ADOPTION OF ARSENIC-SAFE DRINKING WATER PRACTICE IN RURAL BANGLADESH: AN AVERTING BEHAVIOR MODEL

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ABSTRACT

The aim of this paper is to analyze the factors that influence adoption of safe drinking water practices in arsenic affected rural Bangladesh. In this study, households from two severely arsenic contaminated areas of Bangladesh were asked about their behavior and actions to reduce potential health risk associated with drinking the contaminated water. Based on averting measures undertaken by households to reduce potential health risk, the paper analyzes the factors that influence households' decision to collect water from arsenic free sources using a binary logistic model. Among all explanatory factors included in the model, awareness of health consequences from drinking arsenic contaminated water and ownership characteristics of safe drinking water sources had the highest explanatory power. Households that are aware of negative health consequences of drinking arsenic contaminated water are more likely to adopt safe drinking water practices. Furthermore, places where safe drinking water option is owned by Government (GO) and/or Non-Government (NGO) organizations, households are more likely to collect water from arsenic free sources compared to places where available safe drinking water options are privately owned. The relevance of the explanatory variables in the estimated model suggests that effectiveness of 'arsenic safe drinking water adoption campaign' requires raising awareness about health risk associated with drinking arsenic contaminated water. As access to print media (like newspaper) is constrained by high level of illiteracy in the rural areas, radio and TV must play a more important role in publicizing negative health consequences of drinking arsenic-contaminated water.

Introduction

The World Health Organization (WHO) considers the widespread arsenic contamination of tube well water in Bangladesh as a public health emergency (Smith et al. 2000). A majority of shallow tube wells that used to be the primary source of drinking water for rural inhabitants in Bangladesh have recently been found to contain arsenic levels that are higher than safe levels. According to conservative estimates by WHO, five to ten million tube wells in Bangladesh may be contaminated with arsenic. Estimates show that 265 out of 469 upazillas (sub-districts) in Bangladesh are now affected (DCH, 2002) and 20-30 million people live close to a contaminated well (World Bank, 1999). Long term consumption of arsenic contaminated water leads to serious health effects including localized gangrene and cancers of skin, lung, bladder and kidneys. Bangladesh Arsenic Mitigation Water Supply Project screening team found 1.1 cases of arsenicosis per thousand people (BAMWSP, World Bank 2002).

The government, along with some leading NGOs, installed arsenic safe drinking water options like deep tube well, filtered pond-water system (pond sand filter), rain water harvesting system, and dug wells in highly arsenic concentrated areas. The installations of safe drinking water options were mainly community based (one safe drinking water option for each community consisting of approximately fifty families) and supply driven instead of being demand driven (Implementation Plan for Arsenic Mitigation in Bangladesh, 2004). For quite a long period the government, NGOs, and other development organizations have been campaigning to encourage rural households to adopt arsenic-safe drinking water practices. However, the response from the households has been less than expected. Even when community-based safe drinking water options and household techniques to remove arsenic from drinking water are available, none of these have been widely adopted either because of their cost or perceived inconveniences. The question therefore is why do some households choose to collect water from arsenic-safe options or choose to treat water using arsenic removal techniques, while other households continue to use arsenic-contaminated sources. From a policy perspective, it is urgent to investigate what factors induce rural households most in adopting arsenic safe drinking water practices.

The purpose of this study is to empirically examine the factors that induce safe drinking water practices in rural Bangladesh. In a large-scale survey carried out toward the end of 2005, more than nine hundred households in two highly arsenic concentrated upazillas (sub district) of Bangladesh were asked about their drinking water practices. The study revealed that 'awareness of arsenic related health risk' (measured through respondent's stated knowledge about negative health consequences of drinking arsenic contaminated water) is the most powerful indicator for adoption of safe drinking water option. The study further revealed that awareness is highly correlated with the education of adult male and female family members and respondents' exposure to print and electronic media.

The remainder of this paper is organized as follows. The next section discusses the relevant literature on averting behavior, followed by development of the model of the present study. Next, a description of the case study area is provided, followed by the methodology, including a description of the general survey and sample characteristics. Output from the regression analysis, the conclusions and recommendations follow subsequently.

Averting Behavior Approach of Safe Drinking Water Adoption

The literature on averting behavior is divided into two major branches: one calculates averting expenditures in an attempt to measure a lower bound on Willingness to Pay (WTP), while the other estimates determinants of averting behavior (Whitehead et. al., 1998). A number of averting expenditure studies have measured average monthly expenditure made by households to avoid health risk associated with contaminated water. A study carried out by Harrington et al. (1989) found that nearly one hundred percent of the sample households adopted a combination of different water purification methods like hauling water, boiling water, and/or purchasing bottled water. The estimated averting expenditure per month on averting measures varied from \$153 - \$483 in 1996 price. A similar type of study carried out by Abdalla (1990) obtained substantially different results in terms of averting expenditure. The survey conducted by Abdalla in Pennsylvania revealed that seventy-six percent of the sample households adopted more than one water purification technique and the estimated average monthly expenditure on averting measures ranged between \$26-\$32. The estimated average averting expenditure in rural West Virginia ranges from \$32 and \$36 per month in a study by Collins and Steinback (1993) and between \$16 and \$35 per month in the study by Laughland, et al. (1993).

A considerable literature exists in the second branch of averting behavior study that focuses on determinants of averting behavior. A study carried out by Smith and Desvousges (1986) found that the adoption of water purification techniques depends on perceived health risk from contaminated water, age of the respondents, smoking habits, and respondent's subjective rating of their water supply safety. Abdalla et al. (1992) showed that households' averting action depends on information about water quality, perceived health risk, and the number of children in the household. Laughland et al. (1996) found that perceived convenience of averting behavior measure largely determines averting behavior. An empirical examination carried out by Whitehead et al. (1998) revealed that respondents' awareness about negative health impact of contaminated drinking water increases the probability of safe drinking water adoption. The study also indicated that the perceived quality of present drinking water and respondents' level of education act as strong determining factors of safe drinking water practice. Jalan et al. (2003), based on a sample drawn from Delhi population, argued that listening to radio and reading newspaper increased likelihood of safe drinking water adoption. Dasgupta (2001) and McConnell and Rosado (2000) used data from Delhi and an urban area in Brazil respectively to show that education of the household head is statistically significant in a household's decision to purify drinking water.

We are not aware of any previous research in Bangladesh investigating household's decision of adoption of safe drinking water practices. The existing literature on safe drinking water practice in Bangladesh consists of one contingent valuation study by Ahmad et al. (2004). The study measured benefit of arsenic-safe drinking water to the rural people and concluded that rural people in arsenic-affected areas of Bangladesh place a low value on arsenic-free drinking water (estimated benefit from arsenic safe drinking water was only 10 to 14 percent of the cost of safe water supply). Furthermore, the study reveals that WTP for arsenic safe drinking water varies significantly with different levels of awareness, household income, the level of education, and occupation of household heads.

The Model

Water collection in rural Bangladesh traditionally has been free of cost. In our case study area, expenditure data on safe drinking water do not truly reflect averting behavior (if a household does not spend money for water collection/purification it does not mean a lack of averting behavior). In most of the cases, GOs and NGOs installed safe drinking water options without any charge or fee. Other than GO/NGO installed water sources, households collect water from neighbors' tube wells which are cost free options as well. Given the partial and incomplete nature of payment for drinking water collection in our study area, estimation of lower bound of willingness to pay for collection of drinking water seems methodologically inappropriate. As a result, the study aims to focus on determination of factors that influence adoption of safe drinking water practice rather than estimation of lower bound of WTP.

The theoretical model of this study is based on standard microeconomic principles and previous research. Existing empirical literature shows evidence that respondents' perceived health risk from contaminated water has a significant impact on household decisions to adopt safe drinking water practices (Smith and Desvousges 1986; Abdalla et al. 1992; Whitehead et al. 1998). Moreover, the perceived convenience of averting measures has been found to play a role in decision to adopt safe drinking water practices (Laughland et al. 1996). Some socio-economic and demographic characteristics (i.e., education, income, occupation, etc.) were found to have a significant impact on a household's choice of drinking water sources. The context of the present case study requires the testing of an additional explanatory factor: the ownership of drinking water source.

In our model, health risk exposure is measured through people's source of water collection: households that collect drinking water from arsenic contaminated sources are exposed to arsenic related health risk and vice versa. Household may reduce their risk exposure to zero level by switching to an arsenic safe water source. In the case study area, a household does not incur any monetary cost for switching to arsenic safe water source; so the only impediment that may explain households' behavior for not adopting safe drinking water practice is 'inconvenience'. Several factors may contribute to 'inconvenience', i.e. psychological adjustment cost of changing from a water option to which the households have been habituated for a long time, the different taste of water collected from the new water source, the psychological adjustment cost of traveling to a different place or house (courtyard) for water collection, opportunity cost of time to travel the extra distance, and restricted access to safe drinking water sources. We assume perceived health risk is a function of awareness level (knowledge about health risk associated with arsenic contaminated water) and realized health risk (family members affected by arsenicosis disease increases health risk perception).

Each household "i" chooses between drinking water from contaminated but convenient source or collecting water from an arsenic safe source by undertaking 'inconvenience cost'. Let q^0 and q^1 be denoted by arsenic contaminated water and arsenic safe water source respectively; 'Y' denotes yearly average household income; 'R' indicates the arsenic related health risk exposure which is a function of respondent's awareness (denoted by A) and realized health risk (denoted by H); other socio-economic characteristics of the respondent/household are denoted by vector S. The utility functions associated with decisions regarding water collection from different sources can be written as:

Arsenic contaminated source

$$U^0 = v^0 (q^0, Y, R (A, H), S, e_0) \quad (1)$$

Arsenic safe drinking water source:

$$U^1 = v^1(q^1, Y, I, S, e_1) \quad (2)$$

e_i is a residual that captures unobserved household characteristics and errors in optimization. The "e_i"s are assumed to be identically and independently distributed. 'I' is the inconvenience vector that includes all factors that discourage households from adopting safe drinking water practice. A household's utility decreases in both with increases in 'inconvenience cost' and 'health risk exposure'. Again, 'health risk exposure' and 'inconvenience cost' are mutually exclusive within a household's utility function as we assume adoption of arsenic safe drinking water practice reduces arsenic related health risk to zero. A household's decision to adopt safe drinking water practice depends on the utility obtained from reduced health risk and disutility obtained from incurring psychological 'inconvenience cost'. We assume that a household's marginal utility gain from health risk reduction is at least equal to or higher than the marginal utility loss incurred by the inconvenience cost of safe drinking water collection $[(\partial U/\partial R) \geq (\partial U/\partial I)]$. As a household's perceived health risk largely depends on awareness level of health risks from arsenic-contaminated water, it might be expected that higher awareness level will contribute to higher disutility from health risk exposure to households who collect water from arsenic contaminated sources and hence a risk reduction by adopting safe drinking water practice will cause higher utility gain. Hence, the marginal utility gained from incurring 'inconvenience cost' will vary across awareness levels. Respondents/households will choose to collect water from arsenic-safe source only if:

$$v^1(q^1, Y, I, S, e_1) \geq v^0 (q^0, Y, R(A, H), S, e_0)$$

Based on the above theoretical reasoning, a household's decision to adopt arsenic safe drinking water option can be elaborated for this specific study in the following form:

A household's decision to bear inconvenience costs in order to reduce arsenic related health risk exposure is expected to depend on several factors. First, the decision to collect water from an arsenic safe source is expected to be positively related to awareness of arsenic related health consequences. Second, safe drinking water practice is expected to be influenced by household characteristics such as education level of adult male and female household members, occupation of heads of households, and types of latrine used by household (an indicator of health consciousness). Again, it could be expected that all these household characteristics are highly and positively correlated with household income level. Therefore, we expect household income to have a positive impact on the adoption of safe drinking water practice. Third, the number of times a household collects drinking water is expected to be negatively related to the dependent variable based on the assumption that the higher the number of times a household collects drinking water, the higher is the inconvenience cost and hence it leads to the household being discouraged from adopting safe drinking water option. Furthermore, we expect ownership of safe drinking water option to be an important determining factor of safe water practices since access to drinking water option in rural areas is largely dependent on ownership type. The functional form of the model to be estimated can be written in the following form:

$$D = f(INCM, AWARE, NGO\_D, NTIMES) \quad (3)$$

The binary variable D is the indicator for whether or not a household adopts safe drinking water practices (D=1; if household collects water from arsenic safe option or use home purification technique; D=0 otherwise) where,

(i) INCM= total annual household income (in thousand taka) from all sources
(ii) AWARE=knowledge about arsenic related health consequence (Aware=1, Not Aware=0)
(iii) NGO_D=GO and NGO owns arsenic safe drinking water technology (GO/NGO owns drinking water technology=1, otherwise=0)
(iv) NTIMES=number of times households collect water per day

General Survey and Sample Characteristics

Survey set-up and Sampling Procedure

Data for the Averting Behavior study was taken from a sub-sample of an extensive rural household survey looking at the sustainability of different arsenic-free drinking water options in some severely arsenic-affected upazillas (sub districts) of Bangladesh. Study sites for the original study were selected after studying available information about arsenic concentration levels, the number of arsenic-affected people, and GO/NGO interventions in different upazillas of Bangladesh. We selected fifteen villages from two unions of Sonargaon (Narayanganj), and nine villages from three unions of Hajiganj (Chandpur) as they cover two different highly arsenic concentrated areas of the country and also are similar in nature and degree regarding interventions by GOs and NGOs. Sonargaon Upzilla is only thirty kilometers (km) away from Dhaka City beside the Dhaka-Chittagong highway. Hajiganj Upazila is situated 95 km southeast of Dhaka City in the southeastern part of Bangladesh under Chandpur district: 90% of the tube wells in both upazillas are arsenic contaminated. The Department of Public Health Engineering (DPHE) installed deep tube wells, tara pumps, pond sand filters, rainwater harvesters, ring wells etc. in Hajiganj. BRAC (Bangladesh Rural Advancement Committee) installed (and provided) both community (and household based) arsenic free and arsenic removal technologies in Sonargaon in association with DPHE and UNICEF. For details of the study area see Table 1. Villages were selected from upazillas that met the criteria of having high arsenic concentration, where there is a drinking water problem due to arsenic, and where they have ongoing external mitigation projects. Systematic random sampling method was used to select households for the study. In each para (a small village unit consisting of around fifty households), every fifth household located near an arsenic-free drinking water option was interviewed. For details of the area-wise distribution of sample, see Table2.

For this study, a subset of approximately nine hundred and thirty five households was selected from the original sample of 2,000 households surveyed for the sustainability study. The head of the selected household was administered a structured questionnaire in a face-to-face interview that lasted approximately 30 minutes. Primary data were collected from mid-December 2005 until mid-January 2006. The household survey was developed by the research team in mid November 2005 and was finalized after two pretests on fifty respondents in Nilkanda village of Sonargaon (Narayanganj) and Putia village of Daudkandi (Comilla). The eleven field interviewers were trained before administering the questionnaires in the pre-test and main survey sites.

Items in the questionnaire were organized around several variables. The first set of questions referred to socio-economic characteristics such as the main profession of the family, family size, education level etc. Questions that addressed averting behavior asked respondents about:

- Household's present source of drinking water;
- The respondent's knowledge about the presence of arsenic in past and current drinking water sources;
- Whether or not the household was aware of the consequences of drinking water from arsenic-contaminated sources.

One of the averting behavior questions was: Do you collect drinking water from arsenic-contaminated source? (YES or NO). Households who said 'no' were subsequently asked what alternative arrangement they had made after their previous drinking water source was found to have a level of arsenic higher than the safe level. Households were then asked a series of questions regarding features of safe drinking water options, i.e. how long had the household been using safe drinking water option, who was the owner of the water option, and the cost of water collection.

Basic Statistical Results of the Survey

An upazilla-wise summary of socio-economic and demographic variables is presented in Table 3. Of the nine-hundred and thirty-five respondents interviewed, the average household consisted of about six family members, of whom more than one (usually male) member is earning an income. The average age of the respondent is around 40 years. About ninety six percent of the households interviewed were Muslims and the rest were Hindus. Only 46% of household heads completed at least 5 years of primary education, 33% of households depended on agricultural activities for their primary income, principally crop production, livestock rearing, and open water fishing, and the remaining households relied on a salaried job or trading as a source of income. Almost all houses are made of tin (both roof and walls) and around half of the sample households (55%) use sanitary latrines. Around eighty percent of the sample households have electricity connection in their dwellings. The5% trimmed average annual household income is about seventy three thousand Taka ($1091), while half of the households have per capita income per month of Taka 962 ($14) which is close to the national per capita average rural income (Taka 924: BBS, 2005).

Ninety-nine percent of the respondents indicated that it is very important for them to ensure arsenic-free drinking water for their family. However, only forty percent of the respondents said they were aware of the negative health consequence of drinking water from arsenic-contaminated sources. A majority (87%) had their tube wells tested for the presence of arsenic under the screening programs undertaken by GO and NGOs, and in fifty percent of the cases the tests turned out to be positive (arsenic above the safe level). Households that did not test for arsenic in their drinking water source indicated that no one had ever come to test their drinking water source and that they did not know how to and where to get the test done. Eight percent of the households had at least one family member affected by arsenicosis disease and one-third of them had more than one family member affected.

Correlatiosn among different variables

When relating respondents' stated knowledge about awareness of arsenic-related health consequences to socio-economic characteristics of household, a number of interesting results were obtained (see Table 4). First, on arsenic related health awareness male respondents seemed more aware of arsenic related health impact than female respondents. Second, educational attainment of adult male ($r=0.308$; $p<0.01$) and adult female family members ($r=0.266$; $p<0.01$) in the household are positively correlated with respondent's arsenic-related health awareness level, implying that the higher the educational attainment (in number of years of schooling) of male and female adult family members, the more likely the respondent is aware of arsenic-related health impacts.

Table 1: Details of Study Site

Division	District	Upazilla	Unions	% TW Contaminated
Chittagong	Chandpur	Hajiganj	Purba Barkul	97
			Uttar Rajargaon	96
			Hatila	96
Dhaka	Narayanganj	Sonargaon	Aminpur	75
			Sonmandi	89
			Uttar Rajargaon	96

Table 2: Distribution of Sample Across Study Area

Upazilla	Frequency	Percent
Sonargaon	601	64.1
Hajiganj	337	35.9
Total	938	100.0

Table 3: Upazilla Wise Summary of Socio-Economic and Demographic Characteristics of Sample

	Sonargaon	**Hajiganj**
Number of households	601	337
Mean yearly income (in Tk)	84599	89342
Mean calorie consumption per person/ day (in Kcal)	3497	3197
General characteristics		
Respondents age	37	42
Occupational distribution (%)		
Farmer, fisherman, forestry & livestock	38	30
Salesman, trader and transport worker	33	26
Service holder and professional	14.2	29
Day laborer	11.8	11.5
Others	3	3.5
Educational qualification (%)		
Illiterate	31.3	10.1
Primary school (Class 1-5)	26.6	31.2
Average family size (in numbers)	5.44	6.05
Family members generate income (in numbers)	1.37	1.62
Main material of the walls (%)		
Brick/Cement	15.6	11.6
Tin	83.5	78.5
Main material of the roof (%)		
Tin	92.7	88.1
House having electricity (%)	95.3	59.6
Source of energy (%)		
Wood/Coal	78.8	96.5
Type of latrine used (%)		
Sanitary	42.4	76.7
Respondents read newspapers daily (%)	10.3	17.5
Respondents listen to radio prog./news daily (%)	16.6	63.2
Respondents watch BTV prog./news daily (%)	65.5	41.8

As expected, a positive relationship was found between respondents' exposure to different types of media (both print media and electronic media) and arsenic-related health awareness. This indicates that the higher the respondent's exposure to both print and electronic media, the higher is the health-related awareness level. Amongst the different types of media, print media was found to have the highest positive correlation (0.301, $p<0.01$) to awareness of arsenic-related health consequences. Furthermore, the type of latrine used by households was found to be positively and significantly correlated (0.275, $p<0.01$) with arsenic-related health awareness level, indicating that respondents who have sanitary latrines have a higher level of knowledge about the negative health impact of drinking arsenic-contaminated water than respondents who do not have sanitary latrines in their house. Finally, we found a statistically significant (Mann-Whitney Z statistic equals –9.116, $p<0.001$) relationship between respondents awareness level and a household's yearly total income (respondents who belong to a high income household are more aware). This result is not surprising as all the variables that are correlated with awareness are also positively correlated with income level (see Table 5).

Table 4: Correlation between Awareness about Arsenic Related Health Consequences and Some Socio-Demographic Variables

	Awareness	Education level of male adult family members	Education level of female adult family members	Respondent's sex	Respondent's age	Type of latrine use	Any family member affected by arsenicosis	Read newspaper at least once in a week	Listen to radio program at least once in a week	Watch TV program at least once in a week
Awareness	1									
Education level of male adult family members	0.308**	1								
Education level of female adult family members	0.266**	0.611**	1							
Respondent's sex	0.154**	0.137**	0.000	1						
Respondent's age	0.054	0.153**	0.046	0.256**	1					
Type of latrine use	0.275**	0.412**	0.422**	0.045	0.090**	1				
Any family member affected by arsenicosis	-0.046	-0.079*	-0.076*	0.005	0.032	-0.094**	1			
Read newspaper at least once in a week	0.301**	0.382**	0.303**	0.197**	0.100**	0.300**	-0.036	1		
Listen to radio program at least once in a week	0.263**	0.253**	0.281**	0.026	0.099**	0.234**	-0.038	0.242**	1	
Watch TV program at least once in a week	0.150**	0.188**	0.184**	-0.015	-0.080*	0.115**	-0.010	0.172**	.097**	1

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

However, we failed to obtain any significant positive correlation between respondent's awareness level and incident of arsenicosis disease in the family. It was expected that respondents who have at least one family member affected by arsenicosis disease would be more aware about arsenic-related health consequences than respondents who did not have family members affected by arsenicosis. This finding can be explained by several factors. First, several variables (i.e. education level of adult male and adult female household members, and use of latrine type) that were found to have positive correlation with awareness, are significantly negatively correlated with incidence of arsenicosis disease in the family. Though the correlation is very low, it indicates households that have family members affected by arsenicosis disease are less health conscious (as they do not use sanitary latrine) and less educated (adult male and female family members have fewer years of educational attainment). Second, households that have family members affected by arsenicosis disease earn significantly lower average yearly income (Mann-Whitney Z statistic equals -1.923, $p<0.10$) than households that do not have any arsenicosis patient in the family. This result implies that relatively poor households are more likely to be affected by arsenicosis. Finally, the correlation coefficient between households having arsenicosis disease and all types of media exposure is negative, though the correlation coefficient is not significant at the ten percent level. Therefore, the fact that awareness and incidence of arsenicosis disease in the household do not have any positive relationship can be explained by lack of education, health consciousness, income, and insufficient access to media.

Factors Explaining Adoption of Safe Drinking Water Practices

Although all respondents indicated that ensuring the supply of arsenic safe drinking water for their families is very important for them, in practice less than two-thirds of the sample households collect drinking water from arsenic free sources. The most cited reasons for households not adopting safe drinking water practice (or not collecting water from arsenic free source) is 'safe water option is located far away from the residence (61%)' followed by reasons like 'arsenic level is not very high in my drinking water source (22%)' and 'I am not aware of the harmful health consequences of drinking arsenic contaminated water (13.3%)'. Ten percent of the households adopted household technology for arsenic removal from drinking water, and the most common household-based arsenic removal technology was the 'Three Pitcher Method' followed by the 'Bucket Filter' system.

Binary Logistic regression was applied to estimate effects of the explanatory variables on binary discrete choice to use water from arsenic free source. Table 6 summarizes results of the estimated regression models. We came up with two statistically significant models that differ because the two variables, household income and awareness level, could not be used together in the same model due to high multicollinearity. Both models turned out to be significant at less than one percent level (see Table 6 for likelihood ratio test) which implies that the models (as a whole) are significantly different from the one with constants only. The models have an identical predictive ability (73%). The Wald test statistics (commonly used to test significance of individual logistic regression coefficients) turned to be significant at less than five percent level for each independent variable identified in the theoretical model (see equation 3).

In the first model, household income, as predicted, has a significant positive impact on a household's safe drinking water adoption decision. Each one thousand taka increase in the annual income level increases the likelihood of adopting safe drinking water by 1.007. In the second model, awareness level about arsenic related health consequences was highly significant regarding safe drinking water adoption decision. Indeed, the awareness of arsenic related health consequences seems to have the highest explanatory power among all other variables included in both models. Households aware of the negative health consequences of drinking arsenic contaminated water are 1.7 times more likely to adopt safe drinking water practices. This finding is highly consistent with the theoretical set up of the study where it was predicted that high awareness level of households regarding arsenic-related negative health consequences will, in turn, cause high utility gain from health risk reduction from adoption of arsenic safe drinking water.

In both models, all other explanatory variables turned out to be significant with stable coefficient values and signs. The estimated coefficients in both models indicate places where GO and NGO intervention in terms of installation of safe drinking water technology took place, households are more likely to collect water from arsenic free sources compared to places where available safe drinking water options are privately owned. In privately owned drinking water options, neighbours' unrestricted access is not guaranteed, whereas GO/NGO installed water options are treated as common property and, therefore, households feel they have more unrestricted access to the water source. This implies that given the nature of ownership of safe drinking water option (privately owned or public), 'inconvenience' cost varies (higher inconvenience cost if water option is privately owned and vice versa) significantly.

Finally, the variable 'number of times a household collects drinking water per day', as predicted, is negatively related to collecting water from an arsenic-free source, and the coefficient is highly significant (less than one percent) in both models. This implies that the more trips the person who collects water for the household has to make to the drinking water source each day, the lower the likelihood of the household adopting safe drinking water practice. The number of times drinking water is collected for the family is positively correlated with family size ($r=0.185$; $p<0.01$) i.e. the bigger the family, the more trips made to collect drinking water, which means more work for the water collector who then is more likely to feel reluctant to travel a long distance and finds it more convenient to collect water from the source located nearby even though the water source carries arsenic above the safety level.

Summary and Conclusions

This paper investigated the determinants of safe drinking water practice in rural Bangladesh using an averting behavior approach.

The analysis based on a binary logistic model showed that the explanatory variables explained attitudes of the target population as posited. Explanatory factors such as awareness of arsenic-related negative health consequences, GO/NGO intervention in terms of safe drinking water option installation, number of times households collect drinking water, and total annual household income were theoretically justifiable and statistically significant.

The relevance of the explanatory variables in the estimated models suggests that effectiveness of 'arsenic safe drinking water adoption campaign' requires promotion of complementary services. The first and foremost requirement for adoption of safe drinking water option is 'awareness of health risk associated with drinking arsenic contaminated water.' Mass media can play a very effective role in awareness building. As access to print media (like newspaper) is constrained by high illiteracy rates in the rural areas, radio and TV can play an important role in publicizing negative health consequences of drinking water from arsenic contaminated sources. As water collectors in rural households are usually women, awareness raising programs should target women first. Once women are informed and convinced about the danger of drinking arsenic contaminated water, they will be ready to bear the 'inconvenience cost' of switching water sources. Furthermore, the study reveals that ownership of safe drinking water option works as an obstacle for rural households in water collection as, in privately owned water sources, a neighbour's access might be restricted. This ownership issue should be addressed by the government and other implementing agencies. Since the government is unable to provide safe drinking water to each and every community, access to privately owned safe drinking water sources should be unrestricted.

Table 5: Correlation between Household Yearly Income and Socio-Economic Characteristics

	Yearly household income	Respondent's occupation	Type of latrine use	Education level of adult male family members	Education level of adult female family members
Yearly household income	1				
Respondent's occupation	0.100**	1			
Type of latrine use	0.244**	0.022	1		
Education level of adult male family members	0.330**	0.093**	0.315**	1	
Education level of adult female family members	0.330**	0.107**	0.335**	0.565**	1

Explanatory note: **Spearman rho**
** Correlation is significant at the 0.01 level (2-tailed).

Mann-Whitney Z Statistic (2-tailed sig.): Yearly Income and Awareness.

	Aware	Not Aware	MW test Z-statistic (2-tailed sig.)
Total income of household from all sources (US$/Year)	1599 (570)	970 (439)	-9.116 (p<0.01)

Explanatory notes:
a) Mean values (standard deviations in parentheses)
b) MW: Mann-Whitney test

Mann-Whitney Z Statistic (2-tailed sig.): Yearly Income and Arsenicosis Disease

	Family members affected	Family members not affected	MW test Z-statistic (2-tailed sig.)
Total income of household from all sources (US$/Year)	1003 (691)	1251 (705)	-1.923 (p<0.10)

Explanatory notes:
a) Mean values (standard deviations in parentheses)
b) MW: Mann-Whitney test

Table 6: Binary Logistic Regression (Dependent Variable = Water Collection from Arsenic Safe Sources)

	Marginal effects	
Explanatory variables	**Model 1**	**Model 2**
Constant	1.130*** (0.207)	1.159*** (0.206)
Household income (in thousand Taka)	0.007*** (0.001)	-
Awareness about arsenic related health consequences	-	0.556*** (0.159)
Number of times households collect drinking water per day	-0.351*** (0.082)	-0.282*** (0.071)
GO/NGO intervention	0.327** (0.152)	0.419*** (0.157)
-2 Log Likelihood	1030.12	1053.02
Chi-square	53.35 (df=3, *p*<0.01)	34.41(df=3, *p*<0.01)
Percentage correctly predicted	71.8	72.1
N	935	935

** p < 0.05 ; *** p < 0.001

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