

# Assessing Vulnerability of the Arsenic Exposed Population in India

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**Abstract:** Arsenic contamination of groundwater is one of the most serious environmental health disasters occurred in India. Out of an estimated 9.7 million arsenic exposed population, nearly one million are showing various forms of clinical manifestations, including cancers. The current study aims to assess the social and health vulnerability of the affected population to cope with arsenic pollution at the household and community levels. In arsenic affected villages, an extensive study has been conducted, which included household surveys, focus groups, informal discussions and interviews of concerned authorities, civil society organizations, political leaders and technical experts. Secondary data was collected by reviewing literature and policy documents. The World Health Organization's (WHO) International Classification of Impairment, Disability and Handicap (ICIDH) was used to measure the consequences of arsenicosis. Poverty was one of the major determinants of arsenic exposure level, severity of manifestations and consequences, which has a link with a subject's occupation, nutritional status, access to health care and good governance. The existing knowledge gap between the scientific community and local government has been the major obstacle in implementing a sustainable mitigation strategy. Social disparity (including gender) and lack of a political will have resulted in poor community participation during decision making and grass root planning respectively. Hence, several strategies cannot benefit in terms of improvement of symptoms. Rather, physical disability and disfigurement due to symptoms have made the poor more vulnerable to economic and social exclusion. The study has revealed that there is a need to incorporate the social determinants of arsenicosis in mitigation policy in order to reach out to the vulnerable section of the community.

**Key words:** Chronic arsenicosis, consequences of diseases, disability, ICIDH, disparity, handicap, nutrition, occupation, policy, socio-economic status.

## Introduction

Arsenic contamination of groundwater is the most life threatening environmental health disaster in India. As per the WHO's recommended guideline value (10 ppb), around 9.5 million people living in West Bengal (an eastern state of India) are at risk of contracting arsenicosis due to consumption of arsenic-contaminated groundwater. The earliest manifestations of arsenicosis are darkening of the skin (melanosis) with/without a whitish patch (leucomelanosis) and corn-like swellings of palms and soles (keratosis). Unfortunately, two decades after the detection of the first chronic arsenicosis case, no comprehensive strategy to combat the disease has yet been developed (Chakraborti, 2008). However, the

disease has drawn a lot of attention from the research community around the globe, who have contributed significantly to the understanding of the bio-medical, engineering, geological, and agricultural aspects of the challenges posed by arsenic contamination of groundwater (Chakraborti et al., 2004; Nickson et al., 2000). Nevertheless, the social dimension of the problem has received inadequate attention by the scientific community and the policy-makers at large (Hanchett, 2004). The social dimension of health is defined as the inequality and inequity, which essentially determine the adverse health outcomes and the further consequences, and also includes inaccessibility to solutions, to bring benefits to the vulnerable population (Kaufman and Cooper, 1999). Lack of understanding of a complex social

structure, and physical and social consequences of the disease have resulted in failure of the techno-centric approach to benefit the community. By presenting empirical evidence collected from the arsenic-affected villages of West Bengal, this paper attempts to assess the social and health vulnerability of the affected people and their ability to cope in their day-to-day activities.

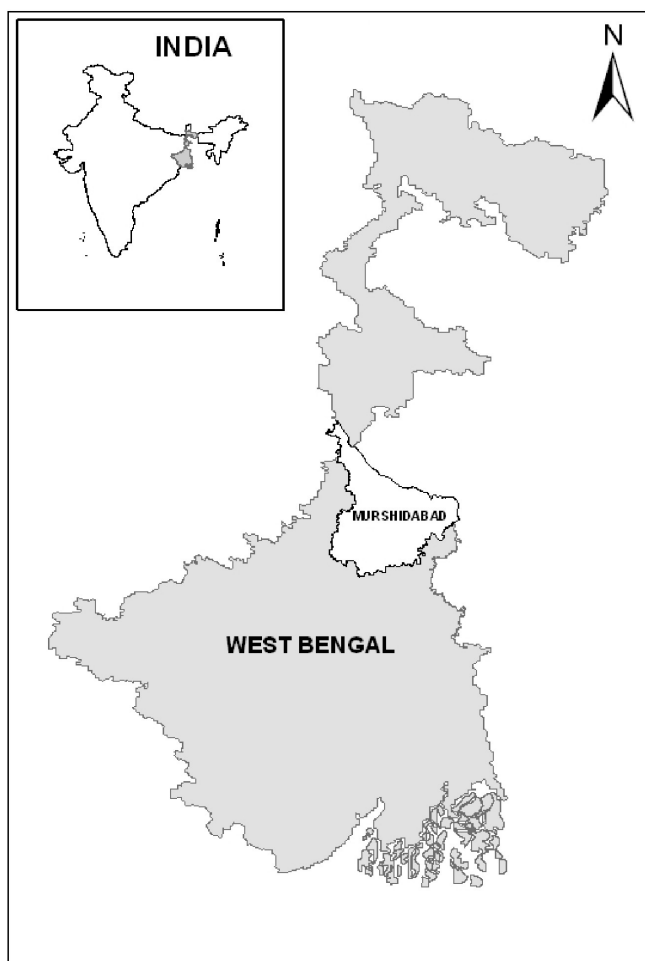
## Methodology

### Study Area and Population

Five villages were randomly selected from the list of known arsenic affected villages from an administrative block of the district of Murshidabad (Figure 1). The total

population of the selected villages was 9844, and around 80% of households were economically dependent on agriculture as a primary source of income. Due to previous surveys and awareness programmes, the majority of the villagers were familiar with the arsenic contamination of groundwater (Rahman et al., 2005). Since the people's response to arsenic contamination was one of the study components, it was an important selection criterion. Furthermore, the village administrative office (*panchayat*<sup>1</sup>) provided the researchers with an up-to-date household socio-economic survey report, which was later used in this study. General public health infrastructure has been in very poor condition. Due to a lack of manpower and medicine in the existing primary health centres, the majority of villagers have relied upon private service providers, who often have failed to provide quality care such as rational treatment of arsenicosis patients. More than 90% of the population depended on groundwater for drinking and cooking. Groundwater is also the principal source of water for irrigation (depending upon the nature of crops and the season). Often, farmers drink water from their irrigation wells during farm activities. Approximately 62% of the village tube wells and 73% of the shallow tube wells for irrigation purposes were contaminated with arsenic. Arsenic levels in different sources of drinking water (hand pumps, irrigation pumps, dug wells, and ponds) were within the range of 0–600 ppb (95% Confidence Interval 7.6–120).

The entire population of the study villages was screened (i.e. presence of skin manifestation) for identification of arsenicosis cases by a house-to-house survey. A structured schedule was developed for the collection of in-depth data from the identified arsenicosis cases. But prior to the study, pre-testing and validation of the schedule was conducted. Through the screening process, a total of 410 cases were identified with the symptoms of melanosis and leucomelanosis, and out of those, 282 cases had keratosis. These cases were clinically examined and interviewed using the schedule. Apart from the interviews, focus group discussions, informal interactions and walkthrough surveys were conducted for more qualitative information. The field-based data were collected in two phases: the first phase was carried out



**Figure 1: Murshidabad district in West Bengal.**

<sup>1</sup> Panchayat is a body of elected representatives for a village. They act as a conduit between the local government and people, and make decisions on issues key to a village's social, cultural, and economic life. Now all government developmental projects are mostly executed or supervised through the panchayat. The underlying idea of strengthening the panchayat is to bring the benefit of development to the rural community, to encourage community participation in decision-making, to promote community ownership for sustainable development, and to reduce bureaucratic hurdles existing in top decision-making bodies. Despite all the criticism, the panchayat in West Bengal is considered to be one of the best systems in India and often viewed as a role model for other backward states (Ghatak and Ghatak, 2002).

during 1997–2004 and a follow-up study in the same study villages in 2005–2006.

### Measurement of Arsenic Exposure

The arsenic concentration in a principal water source does not indicate true exposure as people drink water from multiple sources. A detailed water intake history of the individuals (for the previous year from the date of the interview) and the arsenic level of the respective sources were taken into account to measure arsenic exposure level. Reports for arsenic levels in all hand pumps were obtained from the Public Health Engineering (PHE) department, Murshidabad district, and School of Environmental Studies (SOES), Jadavpur University, Kolkata. Arsenic was also tested in all water samples of hitherto untested water sources (irrigation pumps, ponds) with the help of scientists from Bose Institute, Kolkata. Average daily intake and the approximate duration of intake from source(s) (in days) in the previous 365 days from each source were recorded from each respondent. The average arsenic exposure (milligram of arsenic per litre of water per day) was measured.

Average daily intake of arsenic (mg)/litre of water

$$= (A_1 \cdot L_1 \cdot D_1 + A_2 \cdot L_2 \cdot D_2 + \dots A_n \cdot L_n \cdot D_n) / (L_1 \cdot D_1 + L_2 \cdot D_2 + \dots L_n \cdot D_n)$$

where  $A$  is arsenic concentration (milligram) of any particular source per litre,  $L_n$  is quantity of water intake from the respective source in litres per day, and  $D_n$  is duration of water intake from the respective source (in days) in the last year.

### Measurement of Socio-Economic Status (SES)

The assessment of SES was context specific and based on the villager's own perception of daily minimum needs, deprivation, disparity, leisure and comfort and reflected more robust measurements of quality of life for the study population. During pre-testing of the schedule, people across various economic and occupational groups in the study area were asked about their subsistence requirement (food, cloth, housing, health, debt etc.) and indicators of comfort and affluence. Further, they were also asked about the nature and amount of household property required to maintain various levels of SES. Although a majority of the people were poor, a distinct variation had been noticed among them as far as quality of life was concerned. Therefore, the poor were further divided into below subsistence level (SES I), subsistence level (SES II), and just above subsistence level (SES III). Households that could afford their minimum requirements were included in SES II. Those who couldn't afford one or

more of the basic requirements were included in SES I. People who could afford better food security, health care, the burden of repaying a larger debt, to keep a small savings during non-harvesting period, a basic minimum education, better quality fodder, and more expenditure in cultivation were included in SES III. The households that could easily afford more than what SES III defined – in terms of entertainment (a radio, TV, video, movie, and cultural programme in district towns), education above the primary level, maintaining their proper food habit and health status, and an ability to cope with natural calamity were included in SES IV (comfortable position). SES V (the rich) were those who had better resources and quality of life than SES IV, such as food, cloth, health, private transport, entertainment and education and played a lead role in all cultural and political activities.

### Measurement of Nutritional Status

Nutritional status of the individual was assessed by measuring Body Mass Index (BMI = weight (kg)/height ( $m^2$ ). A BMI of 20–25 is considered normal, 18.5–20 as below normal and below 18.5 as malnourished (Asthana, 1998).

### Consequences of Arsenicosis

WHO's International Classification of Impairment, Disability and Handicap (ICIDH), was used as the guiding tool to define the consequences of disease (WHO, 1980). As per ICIDH, disease (in the context of arsenicosis) is followed by three consequences – impairment (melanosis, leucomelanosis and keratosis), disability (functional limitation and difficulties) and handicap (individual's disadvantage to perform and respond due to disabilities and impairments). Disadvantage is a result of the patients being unable to conform to the norms of his/her life and surroundings and thus the handicap has been considered a social phenomenon (Wood, 1989; Vrankrijker, 1989).

During pre-testing of the schedule, the author identified two disabilities: (a) locomotor (walking, climbing, running, cycling), and (b) gripping. The locomotor and gripping disabilities were also found to limit the individual's ability to care for themselves, such as during excretion, feeding, and bathing (known as a personal care disability). Three dimensions of handicaps were observed, i.e. physical independence, occupational, and social integration. The physical independence handicap comprises essentially the disadvantages the individuals face in maintaining and sustaining a customary effective independent existence. Occupational handicap refers to the disadvantage in maintaining an

individual's ability to occupy his/her time in the manner customary to age, sex, culture, and occupation. Social integration handicap is the disadvantage found in maintaining the individual's ability to participate and follow customary social participation and interaction (WHO, 1980).

### Measurement of Impairments, Disabilities and Handicaps

The severity of impairments was categorized into mild, moderate and severe. The severity scale of disability ranged from having difficulty performing any activity (scale 1), ability to perform with assistance (scale 2) to the inability to perform even with assistance (scale 3). There were also a number of respondents who did not face any difficulty despite having manifestations (scale 0). Severity grades of the physical independence handicap ranged from no disadvantage (grade 0) to disadvantage in performance but ability to manage personal care without adopting any alternative methods (grade 1), adopting an alternative lifestyle (grade 2) and complete dependence (grade 3). Severity grades of the occupational handicap ranged from no handicap (grade 0) to slowing down the customary normal activities (grade 1), taking up an alternative occupation (grade 2) and complete inability to take even alternative occupations (grade 3). Severity grades of the social integration handicap ranged from no handicap (grade 0) to inhibition in participation (grade 1) and restriction in participation (grade 2) (WHO, 1980; Vrankrijker, 1989).

### Mitigation Policy

Although there is no national policy on arsenic mitigation programmes, the taskforce constituted by the planning commission have made a number of suggestions, such as the promotion of arsenic filters, rainwater harvesting, extraction of water from safer layers, dug wells etc. (GoI, 2007). However, the latest master plan of the provincial government (West Bengal) has essentially emphasized a piped water supply, either from a river or deep underground aquifers, installation of an arsenic removal plant with the existing piped water supply and rainwater harvesting. But it has rejected the dug well due to the threat of bacteriological contamination (GoWB, 2008). The PHE department of Murshidabad district supplied some expensive community filters (arsenic removal plant) fitted to hand pumps. However, due to technological problems, poor maintenance, and lack of community mobilization, most of the pumps became defunct shortly after being installed. Further to this, there has been no

clear strategy to dispose off highly toxic arsenic sludge produced from the filters, which may pollute the local ecology if not managed properly. Due to the lack of political will and public accountability, the medical care has not been decentralized to benefit the poor sufferers. Despite the presence of an active *panchayat* system in the state, people's participation in the decision-making process regarding the arsenic mitigation programme was not visible. The *panchayat* of the study villages was mostly governed by a local ruling class represented by higher SES. Corruption and poor governance has resulted in a supply of spurious quality materials and improper planning, which eventually resulted in a failure to provide arsenic safe water.

## Results and Discussions

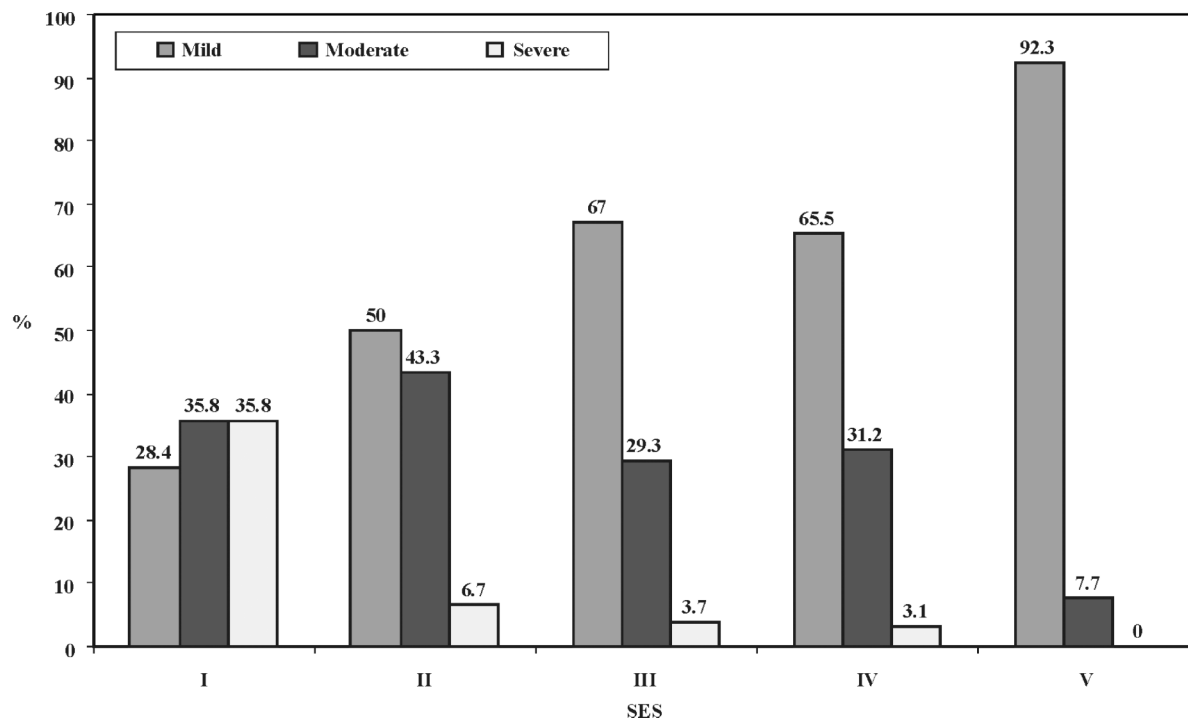
### SES

The severity of impairments increased with a higher arsenic exposure level and the relation was statistically significant (Chi-square test,  $\chi^2 = 0.012$ ). Moreover, the severity of melanosis and leucomelanosis was significantly related to SES (Chi-square test,  $\chi^2 = 0.009$ ) (Figure 2). Poor people suffered from more severe manifestations, even with the same level of exposure as the rich people. Furthermore, cases in younger age brackets were mostly found among the poor strata of the community, possibly due to malnutrition resulting in earlier appearance of symptoms. Also, participation in farm activities from younger household members resulted in early exposure to arsenic-laden irrigation water and additional toxic burden. Arsenic exposure levels have been intimately linked with the nature of occupation, such as the landless agricultural labourers and small farmers who have been exposed to higher levels of arsenic (200–600 ppb per day) compared to the other occupations.

As filtered or surface water was found to be arsenic safe, health authorities advised the community in the study area to shift to the dug wells and arsenic filters for drinking and cooking. But, only higher SES households could afford shifting to these newer options. Many of them have experienced an improvement in the symptoms as a result. Based on the hospital records and the medical history given by health workers, household members, and neighbours of the diseased people, there was a report of 22 deaths in the study area due to suspected arsenicosis. Except one, all were from the poorer sections of the community (SES I–III).

### Gender

Males have suffered from symptoms almost twice as much as females (272 males and 138 females). The



**Figure 2: Severity of melanosis and leucomelanosis and SES.**

greater proportional severity of manifestations and mortality (18 deaths among males against four among females) was possibly due to the fact that a greater proportion of males have been exposed to higher levels of arsenic than females, as evidenced from the first-phase of the study. Women were less exposed to arsenic due to gender-specific occupational patterns and their links with water resources. As men had multiple water sources to drink, their chances of getting afflicted with arsenicosis were greater. The follow-up study in 2005 has reported the death of eight males and two females (from 2000 to 2005).

### Nutrition

The association of severity of symptoms (melanosis and leucomelanosis) and BMI category was found to be statistically significant (Chi-square test,  $\chi^2 = 0.02$ ). People with a lower BMI were the worst sufferers of the disease, as 14%, 56%, and 30% of the malnourished people (BMI <18.5) showed mild, moderate and severe varieties of impairments, respectively. On the other hand, 88%, 10%, and 2% of well nourished people (BMI 20–25) showed mild, moderate, and severe varieties of impairments, respectively. BMI was found to be significantly related to SES (Chi-square test,  $\chi^2 = 0.004$ ). A combination of cereals and pulses is considered as a staple food and the latter is considered a good source of protein, which is

believed to be essential to fight against toxic manifestations including arsenic. However, Table 1 shows a lower intake of staple food among the poor, particularly the pulses.

**Table 1: Consumption (kg/adult/month, mean  $\pm$  SD) of cereals and pulses by SES**

SES	Cereals	Pulses
I	13.73 $\pm$ 1.4	0.28 $\pm$ 0.09
II	14.25 $\pm$ 1.3	0.65 $\pm$ 0.20
III	14.81 $\pm$ 1.8	0.96 $\pm$ 0.41
IV	15.35 $\pm$ 2.1	1.26 $\pm$ 0.16
V	15.94 $\pm$ 2.2	1.31 $\pm$ 0.29

### Medical Care

There are no appropriate medical treatments available to cure arsenicosis, except some palliative cares, such as keratosis softening ointments and care of serious illnesses such as cancers or liver failure due to prolonged exposure. The existing medical treatment facilities were available only in the state capital, Kolkata, which is nearly 250 kilometres from the study villages. A total of 11 cases visited Kolkata to get proper treatment, and eight of them were from higher SES (IV and V). Most of the poor villagers had to rely on unqualified doctors, government doctors in a general clinic of rural hospitals, or district health headquarters. Although these medical cares were

not effective, they were nevertheless costly for the poor who mostly managed by borrowing money or selling property. The gender disparity with regard to seeking treatment was clearly apparent. For instance, 97% of males sought medical treatment against 88% of females. Males get more attention in the households for two reasons: (1) a traditional gender bias against women; and (2) more severe forms of clinical manifestation among males. From a total of 24 people who had not taken any medical care, 16 did not due to lack of money. The other eight were not aware of the manifestations although they had mild pigmentation over their chest and back, which was diagnosed only during the initial survey for this study. All these cases that had no money belonged to very poor households (SES I and II) and the majority (13) of them were females.

### Disability: Distributions and Determinants

Figure 3 shows that a higher proportion of severe keratosis (as compared to mild and moderate varieties) is associated with a higher scale of gripping disability. In other words, a higher proportion of mild keratosis is associated with a lower scale of gripping disability. Therefore, the range of disabilities (and no disability) was essentially determined by the severity and nature of impairments. A similar nature of association between a walking disability and keratosis were also observed. Interestingly, in both scenarios, the majority of cases

faced difficulty in walking but continued with normal activities (Scale 1). However, the proportion with a gripping disability was of a higher scale than those with a walking disability and it had significance on occupational activities (described later).

SES was a determinant of the severity of manifestations, and hence disabilities. It also determined the availability of assistance, as members of the rich households got more spare time and also kept servants or maids for assistance. On the contrary, cases from lower SES were involved in more strenuous work, and thus even mild manifestations made their work more difficult to accomplish. The households from higher SES have owned toilets, had access to clear water sources, and thus faced less difficulty in maintaining their own personal care. Poor households, and especially women, continued to face difficulties. Seasonal variations influenced the role of the physical environment, which influenced life style. During the peak of summer, when the water table went further down and hand pumps became dry, poor people had to traverse greater distances in search of water and thus further aggravated the disability.

### Handicap: The Social Consequences of Arsenicosis

The handicap due to arsenicosis was identified according to grades. Grade 0 of the physical independence handicap either had no difficulty or difficulty in performance, but the people could manage personal care without adopting

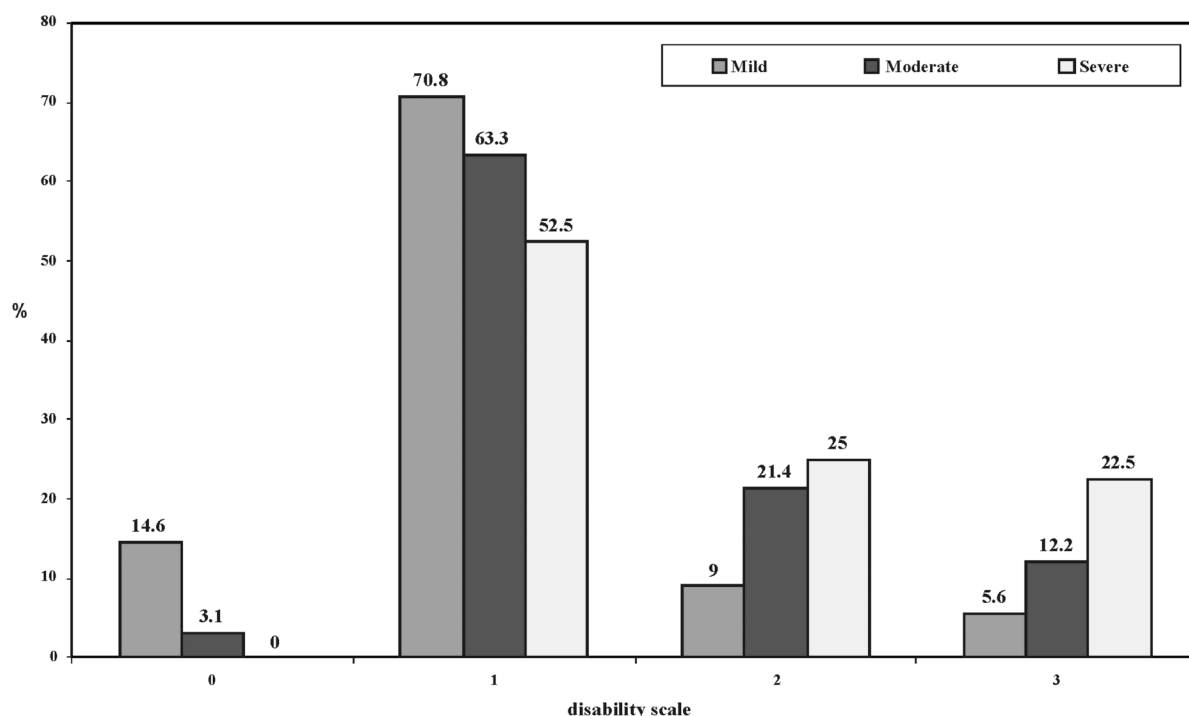


Figure 3: Severity of keratosis and scale of gripping disability.

any alternative methods or had a physical environmental advantage (such as closer location of bathing place, toilet), which eased their difficulties and helped them to maintain their habitual activities and they could avert becoming handicapped, while cases with grade 1 and 2 handicaps adopted alternative lifestyles and depended completely on others respectively. In occupational handicaps grades 1, 2 and 3 indicated slowing down the occupational activities, taking up alternative occupations and complete inability to take up alternatives respectively. This wide range in severity grades depended upon SES, occupation, gender, and family support. It is important to note that the social integration handicaps were predominantly due to the impairments. This handicap was the result of embarrassment, shyness, and a social stigma due to disfigurement of the body made by pigmentation patches and keratosis. However, there were 42 cases of social integration handicaps, who have also expressed their inability to interact socially due to a walking disability.

### Handicap and Social Factors

SES, occupation and gender were the major determinants (apart from impairments and these disabilities) of three types of handicaps. People from lower SES suffered more from the consequences of arsenicosis. The obvious reason, as mentioned before, was that, compared to the rich, the poor suffered more from impairments. Coping mechanisms, occupational patterns, and support from household members favoured the respondents from higher SES. For instance, cases from the households having their own toilets had lesser chance of a physical independence handicap due to personal care disability.

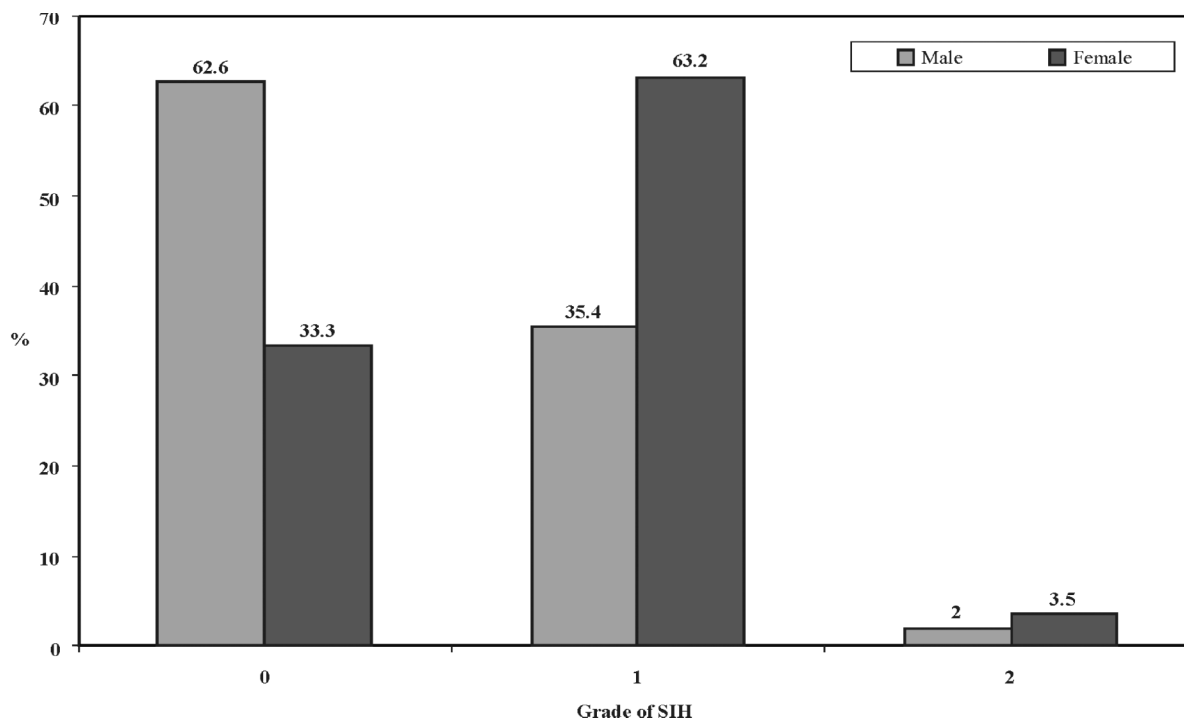
Table 2 shows the distribution of occupational handicaps on account of a gripping disability due to

keratosis and the conversion rate (from gripping disability to occupational handicap or proportion of handicap in disability) in each occupation category. It was found that disabilities in landless labourers and small farmers, who required more physical effort in their regular occupational activities, have placed them in a more disadvantageous position. Household work, generally performed by women, was the next most laborious work that included secondary economic activities (for example, processing of agricultural products before selling them to market). So the women involved in household activities showed the next highest proportion of occupational handicap. Conversion rates were also found more among the landless labourers and small farmers (53.9%) followed by household activities (48.7%). This was also another indication of more vulnerability among the cases from low SES and the specific occupations.

Figure 4 shows that the proportion of a higher grade (1 and 2) of social integration handicap on account of keratosis is higher among females (66.7%) than males (37.4%), despite the fact that women had less severe forms of impairment. However, the proportion of a higher grade of social integration handicap due to melanosis and leucomelanosis was greater among males (50.4%) than females (26.1%). Indeed, the woman's status in the society has always been lower than men, and in a more disadvantageous state. The chest and back (which are the commonest sites for melanosis and leucomelanosis) can be covered by cloth, but the women could not hide keratosis of palms and soles. So, even milder keratosis on women could lead to embarrassment, harassment, and verbal abuse. Therefore, the household members also did not allow women, particularly unmarried girls, to interact in social gatherings to avoid stigma.

**Table 2: Occupational handicap and conversion rate in each occupation category**

<i>Occupation</i>	<i>Grade of occupational handicap</i>				<i>Total No. with handicap (Grade 1 + 2 + 3)</i>	<i>Conversion Rate</i>
	<i>0</i>	<i>1</i>	<i>2</i>	<i>3</i>		
Landless labourers and small farmers	73	29	25	22	76	53.9%
Household work	44	15	13	9	37	48.7%
Students	9	3	0	0	3	30.0%
Land-owning farmers	8	3	0	0	3	30.0%
Migrant labourers	9	2	0	0	2	20.0%
Milkman	3	1	0	0	1	33.3%
Artisan	2	1	0	0	1	50.0%
Barber	2	0	0	0	0	0
Service	2	0	0	0	0	0
Business	2	0	0	0	0	0
Others	2	0	1	0	1	25.0%
	158	54	39	31	124	48.1%



**Figure 4: Grade of SIH due to keratosis and gender.**

## Conclusion

The present study has established the complex inter-linkage of social, economical, and cultural factors in the distribution and consequences of arsenicosis. It has also highlighted the role of governance and policies in facilitating the incidence and magnitude of the chronic arsenicosis. The paper reveals that the poor agrarian population is the most affected. This environmental disaster pushed the sufferers and their families into a debt trap due to occupational handicaps and medical expenditure, and eventually affected the rural economy. The population who were deprived of securities regarding economy, food and nutrition, health and other social safety nets, bear multiple burdens of arsenicosis problems. The pattern of occupation and its linkage with water quality have increased the incidence of arsenicosis among a particular section of the society that was already poor and marginalized. Further, lower nutritional status and inaccessible medical care facilities left the poor grappling with the toxic effects of arsenic. Various forms of disabilities affected their very existence, self-esteem, livelihood, and social position. Physical incapacity occurring in the respondents belonging to lower SES mostly affected their normal activities. These consequences further push them to a more vulnerable position. Lower productivity and economic indebtedness have reduced choices and the freedom to decide their

life pattern. Women are particularly vulnerable due to a lack of choice on health expenditure and education. In order to support ailing elder family members, young children are sacrificing their future growth.

This paper reveals that it is imperative to address the existing disparities and people's perception in mitigation strategies to make it more effective and sustainable. Currently, the entire debate on environmental health and its approach towards managing arsenicosis, is on the crossroads. Indeed, an appropriate technology is needed to check further contamination of groundwater with arsenic, to provide arsenic-safe water, and to develop novel methods of medical management. But the appropriateness of any technology in any given context is often determined by various sociological dimensions that have been disregarded in the current policy framework. The study shows that community participation in decision-making has not been given importance. Current policies are imposed without considering the social dimensions of the disease and its impacts on people's lives, and their implications in implementation. Community perception of the health problem, and community collective actions, were not given any place in the policy discourse. This social exclusion further deteriorated the quality of life. Poor people with limited bargaining capacity and insignificant presence in collective action at the local level were further alienated due to a social stigma, which has been defined



in the study as social integration handicap. Although the present research was limited to five villages, there is further scope for future research and action. The current master plan has apparently brought hope to provide potable water, free from arsenic, at door steps. But the challenging task is to maintain the water quality until point-of-use, as traversing the pipeline for long distances might expose it to microbial contamination due to leakage. It is particularly important for rural West Bengal, where open field defecation is still widely practiced.

Lastly, the relevance of the study in environmental health discourse is the identification of the existing gap between the scientific community and society at large, and its implication in the proper understanding and management of chronic arsenicosis. For instance, there is a need to assess the dietary source of arsenic as an additional but important route of exposure (Duxbury, 2003). It is another research challenge, as current exposure analysis utilizes only drinking water sources and thus reduces the exposure estimation. Therefore, to avert further adverse ecological impact and human suffering, it is important to integrate the multidisciplinary scientific knowledge and approach with the societal need.

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