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Interim evaluation of a large scale sanitation, hygiene and water improvement programme on childhood diarrhoea and respiratory disease in rural Bangladesh

Tarique Md. Nurul Huda^{a,*}, Leanne Unicomb^a, Richard B. Johnston^b, Amal K. Halder^a,
Md. Abu Yushuf Sharker^a, Stephen P. Luby^{a,c}

^a International Centre for Diarrheal Diseases Research, Bangladesh

^b Swiss Federal Institute of Aquatic Science and Technology, Switzerland

^c Centers for Disease Control and Prevention, USA

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ABSTRACT

Started in 2007, the Sanitation Hygiene Education and Water Supply in Bangladesh (SHEWA-B) project aims to improve the hygiene, sanitation and water supply for 20 million people in Bangladesh, and thus reduce disease among this population. This paper assesses the effectiveness of SHEWA-B on changing behaviors and reducing diarrhoea and respiratory illness among children < 5 years of age. We assessed behaviors at baseline in 2007 and after 6 months and 18 months by conducting structured observation of handwashing behavior in 500 intervention and 500 control households. In addition we conducted spot checks of water and sanitation facilities in 850 intervention and 850 control households. We also collected monthly data on diarrhoea and respiratory illness from 500 intervention and 500 control households from October 2007 to September 2009. Participants washed their hands with soap < 3% of the time around food related events in both intervention and control households at baseline and after 18 months. Washing both hands with soap or ash after cleaning a child's anus increased from 22% to 36%, and no access to a latrine decreased from 10% to 6.8% from baseline to 18 months. The prevalence of diarrhoea and respiratory illness, among children <5 years of age were similar in intervention and control communities throughout the study. This large scale sanitation, hygiene and water improvement programme resulted in improvements in a few of its targeted behaviors, but these modest behavior changes have not yet resulted in a measurable reduction in childhood diarrhoea and respiratory illness.

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Introduction

In 2008, an estimated 1.3 million children <5 years of age died globally, including an estimated 20,000 in Bangladesh, due to diarrhoeal diseases. An additional 1.6 million children <5 years died due to pneumonia, including an estimated 26,000 in Bangladesh (Black et al., 2010). Numerous small scale interventions focused on improving hygiene practices and water treatment have been effective in reducing child diarrhoea (Clasen, Roberts, Rabie, Schmidt, & Cairncross, 2006; Curtis & Cairncross, 2003; Ejemot, Ehiri, Meremikwu, & Critchley, 2008; Fewtrell et al., 2005; Luby et al., 2005; Shahid, Greenough, Samadi, Huq, & Rahman, 1996) and handwashing interventions with soap have reduced acute respiratory illness (Luby et al., 2005; Rabie & Curtis, 2006). There is also evidence that water storage and sanitation interventions

targeting up to a few thousand households can reduce diarrhoea (Daniels, Cousens, Makoae, & Feachem, 1990; Doocy & Burnham, 2006; Fewtrell et al., 2005; Roberts et al., 2001).

Many available, affordable and effective interventions linked to improved child health do not reach children in greatest need, due to difficulties in scaling up. Scaling up refers to the increased financial, human and capital resources required to expand coverage of locally tested pilot or experimental interventions so that benefits will increase and be shared with a larger target population (Mangham & Hanson, 2010; Simmons, Fajans, & Ghiron, 2007). Difficulties in scaling up proven effective interventions include weakness in delivery systems, inappropriate delivery strategies, limited resources, difficulties in estimating resource requirements and spending those resources effectively and efficiently, and the short timeframe for planning, implementing, integrating, and sustaining the interventions (Mangham & Hanson, 2010; Vitoria, Hanson, Bryce, & Vaughan, 2004). However, historically, large scale interventions have not been rigorously evaluated, and their health impact is unclear (Bajracharya, 2003; Biran et al., 2009; Bowen

* Corresponding author. Tel.: +880 2 7551934.

E-mail addresses: tariquehuda@yahoo.com, Tarique.Huda@ishtm.ac.uk (T.Md.N. Huda).

et al., 2007; Nanan, White, Azam, Afsar, & Hozhabri, 2003). In Myanmar, the National Sanitation Week and Social Mobilization for Sanitation and Hygiene programme contributed to a significant increase in access to sanitary means of excreta disposal and handwashing with soap and water after defecation, but no health outcome was measured (Bajracharya, 2003). An evaluation of a water, sanitation and hygiene programme implemented in Pakistan showed a significant reduction in diarrhea, but this evaluation did not capture the interim behaviors that lead to reduction in diarrhea (Nanan et al., 2003). Overall, it remains unclear if interventions that have resulted in less diarrhea and acute respiratory illness in children <5 years of age in carefully controlled trials, targeting up to a few thousand households, can still achieve a similar level of health benefits when taken to a large scale.

In 2007 the Government of Bangladesh launched the Sanitation, Hygiene Education and Water Supply in Bangladesh Programme (SHEWA-B), an intervention funded by the United Kingdom's Department for International Development (DFID), with technical support from United Nations Children's Fund (UNICEF). SHEWA-B, a large scale 5 year programme, targets 20 million rural people and aims to improve standards of hygiene practices and behavior on a sustainable basis, while ensuring adequate sanitation and safe water supply. The International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDR,B) was requested to design and conduct a rigorous evaluation of the effectiveness of SHEWA-B (Halder et al., 2010; Luby et al., 2009). This paper assesses the effectiveness of SHEWA-B on changing targeted behaviors and its impact on diarrhea and respiratory illness among children < 5 years of age after first 18 months of implementation.

Methods

Study population

The SHEWA-B program targeted 68 sub-districts in 19 districts. The government and UNICEF selected the specific intervention sub-districts because of the perceived need and the absence of other active programs addressing water, sanitation and hygiene in these communities. Sub-districts are further subdivided into unions. To select the assessment population, we first listed all unions, the smallest administrative unit in Bangladesh, comprised of a number of villages, under their sub-district and district location. Then we randomly selected 50 unions where the probability of selection was proportional to the size of the union. In each union, a group of 10–17 households from a randomly selected village was considered a cluster. For each SHEWA-B sub-district where we chose a union for evaluation we selected a control sub-district that had similar geography, hydrogeology, infrastructure, agricultural productivity, and household construction, and where the government confirmed that no other major water-sanitation-hygiene programs were ongoing.

Once a union was selected, the research field team selected a village from an enumerated list of the union villages using a random number generator. We traveled to the selected village, asked residents to identify the village centre, and then enrolled the first closest eligible household. A household was considered eligible if it had a child <5 years of age and a guardian of the child agreed to participate in the study. To enroll the next household, we skipped the next two closest households, and then looked for the next closest eligible household. The process for enrolling the next closest household was repeated until the sample size from the selected union starting point was met.

We calculated required sample sizes for different survey components considering the outcome indicators of interest for each component. For the structured observation of handwashing with soap, we estimated a baseline of 28% that would increase to 43% after

2 years of intervention. For the cross sectional survey we estimated the proportion of households using their own or shared latrine to be 66% at baseline and increasing to 75% after 2 years of intervention. For calculating the sample size to measure diarrhea prevalence in the last 15 days we estimated 25% at baseline decreasing to 17.5% after 2 years of intervention. While calculating the sample size, we assumed 80% power, 95% confidence and a design effect of 2 to offset village level clustering. We aimed to enroll 1000 households for structured observations, 1700 household for the cross sectional survey and 1000 households for diarrhea surveillance, all equally split between intervention and control communities.

SHEWA-B intervention

Based on a large three year pilot program (Eusuf and Associates, 2006), the project engaged local residents, under the guidance of local non-governmental organizations (NGOs), to develop their own community action plans, including targets for improvements in latrine coverage and usage; access to and use of arsenic-free water; and improved hygiene practices, especially handwashing with soap. SHEWA-B trained and recruited more than 10,000 local residents who had at least 10 years of schooling to serve as community hygiene promoters. These promoters received 10 days of training on behavior change communication materials related to water, sanitation and hygiene. They visited households, facilitated courtyard meetings and organized social mobilization activities. These included water, sanitation and hygiene fairs, village theater, and group discussions in tea stalls, the social meeting point for village men. During the promotional activities the promoters used flip charts and flash cards. The messages alerted participants to the presence of unobservable "germs" in their home environment and practices that would minimize the impact of germs on the health of the family. The promotional activities were intended to encourage active participation of the community members. Each community hygiene promoter was expected to reach an average of 2000 individuals every two months through household visits and courtyard meetings. Since SHEWA-B was a programme implemented at large scale, the position of the community hygiene promoters was considered as an intermediate between volunteers and paid staff, so that their incentive was affordable to the local government. Incentives included prestige as well as a modest salary, approximately 1 US dollar per day, which is approximately one half that of an unskilled laborer. The community hygiene promoters were trained to deliver 11 key messages (Box 1).

Box 1.

The 11 key messages

1. Wash both hands with water and soap before eating/handling food
2. Wash both hands with water and soap/ash after defecation
3. Wash both hands with water and soap/ash after cleaning baby's bottom
4. Use hygienic latrine by all family members including children
5. Dispose of children's feces into hygienic latrines
6. Clean and maintain latrine
7. Construct a new latrine if the existing one is full and fill the pit with soil/ash.
8. Safe collection and storage of drinking water
9. Draw drinking water from arsenic safe water point
10. Wash raw fruits and vegetables with safe water before eating and cover food properly
11. Manage menstruation period safely

Key outcome indicators

UNICEF and the Government of Bangladesh were particularly interested in the impact the program had on diarrhea and respiratory illness among children <5 years of age. Key behavioral indicators targeted by SHEWA-B that may affect these health outcomes include handwashing, latrine use, feces and waste disposal, and water storage (Curtis et al., 1995; Lanata, Huttly, & Yeager, 1998; LeBaron et al., 1990; Roberts et al., 2001; Stanton & Clemens, 1987; Traore et al., 1994).

Data collection

The research assistants collected baseline data in 2007 from intervention and control households. To provide early feedback on the effectiveness of the intervention efforts in intervention households, we conducted an interim assessment after 6 months of promotional activities. In 2009, after approximately 18 months of promotional activities, data were collected from a different randomly selected set of intervention and control households.

Structured observation

The research assistants conducted 5 h of structured observation of handwashing and child feces disposal behaviors of all persons in the selected households from 9 AM to 2 PM. This time was considered culturally acceptable for visitors and the usual time for a range of personal hygiene and food preparation behaviors. Using a pretested instrument the field team noted behaviors at key handwashing opportunities, such as after own or child's defecation, prior to preparing and serving food, prior to eating and feeding a child. The research assistants noted whether the household residents washed their hands or not, and if so, if they used water only, soap, and/or ash. Within each household, during the 5 h of observation, research assistants often observed multiple occasions of the same opportunity for handwashing and recorded each episode separately.

Cross sectional survey

After completing all the household observations the research assistants returned to administer a cross-sectional survey and perform a spot check. The cross sectional survey included demographic information, data on households' hygiene, sanitation, water supply status, as well as household construction and possessions to permit a measurement of acquired household wealth. The spot checks included information on type of household water and sanitation infrastructures.

Monthly surveillance

We recruited and trained one educated female resident from each evaluation community to collect information on disease burden. These community monitors visited each enrolled household each month for 24 months after baseline, and administered a brief questionnaire. This monthly surveillance questionnaire included information on any episodes of acute respiratory illness and diarrhea of each child <5 years of age during the two days preceding the interview.

Measurement of indicators

We classified improved latrines using the WHO/UNICEF Joint Monitoring Programme definitions (WHO & UNICEF, 2008). We considered lack of access to a latrine as reported by the respondent

and verified by spot check of the household as an indicator of open defecation. Any latrine was considered clean if no feces were observed in and around the slab of the latrine. We classified disposal of child's feces as appropriate if feces were observed to be disposed in a toilet or in a specific pit.

We classified a household as having appropriate solid waste disposal if it had either a drum or a specific pit, and our survey team visually confirmed that household solid waste was disposed there, with no waste observed outside the pit or drum. We classified water drainage as appropriate if a household had either a drain (constructed with or without concrete and cement) or a soak pit. We considered a household to store water in a covered container if all the containers found in the house were fully covered at the time of visit to the household.

We classified acute respiratory illness as having cough and fever or difficulty breathing and fever within 48 h prior to interview (Alam, Henry, & Rahaman, 1989; Boerma, Black, Sommerfelt, Rutstein, & Bicego, 1991; Zafar, Luby, & Mendoza, 2010). Diarrhea was defined as the passage of 3 or more loose or watery stools in the preceding 24 h period and we collected data on episodes of diarrhea in the 48 h prior to interview.

Statistical methods

We evaluated the change in outcome indicators related to water use, sanitation and hygiene between the baseline and follow-up within the intervention communities and compared these differences to any differences observed in the control group during the same period using linear mixed effect logistic regression. We allowed for random effects within village cluster and within household nested in the village. The logistic regression models consist of main effects for: 1) intervention or control study groups; 2) time of data collection; baseline or 18 months; and 3) interaction between 1 and 2.

To account for the repeated observations for diarrhea and acute respiratory illness in single households and the clustering of observations in villages, we used generalized estimated equations to calculate the cluster adjusted *P* values and 95% confidence intervals.

To analyze the data on behavior change we used STATA software version 10 for linear mixed effect logistic regression analysis. We used SAS for Windows, (PROC GENMOD) Version 9.1 (SAS Institute, Cary, NC, USA) for the generalized estimated equations modeling to analyze the data on health outcome.

Human subject protection

All study participants provided written informed consent. The Government of Bangladesh Department of Public Health Engineering and UNICEF approved the evaluation. ICDDR,B administration provided an expedited approval of the study.

Results

There was little difference in social and demographic characteristics between the intervention and control households both at baseline and 18 months (Table 1).

Participants washed their hands with soap < 3% of the time around food related events, including before preparing food, before serving/handling food, before eating and before feeding a child, at baseline and after 18 months. There was no significant difference in food related hand washing behavior from baseline to 18 months in the intervention group compared with the control group (Table 2).

Residents of intervention households increased the frequency that they washed both hands with soap or ash after cleaning

Table 1
Comparison of socio-demographic characteristics of respondents and households at baseline and at 18 months assessment.

	Baseline		18 months	
	Intervention (N = 848) (%)	Control (N = 844)(%)	Intervention (N = 849) (%)	Control (N = 850) (%)
Household head Male	96	92	95	92
Household size (avg.)	5.7	5.3	5.6	5.4
<i>Occupation of father of the youngest child</i>				
Farmer/cultivator/homemaker	23	25	20	19
Traders/business occupation	21	16	19	15
Daily wage labour/boatman/shoe or umbrella mechanic	18	25	22	30
Service	10	9	12	7
Skilled worker/profession	10	9	11	11
Rickshaw/Van puller	10	7	8	10
Staying abroad	5	8	7	7
Household head untraced, disabled, domestic maid, retired, unemployed	2	2	2	2
<i>Education of father</i>				
No education	35	38	36	43
Up to primary	32	29	27	31
Up to secondary	24	25	29	20
Above secondary	9	8	9	6
<i>Education of mother</i>				
No education	33	29	29	32
Up to primary	33	34	33	36
Up to secondary	32	34	35	31
Above secondary	2	3	4	2
<i>Proportion who own</i>				
Electricity	42	49	50	41
Television (B/W)	20	18	19	16
Television (color)	8	10	11	9
Refrigerator	2	3	3	3
Motorcycle	3	1	3	2
Mobile phone	29	30	50	38
Self owned living house	95	93	92	92
Avg. amount of homestead land (Acres)	0.2	0.2	0.2	0.1
Avg. amount of land other than homestead (Acres)	0.8	0.9	0.7	0.7

a child's anus from 22% at baseline to 36% at 18 months assessment. Residents of control households increased the frequency that they washed both hands with soap or ash after cleaning a child's anus from 24% at baseline to 27% at 18 months. The improvement in the frequency of washing both hands with soap or ash after cleaning a child's anus in the intervention group was significantly greater than the improvement in the control group ($P < 0.05$) (Table 2).

Residents of intervention households increased the frequency that they washed both hands with soap or ash after defecation from 17% at baseline to 30% at 18 months. Residents of control households increased the frequency that they washed both hands with soap or ash after defecation from 18% at baseline to 23% at 18 months. The improvement in handwashing after defecation in the intervention group was not significantly greater than the improvement observed in the control group ($P = 0.20$) (Table 2).

During the baseline, spot checks identified that 10.3% of households in intervention areas had no access to latrine. This decreased to 6.8% after 18 months, and was significantly greater than in the control communities ($P < 0.05$) (Table 2).

The proportion of households with latrines with no visible feces on and around the slab, appropriate disposal of child feces, and drinking water stored in a covered container improved from baseline to 18 months in the intervention communities. Similar improvements were also seen in the control communities, so there was no significant difference between intervention and control communities. Other indicators related with access to improved latrines, solid waste disposal and drainage systems, and covered containers for water storage did not improve significantly in the intervention communities when compared with control communities (Table 2).

The prevalence of childhood diarrhea and respiratory illness was similar in the intervention and control communities. Overall, during monthly visits during the first 24 months, 10.1% of children <5 years of age living in intervention communities were reported to have diarrhea in the preceding two days compared to 9.9% of children <5 years living in control communities ($P = 0.56$) (Fig. 1). Similarly, 12.6% of children <5 years in the intervention areas had respiratory illness on monthly visits compared to 13.0% in the control area ($P = 0.61$) (Fig. 2).

Discussion

After 18 months of promoting key behaviors related to sanitation, hygiene, and safe water, targeting 20 million rural Bangladeshis, the improvements observed for a few key behaviors were modest. These included an increase in washing both hands with soap/ash after cleaning a child's bottom, a decrease in the number of households lacking access to a latrine, and an increase in storage of drinking water in containers. Our evaluation of SHEWA-B included matched intervention and non-intervention control groups, all with similar socio-demographic characteristics, increasing the likelihood that these improvements were due to the intervention. However, our evaluation found, at this stage, no reduction in the prevalence of diarrhea or respiratory disease among children <5 years of age in the households from the intervention areas. These data suggest that SHEWA-B has not yet improved behaviors related to handwashing, latrine use, feces and waste disposal, and water storage sufficiently to lead to a detectable decrease in diarrhea and acute respiratory illness.

The lack of a measurable impact on the majority of targeted outcomes was not because of low statistical power. The sample size

Table 2

Changes in sanitation, hygiene and water use behaviors comparing baseline with 18 months assessment.

	Intervention				Control				P value ^a
	Baseline		18 months		Baseline		18 months		
	n	% ^b	n	% ^b	n	% ^b	n	% ^b	
Handwashing									
Total no. of handwashing opportunities observed	10417		12000		10129		12061		
<i>Used soap/ash while washing both hands</i>									
After cleaning child's anus	208	22	191	36	199	24	183	27	0.03
After defecation	172	17	151	30	177	18	152	23	0.20
<i>Used any soap while washing both hands</i>									
Before preparing food	1003	0.6	1238	1.1	831	0.4	1168	1.1	0.72
Before serving food	872	0.7	1103	1.3	845	1.4	1035	2.1	0.85
Before eating	3472	0.4	4162	1.2	3563	0.4	4314	1.1	0.61
After eating	2795	0.3	2438	0.7	2633	0.3	2581	0.5	0.48
Before feeding a child	813	0.7	1264	2.5	871	1.2	1255	1.9	0.22
Sanitation									
<i>Type of latrine</i>									
Improved latrine	848	45	849	38	844	39	850	38	0.082
Unimproved latrine	848	45	849	55	844	53	850	53	0.003
No access to a latrine	848	10	849	6.8	844	7.6	850	8.5	0.02
Households with Clean latrine	735	36	786	45	745	39	775	47	0.63
Appropriate child feces disposal	162	9.3	128	16	144	9.0	143	15	0.84
<i>Waste disposal</i>									
Appropriate solid waste disposal system	848	3.3	849	8.6	844	2.8	850	8.4	0.89
Appropriate water drainage system	848	43	849	51	844	40	850	52	0.28
Appropriate solid waste and water waste disposal system	848	1.8	849	4.4	844	1.5	850	5.9	0.15
<i>Water storage</i>									
Households store drinking water in a container	848	58	849	69	844	68	850	73	0.04
Stored drinking water in a covered container	848	20	849	24	844	24	850	25	0.26

^a P value for Difference of change associated with time (Baseline, 18 months) between the intervention and control communities. Adjusted for clustering by village and household (linear mixed effect logistic regression).

^b For each indicator presented in the row, the % calculations were made as follows, using Before preparing food and "used soap while washing both hands" as an example: n = no. of observations where households member prepared food and washed both hands with soap and N = no. of observations where households member prepared food.

was sufficient to detect expected effects of the intervention, and the baseline estimates for each indicator were based on the pilot study conducted prior to SHEWA-B in the similar areas of Bangladesh.

There is little available published literature as to how best to scale up successful small scale water, sanitation and hygiene promotion interventions and still obtain a similar level of health benefit. Previous hand washing intervention trials with several thousand enrolled households found significant reductions in diarrhea and respiratory illness, but those studies often provided free soap with frequent community meetings and weekly household visits (Han & Hlaing, 1989; Khan, 1982; Luby et al., 2005; Luby et al., 2004; Stanton & Clemens, 1987). For example, an evaluation in a refugee camp setting suggested that improved water storage reduced the risk of diarrhea by 31% (Roberts et al., 2001). However, we were unable to identify any other evidence that water storage promotion implemented at large scale at the community level improved health. Only a few studies found sanitation interventions associated with reduction in diarrhea, and these often provided

sanitary hardware and installation of infrastructure. (Barreto et al., 2007; Daniels et al., 1990; Esrey, Potash, Roberts, & Shiff, 1991). For example, a study that used a before and after assessment design in Salvador, Brazil found a city wide reduction of diarrhea after city wide improvement in sanitation coverage (Barreto et al., 2007).

There is some evidence of health impact when multiple water sanitation and hygiene interventions were introduced jointly, but those were studies of up to a few thousand households and often had provision of infrastructure (Aziz et al., 1990; Hoque, Juncker, Sack, Ali, & Aziz, 1996; Mertens et al., 1990; Messou, Sangare, Jossieran, Le Corre, & Guelain, 1997). Assessment of a large scale integrated package of water, sanitation and hygiene activities implemented in Pakistan found that the children from non-intervention villages had a 33% higher adjusted odds ratio for diarrhea compared to those from the intervention villages after 5 years. However, the study used a case-control design so that the intervention was not randomly assigned. As a result, the villages that were selected for the interventions were different from the

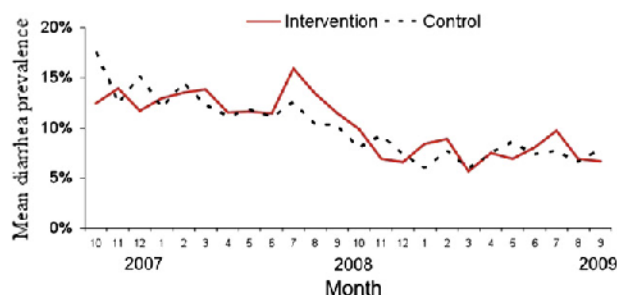


Fig. 1. Prevalence of diarrhea in the previous 48 h among children < 5 years of age in the intervention and control groups (October 2007–September 2009).

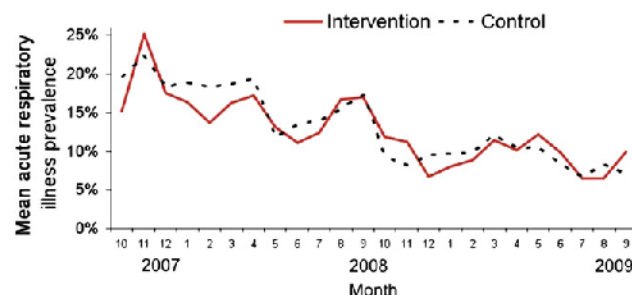


Fig. 2. Prevalence of acute respiratory illness in the previous 48 h among children < 5 years of age in the intervention and control groups (October 2007–September 2009).

control villages (Nanan et al., 2003). Another large hygiene promotion programme conducted in Burkina Faso measured behavior change, but not health impact (Curtis et al., 2001).

The evaluation findings suggest that SHEWA-B did not yet result in a measurable decrease in the prevalence of diarrhea and acute respiratory illness because it did not yet sufficiently improve the targeted behaviors. When compared with the control group there were modest improvements in handwashing with soap after cleaning a child's bottom after defecation. While significant improvement was seen in handwashing with soap after defecation from 17% to 30%, this was not significantly different from improvements in control areas. Improvements in handwashing before preparing food or eating were not significant. In over 64% of observed instances, hands were not washed with soap after defecation and after cleaning a child's anus. In studies targeting up to a few thousand households, lower incidence of diarrhea was found when handwashing with soap was promoted before preparing food, before eating, and after defecation (Khan, 1982; Pinfold & Horan, 1996; Shahid et al., 1996; Wilson, Chandler, Muslihatun, & Jamiluddin, 1991).

While there were fewer households lacking access to a latrine in the intervention communities compared to the control communities, there were similar proportions of households with access to an improved latrine after 18 months. In a previous study, reduced reported diarrhea was associated with latrine ownership (Daniels et al., 1990).

Eighteen months of SHEWA-B intervention did not sufficiently improve targeted behaviors nor did it reduce diarrhea and respiratory illness. Perhaps the intervention, as designed, was insufficient to produce the targeted behavior change. The SHEWA-B intervention promoted hygiene primarily through increasing awareness and imparting health information, strategies that in some context have been ineffective (Biran et al., 2009; Scott, Curtis, Rabie, & Garbrah-Aidoo, 2007). Knowledge is often insufficient to change behavior. The pilot programme implemented before SHEWA-B in rural Bangladesh used a similar intervention, and found marked improvement in self-reported behaviors (Eusuf and Associates, 2006), but the assessment of the pilot likely overestimated the effect of the intervention, because it did not enroll a control group and depended upon self-reporting of behavior.

Alternatively, perhaps the intervention design was sound, but it was not implemented with sufficient thoroughness to achieve the study targets. SHEWA-B was implemented by local NGOs who were monitored by local government staff and community leaders. UNICEF assessed the NGOs' performance considering financial management, progress toward community action plan and targets, and household feedback on community hygiene promoter's visit. The assessment concluded that 41 out of 58 NGOs (71%) performed well enough for contract extension (Personal communication, Luzma Montano, UNICEF, Bangladesh). However, we do not have systematic data on process indicators to inform us if the communities were actually reached by the interventions, how often, and how effectively. As a result we cannot confirm how closely the program intervention was implemented as designed. Future evaluation of similar large scale programmes would benefit from rigorous monitoring of the implementation process and coverage.

SHEWA-B targets a large population. Even with 10,000 community hygiene promoters, each person was responsible for educating about 2000 individuals. Moreover, we do not know whether 10 days training was sufficient to equip the community hygiene promoters with the skills necessary to facilitate the implementation of the community action plans as designed.

How much behavior change can be expected from a large scale water, sanitation and hygiene intervention? Among the behaviors that improved after 18 months of SHEWA-B, the magnitude of the

behavior change was similar to other large behavioral interventions. In our study there was a 14% improvement in observed handwashing behavior after cleaning a child's bottom compared to 18% increase in a study done in Burkina Faso (Curtis et al., 2001). There was not yet an improvement in child's feces disposal in our study, which may compare similarly to the study done in Burkina Faso (Curtis et al., 2001). While SHEWA-B did not yet change the behavior substantially enough to see improvement in health, we do not know how much change in behaviors is needed. Many of the significant improvements were seen in the first 6 months (data not shown), and only marginal further improvements were detected over the next 12 months. So, additional time is not necessarily beneficial.

Our evaluation of SHEWA-B was designed to avoid specific pitfalls identified by earlier researchers (Blum & Feachem, 1983). First, the SHEWA-B evaluation enrolled a control group carefully selected in consultation with Department of Public Health Engineering of the Government of Bangladesh, who were responsible for implementing SHEWA-B and confirmed that there was no similar intervention ongoing. If there were other broad effective national campaigns, we would have been aware of them. If any campaign had been effective in improving hygiene behavior in the control group we would have seen parallel improvement in the control group with the intervention group. However, we saw very little improvement in the behavior of the control group, and so no evidence of their being a broad national program. We avoided comparing a single intervention community with a single control community by enrolling a random sample of 50 intervention and 50 control communities. This provided a sufficient sample size to permit assessment of the SHEWA-B in a wide variety of settings that are representative of the target population. The primary outcome for health was a 48 h recall of diarrhea and respiratory disease, a recall period that has been demonstrated to be the most accurate (Zafar, Luby, & Mendoza, 2009).

In this study we have found that prevalence of diarrhea and acute respiratory illness reduced gradually over an 18 month period both in the intervention and control areas. Possible explanations for this reduction include the aging of the cohort, the variability of diarrhea measurements (Luby, Agboatwalla, & Hoekstra, 2011), and surveillance fatigue. The community monitors who collected data on disease frequency were not aware of the hypothesis that framed this analysis. Child illness in these communities is common and not shameful, so we would not expect any biases in reporting. Although, community monitors did not have the same level of skills as the research assistants employed for this study, they were carefully trained using simple instruments and their results were consistent with the very modest changes seen in behavior by the more highly educated research team.

Handwashing behavior is difficult to assess. Responses to questions about hand washing are substantially different from observed behavior and are considered less valid (Manun'Ebo et al., 1997). Thus data from structured observations have been used to assess handwashing, but we also collected other measures of handwashing including spot checks for handwashing infrastructure, measures of hand cleanliness, and reported handwashing that all showed results consistent with the very modest impacts observed in structured observation (data not shown). We observed fewer defecation-related than food-related handwashing opportunities, because we missed many defecation events performed early in the morning. However, for both intervention and control groups we followed similar observation timings to collect data. It is possible that the intervention led the study participants to understand that washing both hands with soap after fecal contact was appropriate behavior. If so, then in the presence of an observer, the study participant may have been more likely to wash both hands

with soap because of this social expectation (Ram et al., 2010). However, a study conducted in India found that the presence of an observer did not influence study participants' handwashing practices (Biran et al., 2009), though this may have been such an ineffective intervention that it simply did not affect the social norm. We attempted to reduce the impact of the observer by conducting observations for extended 5-h periods rather than shorter time intervals that have been associated with increased reactivity (Ruel & Arimond, 2002). Furthermore, we enrolled a new set of randomly selected households for the post intervention evaluation which likely minimized the reactivity that could occur from conducting repeat observations.

The ongoing health impact evaluation of SHEWA-B provides a singularly rigorous assessment of the impact of a large scale intervention on behavior and health in the target communities. The approach of SHEWA-B targeting multiple interventions with several sanitation, hygiene and water related key messages, implemented at large scale, was insufficient to change most health practices and the health status of children <5 years of age in rural Bangladesh after the first 18 months of implementation. Although the intervention to date has not reached the majority of its behavioral and health targets, the commitment to a rigorous external evaluation provides valuable insights for program donors and implementers on how this and other large scale intervention programs can be improved. The 6 month assessment of SHEWA-B helped to make the programme targets more realistic, while the 18 month assessment led UNICEF and program implementers to revise the behavior change strategy by focusing on fewer behaviors and using mass media to support the communication messages. More research on how to implement proven water sanitation and hygiene interventions at scale will benefit future investment in large scale water, sanitation and hygiene intervention programmes. Additionally, continuing rigorous evaluation and dissemination of results could help to improve ongoing programs and answer key questions about how to scale up such interventions effectively and thereby improve the health of children <5 years of age in low income countries.

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