Arsenic Toxicity and Pregnancy Outcomes: A Case Study of West Bengal

Background and importance of the study

Groundwater is a significant source of drinking water in many parts of the world. Well-protected groundwater is safer in terms of microbial quality than water from open dug wells and ponds. It is, however, prone to chemical contamination from natural sources or by anthropogenic activities. The World Health Organization (WHO) recognizes arsenic (As) as the most serious inorganic contaminant with toxic properties found in groundwater on a worldwide basis (WHO 1981). The International Agency for Research on Cancer (IARC) has classified arsenic as a Group 1 human carcinogen (IARC 2001). While earlier maximum allowable concentrations recommended by WHO for arsenic in drinking water were higher, in 1993 the provisional WHO guideline value was reduced to ≤0.01 milligram/Litre (mg/L) or 10 parts/billion (ppb) or 10 μg/L based on concerns regarding its carcinogenicity in humans (WHO 2004). However, a number of countries (including India) still operate at ≤0.05 mg/L standard, which corresponds to the provisional WHO guideline value before 1993. In recent years both the WHO guideline value and the current national standards for arsenic have been found to be frequently exceeded in drinking water sources, with Bangladesh and India having to cope with the largest mass poisoning from arsenic.

Development of skin lesions is the most widely reported and recognized symptom of arsenic exposure. However, chronic exposure may affect all the organs and systems of the human body including the respiratory, gastro-intestinal, cardiovascular, nervous and reproductive systems, the effects being both local and systemic (Abernathy *et al*. 1997). There is extensive documentation of reproductive and fetal developmental effects in a variety of animal species (Hood *et al*. 1988, Gerver *et al*. 1982, Zierler *et al*. 1988) with only a handful examining the same in case of human pregnancy outcomes (Aschengrau *et al*. 1989, Borzsonyi *et al*. 1992). The recent studies observed that arsenic readily crosses the human placental barrier, giving rise to arsenic concentrations that are about as high in cord blood as in maternal blood and thus affects fetal development (Concha *et al*. 1998). However, the anecdotal obstetric histories, which suggest reproductive toxicity at exposures sufficient to cause maternal toxicity, are highly debatable due to limited human data. Ecologic studies in Chile, Sweden, Hungary and Taiwan have also suggested associations between high arsenic exposure and spontaneous abortion, stillbirth, and preterm birth rates (Hopenhayn-Rich *et al*. 2000, Nordstrom *et al*. 1978, Borzsonyi *et al*. 1992, Yang *et al*. 2003). Case-control studies from Massachusetts and Texas have shown weak associations between arsenic exposure and pregnancy outcomes (Aschengrau *et al*. 1989, Ihrig 1998). However, studies suggest that arsenic exposure during pregnancy can adversely affect several reproductive endpoints, including spontaneous abortion (Ahmad *et al*. 2001, Aschengrau *et al*. 1989, Borzsonyi *et al*. 1992, Chakraborti *et al*. 2004, Rudnai and Gulyas 1998), pre-term birth (Ahmad *et al*. 2001, Chakraborti *et al*. 2004, Yang *et al*. 2003) stillbirths (Ahmad *et al*. 2001, Aschengrau *et al*. 1989, Borzsonyi *et al*. 1992, Chakraborti *et al*. 2004, Ihrig 1997, Rudnai and Gulyas 1998) low birth weight (Chakraborti *et al*. 2004, Hopenhayn *et al*. 2003, Yang *et al*. 2003,) and neonatal and perinatal mortality (Borzsonyi *et al*. 1992, Chakraborti *et al*. 2003, Hopenhayn-Rich *et al*. 1998, Rudnai and Gulyas 1998). Though most of the above studies pointed out potential reproductive effects of arsenic exposure in humans, information on several confounding factors, including lifestyle and personal factors that affect birth weight, congenital malformation and other outcomes was not available.

Objectives

With this background, the present paper tries to examine the risks of spontaneous abortions, stillbirths, and preterm births among women of the exposed group (consuming various concentrations of arsenic in their drinking water) compared to the non-exposed group. It further tries to assess the effect of socio-economic and health factors on such risks.

Data and methods

The study area was Murshidabad district in West Bengal, where a cross-sectional case-control study was conducted during 2006. Among the total 26 blocks of the district, 19 are arsenic affected according to the data of the Public Health and Engineering Department (PHED 2004). Since the level of arsenic contamination varies greatly within a district, all these 19 blocks were ranked according to their mean level of arsenic concentration after which they were divided into four quartiles. From each quartile one block was selected randomly. From the four selected blocks, eight villages, two from each block were chosen as case villages for the present study. In each block the villages were ranked according to the mean arsenic concentration provided by the PHED to the villages by arsenic concentration level in the tubewells. Two villages were chosen randomly, one from above the 50 percentile value and one below it. From the remaining seven blocks which are not affected by arsenic (here treated as control villages), two blocks were chosen purposively from which four villages, two from each block were again selected purposively. In all, 12 villages were selected for this study, eight from case and four from control villages respectively. The target population of this study was individual households within selected villages. Prior to the selection of the respondents, PHED tested tubewells were first identified according to given landmarks and then five tubewells were randomly selected from each of the villages. The reason behind choosing five tubewells was purely based on the logic that we wanted to restrict the sample size to about 360 households (for coverage purpose) and most importantly in the study district, approximately 35 persons (about six households) depend on a single tubewell for water. In all, the sample size consisted of 360 households, 240 and 120 for case and control villages respectively.

Subject eligibility

After identification of the households using the selected tubewells, all women living in these households were identified and their eligibility status was determined. Eligible participants included ever-married women of reproductive age 15-49 years at the time of survey and who previously had at least one pregnancy. The exposed group consisted of women who had been drinking arsenic-contaminated water (≥0.05 mg/L) for at least five years, whereas the non-exposed group consisted of respondents who had been drinking arsenic-safe water (≤0.01 mg/L). The subjects in the non-exposed group were matched for age, standard of living (SLI), education, and age at marriage. A total of 540 eligible women were identified. Seven declined to participate, and so 533 women were interviewed for this study.

Data collection

A semi-structured interview schedule was used to collect quantitative information from the respondents. There were two broad sections in the interview schedule: first, a household section which was designed to capture the socio-economic and demographic characteristics along with sources and use of water facilities for different purposes. The second section tried to capture the individual characteristics of women in their reproductive ages (15-49 years) including a detailed overview of their pregnancy history, including adverse pregnancy outcomes (i.e., spontaneous abortion, stillbirth and preterm birth), antenatal care, and on several confounding factors, including lifestyle and personal habits. The operational definition of stillbirth was considered to be any delivery after 28 completed weeks of gestation in which the baby did not breathe or show any sign of life (Dutta 1994). A preterm birth was considered to be any live birth before completion of 8 months, or 37 weeks from the last menstrual cycle (Dutta 1994). A natural failure of pregnancy within the first 28 weeks of gestation was regarded as spontaneous abortion (Dutta 1994). During analysis we calculated stillbirth, spontaneous abortion and preterm birth rates using the total number of live births as the denominator. Subsequently, the pregnancy outcome events have been compared in the exposed and non-exposed groups.

Summary of findings

Skin lesions due to chronic arsenic toxicity have been found in almost one-third of the study population with a history of exposure of more than 15 years. The mean number of pregnancies, live births, stillbirths, spontaneous abortions and preterm births were 3.74, 3.33, 0.18, 0.23, and 0.23, respectively among the exposed group and 3.22, 3.07, 0.07, 0.07, and 0.08, respectively, in the non-exposed group. In the exposed and non-exposed groups respectively, 89.1 percent and 95.5 percent of the pregnancies ended as live births; the difference was statistically significant ($z = 3.2$; $p = 0.002$). Adverse pregnancy outcomes measured as spontaneous abortion, stillbirth and preterm birth rates were 68.8, 53.1, and 68.8 per 1000 live births, respectively, among the exposed group and 23.7, 23.7, and 27.1 per 1000 live births, respectively, among the non-exposed group. The results showed a statistically significant difference in the adverse pregnancy outcomes rates ($p < 0.05$) when compared between these two groups. The pregnancy outcome rates were higher among the exposed group, i.e., for women who had been drinking arsenic-contaminated water (≥0.05 mg/L) for more than 15 years than among those who had been drinking arsenic-contaminated water for less than 15 years. In spite of several limitations, the strength of this study is the availability of individual arsenic exposure data and determination of risk at different arsenic concentration levels. The field data support the accumulating evidence that chronic arsenic exposure is associated with an increased risk of spontaneous abortion, still birth and preterm birth.