

Implications, Perception, Arsenicosis Health Status, Averting Behavior and Willingness to Pay for Arsenic Free Water

—— Order Logit and Spatial Analysis

Executive summary

The following five chapters weave together the stories of my dissertation;

Chapter 1 is general introduction which provides a technical overview of arsenic and arsenic contamination, severity and background of the problems. The high arsenic groundwater in Bangladesh has become a priority health issue. A systematic survey throughout the country by the Department of Public Health Engineering and the British Geological Survey indicate that tube well water from 59 out of the 64 districts has been contaminated with unacceptable levels of arsenic exposing an estimated 75 million people to the risk of chronic arsenic poisoning in the country. The present value of output lost was calculated to be US\$22.89 billion on the basis of the assumption a constant discount rate of 10% over a 50-year period (WSP, 2005). Contamination of water supplies with arsenic has a major negative impact on most of the MDGs targets. Bangladesh is facing an increasing threat of arsenic contamination in groundwater which is associated with risk of skin cancer, cardiovascular, black foot disease, hypertension, adverse reproductive - outcomes, neurological disorder (Haque et al. 2003, Smith et. al., 1998) as well as other social and psychological problems. Therefore, the main purposes of the present study are to analyze the arsenic exposure to human, arsenic concentration in urine and tube well water, the determinants of arsenicosis patients' perception about chronic arsenic poisoning, social and psychological implications of arsenicosis, the determinants and spatial dependence of households' knowledge about arsenic contamination, various factors influence arsenicosis health status, averting behavior and willingness to pay for arsenic free water.

Chapter 2 examines the nature and the severity of the problem. The historical consistency of arsenic concentration is of particular concern with shallow ground water, which might be subject to greater fluctuation than water from a deeper well (National

Research Council, 2001). A study conducted within highly contaminated areas has found that 17–35% of the populations examined have skin lesions, and up to 3.4% of them have gangrene and ulcers (Hassan et al. 2005). Approximately one-third of the hand tube wells in Bangladesh contain arsenic more than 10 µg/L, the recommended level of arsenic in drinking water by the WHO (Kinniburgh and Smedley, 2001). The cause of the arsenic problem may be natural and the effect of arsenic poisoning gradual, yet millions of lives are in danger. This simple fact cannot be ignored. Action is sorely needed; however, for any individual or organization to act effectively and efficiently a thorough understanding of arsenic and its occurrence is essential. The present study empirically analyzes the arsenic exposure to human, arsenic concentration in urine and tube well water and body mass index of sample respondents of a population survey.

Melanosis in the palm, sole and trunk were the common signs in the patients. The present study shows that the highest amount of skin lesion was melanosis in palm (43.74%) and the second highest in trunk (37.49%). It was found that the sample respondents had an average body mass index of 19.52 while the BMI of the sample respondents varied from 14.06 to 33.4 with standard deviation 3.02 which was represent the broad characteristics of BMI of rural residents. The average level of arsenic concentration in the drinking water was 285.37 ± 193.13 µg/L with the ranging from 0 to 715.63 µg/L. The mean arsenic concentration in the urine of the sample respondents was 637.85 ± 478.69 µg/L creatinine. The concentration levels varied from 93.03 – 3198.00 µg/L creatinine. This study found high arsenic concentration in urine and drinking water and low body mass index.

Chapter 3 identifies the determinants of the patients' perception about arsenicosis and investigates the gender differences of social and psychological sufferings from chronic arsenic poisoning for reducing the disease burden and avoidable deaths by examining four specific questions; First, what is the socio-economic conditions of arsenicosis sufferers? Second, what is the major problems of arsenicosis sufferers in case of child development, getting marriage and married life? Third, do substantial gender differences exist in the perception of social and psychological implications of arsenicosis?

Finally, how do the different determinants associate with arsenicosis patients' perception?

Findings show that victims may face a crisis in maintaining their usual emotion, love and affection within their daily life. Respondents informed that arsenic poisoning causes a wide range of social and psychological problems. An unhappy conjugal situation might arise from the following reasons: anxiety and possibility of ending a marriage, physical disability due to arsenicosis. About one fourth of the respondents (27%) indicated that a marriage might end in divorce if the wife suffered arsenicosis. Physical and mental development of a child in an arsenic-affected family may be interrupted because of different reasons. A considerable percentage of respondents (28%) assumed that unhappy family life may hamper psychological development of the children. The reported reasons for this were as follows: the child might be deprived of love and affection due to arsenic-related problems of the father and/or mother; children might be neglected socially due to parent's unhealthy condition; father's and/or mother's illness may result in increased workload and create physical and mental pressure on the children. Female respondents were less vulnerable in the case of social problems ($p < .01$) and more vulnerable for the psychological problems ($p < .001$) of arsenicosis than male respondents. The results based on logit analysis showed that education ($p < .01$) and household income ($p < .05$) were significantly correlated to respondents' perception about arsenicosis.

Chapter 4, the first address to investigate how and to what extent various factors influence households' knowledge including neighborhood effects about arsenic contaminated drinking water. Although problem reached public concern almost 17 years ago, even now, many who are drinking arsenic contaminated water are not even aware of this fact. The impact of arsenic contamination on individuals and households is not just a matter of the presence of arsenic in ground water. Exposure depends on factors such as awareness, household characteristics, actions taken to reduce exposure. Arsenic contamination has had a profound impact at both the individual and community levels. Reports have attributed disease and death caused by arsenic toxicity to lack of knowledge about the source of this metal (Hadi, 2003). Arsenic in drinking water is a major public health concern in Bangladesh, affecting several millions of people who

live in rural areas, because of insufficient financial resources and public health infrastructure and lack of awareness. In fact, much of the delay in implementing actual mitigation programs in Bangladesh resulted from lack of knowledge concerning arsenic. Econometric models taking into account spatial interactions among economic units have been increasingly used by economists over the last several years and some important advances have been done in both theoretical and empirical studies. Spatial econometrics is becoming more popular in many scientific fields including social sciences. More recently, spatial interaction has increasingly received more attention in mainstream econometrics as well, both from a theoretical as well as from an applied perspective (Anselin, 2001; Anselin, 2002; Anselin & Bera, 1998).

With this background, my study is focused on detecting the spatial dependence and investigating the determinants of households' knowledge about arsenic contaminated drinking water. This chapter is important for several reasons. First, the present study is the first to address the spatial dimension for environmental health problem awareness in Bangladesh, second, this methodology provides consistent and efficient estimation and third, my results have important implications for policy both at the regional and national level, especially those involving the design of regional coordination for arsenic free drinking water.

The results from spatial models strongly indicate that the households' knowledge about arsenic contaminated drinking water are combination of the household characteristics, arsenic related factors of individual districts and the households' knowledge of their neighbors districts. Five characteristics- literacy rate, daily wage rate of agricultural labor, household size, arsenic status and percentage of red mark tube well are significantly related to household knowledge of a district. Based on the AIC, SC and log likelihood, all of the spatial models are preferred to the without spatial weight specification, but the spatial lag model that utilizes the binary joins contiguity weights matrix provides the best fit of the data. The models in which I assume a common spatial lag coefficient for all districts, this results indicate that one percentage increase in the average households' knowledge of neighboring districts generates between a 0.33 and 0.61 percentage increase of a given district households' knowledge, depending on the

specification. Using either a binary or inverse distance weights matrix in the estimation of spatial effects, these results provide strong evidence that significant spatial correlation exists in district, divisional and regional level models. Ignoring neighborhood effects/spatial effects can bias estimates and lead to significant inflation or deflation of the actual potency of key determinants of households' knowledge. These results suggest that districts should pay particular attention to policies in neighboring districts and policy makers should realize that improving the households' knowledge level in neighboring districts are likely to affect households' knowledge in their own district, therefore, a key issue for policy development is how to stimulate educational attainment, promote daily wage of agricultural labor and decrease household size and population density could increase household knowledge and result in sustainable development and poverty alleviation of regions that are both knowledge on arsenic pollution and economically lagging. This needs to be addressed both in terms of national level policies and more emphatically within regional and sub-regional development strategies than it has been hitherto.

Chapter 5, first attempts to address the shortage of developing country studies by investigating the determinants to how and to what extent these various factors may influence arsenicosis health status, averting behavior and willingness to pay for arsenic free water. The relationship between socioeconomic characteristics and health has been well documented in the health economics literature for many decades (Fox, 1989; Lynch & Kaplan, 2000; Townsend & Davidson, 1982). Increased incidences of chronic disease as well as low self-perceived health are existed in the lower SES classes (Dalstra et al., 2005; Warren et al., 2004). An understanding of the causal pathways that lead to this SES and health relationship is important for effective policy interventions to reduce the burden of ill-health. Specifically, education leads to knowledge, credentials and social networks, which in turn leads to employment, giving individuals a sense of purpose and attachment to the community; employment is a source of income which gives access to improved housing, nutrition, material wealth and other resources, all which can lead to better mental and physical health states (Lynch & Kaplan, 2000; Ross & Mirowsky, 1999; Karmakar and Breslin, 2008). Studies by Cavelaars et al. (1998) and Dalstra et al. (2005) have found specific associations between low education and

poor health outcomes. Smoking behavior, alcohol consumption, exercise and obesity are healthy lifestyle factors that have been known to influence self-perceived health and other physical health outcomes (Bhattacharjee et al., 2003; Manderbacka et al., 1999).

The ordered logit results from different specifications show that the age, age square, household size, BMI, education, household monthly income, vegetable consumption and smoking behavior have strong consistent association with arsenicosis health status. The binary logit specifications were used to estimate the association between outcomes and key household attributes. Among the determinants, the present study is focused on whose education is the most influential factor for switching from red source to green source for drinking water. Structure of the model allows to estimate the marginal effects of latent status of red mark tube wells. Maximum likelihood regression analysis results show that the education level of respondents, gender, household monthly income, vegetable consumption and participation of NGO(s) activities have a statistically significant association with willingness to pay for arsenic free water. These findings have several policy implications those agencies and policy initiatives operating at local and or national levels concerned with tackling the arsenic contaminated drinking water related problems that are primarily concerned with sound health and poverty alleviation agenda. Since Bangladesh has committed to the Millennium Development Goals (MDGs), arsenic contaminations in drinking water is challenge for the goal tenth (access to safe water), moreover, it is a threat for the most of the MDGs. Therefore, the country should be relentless in its efforts to meet these goals and incentives and investments in this sector will be rewarding.