Arsenic Contamination, Nutrition and Economic Growth in Bangladesh

Mark M. Pitt
Brown University

Mark R. Rosenzweig
Yale University

Nazmul Hassan
University of Dhaka

I. Policy Motivation In the 1970s and 1980s, the government of Bangladesh, with the support and financing of the United Nations Children's Fund, promoted the digging of tube wells to provide clean drinking water and reduce the incidence of diarrheal disease. Prior to this, drinking water came from surface water sources, which were identified as a principal source of diarrheal disease. In the late 1990s, evidence indicated that groundwater, unlike surface water and by then the main source of drinking water, irrigation and water for cooking in Bangladesh, was contaminated by naturally-occurring arsenic in 59 of the country's 64 districts. The contamination of groundwater by arsenic in Bangladesh is the largest poisoning of a population in history.

The objectives of this project are to identify (i) how arsenic concentrations that result from the ingestion of arsenic affect the capabilities and productivity of the rural Bangladesh population and (ii) how changes in food consumption, by affecting arsenic ingestion and excretion, affect arsenic concentrations.

New empirical methods based on medical evidence providing the genetic basis for arsenic methylation (excretion) and new panel data linking rural family members residing in different localities provide improved estimates over a large population of the impact of arsenic ingestion and retention on a wide variety of productivity measures.

II. Policy Impact These estimates provide the essential information needed to assess the benefits from the eradication of arsenic-contaminated water sources or their amelioration, provide information on which groups will benefit most from ameloriative interventions, and provide the basis for anticipating how, if at all, economic growth will affect arsenic contamination in the Bangladesh population.

III. Audience Health and resource policy-makers; Policy-makers concerned with increasing rural productivity

IV. Policy Implications

a. *Curtailing the ingestion of arsenic will have benefits for the whole rural Bangladesh population, not just the rural poor*

Our new assessments of arsenic retention in residents of rural Bangladesh, based on a survey of over 12,000 individuals in 625 villages and trace metal analysis using inductively-coupled plasma mass spectrometry of over 4,000 sets of toenail clippings, indicate average contamination levels 20 times those found in individuals in the United States. While there is substantial individual variation in arsenic concentrations, there is no relationship between contamination and landholdings or schooling levels. The problem is widespread in rural Bangladesh and unrelated to level of living.

b. *Curtailing the ingestion of arsenic or ameliorating its effects will increase the nutritional status and schooling of both males and females in the rural population*

Our estimates indicate that a one-standard deviation reduction in retained arsenic concentrations will increase weight by almost one kilogram and weight-for-height by 1.6% on average for men and

women. For the population aged 15-23, the same decrease in arsenic concentrations will increase school attendance on average by six percentage points (a 75% increase in attendance for this age group).

c. *Curtailing the ingestion of arsenic or ameliorating its effects will increase the cognitive ability and strength of males, but will have little impact in these dimensions of capabilities for women*

Our estimates indicate that a one standard deviation decrease in retained concentrations of arsenic in males aged 15-29 will (i) increase cognitive skill, as measured in our study by a universally accepted culture-free assessment instrument (the Raven's Color Progressive Matrices test), by 6% and (ii) increase strength, measured by grip and pinch assessments using calibrated dynometers, by 2.1-3.3%. We found no effects of retained arsenic variability on any of these measures for women.

Are these effects large? To benchmark these policy effects, we compared them to those resulting from a change in the value of a household's land, which we also estimated. For the performance on the cognitive skill test, our estimates indicated that it would take a 1,000,000 *taka* increase in land value, more than double the mean land value in the sample, to increase test performance by the same amount as reducing arsenic concentrations by one standard deviation.

d. *Curtailing the ingestion of arsenic or ameliorating its effects will have real economic benefits*

Our estimates indicate that a one standard deviation decrease in retained concentrations of arsenic in males aged 15-29 will increase their wage rates by 10%, consistent with our findings on schooling, cognition and strength. As 75% of males in this age group work for wages, this result implies that reducing retained arsenic in males will have real and significant economic benefits. As few women in rural Bangladesh work for wages it was not possible to assess the impact of arsenic reductions for women's earnings.

e. *Ameliorative interventions, such as folate supplements that decrease arsenic retention, should be targeted to populations with lower rather than higher levels of concentrations.*

Our large sample size and methodology allowed for the identification of non-linear impacts of retained arsenic. Our estimates indicated that the effects are indeed not linear: for all outcomes we studied, the effects were stronger at lower than at higher levels of retained arsenic. This means that interventions that marginally improve arsenic methylation (excretion) such as dietary supplements will have greater impacts on productivity and nutritional status if targeted towards populations with lower concentrations of retained arsenic. For example, the elimination of all arsenic contamination down to levels such as those found in the US sample for the median male (the person at the mid-point in the distribution of retained arsenic concentrations) would increase the number of correct answers in the abridged Raven's CPM by 6.3%. For men with higher arsenic concentrations, at the 80th percentile, the same reduction in arsenic would increase test performance, by 5%, and for the top 10%, by only 3.8%. For the wage estimates we found that eliminating arsenic concentrations for the median male wage worker would increase his wage rate by 8.8%, while the same marginal reduction for workers in the top 10% of the retained arsenic distribution would only increase wages by 3.5%.

f. *Changing diets to reduce arsenic ingestion and retention will not improve the overall health of the Bangladesh population.*

Our estimates indicated that the consumption of vegetables and fruits increases concentrations of retained arsenic. Reducing consumption in those food groups would decrease other dimensions of health and so would not be an effective mechanism for reducing the impact of arsenic-contaminated water sources.

g. *Economic growth will not reduce the impact of arsenic contamination*.

Our estimates show that variation in land wealth does not significantly affect the consumption of foods exacerbating arsenic contamination and has little effect on retained arsenic concentrations.

The Bottom Line: Implementation of a policy that directly eliminates arsenic in water that is used for irrigation, cooking and drinking would have important economic and health benefits for the entire rural Bangladesh population. General growth policies will not help, nor will improvements in education. Radical changes in the composition of foods consumed will also not improve health.