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Household's willingness to pay for arsenic safe drinking water in Bangladesh

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ABSTRACT

This study examines willingness to pay (WTP) in Bangladesh for arsenic (As) safe drinking water across different As-risk zones, applying a double bound discrete choice value elicitation approach. The study aims to provide a robust estimate of the benefits of As safe drinking water supply, which is compared to the results from a similar study published almost 10 years ago using a single bound estimation procedure. Tests show that the double bound valuation design does not suffer from anchoring or incentive incompatibility effects. Health risk awareness levels are high and households are willing to pay on average about 5 percent of their disposable average annual household income for As safe drinking water. Important factors influencing WTP include the bid amount to construct communal deep tubewell for As safe water supply, the risk zone where respondents live, household income, water consumption, awareness of water source contamination, whether household members are affected by As contamination, and whether they already take mitigation measures.

1. Introduction

Groundwater Arsenic (As) contamination in Bangladesh is recognized as the worst in the world with 97 percent of the population using groundwater for drinking and other domestic purposes (Hossain, 2006). The presence of As in groundwater above World Health Organization (WHO) standards was first detected in the early 1990s. Exposure to high levels of As through ingestion (mainly drinking water) for extended periods of time has been associated with skin lesions (Ahsan et al., 2006; Lindberg et al., 2008; Pierce et al., 2010; Argos et al., 2011), melanosis (Milton et al., 2004; Rahman et al., 2006), hyperkeratosis, jaundice, cardiovascular diseases (Chen et al., 2011) and cancers of various organs or tissues such as skin, lung, and bladder (Smith et al., 2000; Lamm et al., 2003; Steinmaus et al., 2003; Bates et al., 2004; Marshall et al., 2007). Clinical manifestations of chronic As poisoning also include the non-cancer end points of hyper- and hypo-pigmentation, keratosis, hypertension, cardiovascular diseases and diabetes (Ng et al., 2003). Thus, human exposure to As is a major public health concern in Bangladesh, where between 30 and 40 million people are estimated to be potentially at risk of As poisoning from drinking water sources (Ahmad et al., 2006). The annual estimated health costs associated with As contamination in tubewell water in Bangladesh is 2.7 billion US Dollar (USD) (Maddison et al., 2005). Khan and Haque (2010) estimate the cost of illness in Bangladesh, including mitigation expenses, at 51 USD per household per year.[1]

Only a very few studies have estimated a household's willingness to pay (WTP) to secure the benefits of having As safe drinking water access in Bangladesh, of which the study by Ahmad et al. (2005), also published in this journal, is the most widely cited. In the latter study, mean household WTP for piped water supply in an As affected area varied between USD 43 and 79 per month depending on whether provision was for a public or a domestic connection. This was only USD 3–10 more than what people were willing to pay for a piped water supply who are living in an As safe area. This difference was used as an indicator for public WTP for As safe drinking water.

The main objective of this study is to estimate public WTP for As safe drinking water by investing in communal deep tubewells

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[1] All money amounts presented in this paper refer to 2010 price levels.

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(DTW) across different As-risk zones in rural Bangladesh, where the problems associated with As contaminated shallow tubewells (STW) are well known. Although the valuation approach employed in this study is similar to that of Ahmad et al. (2005) in that we also ask rural households first for their WTP to contribute to the one-off capital investment costs of a communal DTW for As safe water supply and then for their WTP to contribute to the communal DTW's monthly operation and maintenance costs, the study design differs in a number of significant ways. First of all, WTP is directly related to As safe drinking water. Secondly, a double bound dichotomous choice (DBDC) WTP question is use instead of a single bound dichotomous choice (SBDC) WTP question for the one-off capital and monthly operation and maintenance costs. The DBDC elicitation format typically reduces the size of referendum based welfare measures and at the same time improves their statistical efficiency (Cameron and Quiggin, 1994; Alberini, 1995). Possible reasons for the SBDC–DBDC gap are given in Carson and Grooves (2007), which relate primarily to incentive compatibility differences between the two WTP questions. Incentive compatibility means two things here: that the question is interpreted as it was intended and answering truthfully is the optimal strategy for respondents (Carson and Grooves, 2007). Bateman et al. (2008) add to this a learning effect. Due to choice repetition and experience, the DBDC format is expected to produce more precise preferences and WTP values as the possible influence of procedural and descriptive influences on stated preferences is reduced and respondents become more familiar with the valuation task at hand and learn about their preferences. The only other study which investigated public WTP for As safe drinking water in Bangladesh (Akter, 2008) applied, contrary to the NOAA Panel (Arrow et al., 1993) recommendations, an open-ended WTP question for an undefined fee for using the household's current water source. As expected (McFadden, 1994; Willis et al., 1995), this yielded a substantially lower mean WTP value (about 28 USD per household per year in 2010 prices). The open-ended elicitation format tends to produce larger numbers of non-response, zero or protest responses compared to other formats, and respondents have been found to experience more uncertainty in answering open-ended than DC WTP questions (Bateman et al., 1995).

2. Methodological approach

2.1. Theoretical model

The economic valuation method applied is contingent valuation (CV), a social survey method where individuals are presented with information about a specific environmental change, the values of which are not accounted for in economic markets or captured through market-based instruments. In CV surveys, individual perception, attitudes and preferences regarding some environmental change and its non-market value are elicited. In order to measure the effect of the suggested change on people's welfare, respondents are typically asked for either their willingness to pay (WTP) or willingness to accept (WTA) compensation for the gains or losses involved (Carson and Mitchell, 1989; Bateman et al., 2002). Of these options, the WTP approach has become the most frequently applied and has been given peer review endorsement through a variety of studies (Arrow et al., 1993). Aggregated across those who benefit from the environmental change, the WTP or WTA amount provides an indicator of the associated total economic welfare impact, also referred to as total economic value (TEV) (Pearce and Turner, 1990). In the welfare aggregation procedure across beneficiaries, a variety of influencing factors have to be accounted for, often related to the spatial distribution of the benefits and the beneficiaries (Bateman et al., 2006).

The application of CV to value changes in individual risk exposure has increased considerably over the past decades and is nowadays widespread (e.g. Dekker et al., 2011; Lindhjem et al., 2011). A money measure of a change in risk is defined as a positive or negative payment, which holds expected utility constant under different risk levels. All other things being equal, the higher the utility obtained from a risk reduction, the greater this amount is expected to be (Johansson, 1995). Typically, existing studies investigate the consistency between stated WTP and the changes in risk exposure levels using probabilistic representations of risk levels (e.g. Vassanadumrongdee and Matsuoka, 2005). Based on evidence that the lay public may find such probabilistic representations of risk levels difficult to understand and interpret (Loomis and DuVair, 1993; Viscusi, 1998; Corso et al., 2001), 'natural experiments' have been proposed to test the sensitivity of public preferences to hypothesized changes in risk in cases where different groups of individuals are at different pre-existing levels of real-world risks (Bateman et al., 2005). This approach is especially appealing in this study, where As exposure through drinking water varies widely across individuals and communities (Khan et al., 2009) and the developing country context is characterized by a high illiteracy rate (Whittington, 2010). The cognitive burden of understanding and interpreting probabilistic representations of risk especially on large groups of illiterate people is avoided by relying on differences in risk awareness and experiences linked to sampling in different risk zones.

In general, the level of risk exposure faced by an individual depends on two main factors: an exogenous and endogenous element (Brouwer et al., 2009). The former refers to facts or factors, which are beyond an individual's control (R), and the latter to the fact that people can take actions (P) which reduce the likelihood of an undesirable event from occurring (self-protection) or reduce the costs of the event if it occurs (self-insurance) (Shogren and Crocker, 1991). Individual risk-reducing behaviour will influence the ex-ante risk level affecting each person. In equilibrium, economic theory predicts that individuals equate the marginal benefits of self-protection or insurance (expected avoided disutility) with the marginal costs (price of self-protection or insurance), subject to their budget constraint. Hence, theoretically WTP_i for a reduction in risk exposure will depend on (Bateman et al., 2005) (i) the realized level of risk, which is determined by exogenous risk R and self-protection activities P_i, (ii) income Y_i, and (iii) an individual's disutility from risk exposure (risk aversion) S_i. This is shown in Equation (1).

$$WTP_i = \beta_0 + \beta_S S_i + \beta_R R + \beta_p P_i + \beta_Y Y_i + \varepsilon_i \tag{1}$$

where the β's refer to the corresponding vectors of estimated coefficients and ε is a random error term, assumed to be normally distributed with zero mean and variance σ^2. In this study, exogenous risk exposure is measured by creating different risk groups as in Ahmad et al. (2005), including a risk free control group based on Bangladesh guideline values for As concentration in drinking water of 50 $\mu g\ L^{-1}$ (DoE, 1994). Different groups face different risk exposure levels dependent upon their residential location and the concentration of As in their drinking water sources. Individuals can self-protect by taking mitigation measures such as investing in HAsRFs or DTW. Poor households, who often make up the highest proportion of As affected households, are expected to be the main beneficiaries of such investments (Roy, 2008). The endogenous risk component hence consists of protective measures respondents take and is controlled for through the information collected in the survey. The natural experiment is obtained by presenting groups who face different