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Determinants of Willingness to Pay for Safe Drinking Water: A Case Study in Bangladesh

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Abstract: The aims of the current study are to estimate the economic value of arsenic safe drinking water in rural Bangladesh and to identify the determinants of household willingness to pay (WTP) for safe drinking water. In this study, households living in different highly arsenic concentrated areas in Bangladesh were asked for their WTP for the collection of arsenic safe drinking water using an open ended WTP question. The study estimates an average WTP of US$9 per year for safe drinking water which is less than one percent of the average annual household income. Stated WTP amounts have been found varying significantly with respondents' levels of mass media exposure, standards of living (measured through the types of latrine used by households), respondents' age, number of children in each household, the levels of education of the adult family members and distance of arsenic-free drinking water source.

Key words: Contingent valuation, arsenic, drinking water, Bangladesh, willingness to pay.

Introduction

World Health Organization (WHO) has referred the widespread arsenic contamination of tube well water in Bangladesh as a public health emergency (Smith et al., 2000). Majority of the shallow tube wells, that used to be the primary source of drinking water for rural inhabitants in Bangladesh, have recently been found carrying arsenic higher than the safe level. According to a conservative estimate 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 contaminated well (WB, 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, WB, 2002).

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 well in highly arsenic concentrated areas in Bangladesh. The installations of safe drinking water options were mainly done on community basis (one safe drinking water option for each community consisting of approximately fifty families) and was based on a supply driven instead of demand driven approach (Implementation Plan for Arsenic Mitigation in Bangladesh, 2004). Although, according to the National Policy of Arsenic Mitigation in Bangladesh (2004), villagers are expected to pay for the installation and operation and maintenance cost of arsenic safe water sources, access to safe drinking water sources, especially water sources established under government ownership and management, is still free of cost. Some NGOs have successfully implemented a monthly user fees for water collection in some parts of Bangladesh. However, water pricing policies for collecting water from these arsenic safe drinking water establishments so far have been based on cost recovery and ability to pay principles. The economic valuation of arsenic safe drinking water of concerned users has not been taken into consideration in determining the water price. Therefore, an important policy question that arises in this context is whether or not the current arsenic safe water price reflects the true value of safe drinking water. In order to ensure widespread supply of safe drinking water and longer term sustainability of these water establishments, an appropriate water pricing policy that reflects true opportunity cost of safe drinking water is immensely important. Hence, empirical research that investigates the economic value of safe drinking water to its users is necessary to guide policy formulation.

The aim of the current study is to estimate the economic value of safe drinking water in rural Bangladesh. Using econometric modelling of stated willingness to pay (WTP) values, the paper, furthermore, aims to identify the determinants of household WTP for drinking water. Contingent Valuation Method (CVM), a widely used non-market valuation technique, was applied to attain the objectives of the study. In a large scale survey in 2005, more than five hundred households from different highly arsenic concentrated parts of Bangladesh were asked for their WTP for water collection from an arsenic safe drinking water source. The current study is the second application of CVM in Bangladesh in assessing the value of safe drinking water. Ahmed et al. (2004) carried out the first CV study where a closed ended dichotomous choice format question was used to elicit respondent WTP. The current study uses an open ended WTP question instead of a closed ended question and estimates an average WTP for safe drinking water which is higher than the estimate provided by Ahmed et al. (2004). Furthermore, the estimated linear regression model demonstrates construct validity of the open-ended WTP values as the independent variables used in the model were quite capable in explaining the variations in the stated WTP values.

The remainder of the paper is organized as follows. The initial section discusses the analytical framework of the study, followed with a section describing the survey. The next section presents the WTP results. Finally, the last section gives the conclusion.

Analytical Framework of the Study

The theoretical model of the current study is based on standard microeconomic principles and previous research (Larson and Gnedenko, 1999; Courant and Porter, 1981; Harrington and Portney, 1987; Gnedenko et al., 2003; Calkins et al., 2002; Ahmed et al., 2004). Let the arsenic contaminated water source be denoted by q^0 and arsenic free drinking water source be denoted by q^1. Let '*I*' denote the yearly average household income and '*A*' denotes the respondent's awareness about arsenic related health risk. Let '*S*' be the vector of socio-economic characteristics of the respondent/household and '*M*' be the expenditure that household agrees to make for the collection of arsenic safe water. Household's decision of paying money for water collection depends on the utility they obtain from different water sources. Household will agree to pay for water collection from the arsenic safe source if and only if:

$$v^1(q^1, I - M, A, S, e_1) > v^0 (q^0, I, A, S, e_0)$$

where e_0 and e_1 are the error terms distributed normally with mean zero and variance 1.

WTP is an amount that compensates utility loss due to reduction in income by improvement in water quality and leaves household on the same indifference curve. Thus, WTP for water collection from existing arsenic-free source is given by the amount *M* which will satisfy the following equality:

$$v^0 (q^0, I, A, S, e_0) = v^1(q^1, I - M, A, S, e_1)$$

WTP, technically called equivalent variation, can be written as a function of several exogenous variables, in the following functional form:

$$\text{WTP} = f(\text{INCM, EDCN, CHILDN, AGE, SEX, DIST, LTRNE, OCCUP, RADIO}) \quad (1)$$

where WTP = respondents' WTP for drinking water collection from present arsenic-free source; INCM = average annual household income (in Tk); EDCN = education level of adult family members (in years of education attainment); CHILDN = number of family members aged below 18 years (in numbers); AGE = age of the respondent (in years); SEX= sex of the respondent (male = 1, female = 0); DIST = distance of the current arsenic-free water source (in yards); LTRNE = type of latrine use (sanitary = 1, non-sanitary = 0); OCCUP= respondent's occupation (dummies for three different occupation groups, i.e. a: farmers, forestry and fisherman, b: business and sales, c: service holders and professionals); RADIO = frequency of listening to radio programmes (respondent listens to radio programme at least once in a week = 1, otherwise = 0).

The variable INCM explains ability to pay whereas EDCN, CHILDN, AGE, SEX, OCCUP, and LTRNE are some socio-demographic characteristics expected to influence household decision of paying for water collection. The variable RADIO is used as an indicator of household awareness about the arsenic-related health risk. The DIST variable captures the feature of the arsenic-safe drinking water source. Hypotheses about the factors affecting WTP may be derived from the indirect utility function from the maximization problem in equation (1). Explanatory variables— INCM, EDCN, CHILDN, AGE, RADIO, and LTRNE—are expected to have positive coefficients whereas DIST variable is expected to have a negative relation with stated WTP. However, the signs of the coefficients of variables SEX and OCCUP are to be tested empirically.

Set-up of the Survey

Data for the CV study was taken from a sub-sample of an extensive rural household survey looking generally 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 intervention done by government organizations (GOs) and non-government organizations (NGO) in different upazillas of Bangladesh. Fifteen villages from two unions of Soanargaon, eight villages from three unions of Babuganj, and nine villages from three unions of Hajiganj were selected for final survey. For details of the study area see Table 1. A list containing name and address of the leaders of ‘drinking water committee’ was collected from GOs and NGOs. A stratified sampling procedure was used to draw sample from the list. For detailed areawise distribution of sample see Table 2.

A subset of approximately 550 households was selected from the original sample of 2000 households surveyed for the original study. Households were interviewed face-to-face from December 2005 till January 2006 using fully structured household questionnaire. The valuation question was posed to the respondents in the following form:

> Given the high demand of arsenic-safe drinking water in this village and cost of maintaining the water option, Government (or NGO or the owner of the water source) is considering to impose a fee on the water users. If a fee is imposed, would you still be willing to collect water from this source by paying the fee?

The elicitation method adopted to receive WTP responses was an open-ended one. Close-ended WTP-questions like “Would you agree to pay __N_Tk on behalf of your entire family per year to collect water from current arsenic-free source?” could prevent formulating respondents own estimate (Gnedenko et al., 2000). Instead, the following WTP-questions were asked in open-ended form:

> “How much money would you be willing to pay for collecting water from the present source on behalf of your entire family?”
> _________1=daily; 2=weekly; 3=monthly; 4=yearly.

This question gave the respondent freedom to formulate own estimate at the same time to choose preferred time frame for payment.

Table 1: Details of study site

Division	*District*	*Upazilla*	*Unions*	*% TW contaminated*
Barisal	Barisal	Babuganj	Agarpur	83
			Dehergati	80
			Kedarpur	84
Dhaka	Narayanganj	Sonargaon	Aminpur	75
			Sonmandi	89
Chittagong	Chandpur	Hajiganj	Hatila	96
			Purba Barkul	97
			Uttar Rajargaon	96

Table 2: Distribution of sample across study area

Thana	*Frequency*	*Percent*
Sonargaon	170	30.7
Hajiganj	223	40.3
Babuganj	161	29.1
Total	**554**	**100.0**

Contingent Values for Safe Drinking Water

General WTP Results

An overwhelming majority of the households (77%) agreed to pay fee for safe drinking water collection while 116 respondents (21% of the sub-sample) refused to pay money for collecting water from the existing source. Those who were not willing to pay were asked why not. The most common reason was that they do not have money to pay for drinking water (income constraint, 58%), followed by reasons like "I have never heard of paying money for drinking water" (21.2%), "collecting safe drinking water is not important to me" (0.7%) and "there is no guarantee of getting safe drinking water after spending money" (9.5%). Respondents who denied paying because of income constraint indeed earned significantly lower annual household income (average income of Tk. 42,814 or $689[1] than those respondents who denied paying for other reasons (i.e., never heard of paying for drinking water or arsenic-free water is not important to me) (average income of Tk. 97,170 or $1494[2]).

The descriptive statistics of the stated WTP values are presented in Table 3. Mean WTP value is US$9.49 per household per year which is 0.85 percent of annual average household income of the sub-sample. Median WTP equals US$4.6 (0.4 percent of average annual household income) per household per year. The mean WTP value is substantially different than median value because of the influence of relatively small number of high WTP values. Trimming off five percent minimum and maximum WTP values, average estimated WTP becomes US$7.2 which is 0.63 percent of annual average household income.

Determinants of WTP

In the following paragraphs, results from the linear regression on stated absolute WTP values are summarized. The model described earlier in equation 1, has been estimated using stepwise backward estimation procedure. Table 4 summarizes regression results of the best fit regression model. The variables INCM, SEX and OCCUP have been dropped off during the backward estimation procedure for not having statistically significant coefficients. The best fit model has an explanatory power of R square = 0.393; adjusted R square = 0.137. The adjusted R square of the regression is low, but this seems common in WTP studies relying on OLS estimator and cross-section data[3]. Nevertheless, theoretically motivated variables are significant and their coefficients have expected signs.

As expected, the regression result shows an inverse relationship between distance of drinking water source and WTP which implies that people who travel longer distance from their dwelling to collect water, tended to offer a lower price for safe drinking water. Respondent age has significant impact on stated WTP for safe drinking water with theoretically expected sign. The negative relationship between age and WTP for drinking water implies that younger the person is the higher is the expected discounted future benefit from investing in health risk reduction and hence results a higher WTP. Gnedenk et al. (2000) find similar empirical evidence between age and stated WTP for drinking water in their case study. As theoretically expected, exposure to mass media (the variable RDIO) has been found having statistically significant influence on household's WTP. Households who listen to radio programmes at least once in a week were willing to pay higher price for the collection of safe drinking water. This finding is consistent with existing empirical studies. Jalan et al. (2003) find that listening to radio and reading newspaper raise adoption of purification techniques in a sample drawn from India. Due to high rate of illiteracy in the sample of the current study, radio listening is used as an indicator of exposure to mass media.

Table 3: Descriptive statistics of the household WTP (US$ per household per year)

	N	*Minimum*	*Maximum*	*Mean*	*Trimmed mean*	*Median*	*Std. Deviation*
WTP (US$ per year per household)	499	.00	184	9.49	6.9	4.6	17

[1] US$1=Tk 65

[2] Differences are tested using the non-parametric Kruskal Wallis Test (p<0.01).

[3] Calkins et al. (2002) and Whittington et al. (1988) reported an adjusted R^2 of 0.14 and 0.25 for their WTP regression.

Table 4: Estimated linear WTP model (stated WTP as dependent variable)

Explanatory variables	*Model*
Constant	282.34*
	(1.71)
Awareness indicators	
Educational Attainment of adult family members (EDCN)	18.73**
	(2.09)
Listen to radio programme at least once a week (RADIO)	425.75***
	(4.00)
Latrine type (LTRNE)	361.88***
	(3.43)
Socio-demographic characteristics	
Age (AGE)	-6.60*
	(-1.83)
Number of children (CHILDN)	93.82***
	(3.02)
Distance of current drinking water source (DIST)	-.19*
	(-1.63)
R squared	0.4
Adjusted R squared	0.14
F	12.47***
N	499

* $p < 0.10$; ** $p < 0.05$; *** $p < 0.001$

The variable 'CHILDN (number of small children in a household)' has been found to have significant positive relation with stated WTP values in the estimated regression model. This implies, other things remaining the same, the higher the number of children in a household, the higher is the expected utility gain from avoiding adverse health effects associated with arsenic contaminated water. This result is consistent with the findings of existing empirical literature. The study by Gnedenk et al. (2000) and Calkins et al. (2002) find similar relationship between children and stated WTP amount. The variable 'EDCN (levels of education of adult family members)' has statistically significant positive impact on stated WTP amount implying that, other things remaining the same, the higher the educational attainment of the adult family members (in terms of the number of years of schooling), the higher value they place on safe drinking water. Finally, as expected, the coefficient of the variable 'LTRNE' turned out to be positive implying that, other things remaining the same, households using a sanitary latrine were willing to pay high price for safe drinking water.

Unlike the existing literature on contingent valuation of drinking water, the current study failed to find any significant relationship of income with WTP for drinking water. However, household income indirectly influences WTP. The explanatory variables of the estimated regression model that have significant impact on WTP (except distance of current safe drinking water option), have been found positively correlated with household income (see Tables 5 and 6). This implies that although yearly household income does not play a direct role determining WTP, an indirect positive relationship exists between income and WTP (high bidders belong to higher income group).

Table 5: Pearson correlation coefficients

	Yearly income of household	*Number of children per family*	*Education of adult family members*
Yearly income of household	1		
Number of children per family	0.110(*)	1	
Education of adult family members	0.371(**)	0.103(*)	1

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

Table 6: Mann-Whitney Z Statistic (2-tailed sig.)

	Yearly income of household from all sources
Listen radio programme daily or at least once in a week	-3.622 ($p < 0.000$)
Use what type of latrine	-4.231 ($p < 0.000$)

Conclusion

In this paper, the economic value of safe drinking in rural Bangladesh is estimated using CVM. The previous study conducted by Ahmed et al. (2004) using the same methodology but different elicitation format (closed ended) reveals a WTP of 0.2 to 0.3 percent of annual household income whereas the current study reveals that the households are willing to spend up to 0.83 percent of their annual average income to collect safe drinking water. Even the trimmed mean value of WTP (a conservative welfare estimate) is 0.63 percent of annual average household income which is significantly higher than the estimates provided by Ahmed et al. (2004). Therefore, the first conclusion that can be drawn from the result of the current study is that the estimated WTP for safe drinking water may vary depending on the different elicitation formats of CVM. The WTP values estimated by the current study perhaps provides an upper bound of the household valuation of safe drinking water in rural Bangladesh.

A multivariate linear regression model is estimated using stepwise backward estimation procedure to test for the determining factors against stated WTP values. Theoretically expected explanatory variables such as education of adult family members, exposure to mass media, use of sanitary latrine, distance of drinking water source, number of children in a household and age of respondent, have been found capable in explaining the variations in stated WTP values. Although the current study fails to detect any direct relationship between household income and stated WTP, an indirect relationship between annual average household income and stated WTP is observed through an extensive correlation test. The relevance of the explanatory variables in the estimated model suggests that an effective safe water pricing scheme requires promotion of harmonizing services. Such services include access to education and mass media and improved sanitary facilities. In other words, installation of safe drinking water alone and without being supplemented by other inputs (such as education, improved sanitary facilities, and awareness rising through mass media) would not bring desired and sustainable outcomes.

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