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Eliminating Arsenic Consumption: Switching Drinking Water Sources through Intensive Awareness Programmes in Rural Bangladesh

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Chronic exposure of arsenic poisoning can cause adverse health effects including skin and lung cancer (Hopenhayn-Rich *et al.,* 1998). The process may take between five and fifteen years to reveal clinical manifestations of arsenicosis (Guha Mazumdar *et al.,* 1998). Human sensitivity to the toxic effects of inorganic arsenic exposure is likely to vary based on genetics, metabolism, diet, health status, sex, and other possible factors, and risk of toxic effects is high among children and malnourished people (National Research Council, 2000). Hundreds of millions of people have been exposed to arsenic contamination through drinking water in various countries of the world (Kamal and Chowdhury, 2002).

The problem of arsenic poisoning in the groundwater of Bangladesh has been described as the biggest mass scale poisoning in its history (Smith *et al.,* 2000). As large part of the population of the country has been drinking water contaminated with arsenic at concentrations >0.05 mg/l (Dhar *et al*., 1997; Biswas *et al.*, 1998; Khan *et al.*, 1997; Bagla and Kaiser, 1996), the permissible limit by the World Health Organization. About 95% of the approximately 120 million people drink tubewell water in Bangladesh drawn from alluvial aquifers underlying the Ganges and Brahmaputra delta (UNICEF, 1999; Hoque *et al.*, 2001). Some 30-70 million people of the country are thought to be exposed to this poisoning (Dhaka Community Hospital, 1998). More than 14,000 arsenicosis patients were identified and the figure is increasing with the progress of patient survey programme (Chowdhury, 2002). Apart from health, environmental and nutritional damage caused by arsenic poisoning, its

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socioeconomic consequences at family and community level are also crucial.

Provision of safe water for the arsenic exposed people in rural areas has become a challenge for a number of reasons. First, the water sources in rural areas in Bangladesh are individual tubewells mostly privately owned. The challenge, therefore, is to provide each of these families with individual household-based water supply system which seems not to be cost effective in terms of initial cost and monitoring aspects of water quality and/ or organise people to supply them with community-based options, which requires mass motivation towards community-based approach. The other problem is lack of a locally available, low-cost, and widely-accepted arsenic safe water supply system. Well-switching could be a viable options for significantly reducing arsenic exposure in short term (van Geen *et al.,* 2002). There are undoubtedly significant socioeconomic barriers to well-switching, since most wells are privately owned (Hanchett *et al.,* 2000). Convincing people to use a safe water source becomes a great challenge since people were once motivated to use tubewell water over the decades to avoid water born microbial diseases. Although Crane and Carswell reported that long-term behavioural change among the marginalized groups might be difficult through education only (Crane and Carswell, 1992), health communication through mass media has been found to be effective in raising knowledge and facilitating behavioural change (Valente *et al*., 1996). Duration of credit programme participation and exposure to the media are found to raise health knowledge significantly among women (Hadi, 2001). A study on the role of awareness raising activities on switching people over from unsafe to safe water sources is, therefore, expected to be useful for the policy makers and programme implementers in designing and implementing programmes on safe water supply in the arsenic affected areas of Bangladesh.

MATERIALS AND METHODS

Interventions of BRAC in the project area

BRAC, a non-governmental organization, conducted an action research project on community-based arsenic mitigation in Sonargaon and Jhikorgachha sub-districts of Narayanganj and Jessore districts respectively in Bangladesh from June 1999 to December 2001 (Chowdhury *et al.,* 2000). Although both the sub-districts are within the zone of severe arsenic contamination, substantial variation in physiography and manifestation of arsenicosis exist. Sonargaon is a lowlying area and is flooded every year. On the other hand, Jhikorgachha is usually flood-free area and is an area of relatively low rainfall.

A combination of approaches was used to raise people's knowledge about arsenic contamination and the consequences of drinking contaminated water on human health. The approaches included workshops and meetings with community leaders, service providers, school teachers and religious leaders, meetings with villagers, distribution of printed materials among the people and posting them at key public places, and the use of print and electronic media. People of these villages were informed of the status of arsenic poisoning in their locality as well as the possible remedies to the problem. Representatives of different stakeholders including block supervisors, tubewell mechanics, elected chairmen and members of Union Parishad (lowest administrative unit), school teachers, religious leaders, health and family planning workers, and workers of non-government developmental agencies attended the workshops.

During the project period, different types of safe water options including surface water treatment units, rain-water harvesting systems, chemical and non-chemical based filter systems, groundwater abstraction through wells and treatment plants were demonstrated to test their technical viability and community acceptance. The potential water options and their relative merits and demerits, costs, maintenance and the selection of possible demonstration sites were also discussed with the villagers. The villagers were also encouraged to participate in cost-sharing for safe water options. People's own evaluations were used to assess the efficiency of these options in the community. Local masons were trained to construct and manufacture these options. Selected arsenicosis patients were provided with *Carocet* tablets (combination of vitamin A, C, and E) and salicylic acid as an ointment. The community health workers of BRAC conducted the field level activities including testing of the tubewell water for arsenic, marking of the tubewell spouts with the appropriate signs of green (safe) and red (unsafe) paint, dissemination of messages, preliminary identification of arsenicosis patients, demonstration of safe water options and promotion of safe water use among the villagers.

The assumption was that all these interventions would lead to increased knowledge level that would help positive behavioural changes and motivate arsenic exposed people toward the use of safe drinking water.

Data source

The study was conducted in February 2002 in Sonargaon and Jhikorgachha sub-districts where BRAC implemented the community-based arsenic mitigation project. A thirty-cluster sampling technique was used to select study villages. Sixty villages, 30 from each of the sub-districts were selected randomly. In each village, 14 households were randomly selected from the households that were using arsenic contaminated tubewell water (marked with red sign while screening in 1999) for drinking. Thus, 839 households were selected from the study areas. Since women, in general, fetch water for drinking and cooking purposes in the rural areas adult housewives aged 15 years and above in the selected households were interviewed to ascertain their awareness level about alternative safe water options. Information on occupation and education of the household heads was also collected.

Statistical analysis

The study assessed the influence of several confounding factors like awareness of alternative safe water sources, education, occupation, socioeconomic status and capacity to purchase safe water options on motivating people to use safe water. Multivariate analysis was done to assess the net effects of the mitigation project on switching over to safe water sources. Logistic regression analysis was done to measure the main effects of various influencing factors on switching water sources.

Although the study aimed to measure the impact of the intervention of awareness raising on switching over from unsafe to safe water use among the people without considering the comparison area, the findings from the study should not be considered as a concrete conclusion for policy implication. However, confounding factors have been taken to control this variation.

RESULTS

Socio-demographic profile of the sample population

Table 1 shows the socio-demographic profile of the sample population. About 32% of the household-heads had never been to school. Most of the people (60%) were engaged in occupation of lower category like agriculture and labour. The rest of them were of high occupation group like service and business. From poverty self-assessment in terms of food, it appears that 35.6% were poor, 40% were average and the rest 24% were of high socioeconomic status. Around 79% mentioned that they had the capacity to buy alternative water options.

Insert table 1 here

Role of household factors and behaviour change

The role of household factors and behaviour change on the rate of switching from unsafe to safe water sources was determined (Table 2). About 47.6% of the people changed from the arsenic contaminated drinking water sources to safe water sources. The rate of switching was high (47.9%) among those who were aware of alternative safe water options than from those who were unaware. People with better education showed the maximum switching rate towards safe water use (55.1%) compared to those with no schooling (37%). High-level occupation and socioeconomic status influenced the maximum number of people (71% and 57% respectively) toward safe water use. About 56.5% of the people having the capacity to buy alternative water options switched from unsafe to safe sources, whereas 14.1% of the people having no capacity to buy alternative water options moved to safe sources.

Insert table 2 here

Role of socioeconomic status

People aware of alternative water options changed their unsafe water sources to safe sources almost three times in number than those who were unaware ($p<0.10$) (Table 3). Influence of education did not play any significant role in changing their behaviour of safe water use. High-level occupation played 1.5 times greater role in switching safe water use ($p<0.05$). The same trend was observed in case of high socioeconomic status compared to poor ($p<0.10$).

Insert table 3 here

Estimated probabilities of switching

Table 4 shows the estimated probabilities of switching to safe water sources by the combination of predictors. The highest probability of switching was shown by the people who were aware of alternative safe water options, poorly educated, high occupation, high socioeconomic status and having capacity to buy water options. It was interesting to note that better education along with all other positive predictors showed lower rate of switching probability compared to the probability of the previous combination. This seems that level of education, from poor to better, played no significant role in changing behaviour of water use. The chance to be switched from unsafe to safe water sources was estimated minimum (0.60) among the people if they were aware of alternative options, from the high socioeconomic status, poorly educated, had low occupation and had capacity to buy water options. The probability declined to 0.34 among those who were not aware of alternative options while other conditions remained same. This means that level of awareness about alternative safe water options played a major role in changing people's behaviour of safe water use.

Insert table 4 here

DISCUSSION

The discovery of arsenic poisoning in drinking water in Bangladesh has created concern for its potential health effects. Sinking of shallow wells saved thousands of lives from water borne diseases from drinking surface water over the years. The problem of arsenic poisoning arose at the time when the country was about to achieve the goal of safe water supply to more than ninety percent of its population, mostly through promotion of shallow wells and motivation to use tubewell water to avoid waterborne pathogens. This behavioural change of water use pattern among the people in the country required a lot of effort. Provision of safe water to the large number of population exposed to arsenic contamination has become a great challenge due to a general resistance to change water consumption and water management behaviour. In some parts of the country, it was also noticed that people were annoyed and confused when corrected information was communicated to them after receiving incorrect information (Hoque *et al.*, 1998). The hardest part of the arsenic mitigation programmes, therefore, seems to be convincing the arsenic exposed people not to use contaminated water. People have become puzzled with these messages since they were motivated to use tubewell water previously. Besides, many of the alternative water options are completely new to them and all these options have some limitations like dependency on chemicals and/ or continuous monitoring, and are not as easy as the hand-pumped tubewells. People's thinking of safe drinking water sources is still oriented to the simplest method like tubewells. Success in motivating people towards using arsenic-free water depends on the people's understanding as well as realizing the various aspects of arsenic problem. In addition, availability of the alternative safe water options and the capacity to buy these options are also vital factors in switching the arsenic exposed people to safe water sources.

The knowledge level of the people regarding arsenic issues in the study areas was found to vary. Almost all of the people were found to hear about arsenic contamination in their areas but they are not equally aware about different safe water options. The present study reveals that after intervention around 48% of the exposed people changed their unsafe water sources to safe sources of at least three options. This was much higher in comparison to one study conducted in 2000 in the mitigation villages where about 42% of people had the knowledge of at least two sources of arsenic-free water (Hadi 2003). The rest of the people are still at risk of potential health hazards although they are aware of their contaminated drinking water sources. It is also evident that awareness of alternative safe water options plays a vital role in switching over to safe water use. About 29% people not aware of safe water options changed their unsafe sources to safe sources using no alternative to tubewells. They moved to the nearest green marked safe tubewells for drinking. Therefore, tubewells found to be uncontaminated could be a potential safe water option for the exposed people in an area.

A comprehensive approach on raising awareness level on alternative water options and motivating towards using safe water is urgently needed to alert people to the problem as well as to avert further deterioration of the present situation. In addition, appropriate measures should be taken to make the water options available and increase the capacity of the people to buy safe waters. Both the government and non-government service providers should come forward with programmes to make the alternative water options available in the arsenic-affected rural areas of the country.

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Table 1: Profile of the sample household

Study variable	Percent	N
Education		
No school	32.3	271
Poor	35.3	296
Better	32.4	272
Occupation		
Low (agri/labour)	60.1	504
High (service/business)	39.9	335
Socio-economic status		
Poor	35.6	299
Average	40.3	338
High	24.1	202
Capacity to buy		
Cannot	21.1	177
Can buy	78.9	662
N		839

Table 2: Proportion of households switched to safe drinking water by socio-economic factors

Study variable	Proportion of switching
All	47.6
Aware of alternative water options*	
Unknown	28.6
Known	47.9
p value	n.s.
Education	
No school	36.9
Poor	50.3
Better	55.1
P value	<.01
Occupation	
Low (agri/labour)	41.3
High (service/business)	57.0
p value	<.01
Socio-economic status	
Poor	38.1
Average	47.9
High	60.9
p value	<.01
Capacity to buy	
Cannot	14.1
Can buy	56.5
p value	<.01

** A person was considered to be aware if s(he) could correctly mention at least 3 out of 12 safe water options, n.s., not significant*

Table 3: Regression results for selected indicators of switching to safe water

Predictor variable	B	Odds ratios
Aware of alternatives		
Unknown		1.00
Known	1.082	2.95*
Education		
No school		1.00
Poor	0.291	1.34
Better	0.222	1.25
Occupation		
Low (agri/labour)		1.00
High (service/business)	0.405	1.50**
Socio-economic status		
Poor		1.00
Average	0.211	1.23
High	0.398	1.49*
Capacity to buy		
Cannot		1.00
Can buy	1.956	7.07***
Constant	-3.301	
-2 Log likelihood	1026.2	
Pseudo R squared	0.20	

** p<0.10, *p<0.05 and ***p<0.01*

Table 4: Estimated probabilities of switching to safe drinking water by the combination of predictors

Combination of predictors	Estimated probabilities
1. Aware of alternative sources, better educated, high occupation, high SES* and had capacity to buy	0.68
2. Aware of alternative sources, poorly educated, high occupation, high SES and had capacity to buy	0.70
3. Aware of alternative sources, poorly educated, low occupation, high SES and had capacity to buy	0.60
4. Not aware of alternatives, poorly educated, low occupation, high SES and had capacity to buy	0.34
5. Not aware of alternatives, poorly educated low occupation poor SES and had no capacity to buy	0.05
6. Not aware of alternatives, not educated, low occupation, poor SES and had no capacity to buy	0.04

* *Socioeconomic status, Note: Above probabilities are calculated from the estimated coefficients in Table 3 by using the following equation:*

$p=exp(a+\Sigma bi\ xi)/[1+exp(a+\Sigma bi\ xi)]$