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ABSTRACT

Background: Waterborne medical conditions represent substantial global burden of diseases. Under-five children are more likely to get these conditions compared to adults. This study examines effect of water, sanitation and hygiene (WASH) intervention of BRAC on waterborne diseases.

Methods: An experimental study was done in 50 sub-districts in rural areas of Bangladesh where WASH programme is in place since middle of 2006. A total of 29,885 households were selected randomly for this study through multi-stage 30 clusters sampling design. The intervention included promotional activities to install tubewells, sanitary latrines and health education for improving hygienic behaviour. Ultra poor received grant for sanitary latrine in the villages where sanitation coverage reached ≥80%. To facilitate intervention, village WASH committees were formed. The intervention was provided through cluster meeting, preventive home visits, popular theater and celebrating sanitation month. Diarrhoea, dysentery, jaundice, worm infections and typhoid fever were considered as marker of self-reported waterborne diseases.

Results: Findings reveal that overall prevalence of waterborne diseases reduced from 10% at baseline to 7% at follow-up ($p<0.001$). Among under-five children it reduced from 22% to 13% ($p<0.001$). Although, prevalence was higher among women than men at baseline ($p<0.001$) no significant difference was noted between them during follow-up. Prevalence was found to be significantly higher among illiterate and who reported to use unsanitary latrine. Logistic regression analyses show that among the under-five children probability of reporting waterborne diseases was significantly higher at both periods. Non-poor and participants from the central, north and the south-east regions were less likely to report waterborne diseases.

Conclusions: This study underlines that to reduce waterborne disease water, sanitation and hygiene intervention plays important role. Attenuation of waterborne diseases might impact on child mortality and economic status of the households where out-of-pocket medical expenditure is pervasive.

Key words: Waterborne diseases, children, rural, water, sanitation, hygiene

INTRODUCTION

The burden of waterborne diseases is paramount in the globe. About 4% of the global burden of diseases is attributable to water, sanitation and hygiene (Prüss *et al*. 2002). Nearly 2.2 million people die every year due to diarrhoeal diseases globally. Of these, 1.8 million deaths occur alone in low-income countries (WHO 2004). Further, in low and middle-income countries one of the tenth leading causes of death is attributable to diarrhea-related diseases (Murrary *et al*. 2001). Globally, diarrhoea alone kills more children compared to malaria and tuberculosis together (Odi 2006). In Bangladesh, every year more than one hundred thousand under-five children die due to diarrhea-related diseases. On average, episodes of diarrhea occur more than twice a year among the children (Bern *et al*. 1992). Research indicates that more than half of acute illnesses are attributable to water, sanitation and hygiene-related across all age groups (BRAC 2008). These diseases are commonly reported in low-income countries as provision of safe water, sanitation and hygiene is sub-optimal. Recent research also shows that due to climate change waterborne diseases such as diarrhea is increasing gradually (CCC 2008). In low-income countries waterborne diseases are well-known public health problem (Tulchinsky 2000). Although burden of waterborne diseases is substantial in most of the low-income countries, intervention for reducing these medical conditions is fragmented.

Research indicates that washing hands without soap after defecation and before eating are common in Bangladesh (BRAC 2008). Several underlying factors such as availability, affordability and negligence are associated with these unhygienic practices. Furthermore, most of the people are not much aware about the route of transmission of waterborne diseases which increase the risk notably. Even many people lack knowledge about potential risks of taking uncovered and inappropriately preserved food items, not washing hands with soap before eating, providing food to children without washing hands with soap, and not washing hands with soap after defecation.

Earlier studies indicate that washing hands with soap reduce risk of diarrhoea substantially (Curtis and Carincross 2003; Ejemot *et al*. 2008). It is worth to note that considering the availability and disinfection capacity ash or soil are also promoted to use for washing hands after defecation (Hoque 2003). Other known modifiable risk factors are use of safe water for drinking, cooking, bathing, washing utensils and foods. Poverty and literacy are significantly associated with various preventive measures such as installation of latrines and tubewells (BRAC 2008). Use of sanitary latrine also reduce incidence of waterborne diseases. However, research shows that lack of money, land, awareness, preference of open defecation and lack of materials are associated with not constructing sanitary latrines (GED 2009). All these factors impede the universal coverage of use of sanitary latrine.

Bangladesh is a low-income country where round the year prevalence of waterborne diseases remains high. Outbreaks are pervasive in dry season and during flood due to scarcities of safe water. During flood provision of water and sanitation

facilities is more likely to damage. Evidence shows that 66% of households in the flood affected areas lost their latrine during flood hence performed defecation in open place due to lack of alternate safe options (Ahmed 2007). In Bangladesh use of safe drinking water has significantly increased over time. Contrary, the use of unsafe water is common for other activities such as cooking, washing utensils and foods. These may lead to increased incidence of waterborne diseases.

In 2006, BRAC initiated water, sanitation and hygiene (WASH) intervention in 150 sub-districts for five years where the availability of sanitary latrines was reported to be low compared to the national level. The project received financial support from the government of the Netherlands. This study aims to examine effect of water, sanitation and hygiene intervention on waterborne diseases. Besides, association of socioeconomic and demographic indicators is also considered in the analyses to investigate its association with the outcome of interest.

METHODS AND MATERIALS

STUDY AREA AND DESIGN

An experimental study was done in 50 sub-districts where WASH programme of BRAC has been offering its interventions since middle of 2006. These sub-districts are known as low coverage areas in terms of availability of sanitary latrines compared to the national level of coverage.

Sampling

A multi-stage 30 clusters sampling design was followed in drawing the sample. In the first step, 30 villages were selected from each sub-district. In the second step, from each village, 20 households were selected proportionately. A total of 29,885 households were interviewed at follow-up while at baseline corresponding figure was 29,985. Lost to follow-up was found to be 7%. Reasons of lost to follow-up were unavailability of the respondents during the time of data collection.

Data collection

Data were collected using structured and validated questionnaire at the home of the participants in person. Data were collected between November-March at baseline while during April-July at follow-up. Informed consent was obtained from the participants before data collection. Field interviewers were given adequate training on data collection before commencement of the field work. A training manual was developed where instructions are provided about data collection procedures. The field investigators used this manual as reference during data collection. Several monitors were employed to oversee the data collection to ensure reliability of data. Besides, respective researchers visited field regularly to check whether the data collection was done appropriately as instructed. Each team consists of one field supervisor to check the accuracy of data. Cross- checking of data was performed each day following the data collection for checking missing information or error if any made during the data collection. Whenever any such issues were evident re-interview was conducted on the following day for necessary amendment.

Intervention

The WASH intervention aims to offer its components to 37.5 million people in 150 sub-districts (BRAC 2008). The intervention is offered in the community, religious and social educational institutions. The intervention package includes promotional activities for installation of sanitary latrines and tubewells. To facilitate sanitation and hygienic practices health education is provided intensively in various settings. The component of health education consists of awareness about i) washing hands with soap/ash/soil after defecation; ii) washing hands with soap before eating, before serving food to the household members and children; iii) using safe water for cooking,

washing and bathing; iv) keeping surroundings of the households, kitchen, tubewells and latrines tidy; v) to construct platform of the tubewells with solid materials; vi) disposal of domestic waste, excreta of poultry and livestock in fixed place and disposal of children faeces in sanitary latrine; and vii) to preserve foods with appropriate cover.

To facilitate intervention activities village WASH committees (VWC) were formed in the intervention areas. The committees consist of teachers, elite, religious leaders and generous people of the community. These committees motivate people to use safe water, and improve sanitation and hygienic practices. They also generate funds from the community for helping ultra poor households for construction of sanitary latrines and tubewells. WASH programme also provides financial support to the ultra poor for constructing sanitary latrine in the villages where ≥80% households possessed sanitary latrines. BRAC staff maintains liaison with government staff and union council representatives to make available water and sanitation-related hardware resources for the community people.

The intervention protocols are provided through organizing cluster meetings in the villages including men, women, adolescents, children and village leaders. Preventive home visits (PHV) are provided to enhance the intervention activities. Other dissemination methods include popular theater, film shows and folksongs. Educational campaigns are disseminated also through radio and television. Sanitation month is celebrated through organizing workshops, rallies, sanitation fair and debate competition to make aware about water, sanitation and hygiene practices. In implementing intervention activities voluntary health workers (*Shaysthyo shebikas*), programme organizers, programme assistances and managers are assigned. To oversee the activities of the staff who have been implementing the intervention protocols senior levels staff are employed from both regional and head offices.

Outcome

Self-reported diarrhoea, dysentery, jaundice, worm infections and typhoid fever were considered as marker of waterborne diseases.

Independent variables

Chronological age, education, economic status and place of residence of the study participants are considered as independent variable. Age was categorized into two groups such as under-five and five and above years. Educational status was grouped as literate and illiterate. Persons who reported to attend schools are considered as literate otherwise illiterate. In the multivariate logistic regression analyses educational status is excluded as literacy status was not applicable for under-five children. Economic status was stratified as ultra-poor, poor and non-poor. For details about the categorizations please see WASH baseline report (BRAC 2008). Place of residence of the study participants are divided into four administrative divisions i.e. Rajshahi, Khulna, Dhaka and Chittagong according to the government guideline. These are located in the north-west, south-west, central and south-east regions of the country respectively.

RESULTS

Profile of the study participants

Among the study participants the proportion of men and women was equal. The under-five children comprised 14% of the total population. The majority of the participants were literate and more than half of the participants were non-poor. A higher proportion of participants represented from the north-west region compared to other three regions (Table 1). The proportion of illiterate and ultra poor was significantly higher among women than men.

Table 1. Profile of the study participants (%)

Indicators	%	n
Sex		
Women	50.2	61,928
Men	49.8	60,978
Age group	13.9	17,101
<5 years old	86.1	10,5801
≥5 years old		
Literacy	65.7	76,149
Literate	34.3	39,791
Illiterate		
Economic status	17.4	21.328
Ultra poor	26.3	32,297
Poor	56.3	69,145
Non-poor		
Place of residence	58.1	71,366
North-west	20.0	24,548
South-west	11.2	13,794
South-east	10.7	13,198
Central		

Status of sanitation and hygiene indicators

Table 2 indicates that a significant improvement was noted in all the selected indicators over time. The improvement was pronounced across the ultra-poor, poor and non-poor. It also shows that use of sanitary latrine was low across the groups. In each indicator a considerable number of households were found to be with unclean latrines and tubewells.

Table 2. Use of sanitary latrine, cleanliness of latrines and tubewells at baseline and follow-up (%)

Indicators*	Ultra poor		Poor		Non-poor	
	Baseline	Follow-up	Baseline	Follow-up	Baseline	Follow-up
Use sanitary latrine during monsoon						
Men	19.7	29.5	24.9	35.1	38.2	47.9
Women	21.0	31.0	25.5	35.9	39.2	48.8
P value	<0.001		<0.001		<0.001	
Bad smell found in latrine	65.9	53.0	69.2	52.9	59.4	44.6
P value	<0.001		<0.001		<0.001	
Latrine was found clean	30.2	46.4	28.7	46.3	36.4	53.9
P value	<0.001		<0.001		<0.001	
Shoes kept near the latrine	2.8	5.9	2.2	5.5	5.9	10.1
P value	<0.001		<0.001		<0.001	
Platform of the tubewell was found clean	23.1	31.1	23.6	34.5	30.8	43.9
P value	<0.001		<0.001		<0.001	

Changes in prevalence of waterborne diseases

At baseline, significantly higher proportion of women reported waterborne disease compared to men. At follow-up no significant difference was noted between men and women in terms of the prevalence of these illnesses. It also shows that prevalence was significantly higher among the illiterate compared to literate in both the study periods. Prevalence was significantly higher among under-five children at baseline and follow-up compared to ≥5 years old population. This was almost three times higher at baseline and double during follow-up compared to the other age group. At follow-up the prevalence was significantly reduced across all the groups. In both the study periods, prevalence was significantly low among those who reported to use sanitary latrine (Table 3).

Table 3. Prevalence of self-reported waterborne diseases by various indicatros and study periods (%)

Indicators	At baseline	At follow-up	p value
Sex			
Men	9.4	7.2	<0.001
Women	9.7	7.1	<0.001
P value	<0.05	ns	
Literacy			
Illiterate	9.2	6.7	<0.001
Literate	7.3	5.8	<0.001
P value	<0.001	<0.001	
Age group			
< 5 years old	21.5	12.9	<0.001
≥5 years old	8.1	6.2	<0.001
Status of latrine use			
Use sanitary latrine	8.5	6.3	<0.001
Use unsanitary latrine	10.1	7.7	<0.001
P value	<0.001	<0.001	

In both the study periods the prevalence of waterborne diseases was significantly higher among the ultra poor compared to the non-poor. No significant difference was noted between the ultra poor and poor in both the periods. The prevalence was found to be significantly decreased across the groups at follow-up (Table 4).

Table 4. Prevalence of self-reported waterborne diseases by economic status and study periods (%)

Study period	Ultra poor	Poor	Non-poor	p value	
	1	2	3	1 vs 2	1 vs 3
Baseline 2006-07	10.8	10.3	8.9	ns	0.001
Follow-up 2009	7.6	7.8	6.7	ns	0.001
P value	<0.001	<0.001	<0.001		

Table 5 indicates that at baseline the prevalence of self-reported waterborne diseases was significantly higher in the central region (Dhaka division) compared to the other three regions. In follow-up the prevalence was found to be higher in the south-west (Khulna division). In the south-east (Chittagong division), the prevalence was lowest than other three divisions in both the study periods. Prevalence was significantly decreased across four regions since the baseline.

Table 5. Prevalence of self-reported waterborne diseases by place of residence of the participants and study periods (%)

Study period	South-west	Central	North	South-east
Baseline 2006-7	10.9 (27,607)	11.2 (15,674)	9.3 (76,767)	7.3 (15,490)
Follow-up 2009	8.6 (24,477)	7.5 (13123)	6.7 (71,103)	6.6 (13,705)
P value	<0.001	<0.001	<0.001	<0.05

Figures in the parentheses indicate numbers

Predicators of waterborne diseases

To examine the predictors of prevalence of waterborne diseases three models were constructed. The model I represents baseline, model II follow-up and model III combined information. In the first two models same covariates were included. However, in model III additional covariate includes the study period. It indicates that at baseline women were more likely to report waterborne diseases. Among the under-five children probability of reporting waterborne disease was significantly higher at both points of time. Non-poor were less likely to report waterborne diseases compared to the ultra poor both at baseline and follow-up. In all three models protective effect of sanitary latrine was noted for these medical conditions. Participants from the central, north-west and south-east regions were less likely to report these medical conditions compared to the south-west. Finally, model III clearly shows that at follow-up prevalence was significantly lower compared to baseline (Table 6).

Table 6. Odds ratios of reporting self-reported waterborne diseases

Covariates	Model I 0R (95% CI)	Model II 0R (95% CI)	Model III 0R (95% CI)
Sex			
Men	1	1	1
women	1.05 (1.01-1.09)*	0.97 (0.95-1.0)	1.0 (0.99-1.1) 2.0
Age			
≥5 years old	1	1	1
<5 years old	3.1 (3.0-3.2)*	2.2 (2.1-2.4)*	2.7 (2.6-2.8)*
Economic status			
Ultra poor	1	1	1
Poor	0.96 (0.91-1.0)	1.0 (0.96-1.1)	1.0 (0.95-1.0)
Non-poor	0.85 (0.81-0.89)*	0.9 (0.85-0.95)*	0.9 (0.86-0.92)*
Status of latrine use			
Use unsanitary latrine	1	1	1
Use sanitary latrine	0.9 (0.8-0.9)*	0.84 (0.8-0.9)*	0.86 (0.8-0.9)*
Place of residence			
South-west (Khulna division)	1	1	1
Central (Dhaka division)	0.99 (0.93-1.1)	0.83 (0.77-0.9)*	0.9 (0.86-0.9)*
North-west (Rajshahi division)	0.81 (0.78-0.85)*	0.74 (0.70-0.78)*	0.78 (0.75-0.8)*
South-east (Chittagong division)	0.63 (0.59-0.68)*	0.73 (0.67-0.79)*	0.67 (0.64-0.72)*
Study period			
Baseline	-	-	1
Follow-up			0.7 (0.69-0.7)*

* indicates statistical significance

DISCUSSION

This study demonstrates that the prevalence of waterborne diseases has significantly decreased over time in the WASH intervention areas. The findings corroborate with previous research (Fewtrell and Colford 2005; Fewtrell *et al*. 2005). Sex difference disappears in terms of prevalence of waterborne diseases at follow-up, which might be an outcome of women-focused intervention offered by the government and non-governmental organizations. It is well known that to increase enrolment and literacy of women, targeted intervention has been implementing over the last few years, which may have an impact on the outcomes. Evidence shows that the educational status and health outcomes are strongly associated. Elimination of sex difference has social implications in a society where better health care is less likely and use of healthcare during illness is infrequent among women (Young *et al*. 2006).

Although equity gains in some indicators inequity persisted between literate and illiterate, poor and non-poor. This is likely as better hygienic practices might be common among the non-poor as they afford to buy appropriate commodities such as soaps for managing hygiene. Similarly it might be anticipated that persons who attended schools are aware of susceptibility of diseases thereby more likely to pursue preventive measures. A disparity between socioeconomic status with prevalence of diarrhoea was found in previous research (Emch 1999; Hasuizume *et al*. 2008). Another inequality was observed between place of residence of the participants, and such variation in health outcomes is documented in many studies (Murray and Schaller 2010; Narayan and Sarah 2005). Hence, to determine inequality between the geographical regions stratified analysis is suggested which helps in allocating resources.

It revealed that the under-five children are more likely to get these medical conditions irrespective of economic status. Another research also indicates that children from all socioeconomic groups are prone to get waterborne disease (BRAC 2008). This might be due to fact that knowledge on child healthcare is inadequate among the caregivers across all the economic strata. This is likely as significantly higher proportion of respondents do not wash hands with soap before providing food to children and even do not wash their hands with soap after cleaning bottom of children (BRAC 2008). Exposure to these unhygienic activities is certainly risk factors of waterborne diseases (Aunger *et al*. 2010).

This study highlights that preventive healthcare regarding the root of transmission of waterborne diseases needs to be addressed meticulously for controlling waterborne diseases. Providing preventive home visits in the households with under-five children might be useful to provide instructions about appropriate child care to optimize the benefits of intervention. Research indicates that preventive home visit is justified by the health outcomes (Lee *et al*. 2003). Beyond these, nutritional status of children and zinc treatment during episodes of diarrhoea should be considered (Larson 2009; Baqui *et al*. 2002). Considerable span of birth-spacing among currently married women in reproductive age might have a positive effect on incidence of waterborne diseases due

to less burden of child care. Prevention of waterborne diseases is of necessary to reduces under-five child mortality and morbidity, and to minimize its related medical expenditure. In Bangladesh, it has been projected that to reduce the burden of diarrhea alone about taka 15 thousands million is needed in referral care and 57 thousands million taka in primary care for the government during 2009-2015 (GED 2009).

Some methodological aspects of this study are discussed before the conclusions, which should be considered during interpretation of the results. A weakness of this study is that data collection periods of two surveys were different i.e. baseline was done between November-March while follow-up during April-July, which may have an impact on the prevalence of waterborne diseases. Research shows that incidence of waterborne diseases varies between seasons (CCC 2008). However, as these medical conditions are common round the year effect might be minimal. Another weakness of the study is absence of control group. Nevertheless, availability of baseline information and random selection of the study participants allow arguing that changes are due to intervention. The strengths of the study include separate teams of field investigators were formed for data collection during baseline and follow-up which may help avoiding information bias. Recall period of diseases was limited to last 15 days from the date of interviews as limiting recall period in short span provides precise estimation of the illnesses.

This study underlines that to reduce waterborne diseases in rural areas water, sanitation and hygiene intervention provide substantial role. Attenuation of prevalence of waterborne diseases might reduce child mortality and impact on economic status of the households where out-of-pocket medical expenditure is common.

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