planners of hygiene interventions should target practices that pose the greatest health risk and that are common enough to make the intervention cost-effective (Curtis *et al.*, 1997; Curtis *et al.*, 2000). According to Ferron *et al.* (2000), the two most important practices to be targeted in health promotion programs are stool disposal and hand washing. Further information about these two practices is mentioned below.

a) *Proper Stool Disposal*

Several studies, including some of those included in this review, have looked at the link between health and improper stool disposal (Stanton and Clemens, 1987; Traore, 1994; Curtis, 2000). Stanton and Clemens (1987) found that an educational intervention emphasizing proper disposal of wastes and other practices resulted in a 41.2% reduction in the incidence of diarrhea. In a case-control study Traore *et al.* (1994) found that in households where children's stools were improperly disposed, there was a 50% increase in the risk of being admitted into hospital for diarrheal related disease. These findings coupled with findings about reduction in diarrheal morbidity associated with the construction of latrines suggest the importance of emphasizing proper and safe disposal of human wastes.

b) *Hand washing*

Hand washing following defecation, after changing diapers, before feeding infants and prior to handling food is important in interrupting fecal-oral transmission of pathogens (Curtis, 2000; Wilson, 1997). Pinfold (1990) found that a study population that received a 20-liter container with a tap and education emphasizing the importance of hand washing had a 57.4% reduction in fecal streptococci detected from fingertip rinses compared to a control population. Wilson *et al.* (1991) found an 89% reduction in diarrheal incidence following an educational intervention also emphasizing hand washing. These findings suggest that hygiene promotion interventions could benefit from the promotion of hand washing. However, the cost of soap and availability of water may limit the applicability of hand washing at every occasion, thus interveners may have select those occasions when hand washing is most needed (Curtis, 2000) such as prior to food handling and after defecation or suggest the use of ash as an alternative to soap (Ferron, 2000)

Other practices that could be targeted include face washing to reduce the incidence of trachoma; reducing the need for water contact or educating people on the need to select safer site for water-related recreation activities to reduce the incidence of water contact diseases such as schistosomiasis; and proper storage of water to reduce contamination.

5. Recommendations and Conclusion

5.1 Recommendations for future studies

The findings from the studies reviewed here suggest that there may be a further need to evaluate the impact of hygiene promotion in water supply and sanitation interventions. Here some recommendations for future studies are provided.

Randomly assigning subjects to either "treatment" or control groups is generally not possible in water and sanitation interventions because of ethical, political, or other considerations (Blum and Feachem, 1983). As such, quasi-experimental studies in which interventions are provided to some communities and not to others (controls) may be one way to evaluate the impact of hygiene promotion in water and sanitation interventions. Quasi experimental studies in water supply and sanitation interventions are associated with some methodological problems, which are outlined in Blum and Feachem (1983). These problems include the possible lack of comparability between the intervention and control groups; the need for large samples to detect significant changes in outcomes; misclassification bias arising from the poor definition of health indicators or the non-recording of facility use; ethical problems; and the length of time and resources required to carry out these studies. However, by taking some factors into consideration, the some of the methodological problems associated with quasi-experimental studies may be overcome.

It is suggested here that future studies could include a quasi-experimental study with the following study groups: -

- Recipients of water and sanitation technology (in combination and separately)
- Recipients of water and sanitation technology (in combination and separately) coupled with hygiene promotion efforts
- Recipients of hygiene promotion efforts in the absence of improved water supply and sanitation infrastructure.
- Controls who do not receive the technical inputs or hygiene promotion messages. This group may serve as recipients of other public health efforts.

Planners should ensure that the different intervention and control groups are comparable in terms of factors like educational level, socio-economic status, family size, housing, coverage and type of water supply and sanitation infrastructure, and baseline rates of water-related diseases. In addition, since large samples are required to demonstrate significant differences in morbidity and mortality, the studies may be limited to those age groups that usually have a higher incidence of disease such as children (Briscoe, 1986).

Alam *et al*. (1989) found that the mean incidence of diarrheal disease per child-year was lower in households headed by a person with no education than those with a household head with one or more years of schooling. This was true in both the intervention and control populations. While the difference was not significant at the 0.10 and 0.05 levels of significance, these results suggests that there may be a need to further investigate the influence of baseline levels of education on the success of hygiene education interventions.

Planners of the interventions should also try to identify and quantitate the infectious agent responsible for selected health indicators to avoid misclassification of disease status

(Briscoe, 1986). In addition, planners should also try to include other health indicators such as height-for-weight measurements when determining the health impact of water supply and sanitation interventions since diarrhea is only one of the symptoms of poor health (Esrey, 1996). Further, planners should ensure that they record compliance with educational messages and the usage of any infrastructure or devices provided to avoid misclassification biases associated with exposure (Briscoe, 1986).

5.2 Conclusions

The literature reviewed in this report fails to conclusively support the hypothesis that hygiene promotion enhances water and sanitation interventions but suggests that the pay-off from hygiene promotion interventions is similar to interventions that provide both infrastructure and hygiene promotion. As such, hygiene promotion messages designed at increasing knowledge about water-related diseases and their transmissions; the use, storage, and disposal of water; and about various hygienic practices may serve as a simple way to reduce morbidity and mortality resulting from water and sanitation-related infections (Wilson, 1991; Alam, 1989).

Given the potential impact of hygiene promotion in reducing water and sanitation related infections, it is suggested that hygiene promotion messages be included in water supply and sanitation interventions. To ensure that these messages are effective, planners of these interventions should ensure that they have a comprehensive understanding of the beneficiaries' knowledge and attitudes, as well as, the cultural and social context of the intervention community (Ferron, 2000). As such, when water supply and sanitation interventions are planned, they should be collaborative studies that combine the knowledge and expertise of social scientists, engineers, epidemiologists, statisticians, and other appropriate professionals (Lindskog 1987; Blum and Feachem, 1983; WASH, 1993).

Appendix

Summary of reviewed studies

Alam N, Wojtyniak B, Henry FJ, Rahaman MM. 1989. Mothers' personal and domestic hygiene and diarrhoea incidence in young children in rural Bangladesh. *International Journal of Epidemiology*. 18(1): 242 – 247

Objectives

- Promotion of consistent and exclusive use of hand pumps
- Improvement of water handling and storage practices
- Disposal of children's feces soon after defecation
- Washing of hands prior to handling food and rubbing hands in ash or using soap following defecation

Study Background

- Teknaf – Peninsula in South Eastern Bangladesh
- Principle water source – hand pumps for drinking water and ditches for washing and cooking

Intervention

- 3 Subunits (population 2173) received hand pumps and health education
- Control area (population 2067) – no project inputs
- Areas were comparable in terms of education of household head, household size, and sanitary conditions before the intervention

Outcomes

- On average a child in the intervention area had 3.4 diarrhea episodes in a year while one in the control area had 4.1 episodes (p-value < 0.01)

Dolin PJ, Faal H, Johnson GJ, Minassian D, Sowa S, Day S, Ajewole J. Mohammed AA, Foster A. 1997. Reduction of trachoma in a sub-Saharan village in absence of a disease control programme. Lancet. 349(9064): 1511-1512

Analysis of the results of surveys of trachoma prevalence conducted between 1959 and 1996 in Marakissa, Gambia.

Age Specific Prevalence of Active Trachoma Infection

Age (Years)	Cases (1959, 1987, 1996)	Examined (1959, 1987, 1996)	Prevalence (per 100 Villages) (1959, 1987, 1996)
0 – 9	92, 12, 7	143, 300, 289	65.7, 4.0, 2.4
10 – 19	31, 5, 3	59, 134, 216	52.5, 3.7, 1.4
Greater than 20	73, 3, 0	199, 313, 337	36.7, 1.0, 0

Changes over the years

- Increases accessibility to the village
- Improved socioeconomic status
- Improved medical care
- Increased community awareness
- Improved educational status

  - 1959 – no children attended school
  - Mid 1980s – Most children were attending primary school and many were moving on to secondary school
- Improved access to safe water
  - Over 20 wells and several hand pumps
- Improved sanitation
  - By 1987 more than half of the compounds had a functioning latrine. However small children were still defecating around the compound. However, stools were usually buried or put into the latrine

*No specific trachoma control intervention effort in the area thus it seems that decreased incidence of trachoma has resulted from public health improvements

Edungbola LD, Watts SJ, Alabi TO, Bello AB. 1988. The impact of a UNICEF-assisted rural water project on the prevalence of guinea worm disease in Asa, Kwara State, Nigeria. *American Journal of Tropical Medicine and Hygiene.* 39 (1): 79-85

Background

- 10/12 local government areas endemic for guinea worm in Kwara community
- Prevalence in Asa > 50 % in some areas
  - 25 communities selected
    - 20 intervention 5 control
  - Villages that were most seriously affected given priority in intervention
  - All 25 villages were similar in terms of educational and social background of people
    - None had electricity, health centers, medical facilities, or protected water supplies at time of intervention

Intervention

- Boreholes were installed at least two years before the evaluation so that there would be an appreciably long duration before the assessment of the impact of the water supply since the guinea worm has a 12 month transmission cycle

Outcomes

Status of guinea worm infection

	Intervention	Control
Pre-Intervention	5134/8604 = 59.6 %	366/702 = 52.1 %
Post-Intervention	724/6425 = 11.3	379/741 = 51.1
% Reduction	81 %	2 %

- 70% of people in each village said that they relied on the borehole as their primary source of water

Discussion

- Education may have increased people's awareness
- Villages where the borehole was accessible to all members of the community had higher reductions in the prevalence of guinea worm infections

- There was a lower reduction in the prevalence where
  - The borehole was shared by more than one community
  - Too many people used borehole (long lines)
  - The boreholes were malfunctioning or non functional

Hoare K, Hoare S, Rhodes D, Erinoso HO, Weaver LT. 1999. Effective health education in rural Gambia. *Journal of Tropical Pediatrics*. 45(4): 208 – 214

Objective

- Measure the impact of a structured health education program on the incidence of infectious diseases in young children in a rural Gambian village. The village had no running water

Intervention

- Mothers of children less than 3 years were included in the study. The intervention group was involved in fortnightly educational talks on hand washing and skin hygiene while the control group was involved in talks on family planning

Outcomes

- There were no significant differences in the number of women in the two groups or in the number of women who attended the fortnightly talks
- There was a significant difference in the mean number of skin infections in the children of the two groups during the rainy season when the incidence of all infectious diseases is high
  - Mean Incidence:
    - Intervention 1.07   Control 1.59 (independent t-test $p = 0.047$ one tailed)
- There were significant trends in the annual incidence of childhood diseases independent of the study group – continual decline in the odds ratios for infectious diseases other than respiratory diseases

Discussion

- Little analysis of the differences between the two study groups makes it difficult to assess the success of the interventions

Hoque BA, Juncker T, Sack RB *et al.* 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(4): 431 – 437

Objective

- Determine the sustainability of a water, sanitation and hygiene (WSH) intervention

Intervention

- Intervention area (approximately 880 households) provided with
  - Tara pumps
  - One twin pit latrine for almost every household
  - Extensive hygiene education – on hygiene practices related to the WSH provisions and the prevention of diarrhea
  - Women involved in the selection of sites, maintenance and data collection

Latrines supplied at no or nominal cost but the users had to help with installation or contribute towards their installation.

- Control area (750 households) received no inputs
- Areas similar in most socioeconomic characteristics and baseline levels of diarrhea morbidity

Study Method

- Five years after the project (1984-1987) a follow-up cross sectional survey on WSH provisions was carried out

Results

Proportion of households using tube well water for various purposes in 1987 and 1993

	% of households in Intervention area		% of households in control area	
	1987	1993	1987	1993
Tube well use	N = 799	N = 607	N = 713	N = 451
Drinking	100	99.4	96	96.7
Cooking	94	97.3	52**	86.2
Washing	87*	75.12	8	10.9
Bathing	82*	69.2	11	5.8
All	88*	66	8	4.9

** Highly significant improvement in area ($p<0.001$)

* Highly significant reduction in area ($p<0.001$)

Use of latrines

Intervention	Control	Country
83%	8%	26%

Observed hygiene practices in the intervention and control areas 1987 and 1993

	% of HH in intervention area		% of HH in control area	
	1987	1993	1987	1993
Practice	N = 770	N = 607	N = 705	N = 451
Water containers covered	96*	72	80*	69
Water pitcher near latrine	66*	47**	5	10
Ash in latrine	62*	36**	1	2
Cleanliness of latrine	73*	57**	2	5

* $p<0.001$ (within intervention area during 1987 and 1993)

** $p<0.001$ (between intervention and control areas in 1993)

Point prevalence of diarrhea morbidity in the intervention and control areas in 1993

	Intervention area	Control area
# of over-5-year-olds	3465	2582
# of under-5-year-olds	375	270
# of over-5-year-olds reporting a diarrhea attack in previous 24 hours**	46 (1.3)*	77 (3.0)
# of under-5-year-olds reporting a diarrhea attack in previous 24 hours***	23 (6)	26 (10)

* Figures in parentheses are percentages

** Relative risk (RR) for over-5-year-olds = 2.25; 1.56 < RR < 3.23; Mantel-Haenszel χ^2 = 20.32 p<0.0001
*** Relative risk (RR) for under-5-year-olds = 1.96; 0.96 < RR < 2.78; Mantel-Haenszel χ^2 = 3.28 p<0.07

- Women's participation contributed towards the sustained impact since in a previously recorded program with limited women's participation, behavioral impacts were hardly detectable

Levin RI, Khan MR, D'Souza S, Nalin DR. 1976. Failure of sanitary wells to protect against cholera and other diarrhoeas in Bangladesh. *Lancet*. 2:86-89

Baseline Study
- Water sources
  - Tanks – surface depressions evacuated for mound construction
  - Other surface water
  - Drilled pipe wells with hand pumps
- Relationship between tubewell use and frequency of cholera and other non-cholera diarrhea
  - Distance from residence to tubewell did not correlate with tubewell usage
  - Among families with high school graduates there were more tubewell users

Study findings
- Disease incidence was approximately the same for canal and tank users (cholera 11.9 and 10.4 and hospital cases of non cholera diarrhea 4.0 and 3.8 per 100, respectively)
- Tube well users had as much or much more cholera and other diarrheal diseases than non-users. This was true even after analysis was stratifies by the educational status or restricted to the 1-14 year age group. Families with high school graduates had less cholera and non-cholera diarrhea whether or not they used tube wells

Discussion
- Surface water preferred for some purposes because of temperature convenience, superstition, ideas of disease transmission, and the high iron content of local tubewell water
- Families with high school graduates had a lower incidence of disease. Thus, protection associated with education and wealth is not related to water use but may be to personal hygiene, nutrition status, and crowding

Naholi M. 1996. The waste recycling project. *Water and Sanitation News*. 3(2): 3-4

Objectives
- Deal with solid waste disposal and provide an income generating activity
- Change the attitudes of Nairobi residents from apathetic to being more responsible
- Create awareness about the health hazards of uncollected waste and provide feasible options for recycling
- Reduce poorly disposed wastes
- Provide an option to city authorities on available and environmentally friendly methods of waste disposal

- Improve the quality of life of the urban poor by selling the products of recycling

Intervention

- Increasing awareness of responsible waste disposal and recycling
- Implementation through community based groups
- Main recycling technology – composting

Outcomes

- Change in attitudes – all participants were sorting their wastes following the intervention
- Organic wastes were composted (inorganic wastes disposed in city council garbage dumps or buried)
- Increased group incomes. For example, compost sales are the biggest income earners for some of the groups.

Nthuli M. 1996. Community management of water and sanitation facilities in peri-urban areas of Mathare Area 4/B in Nairobi. *Water and Sanitation News*. 3(3): 7

The Expanded Sanitation Outreach Programme (EXSOAP) – a pilot project intervention

Baseline Survey

- 75 % of illnesses in Mathare, a slum, were linked to unsanitary conditions
- Affordability and accessibility of water was a major problem

Intervention

- Community owned facility selling water at lower prices
- Cleaning of ditches and drains
- Waste recycling (plastic containers, bottle tops, bottles, biodegradable kitchen wastes)
- Women involved in planning and implementation

Outcomes

- Improvement of the health of vulnerable groups
- Women empowerment
- Collection of solid waste by the city government as a result of liaisons with the city government

Pinfold JV. 1990 Faecal contamination of water and fingertips as a method of evaluating the effect of low cost water supply and sanitation activities on faeco-oral disease transmission. II. A hygiene intervention study in rural northeast Thailand. *Epidemiology and Infection*. 105:377-389

Study Outline

- 60 households with children under the age of six were randomly selected by stratified sampling from the selected village
- Households were ranked according to bacteriological contamination of finger-tip rinses and stored water. The households were then ranked into 20 adjacent triplets so that households in each triplet had similar levels of contamination. Within each triplet, households were randomly assigned to "Education" "Education & Tap" or "Control" groups.

Intervention

- Few and simple messages requiring little extra effort or expenditure.
- Related to
    - Practice of soaking dishes – households asked to wash dishes immediately after use, rinse them, and put them out to dry in order to reduce bacterial proliferation
    - Promotion of hand washing before cooking and eating and after going to the latrine
- Tap provision
    - 20-liter translucent plastic container with tap. This served two functions
        - Reinforced and facilitated the educational messages
        - Gave an indirect indication of use by monitoring the water level and the amount of waste water below it

Results

- Baseline data
    - The village had 422 households and a total population of 2110
    - Uniform educational level of household heads with 90 % having four or less years of schooling
    - 67 % of households owned rain-jars or rain-tanks
    - 95 % of households had access to a toilet
    - Sources of water
        - 1 pond
        - 1 shallow well
        - 4 public tube wells
        - 18 private tube wells
- Pre-intervention data
    - No significant difference in terms of
        - Practice of soaking dishes
        - Indicators of hand washing practices
    - Significant difference in the geometric and arithmetic mean of E-coli in stored water used for drinking and cooking – higher in the "Education" group 11.9(74)/ 50 ml compared to 3.8 (30)/ 50 ml in control [geometric mean (arithmetic mean)]
- Post-intervention data
    - Decline in the number of households leaving dishes to soak in all groups
    - Sequential reduction in control group may have been to dissemination of information
    - Stored water from "Education & tap" group significantly less contaminated than the control group [21.2 (200)/ 50 ml compared to 19.1 (159), respectively p-value < 0.001]
    - "Education" group better than control in water quality and indicators of compliance (difference not significant). However, both showed a declined level in water quality compared to the pre-intervention

<u>Geometric (arithmetic) means of e-coli in stored water / 50 ml</u>

	Control	Education only	Education & Tap
Pre-intervention	14.0 (143)	17.6 (128)	14.8 (141)
Post-intervention	19.1 (159)	14.9 (137)	6.5 (82)

Geometric (arithmetic) means fecal streptoccoci in fingertip rinses

	Control	Education only	Education & Tap
Pre-intervention	16.7 (85)	14.2 (73)	19.1 (77)
Post-intervention	20.8 (122)	12.7 (51)	9.9 (52)

Quick RE, Venczel LA, Gonzalez O. *et al.* 1996. Narrow-mouthed water storage vessel and *in situ* chlorination in a Bolivian community: a simple method to improve drinking water quality. *American Journal of Tropical Medicine and Hygiene 54(5):511-516*

Study Background

- Pilot project to determine the feasibility of introducing a new intervention into a community at risk for cholera

Study Outline

- 42 households selected and randomized into 3 groups
    - A (15 families) – received a 20-liter, narrow mouthed, lidded water vessel and a calcium hypochlorite solution
    - B (15 families) – received the special vessel only
    - C (12 families) – received no vessel or disinfectant
- Families in groups A and B received education about proper use and cleaning of vessel
- Families in group A also received education on proper disinfectant dose and storage
- 9-week intervention phase during which each family was visited every three weeks. During the visits, the disinfectant was replenished and people interviewed about water handling and treatment practices
- Investigation carried out in the rainy season
- Water quality assessed by determining fecal counts

Baseline

- Peri-urban area – many communities in the area lack potable water systems, sewage disposal and trash removal
- All families in this study obtained water from shallow wells (2-5 meters) dug in front of homes
- Most families store drinking water in buckets
- All families dispose human wastes on open ground or in nearby river
- Water treatment
    - 36 (86%) respondents boiled their water
        - 36 % - always
        - 3 % - almost always
        - 61 % - sometimes
    - 1 (2 %) used chlorine as a disinfectant
    - 33 (79%) had no knowledge or experience with chlorine
    - 32 (76%) regularly filtered water through a cloth to remove worms or other visible contaminants

- No chlorine was detected in baseline samples

Baseline Geometric mean fecal coliform and E. coli colony counts in water samples from HH wells and usual household storage vessels

Water Source	Study Group	Fecal coliform colonies per 100ml	SD	E. Coli colonies per 100 ml	SD
Well	A	106	±7.0	84	±6.2
Well	B	123	±9.1	65	±11.3
Well	C	96	±9.4	78	±10.7
Storage	A	34	±17.0	28	±14.5
Storage	B	114	±6.5	63	±8.5
Storage	C	71	±10.7	39	±14.6

No statistically significant differences

Outcomes

Geometric mean fecal coliform and E. coli colony counts per 100 ml in water samples

Sampling Round	Study Group	Fecal Coliform colonies /100ml	SD	P-Value	E. Coli colonies /100ml	SD	P-Value
1	A	2.2	±1.4	Referent	2.2	±1.4	Referent
1	B	43	±5.5	< 0.001	25	±4.7	< 0.001
1	C	36	±17.8	< 0.001	23	±13.8	< 0.001
2	A	2.4	±1.8	Referent	2.3	±1.8	Referent
2	B	57	±19.0	< 0.001	39	±17.3	< 0.001
2	C	29	±5.0	< 0.001	27	±14.1	< 0.001
3	A	2	0	Referent	2	0	Referent
3	B	63	±14.1	< 0.001	41	±11.4	< 0.001
3	C	78	±9.6	< 0.001	54	±9.8	< 0.001

93% of samples in Group A met WHO microbiological guidelines of <1 E. coli colony per 100ml

Discussion

- Need for simple point-of-use treatment and storage system
- Intervention was accepted – only one participant did not continue to use the vessel after the study, most continued using the disinfectant
- Chlorine taste did not impede use – however, this could happen therefore adequate promotion and education may be necessary
- Need to find an inexpensive source of disinfectant
- Problems with study
    - Self selected group may have been highly motivated
    - Performance may have improved because the participants were being observed

Information bias – blinding not possible (chlorine measurements and coliform counts may have reduced the risk of bias)

Quick RE, Venczel LV, Mintz ED, *et al.* 1999. Diarrhoea prevention in Bolivia through point-of-use water treatment and safe storage: a promising new strategy. *Epidemiology and Infection*. 122: 83 – 90

Objective

- To determine the effectiveness of a water quality intervention in reducing the incidence of diarrhoeal disease

Intervention

- Components of the intervention
    - Point-of-use treatment of contaminated source water with disinfectant produced locally
    - Safe storage of treated water
    - Community education
- Houses randomized by a simple public lottery into two groups
    - Intervention 64 households (400 individuals)
    - Control 63 households (391 individuals)
- Intervention households received
    - Disinfectant – Prepared from a 3 % brine solution
    - Water storage container – Narrow-mouthed (to reduce contact with water)
    - Community health workers visiting the household promoted the use of disinfected water for drinking, hand washing, cleaning utensils and produce, and for other uses. They also talked about the importance of water treatment. The health workers also promoted the hygienic practices among the control group
- Information regarding cases of diarrhea was collected and rectal swabs obtained from people with diarrhea

Baseline Survey

- Median Age
    - 14 Years (1 month – 83 years)
- Education (14+ yrs)
    - 14 % illiterate
    - 50 % had < 6 years of schooling
- Water sources
    - 87 % of households obtained their water from shallow (< 5 m deep) uncovered wells
    - 11 % of households obtained their water from covered 50 m deep wells equipped with a hand pump
    - 1.6 % used a household tap in a neighboring community
- Water Storage
    - 77 % stored water
        - Of these 96 % used wide-mouthed containers that allowed hand contact with water
        - 68 % had at least one container that was uncovered
- Water treatment
    - 38 % of respondents reported treating their water
        - 33 % boiled the water

        - 31 % added bleach
        - 23 % did both
        - 8.3 % filtered the water through a cloth
        - 4 % added lemon juice

80 % of households observed to have stored water but only 21 % claimed it had been treated
None of the samples had detectable chlorine

- Median E-Coli Counts
    - 57050 / 100 ml (range 1- 8000000) – Well water samples
    - 46950 / 100 ml (range 1- 8000000) – Stored water
- Hygiene information
    - Washing hands after defecation (126 respondents)
        - 78 % - always
        - 22 % - almost always/sometimes
    - Washing hands prior to food preparations
        - 76 % - always
        - 24 % - almost always/sometimes
    - Hand washing before eating
        - 70 % - always
        - 29 % - almost always/sometimes
        - 2 % - Never
    - Washing raw fruits and vegetables
        - 65 % - always
        - 33 % - almost always/sometimes
        - 2 % - Never
    - Washing cooking and eating utensils
        - 80 % - always
        - 19 % - almost always/sometimes
        - 1 % - Never
- Households with latrines - 55 %
    - Though 47 % reported using it
- 88 % of households possessed animals
- Human and animal feces observed in the yards surrounding 76 % of the households

No statistical significant difference between intervention and control households in terms of

- Demographic characteristics
- Sanitary conditions
- Water handling practices
- Hygienic practices
- Baseline E-coli counts - both in well and stored water

Outcomes

- There was a decline in the number of households that were observed to store water in the special vessels (92 % to 69 %). The most common reason given for this was that the vessels had not been filled on the day of the observation.
- Decline in reported use of vessel from 100 – 98 %
- Proportion of water with detectable chlorine 71 % first visit – 95 %

Percent of households with water observed in storage vessels and chlorine detected in stored water during monthly field visits, Montero, Bolivia, July 1994 – February 1995

Sampling Round	% of intervention household with water in special vessels	% of intervention households with detectable total chlorine in vessel water	% if intervention households with water in special vessel and chlorine in vessel water	% if control households with detectable total chlorine in usual water storage vessel
Round 1	92	71	65	0
Round 2	89	76	69	0
Round 3	89	70	62	6
Round 4	80	71	57	3
Round 5	77	79	61	5
Round 6	69	95	64	6

Median E. Coli colony counts per 100 ml in water stored in special vessels in intervention households and water stored in usual vessels in control households and percent of water samples with no detectable E. coli colonies

	Intervention Household		Control Households		
Sampling Round	Median E. coli colony count per 100 ml (range)	% of HH samples with no E coli Counts	Median E. coli colony count per 100 ml (range)	% of HH samples with no E coli Counts	P Value for comparison of median E coli Counts between groups
Baseline	9200 (0-8000000)	5.1	80000 (0-8000000)	5.4	0.3
1	0 (0 – 3100000)	55.9	84100 (1100-2200000)	0	<0.0001
2	0 (0-305000)	57.9	8400 (0-8000000)	10.3	<0.0001
3	0 (0-95500)	59.3	4950 (0-8000000)	3.3	<0.0001
4	0 (0-105000)	79.2	8800 (400-8000000)	0	<0.0001
5	0 (0-6800)	74.5	8200 (0-8000000)	10.5	<0.0001
6	0 (0-8000000)	71.1	6400 (0-2050000)	13.3	<0.0001

Age-specific diarrhea episodes and mean episodes per person in intervention and control groups

	Intervention Group			Control Group			
Age Group (years)	# of People	# of diarrheal episodes	Mean # of diarrheal episodes per person	# of People	# of diarrheal episodes	Mean # of diarrheal episodes per person	*P* value for comparison of mean episodes between groups
<1	16	11	0.69	27	40	1.48	0.02
1-4	53	41	0.77	64	52	0.81	069
5-14	130	15	0.12	113	33	0.29	0.01
15-44	153	11	0.07	146	12	0.08	0.91
45+	49	5	0.10	40	11	0.28	0.16
Total	401	83	0.21	390	148	0.38	0.002

Discussion

- Households using simple water storage and treatment intervention experienced substantially less diarrhea during the summer diarrheal season

- Intervention was readily adopted and applied
    - Willingness to adopt a novel practice is an important determinant of an intervention's long term success
    - Acceptance demonstrated by high compliance
- Greatest benefit was in those < 1 year (receive continual care and a controlled water source) and in the 5-14 year old group (who can learn what to eat or drink and what to avoid)
- Lack of protection for the 1-4 year old group may be reflective of this age group's ability to explore and inability to avoid exposure
    - Interventions to reduce diarrheal episodes among this age group may include reducing fecal contamination of the household environment
- Presence of waste disposal facilities tended to be protective against diarrhea

Semenza JC, Roberts L, Henderson A *et al.* 1998. Water distribution system and diarrheal disease transmission: a case study in Uzbekistan. *American Journal of Tropical Medicine and Hygiene* 59 (6): 941-946

Study Outline

- Study carried out in Nukus where poor water quality and water shortages pose a threat to the 200,000 residents
- 20 % of people lack access to piped water

Objective

- Determine water-borne incidence through active surveillance

Intervention

- Intervention households (lacked piped water) were supplied with
    - Home chlorination equipment
        - 1.5 % chlorine stock solution
        - Narrow necked water container with a spout
        - Members taught how to add chlorine to the water and provided with hygiene education – asked to obtain all drinking water from the provided vessel, and to wash their fruits and vegetables with the chlorinated water
- Incidence of diarrhea compared to a group with and a group without access to piped water
- 120 households with piped water
- 120 households without piped water
- 62 intervention
- 58 no intervention
- Households visited twice a week for 9.5 weeks. During the visits, compliance and diarrheal cases were monitored

Baseline Survey

Drinking water source

	Total	120 Households with piped water (no intervention	62 Households without piped water (intervention)	58 Households without piped water (no intervention)
Tap in HH/garden	120	120	0	0
Tap on street	24	0	11	13
Tap at neighbors	23	0	9	14
Well	44	3	22	19
Vendor	15	1	9	5
River	18	0	11	7

- Coliform density in intervention and control group not statistically different
- Households with piped water
  - 38 % lacked detectable levels of free or bound chlorine (beginning 07/96)
  - 27 % lacked detectable levels of chlorine (end 07/96)
- Households with no access to piped water were generally in worse sanitary conditions than those with piped water
- Households with piped water – higher socioeconomic status

Outcomes

- Diarrheal surveillance over 9.5 weeks
  - Mean diarrheal rate
    - Piped water 75.5/1000
    - No piper water 179.2/1000
      - Home chlorination group 28.9/1000
  - Home chlorination reduced diarrheal incidence by 85 % (RR=0.15; 95%CI (0.07-0.31 compared to those without chlorination)
- Individuals with piped water access but no detectable chlorine levels had an increased risk compared with those in households with detectable chlorine levels (RR=1.6; 95%CI 0.7-3.7)

Association of risk factors with diarrhea for all ages

Design Variable	*Odds Ratio (95 % CI)*
Home chlorination Status	0.2 (0.1-0.4)
Piped water access	0.9 (0.4-2.0)
Family Size	0.9 (0.6-1.2)
Exposure Variable	
Distance to water source (≤ 200 m) ref.	1
Distance to water source (≥ 200 m)	2.2 (1.0-4.9)
Clean after defecating: Other ref.	1
Clean after defecating: Paper	0.7 (0.5-1.0)
Liters of water stored in home (< 20 L) ref.	1
Liters of water stored in home (>20 L≤ 40L)	2.2 (1.1-4.1)
Liters of water stored in home (>40L)	2.0 (0.9-4.4)

Shahid NB, Greenough WB III, Samadi AR, Huq MI, Rahman N. 1996. Hand washing with soap reduces diarrhoea and spread of bacterial pathogens in a Bangladesh village. *Journal of Diarrhoeal Diseases Research.* 14(2): 85 – 89.

Study Outline

- To investigate the efficacy of hand washing as a low cost intervention to reduce the spread of diarrheal diseases in areas where relatively expensive options like improving water supplies and sanitation facilities are not possible
- Study carried out in a peri-urban village of Dhaka City in Bangladesh. In this area, all water is collected from surface water sources (ponds or canals). Sanitation levels were generally low with little attention placed on separating human wastes from water supplies resulting in a high risk of fecal contamination
- The two populations (intervention and control) were similar in terms of age structure, educational levels, and economic status
- A baseline survey was carried out to assess the prevalence of diarrheal diseases and various etiologic agents. No statistical differences were found

Intervention

- Families in the intervention area were provided with 2 kinds of soap, one for hand washing and the one for other purposes. Use of the soap was confirmed by visual inspection. A pitcher was also provided to facilitate water use
- During visits to the homes, health workers gave instruction emphasizing the use of soap prior to handling food and after defecation or urinating. These visits were on alternate days during the yearlong study
- During every visit, the health workers found out whether anyone had diarrhea and took rectal swabs from the cases and family members

Outcomes

- Substantially lower rates of diarrhea were found in the intervention area except for those caused by rotavirus
- There was a 60 – 69 % lower rate of cases of diarrhea caused by entero-toxigenic *Escherichia coli* (ETEC), *Shigella*, and *Campylobacter jejuni*
- In every age group the intervention resulted in reduction of diarrhea incidence. The reduction ranged from 47 – 73 % with the highest reduction being in the 5 – 9 age group

Frequency of diarrheal cases by individual pathogens

	Intervention (n = 671)				Control (n=695)				
Pathogen	Primary Case	Secondary Case	Total Cases	Incidence Density	Primary Case	Secondary Case	Total Cases	Incidence Density	Incidence Density Ratio (95% CI)
ETEC	16	0	16	0.024	54	0	54	0.078	0.31 (0.19-0.52)
Shigella	17	0	17	0.025	37	7	44	0.063	0.40 (0.23-0.69
C. jejuni	29	3	32	0.048	73	14	87	0.125	0.38 (0.26-0.56)
Rotavirus	4	0	4	0.006	5	0	5	0.007	0.83 (0.22-3.08)

Unknown	183	31	214	0.319	362	222	584	0.840	0.38 (0.33-0.44)
All	249	34	283	0.422	531	243	774	1.114	0.38 (0.33-0.43)

Data from a full year of continuous observation
95% CI = χ^2 test based confidence interval

Frequency of diarrheal disease in intervention and control areas

	Intervention (n = 671)			Control (n=695)			
Age	Person Years	Total Cases	Incidence Density	Person Years	Total Cases	Incidence Density	Incidence Density Ratio (95% CI)
0 – 11 Months	44	49	1.11	33	95	2.88	0.39 (0.29-0.54)
12-23 Months	19	37	1.95	27	99	3.67	0.53 (0.37-0.77)
24-59 Months	68	67	0.99	79	175	2.22	0.44 (0.34-0.59)
5-9 Years	112	36	0.32	113	137	1.21	0.27 (0.19-0.37)
10-14 Years	74	13	0.18	91	57	0.63	0.28 (0.16-0.49)
Over 15 Years	354	81	0.23	352	211	0.60	0.38 (0.30-0.49)
All	671	283	0.42	695	774	1.11	0.38 (0.33-0.43)

Discussion

- A blinded intervention was not possible based on the nature of the study
- Spreading of information may have led to decreases in diarrheal incidence in control areas

The principle investigator made regular unannounced field visits therefore it would be unlikely that under reporting of cases from the intervention area would occur

Stanton BF and Clemens JD. 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 diarrhea. *American Journal of Epidemiology.* 125: 292-301

Study Background:

- Included families from 51 slums in Dhaka, Bangladesh

- Practices associated with high rates of childhood diarrhea
    - Defecation in living areas by children
    - Lack of maternal hand washing prior to handling food
    - Lack of attention to proper disposal of household and fecal wastes with the result that young children had an increased tendency to place waste products into their mouths

Intervention

- 25 areas received educational intervention while 26 did not
- Emphasis given to proper hand washing; defecation away from the house and in a proper site; and suitable disposal of wastes and feces

Outcomes

Number of diarrhea episodes in children (per 100 person –week)

	Pre intervention	Post-intervention
Intervention group	7.3	4.29
Control group	7.6	5.78

Reasons why intervention may have had limited effect

- Chance occurrence
- Inadequate delivery of educational message
- Poor community compliance

Traore E, Cousens S, Curtis V, Mertens T, Tall F, Traore A, Kanki B, Diallo I, Rochereau A, Chiron JP, Megraud F. 1994. Child defecation behavior, stool disposal practices, and childhood diarrhea in Burkina Faso: Results from a case-control study. *Journal of Epidemiology and Community Health.* 48:270-275

Study Outline

- Looked at the association between child defecation behaviors, mothers' stool disposal practices, visible fecal contamination of the environment and the rate of admission to a hospital of young children with symptoms of diarrhea or dysentery
- Cases – children admitted to a pediatric department
- Control 1 – children from the same neighborhood as the cases of approximately the same age as the cases
- Control 2 – Children admitted to the same hospital as the cases without symptoms of diarrhea or dysentery

Outcomes

Distribution of diarrhea cases, their community controls, and hospital controls

Factor	Cases of Diarrhea	Neighborhood controls	OR (95% CI)	Hospital Controls	OR (95% CI)
Where do children defecate					
Pot /Latrine	554 (74)	573 (76)	1.00	452 (72)	1.00
Elsewhere	200 (26)	184 (24)	1.21 (0.92 – 1.58)	175 (28)	1.02 (0.78-1.34)
Stool disposal					

Latrine	488 (65)	519 (69)	1.00	417 (67)	1.00
Elsewhere	267 (35)	238 (31)	1.31 (1.02 – 1.69)	210 (33)	1.20 (0.93 - 1.54)
Stool visible in yard					
No	627 (83)	651 (86)	1.00	549 (87)	1.00
Yes	127 (17)	103 (14)	1.44 (1.03-2.03)	80 (13)	1.43 (1.04 – 1.97)

Discussion

- The results of the study are likely to be affected by recall bias on the part of the interviewee, bias on part of the interviewer, and by the presence of confounding factors
- Stool disposal behavior may be acting as an indicator of other sanitary behaviors, which may be the real risk factors

West S, Munoz B, Lynch M, Kayongoya A, Chilangwa Z, Mmbaga BBO, Taylor HR. 1995. Impact of face-washing on trachoma in Kongwa, Tanzania. *Lancet* 345: 155-158

Study Outline

- Community-based clinical trial to test the impact of a hygiene intervention program following a mass topical antibiotic campaign
- Randomized 3 pairs of villages. One of each pair would receive antibiotic treatment followed by a health education campaign. The other would receive only the antibiotic treatment
- Pairs of villages matched for
    - Maternal education
    - Baseline prevalence of clean faces in young children
    - Trachoma status

Intervention

- Educational campaign –designed to improve face washing of young children
- Treatment campaign – provision of 30 days of topical tetracycline ointment to each member of the village

Outcomes

- 12 months into the program, proportion with clean faces higher in all intervention villages than in the controls

	Percentage of children with clean faces				Percentage of children with sustained clean faces
	Baseline	2 months	6 months	12 months	
Pair 1					
Intervention	27	59	36	39	40*
Control	25	35	22	22	20
Pair 2					
Intervention	15	47	37	41	42
Control	17	40	38	33	36

Pair 3					
Intervention	16	24	26	27	22
Control	17	30	29	23	22
Total					
Intervention	18	41	33	35	35*
Control	19	35	30	26	26

*P-Value <0.05 for difference between the intervention and the control population

<u>Odds of trachoma at 1 year for children in intervention villages compared to controls</u>

	Odds Ratios (95% CI) for Severe Trachoma	Odds Ratios (95 % CI) for Any Trachoma
Intervention Village	0.62 (0.40 - 0.97)	0.81 (0.42 – 1.59)
Age	0.76 (0.68 - 0.85)	0.85 (0.80 – 0.90)
Trachoma at baseline	5.21 (3.51 – 7.74)	5.07 (3.28 – 7.84)

Discussion

- Approach does not work in every village
- A clean face may not be protective of trachoma but may be the result of the absence of disease given that trachoma produces ocular discharge
- Children with trachoma at the beginning of intervention may live in areas where re-infection is more likely
- Since after controlling for baseline trachoma and baseline clean faces, children who sustained clean faces showed a lower likelihood of re-emergent severe trachoma, it is plausible that hygiene education programs are effective

Wilson JM, Chandler GN, Muslihatun, Jamiluddin. 1991. Hand- washing reduces diarrhoea episodes: a study in Lombok, Indonesia. *Transactions of the Royal Society of Tropical Medicine and Hygiene.* 85:819-821

Study Outline

- Central Lombok – highest infant mortality rate in Indonesia mostly as a result of diarrheal disease
- Two administrative units from a small town selected for the study. This town had piped water available for 3 years prior to the study

Intervention

- Women in the intervention village were told about the causes of diarrhea and it was suggested that
    - They wash their hands with soap prior to food preparation and after eating
    - Wash their children's hands with soap prior to eating and following defecation
- The women were also supplied with soap and soap dishes
- In the control villages, information was only given in response to specific questions. However, mothers were told about oral rehydration therapy and encouraged to use it as a treatment option

Outcomes

- The two villages were similar in most indices though there was a higher number of women in the intervention area with > than 6 years of education

Changes in hygiene behavior and attitudes due to hand-washing campaign

	Control Village		Intervention Village	
	Pre	Post[a]	Pre	Post[a]
Wash hands with soap after defecation	1	3	0	92
Always wash hands before cooking	17	3	26	60
Sometimes wash hands before cooking	20	20	14	35
Rinse hands before eating	100	99	100	100
Always rinse children's hands before they eat	82	71	65	97
Soap is expensive	51	74	35	78
Not enough money to buy soap	43	51	32	12

[a] Figures are percentages

Incidence of water-related disease in control and intervention villages

Village	Episodes per 100 children per week	Diarrhea	Skin and Eye Disease
Control	Initial	2.23	1.30
	Follow-up	1.57	0.71
	Reduction	30%	45%
Intervention	Initial	2.94	2.31
	Follow-up	0.33	1.80
	Reduction	89%	22%

Yuan L, Manderson L, Tempongko SB, Wei W, Aiguo P. 2000. The impact of educational videotapes on water contact behavior of primary school students in the Dongting Lakes region, China. *Tropical Medicine and International Health.* 5(8): 538 – 544

Study Outline

- The study was conducted by Hunan Provincial Institute of Parasitic Diseases in collaboration with 16 anti-schistosomiasis stations and 50 schools in the Dongting Lakes region
- The schools were selected by a two-stage stratified sampling system.
- It is estimated that 200, 000 people in this region are currently infected with schistosomiasis, 20% of these being children aged 5-14. The prevalence rate is 3.06-22.0% of total population/village.
- Reasons for the high infection rate include
    - High water contamination
    - Lake conditions that provide an ideal breeding ground for the snail vector of *Schistosoma Japonicum*
    - Cattle form the reservoir of infection which limits the applicability of sanitation interventions such as the use of latrines
- Anti-schistosomiasis stations put signs around unsafe waters but these warnings often went unheeded

Intervention

- Adjacent pairs of the 50 schools were randomly assigned to either the intervention or control groups using a coin toss. The adjacent schools were located in geographically distinct groups that did not interact much. All fourth grade students in the schools were involved in the study (n=2263)
- The students in the intervention area watched 15-minute educational videos and received comic books that contained relevant messages on the transmission and prevention of schistosomiasis
- Observations of water contact behavior were also conducted

Baseline Survey

- Questionnaires used to assess knowledge about
  - The life cycle of the parasite and the stage when it is infective
  - The intermediate snail host
  - Major signs and symptoms of infection
  - How to prevent infection (e.g. the use of boots and waterproof trousers)
  - Safe areas for swimming
- Responses of the two groups to the last four questions were comparable
- A higher proportion of respondents in the intervention area were able to answer the question on the infective stage ($\chi^2 = 9.47$)
- Responses from the baseline survey were used to identify issues to be incorporated into the learning media

Post Intervention Survey

- 2 schools were excluded from the final survey because of floods
- Control and intervention groups differed significantly in terms of knowledge. The results were statistically significant ($\chi^2 = 31.64$, $p < 0.001$)

Outcomes

Change in water contact behavior

	Intervention Schools (%)			Control Schools (%)		
Occasions reported swimming	Pre-test	Post-test	Difference	Pre-test	Post-test	Difference
Once	11.1	7.9	-3.2	9.0	6.0	-3.0
Twice	18.3	11.3	-7.0	20.5	13.3	-7.2
> 3 times	23.7	13.3	-10.4	30.2	12.3	-17.9
Never	46.9	67.5	20.4	40.3	68.3	28.0

Choice of water sources, pre- and post- intervention

	Treatment			Control		
Place	Pre-Test	Post-Test	Difference	Pre-Test	Post-Test	Difference
Unsafe	38.8	31.3	-7.5	39.2	46.4	7.2
Safe	36.1	62.3	26.2	47.3	31.0	-16.3
Safe/Unsafe	25.1	6.4	-18.7	13.4	22.6	9.2
Total	100.0	100.0		100.0	100.0	

Discussion

- Need for leisure activities may prevent children from entirely avoiding water contact
- No opportunities to discuss the contents of the educational materials

- Children may also have found the material more entertaining than educational
- This is a short term intervention that may produce only short-lived behavioral changes

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