

# Murshidabad—The Arsenic Affected District

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**Abstract:** To understand the severity of related health effects of chronic arsenic exposure in West Bengal, a detailed 3-year study was carried out in Murshidabad, one of the nine arsenic-affected districts in West Bengal. **Methods.** We screened 25,274 people from 139 arsenic-affected villages in Murshidabad to identify patients suffering from chronic arsenic toxicity for evidence of multisystemic features and collected biological samples such as head hair, nail, and spot urine from the patients along with the tubewell water they were consuming. **Results.** Out of 25,274 people screened, 4813 (19%) were registered with arsenical skin lesions. A case series involving arsenical skin lesions resulting in cancer and gangrene were noted during this study. Representative histopathological pictures of skin biopsy of different types of lesions were also presented. Out of 2595 children we examined for arsenical skin lesions, 122 (4%) were registered with arsenical skin lesions, melanosis with or without keratosis. Different clinical and electrophysiological neurological features were noticed among the arsenic-affected villagers. Both the arsenic content in the drinking water and duration of exposure may be responsible in increasing the susceptibility of pregnant women to spontaneous abortions, stillbirths, preterm births, low birth weights, and neonatal deaths. Some additional multisystemic features such as weakness and lethargy, chronic respiratory problems, gastrointestinal symptoms, and anaemia were also recorded in the affected population. **Discussion.** The findings from this survey on different health effects of arsenic exposure were compared to those from previous studies carried out on arsenic-affected populations in India and Bangladesh as well as other affected countries. **Conclusion.** Multi systemic disorders, including dermal effects, neurological complications, and adverse obstetric outcomes, were observed to be associated with chronic arsenic exposure in the study population in Murshidabad, West Bengal. The magnitude of severity was related to the concentration of arsenic in water as well as duration of the exposure.

**Keywords:** Arsenic in biologic samples; Arsenical skin lesions; Cancer and gangrene in affected villages; Arsenic-affected children; Arsenical neuropathy.

## INTRODUCTION

Arsenic toxicity owing to groundwater arsenic contamination has been reported from many countries, but the situation is most alarming in Bangladesh and West Bengal, India. The health effects due to chronic exposure to inorganic arsenic in the drinking water may manifest primary dermatological features along with gastrointestinal, liver, respiratory, neurological, haematological, cardiovascular, obstetric, and other factors. It is thought that chronic arsenic exposure may cause multisystemic disorder. Ingestion of inorganic arsenic has been shown to cause skin cancer. On the basis of epidemiological studies from countries such as Taiwan, Argentina, and Chile, the subcommittee on Arsenic in Drinking Water concluded, “evidence is now sufficient to include bladder and lung cancer among the cancers that can be caused by ingestion of inorganic arsenic”.

We report in this paper observations from our studies during June 2000 to July 2003 on dermatological, neurological with special reference to neuropathy, and obstetric complications in patients of arsenicosis in Murshidabad, one of the nine arsenic-affected districts of West Bengal, India.

## METHOD

Protocols for Screening:

We visited high-arsenic-contaminated villages of Murshidabad district based on prior information obtained from our field workers. During these visits, we clinically examined the persons who attended our medical camps. Head hair, nail, and spot urine samples were collected from them immediately after the

clinical examination. In a few cases, we had been to the respective houses to examine subjects. We did not have any bar on age of the subject and examined subjects from 1 year to 70 years.

#### Patient Population:

In our prospective field studies, we examined a sizable number of villagers suffering from chronic arsenic toxicity for evidence of multisystemic features. Out of a total of 25,274 villagers screened from 12 blocks of the Murshidabad district, the number of registered patients with arsenical skin lesions were 4691 adults and 122 children. In severe cases of arsenicosis, we brought the patients to Kolkata and arranged for their treatment. The total number of arsenicosis patients studied for neurological involvement was 249 from eight villages. The study group for obstetric outcome comprised 17 married women from seven villages, whose detailed obstetric history was available. The obstetric group was small because the village women in general were very shy and reluctant to disclose detailed obstetric history and we had to visit some of the respondents' homes with the help of health assistants.

However, inhabitants of some severely affected villages informed us that we could examine only 20 – 25% of the total arsenic-affected population. The probable causes behind this, as revealed during our discussion with the villagers were, 1) in villages, the affected people often considered the disease as contagious and were afraid of isolation once others came to know of their ailment; 2) young girls and women of conservative families did not want to be examined; 3) people were frustrated and felt that there was no cure for the disease; 4) people who were weak and suffering extensively could not travel long distances to come to our camp; and 5) normally we visited the villages during the day, when most of the men folk were out working in the fields and several young boys and girls were in schools.

#### Dermatological Examination:

A. The arsenic dermopathy was diagnosed by the experienced dermatologists on the basis of the following features:

1. Salient dermatological features are melanosis (pigmentation) and keratosis (rough, dry, popular skin lesions). Both may be spotted or diffuse. Melanosis appears earlier than keratosis.

2. Melanosis is diffuse in the palms and soles, and later, over the whole body if arsenic exposure continues. Early melanosis in palms is often overlooked. Melanosis may be spotted as raindrop pigmentation often noticed over chest, back, and limbs. Leucomelanosis (pigmentation and depigmentation side by side) usually appears in a later stage (after discontinuing consumption of contaminated water). Guttate melanosis (like black mole) may sometimes be found. Buccal mucus membrane melanosis on the tongue, gums, and lips (diffuse, patchy, spotted) may also be observed.

3. Starting from palms and soles (palmoplantar keratosis), in advanced cases, keratosis is often distributed over dorsum of hands and feet and even over other body parts. Early keratosis is better felt than noticed and may be missed unless palms and soles are carefully palpated.

4. Large nodules are often precursors of cancer.

5. Bowen's disease is a premalignant condition called intra-epidermal carcinoma in situ, which may be noted as a complication in chronic arsenicosis.

6. Skin ulcer is a late feature of cutaneous arsenicosis that may turn into malignancy.

7. Skin cancers are late complications.

B. Detailed history and systemic examinations in arsenic-exposed persons having a combination of pigmentation (melanosis) and nodular rough skin (spotted palmoplantar keratosis) almost always point to arsenic toxicity, ruling out several isolated causes of melanosis or keratosis. Estimation of arsenic concentration in drinking water and biological samples such as nails, hairs, and urine helps further to clinch the diagnosis.

C. Biopsy from the skin lesions was taken in selected cases, especially when Bowen's disease, carcinoma, and nonhealing ulcer were suspected.

#### Neurological Examination:

Neurological examination was generally undertaken for arsenicosis patients whose skin lesions were already diagnosed by an experienced dermatologist. The neurological part was conducted by the same experienced neurologist to obviate inter-observer variability for each patient of arsenicosis so tested. Observations were recorded for items considered consistent with peripheral motor and sensory neuropathy and for other neurologic abnormalities as well. Pain history and pain-specific sensory

examination were stressed. The items included [as modified from Feldman et al., Kreiss et al., and Galer to characterize neuropathy were 1) pain and paraesthesias (e.g., burning) in a stocking and glove distribution, 2) numbness, 3) hyperpathia/allodynia, 4) distal hypesthesias (reduced perception of sensation to pinprick/ reduced or absent vibratory perception/affected joint-position sensation/affected touch sensation), 5) calf tenderness, 6) weakness/atrophy of distal limb muscles or gait disorder, and 7) reduction or absence of tendon reflexes.

#### Neurophysiologic Studies:

Electrodiagnostic studies were performed in our clinical neuropsychological laboratory to evaluate peripheral nerve and central pathway functions. Action potentials arising from the peripheral nerves (nerve conduction studies) and muscles (electromyography—EMG) were interpreted by using Nicolet Spirit (U.S.), a composite electroneuromyography and evoked potential study machine. Physiological and technical variables such as age, temperature, stimulation, and recording were duly taken into account by the experienced investigator.

#### Obstetric Survey:

The study group was composed of 17 married women in the reproductive age groups of 18 – 40 years with history of at least one pregnancy. All were from lower socio-economic strata and they had been drinking water from arsenic contaminated hand tubewells for 2 to 18 years. However, the actual period of exposure or any temporal increase in arsenic concentration of the water could not be ascertained. The range of arsenic level in their drinking water was 284 – 1474 mg/L. The following pregnancy outcomes in arsenic-exposed women were looked into: 1) spontaneous abortion, 2) stillbirth, 3) preterm birth, 4) low birth weight, and 5) neonatal death. All these parameters were compared to those observed in the control group of women from a non-arsenic exposed district (Medinipur) of West Bengal.

#### Water and Tissue Analysis:

Biological samples such as head hair, nails, and spot urine collected from identified patients along with samples of tubewell water they were drinking were analysed for arsenic content by the flow injection

hydride generation atomic absorption spectrometric (FI-HG-AAS) method. Sample digestion and instrument conditions were described earlier.

## RESULTS

#### Analysis of Biological Samples and Water:

Arsenic exposure was confirmed in the identified patients by the presence of elevated arsenic concentration in hair, nail, urine, and samples of tubewell water they were consuming. The range of arsenic concentrations were found to be:

Water: 248–3003mg/L

Hair: 1548–18245mg/L

Nail: 2717–35076mg/L Urine: 78–2870mg/1.5 L/day

#### Dermatological Findings:

Out of 25,274 villagers examined from 139 surveyed villages of 12 blocks of the Murshidabad district (Table 1), we identified 4813 patients with arsenical skin lesions, i.e., 19% of the total. Of these 4813 cases, children up to 11 years of age were 122 in number while the adult patients were 4691 (male 3320, female 1371). For confirmation of arsenic exposure in patients of cutaneous arsenicosis we also analysed arsenic in water and biological samples (where available).

Comparative prevalence of varied skin lesions both in adults and children. In most of the patients there were mixed lesions as typically observed in arsenicosis. Different forms of melanosis (spotted, diffuse, leuco) were more common with wider skin area involvement in comparison to different forms of keratosis (spotted or diffuse) predominantly involving soles and palms. The most common arsenical skin lesion was spotted melanosis on trunk (84.3% of adults and 75.4% of children) followed by diffuse melanosis on trunk (75.8% of adults and 69.7% of children).

Patients with various types of arsenical skin lesions from the Murshidabad district. Table 2 shows the effects of drinking arsenic contaminated water of 921 mg/L on 11 members in a family in the Hodaherampur village of the Raninagar-I block of Murshidabad. Arsenical skin lesions appeared among all the family members except one within 1–3 years of using this water. They were not aware of such high arsenic concentration in their water until we visited their place. Obviously, we did not notice any leucomelanosis in this case, since they were continuing consumption of high-arsenic-contaminated water unknowingly. This

example also proves that high arsenic concentration in the drinking water may cause early appearance of skin lesions.

We noticed some other features not previously reported in arsenicosis cases. Almost 70 – 75% of the patients with arsenical skin lesions reported severe pruritus or prickly heat type of sensation on exposure to sunlight, even in winter (solar dermaception). Another unique finding was that the face escaped arsenical skin lesions except in some cases of diffuse melanosis. Burning sensation of eyes was noticed in 30% of cases.

#### Case Series of Cancer and Gangrene Patients in Murshidabad:

During our field survey of the 139 villages of Murshidabad we found at least a couple of families from each affected village reporting premature as well as cancer-related death among their relatives who had severe arsenical skin lesions.

A resident from the village of Ghospara in the Beldanga-I block told us that at least 15 people who had severe arsenical skin lesions had died at early ages in his village and of them, four had died of cancer. The dermatological features of nine cancer and one gangrene patients, identified by our medical team, in the Murshidabad district. In the Mokrapur village of Beldanga-I block, villagers informed us that about 20 people who had severe arsenical skin lesions had died young. During our survey of this village, we found an arsenicosis patient suffering from gangrene; we admitted him to Medical College Hospital of Kolkata where one of his feet was amputated by surgery. In the Bhojrampur Thakurpara village of the Hariharpara block we discovered another man suffering from cancer with severe arsenical skin lesions. In our survey of the Chandimati village of the Raninagar-II block, we found an arsenicosis female patient suffering from cancer. A month after we detected her state she died. Furthermore, we found 227 patients with suspected Bowen's disease (carcinoma in situ) and 31 suspected cancer patients. Figure 8 shows an arsenicosis patient with Bowen's on the chest who had been operated on in SSKM Hospital, Kolkata and a cancer patient from the Jalangi block of the village Harekrishnapur.

#### Histopathological Findings from Biopsy of Dermatological Lesions:

Representative histopathological pictures of skin biopsy of different types of lesions are described below:

A photomicrograph of a section of skin tissue showing hyperkeratosis, hypergranulosis, acanthosis, and vacuolated cells.

The section of skin tissue showing atypical pleomorphic epithelial cells with inappropriate keratinization and pearl formation infiltrating the dermis. There is disorganization and breakdown of the basal layer. The picture is suggestive of squamous cell carcinoma.

Atypical epithelial cells with large hyper- chromatic nuclei and vacuolization (clear cells). There is no disorganization of basal layer. The appearance of the section of skin tissue is consistent with Bowen's disease (intraepithelial squamous cell carcinoma).

#### Dermatological Findings in Arsenic-Affected Children of Murshidabad:

In the Murshidabad district, we examined 2595 children for arsenical skin lesions, and of them, 122 (4%) were registered with arsenical skin lesions such as melanosis with or without keratosis. In some specific villages such as Chakmathura, South Ghoshpara (Jalangi block), Khidirpara (Domkal block), Dharampur (Suti-II block), Madanpur, and Benipur (Bhago- wangola-II block), the percentage of affected children was even higher. A detailed survey is required to get an estimate of the total number of affected children. Table 4 lists dermatological features of 12 children from the affected villages of Murshidabad. All had diffuse and spotted melanosis and 10 had keratosis as well.

#### Neurological Findings:

The total number of patients included in the neurologic study was 249, comprising of 131 males and 118 females, age ranging from 11–70 years. Out of them 61% were in the age group of 21 – 40 years. Thus, disabling neurological symptoms affected mostly the young whose activities and earning capacities for the family were primarily affected.

#### Neuropathic Features:

Based on the criteria stated earlier (7 – 9), clinical neuropathy was diagnosed. The diagnosis of arsenic neuropathy in the patients was ascertained by the presence of skin lesions and analyses of arsenic in hair,

nail, and urine, along with water they were drinking. The cases were further categorized, depending on type of neuropathy, into sensory, sensorimotor, or motor types and, into mild, moderate, or severe types according to severity. Other possible causes and alternative explanations were also excluded such as diabetic, alcoholic, nutritional deficiency neuropathies; Guillain-Barré syndrome; intermittent porphyria; tick paralysis; diphtheria; paralytic shellfish poisoning; paraneoplastic syndrome; amyloidosis; dysproteinemias; uremia; pharmacologic agents; and toxins, including metals. Of the 249 subjects examined, neuropathies from arsenic toxicity were identified in 127 (51%); of these, 107 (43%; males 20.1%, females 22.9%) had sensory neuropathy and 20 (8%; males 5.2%, females 2.8%) had additional motor components (sensorimotor neuropathy). There were 17 patients (6.8%; males 4.8%, females 2.0%) with evidence of moderate neuropathy. This was based on rigorous criteria of neuropathy and included cases with impairment of at least two sensory modalities and reduced deep tendon reflexes. Mild (predominantly sensory) neuropathy with subjective complications such as paresthesias, pain, hyperpathia, and objective findings of single abnormalities such as decreased pinprick, vibration, or position sense were diagnosed in 110 cases (44.2%; 20.5% males and 23.7% females). The neuropathy was mild to minimal in nine cases when drinking of arsenic-contaminated water was discontinued for at least 1 year or more. The majority of the patients presented with sensory manifestations of distal paresthesias (41.7%), limb pain (12%), and distal hyperthesias (34.5%), outnumbering motor features of distal limb weakness or atrophy (15.3%). In this series, neuropathic pain was variably presented by patients, and while there was continuing progression in health for some, a gradual diminution was noticed in others. The time course was also variable. Pain and paresthesias were mostly localized to feet. Often a patient's activities of daily living (ADL) were disrupted by insomnia, mood changes, painful ambulation, and diminished working capacity. Negative sensory signs in the early stages of evolution of neuropathy or in milder cases include diminished or absent vibration sense and affected touch sense. In more severe cases, all modalities are affected in a stocking-glove distribution. There may be tenderness of calves. A total of 34.5% of our patients in

Murshidabad had reduced sensations (hypesthesias) in the distal parts of the extremities.

#### Other Neurological Features:

Other associated relevant features in our patients included neuropathic tremor of distal limbs (7.2%), headache (2%), decreased libido (1.6%), vertigo (1.6%), decreased vision not due to ophthalmologic cause (0.4%), and somnolence (0.4%). Autonomic instability may occur but is usually minor and of little consequence. Symptoms of sweating abnormalities (excessive sweating) and postural dizziness were present in 3.2% and 0.8% of cases, respectively, in the present series. Further autonomic function studies are needed to confirm substantial autonomic pathway involvement in arsenicosis.

#### Neurophysiologic Studies:

Electrophysiological studies were performed on 40 patients in our current study. Abnormal sensory and motor nerve functions were detected in a higher percentage of cases with more severe clinical conditions, i.e., 50% with abnormal sensory nerve functions and 20% with abnormal motor nerve functions in the moderate neuropathy and 35% abnormal sensory nerve functions and 15% abnormal motor nerve functions in the mild cases.

#### Obstetric Findings:

##### Pregnancy Outcome and Arsenic Concentration in Drinking Water:

The respondents of the arsenic-exposed group of women were divided into 1) Group A, with arsenic concentration in drinking water ranging 284–400mg/L and 2) Group B, with arsenic concentration ranging 401–1474mg/L. The results from these two groups were compared with those from Group C, the control group from the Midnapore district, West Bengal, drinking water with arsenic concentration less than 3 mg/L. Arsenical skin lesions were present in four of the six subjects of Group A and nine among 11 subjects of Group B. It was noted that the rate of spontaneous abortion increased with increase in arsenic levels in water, i.e., two out of 21 pregnancies of Group A compared to eight of 44 pregnancies of Group B. In comparison to control Group C, both Groups A and B showed increasing trends in spontaneous abortion, preterm birth, and low birth weight rates. But no significant change was observed

in preterm birth, low birth weight, and neonatal death rates between Groups A and B.

#### Pregnancy Outcome and Duration of Arsenic Exposure:

The respondents were also divided and compared on the basis of duration of drinking arsenic-contaminated water into two categories: 1) those drinking for 5 – 10 years and 2) those drinking for more than 10 years.

We compared the pregnancy outcomes for respondents who had been exposed to arsenic for more than 10 years and those exposed for less than 10 years. It was observed that the rates of spontaneous abortion (200 vs. 114 per 1000 pregnancies), low birth weight (478 vs. 259 per 1000 live births), and neonatal death (87 vs. 37 per 1000 live births) were significantly higher among the respondents having a longer exposure. Other obstetric outcomes did not reveal any significant change. Uncomplicated pregnancies with normal term deliveries (eight in 5–10 years exposure group and two in the below-10-years exposure group) were not included in Table 6. Figure 13 shows a woman from Godagari village of Jalangi whose pregnancy was severely affected due to arsenic exposure (1st pregnancy: preterm birth, 2nd: abortion, and 3rd: early neonatal death; arsenic content in drinking water: 1474 mg/L; arsenic content in urine 1767 mg/1.5 L).

#### Other Multisystemic Common Presenting Features:

The following features were commonly encountered in our studied group:

1. Weakness, lethargy, and easy fatigue limited the physical activities, working capacities, and participation in sports of about two-thirds of 4961 adult patients.
2. Chronic respiratory complaints were also common. Chronic cough with or without expectoration was evident in more than 50%. As reported by the villagers, the unique sound of “cough of arsenicosis” from adjacent village homes at night was reported to create an unusual atmosphere. The cough may be painful and sputum may contain blood to be misdiagnosed as pulmonary tuberculosis. In late stages, shortness of breath predominate.
3. Gastrointestinal symptoms of anorexia, nausea, dyspepsia, altered taste, pain abdomen, enlarged liver and spleen, and ascites (collection of fluid in

abdomen) were also observed in more than 50% patients.

4. Moderate to severe anemia was evident in nearly 30% of cases.
5. Leg edema was less common and found in 10% of the cases.

#### DISCUSSION

Groundwater arsenic contamination of drinking water is usually a form of chronic arsenic toxicity that affects human health by producing protean clinical manifestations of chronic arsenicosis. Similar to dermatological findings in the present series, our previous work on different populations from West Bengal and other states of India as well as from Bangladesh reported different forms of melanosis, keratosis, Bowen’s lesions, cancerous skin lesions, skin ulcers, gangrene of distal extremities, leg edema, and conjunctival congestion depending on severity and duration of arsenic exposure. However, Blackfoot disease reported from Taiwan was not observed in our patients. But a common symptom of severe itching (pruritus) on exposure to sunlight observed in these cutaneous arsenicosis patients was not previously reported.

Screening 25,274 villagers from 159 arsenic-affected villages of Murshidabad, we registered 4183 (19%) patients with arsenical skin lesions. This large number of people showing arsenical skin lesions is due to the fact that we had examined villagers from highly arsenic-contaminated villages and we had prior information of the presence of arsenic patients. Undoubtedly, the overall percentage of arsenic-affected people in Murshidabad district will be much less.

The number of cases of Bowen’s disease (carcinoma in situ) and carcinomas in the present series confirms the dermatological, carcinogenic nature of inorganic arsenite as has been stressed in various publications. Several studies have shown that children are at higher risk of arsenic exposure. Among the population exposed to arsenic in drinking water in the Antofagasta region of Chile, cases of cutaneous arsenicism including hyperkeratosis and hyperpigmentation have been described in children as young as 2 years of age. Notably, during our 17 years of field experience in West Bengal and 9 years in Bangladesh we observed that children under 11 years of age typically did not show arsenical skin lesions,

although their hair, nail, and urine contained high levels of arsenic. The exceptions were cases where 1) water contained 1000 mg/L of arsenic or 2) poor nutrition was coupled with 500 mg/L of arsenic. Usually in children diffuse and/or spotted melanosis was observed. Sometimes mild keratosis could also be noted. But in Murshidabad, keratosis on the palms and soles was not rare in children.

In our earlier studies, we reported neurological manifestations due to groundwater arsenic toxicity in populations of West Bengal, Madhya Pradesh, Bihar, and among people receiving homeopathic treatment with ingestion of highly concentrated arsenic compounds. Hotta reported polyneuritis in 32% of arsenic-exposed subjects in 1989. Jenkins reported 37 cases of neuropathy among 57 patients of arsenic intoxication in North Carolina. Some other studies report that arsenic can occasionally cause subclinical or overt peripheral neuropathy in cases of chronic or subacute poisoning. The prevalence of neuropathy in arsenic toxicity as studied by different research groups has shown variations. But reports based on neurological examination of sizeable numbers of patients of arsenicosis are very scanty. The incidence of the present study (51%) was higher compared to our earlier observations in chronically exposed persons (37.3%), but much lower than that observed in a small population of subacute cases. The reason for this higher incidence may be the fact that most of the 249 patients were continuing consumption of arsenic-contaminated water at the time of our survey. The prevalence of paresthesias and limb pain symptoms in the ongoing study in Murshidabad was comparable to our findings in patients studied in Bihar and intermediate between our earlier findings on two populations studied from the Murshidabad and Nadia and Bardhaman districts of West Bengal. Prevalence of positive sensory features such as hyperpathia and allodynia and negative sensory signs such as hypesthesias and neuropathic muscle weakness in the distal part of extremities was similar to our previous findings in Bihar or Murshidabad and Nadia districts, though much lower compared to findings in the Bardhaman district. The electrophysiological study findings corroborated well with some earlier reports. The neuropathic pattern in our patients was more of axonal degeneration with or without demyelination. In this series, electrophysiological evidence of neuropathy was obtained in cases that also had clinical

evidence of neuropathy. In contrast to our earlier studies, there was no case of subclinical (isolated electrophysiological) neuropathy.

Arsenic exposure during pregnancy can adversely affect several reproductive endpoints. Several studies have examined the association between arsenic exposure and adverse pregnancy outcome, including spontaneous abortion, preterm birth, stillbirths, low birth weight and neonatal and perinatal mortality. The recent studies observed that arsenic readily crosses the human placenta, giving rise to arsenic concentrations that are about as high in cord blood as in maternal blood. Investigations in Hungary reported a correlation between increased concentrations of arsenic in well water (60 – 270 mg/mL) and increased incidence of spontaneous abortion and perinatal deaths without an increase in premature births from 1980 – 1987. Another series of evaluations of demographic data from 1970 – 1987 indicated that frequency of stillbirths and spontaneous abortions was increased in a population drinking from wells with arsenic concentrations exceeding 100 mg/L.

In our present study, similar to our previous work, an increase in the rate of spontaneous abortion with increase in the arsenic level of water was observed. However, in Chile, even water with a moderate arsenic content (< 50 mg/L) consumed during pregnancy was associated with reduction in birth weight as compared to a control group with minimal arsenic content (<1 mg/L) in their drinking water. Findings from Taiwan also suggest that in arsenic endemic areas, consumption of the contaminated water was correlated with significantly increased risk of low birth weight. In the same study, the association with preterm delivery was present though not as robust. Similarly, the present study shows low birth weight and preterm delivery rates increasing more consistently with the rise of arsenic level in drinking water than with the duration of exposure.

We observed from this retrospective study that arsenic exposure increased the susceptibility of pregnant women to spontaneous abortions, stillbirths, preterm births, low birth weights, and neonatal deaths compared to the control population. However, other confounders such as repeated child-birth, malnutrition, and other organic causes of spontaneous abortion should be excluded in the study population. Though our study pointed out potential reproductive effects of arsenic exposure in humans, the evidence was not

conclusive. We did not have information on several confounding factors, including lifestyle and personal factors that affect birth weight, congenital malformation, and other outcomes and information on other potential exposures. A large multicentric prospective study will be more appropriate to find out the effect of chronic arsenic exposure on pregnancy.

#### CONCLUSION

The multisystemic features of arsenic toxicity, including dermal effects sometimes leading to gangrene and cancer, neurological symptoms, and adverse obstetric outcomes, were observed in the affected population of Murshidabad. Some additional clinical features such as weakness and lethargy, chronic respiratory syndromes, anemia, and gastrointestinal problems were also noticed in this study. The health effects were observed to be related with the arsenic content in the drinking water as well as the duration of exposure.

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