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# From Issues to Mitigation of Arsenic Contamination: A Ranking-Based Assessment Using the Garett Ranking Approach

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ABSTRACT (10PT)

**Background:** Groundwater arsenic contamination is not simply a water quality concern rather it creates a range of debilitating problems from health issues to socioeconomic and Infrastructure. Therefore, this study systematically evaluated the challenges of arsenic contamination and community-priority interventions using a ranking-based analytical approach. **Method**: The study was conducted in two phases, consisting of a pilot survey in 2022 followed by a final questionnaire survey in 2023. Data on arsenic contamination and mitigation practices were collected using a combination of simple random and purposive sampling. A total of 780 households were surveyed, of which 196 households were identified as affected by arsenicosis. Ten major challenges related to arsenic exposure were ranked, and five mitigation technologies were evaluated based on perceived risk and effectiveness. The Garrett Ranking Method was used to analyze the priority of challenges and preferred mitigation options. **Results**: Physical health problems (68.90) were ranked as the most serious concern among arsenicosis patients, followed by economic difficulties (61.73). The availability of safe water reduced concern about water accessibility (55.08), while the lack of healthcare facilities remained a significant issue (59.06). Misconceptions and myths about arsenicosis contributed to social vulnerability, including social isolation and family-related problems. Regarding mitigation strategies, Public Water Supply Schemes (PWSS) were the most preferred option (67.41), followed by Swajaldhara schemes (54.45) and deep tube wells (50.20). Arsenic treatment units (42.92) and dug wells (34.03) were the least preferred due to maintenance and water quality concerns. **Conclusion**: Arsenicosis is a multi-dimensional crisis requiring improved healthcare access, financial support, and sustainable water solutions. State and Local governments, healthcare providers, and communities must collaborate to support affected individuals and improve the quality of life in arsenic-contaminated areas.

## Introduction

Arsenic contamination of groundwater poses a significant global health challenge, affecting millions worldwide. This pervasive issue is particularly acute in South Asia, notably India and Bangladesh, where millions of the population depend on groundwater for drinking and agricultural purposes (1, 2, 3). The impact of arsenic contamination extends far beyond simple water quality concerns. It creates a complex web of interconnected challenges. Chronic arsenic exposure leads to a range of debilitating health problems, collectively known as arsenicosis. Beyond the physical toll, chronic arsenic exposure is severe and multifaceted, spanning physical, socio-economic and psychological domains. However, arsenicosis remains a serious concern as there is no specific treatment for the condition (4, 5, 6). The most effective way to prevent arsenic poisoning is to ensure access to safe drinking water, either by eliminating the consumption of arsenic-contaminated water or by implementing sustainable water purification solutions (7). In Murshidabad district, various strategies have been introduced to address arsenic contamination and provide safe drinking water to the communities. While extensive research has been conducted on various issues related to arsenic contamination and mitigation strategies, a comprehensive assessment that considers the interconnected challenges remains limited. Additionally, there is still a need for a systematic approach to evaluate the effectiveness of different mitigation strategies and to understand the key factors that influence their adoption and long-term sustainability as it is the best way to cope with arsenicosis. Therefore, this study aims to bridge these gaps by using the Garrett ranking method, a ranking-based analytical approach, to systematically evaluate the challenges of arsenic contamination and community-priority interventions.

Arsenic contamination poses many challenges, but this study focuses on the most serious and significant challenges along with considerations of existing mitigation strategies as emphasised in the current body of literature. Long-term exposure to arsenic leads to significant health effects, such as skin lesions, neurological disorders, and increased risk of cancers (lung, skin, bladder, and kidney) (8, 9) Some demographic groups, most notably children and pregnant women, are more susceptible to its effects (10, 11, 12, 13). Studies link arsenic exposure to adverse development effects such as congenital anomalies, low birth weight, and cognitive deficits (14, 15; 16). The neurotoxicological impairments extend to the students manifesting as deficiencies in visual perception, delayed psychomotor responses, and challenges in attention, speech, and memory processing (17, 18, 19). Beyond its direct health consequences, arsenicosis has deep social and psychological implications that have been well documented in existing literature. Visible skin lesions, especially black patches, may lead to social stigmas, therefore decreasing self-esteem and limiting social interactions (10). Misconceptions surrounding the disease further exacerbate psychological distress, contributing to anxiety, depression, and social isolation among affected individuals (12). Studies have also shown a link between arsenicosis and marital instability, where afflicted people have trouble establishing or sustaining marriages because of societal prejudices (10, 11, 13). In family systems, arsenicosis patients may be emotionally and physically separated from their family members, and in some cases, are perceived as a financial or caregiving burden (10, 11). Additionally, arsenicosis might give rise to heavy costs in terms of medical expenditure, loss of productivity, and decreased household incomes for the affected persons and communities (20, 21, 22). Treatment usually demands a huge budget over the years for arsenic-related diseases and other health services, which is a real challenge for the poor. Also, arsenic contamination reduces agricultural productivity as crops are reduced by soil health deterioration, affecting income in that region and lowering the economy's output (21). Given the severe health and social implications of arsenicosis, there is a strong demand for government intervention to provide arsenic-free water to affected communities. Since establishing alternative surface water sources for all arsenic-affected villages would take years or even decades, groundwater treatment is being considered a short-term solution (23). Various interventions have been implemented in the district to ensure access to safe drinking water, including the construction of dug wells -114, tube wells -2,432, arsenic treatment units -1,131, piped water supply systems - 48 and several Swajaldhara plants (24). However, each of these technologies comes with its own set of advantages and limitations. As a result of a comprehensive literature review, valuable insights were gained into the complex challenges faced by arsenicosis patients and the factors influencing their preference for mitigation technologies. Ten major challenges and five key mitigation strategies were identified in this review, which emerged as critical themes that warrant further investigation.

## Materials and Method

This study is part of the first author's research work. Therefore, a pilot study was conducted in 2022 to understand the most challenging issues arsenicosis patients encounter and the factors associated with mitigation technologies. Additionally, existing literature also gives us an idea for a draft questionnaire form for ranking arsenic contamination issues. The validity of the planned survey schedule was then examined by the pilot survey results. Finally, an enriched revised survey schedule was eventually finalized to survey respondents after fixing the flaws identified during the pilot survey which was used for the final survey of arsenicosis patients. The Murshidabad district comprises 26 distinct blocks, and a sample size of 30 households was selected from each block. Therefore, a total of 780 samples were collected utilizing a combination of simple random and purposive sampling techniques. In this approach, purposive sampling was employed to specifically target arsenicosis patients meeting specific criteria, including a minimum of one year of suffering from arsenicosis. This criterion was designed to gather opinions from victims who have considerable amounts of experience and knowledge of the difficulties that come in their everyday lives. There are a total of 196 patients' opinions were gathered for arsenicosis issues and 780 households' opinions for mitigation technologies. Since the study was conducted in a rural backward district of the country, questionnaires were developed in both English and Bengali language. However, for my research work, three Focus Group Discussions (FGDs) were conducted in three different parts of the district along with in-depth interviews with arsenicosis patients (n = 36) and non-patients (n = 23) which provided valuable insights into the key issues faced by affected individuals and helped to understand their preference rankings.

### *Garrett Ranking Method*

To determine the hierarchy of challenges from the most to the least difficult, this study employed the Garrett ranking method to rank ten key issues (Table 2). Additionally, the same method was used to evaluate mitigation strategies, ranking five different types of risks based on technology-specific solutions (Table 5). The Garrett ranking system operates by assigning numerical values to responses, allowing for systematic prioritisation. In this study, a 10-point numeric scale was used to rank the selected issues, while a 5-point numeric scale was applied to evaluate mitigation options. These rankings were derived from respondent data, with the percentage position value calculated using the following formula.

$$\textbf{Percent Position} = \frac{100\ (\text{Rij} - 0.5)}{\text{Nj}}$$

Rji = Rank given for the $i^{th}$ variable by the $j^{th}$ respondent

Nj = number of variables ranked by the $j^{th}$ respondent

### *Calculation of Garret Value and Ranking:*

A conversion table created by Garrett and Woodworth (1969) was used for converting this computed value into matching Garrett values (Table 1). In the next stage, each Garrett value was multiplied by its corresponding rank score (Tables 3 & 7). Following this, calculations were performed row-by-row for each factor, with individual scores summed to produce the total score for each factor (Tables 4, 6 & 7). The total score was then divided by the total number of respondents to obtain the mean score, as shown in Tables 4 & 7. These mean scores form the basis for Garrett's ranking, with the factor having the highest mean score typically being considered the most significant.

## Results

### *Different Challenges Faced by Arsenicosis Patients*

There are numerous myths and misconceptions related to the contamination of arsenic in the study area. These misperceptions amplify the myriad difficulties already being experienced by arsenicosis-affected individuals, leading to severe disruptions in their lives. Moreover, existing misunderstandings at the level of the local population add to the mental health burden on patients making them more socially isolated and emotionally distressed. Therefore, an attempted was made to systematically evaluate the arsenicosis patient's range of challenges using the Garrett ranking approach to place rankings of the most critical issues.

**Table. Garrett Ranking Conversion Table (The conversion of orders of merits into units of amount of "scores")**

| 1. | Percent | 2. | Score | 3. | Percent | 4. | Score | 5. | Percent | 6. | Score |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 7. | 0.09 | 8. | 99 | 9. | 22.32 | 10. | 65 | 11. | 83.31 | 12. | 31 |
| 13. | 0.20 | 14. | 98 | 15. | 23.88 | 16. | 64 | 17. | 84.56 | 18. | 30 |
| 19. | 0.32 | 20. | 97 | 21. | 25.48 | 22. | 63 | 23. | 85.75 | 24. | 29 |
| 25. | 0.45 | 26. | 96 | 27. | 27.15 | 28. | 62 | 29. | 86.89 | 30. | 28 |
| 31. | 0.61 | 32. | 95 | 33. | 28.86 | 34. | 61 | 35. | 87.96 | 36. | 27 |
| 37. | 0.78 | 38. | 94 | 39. | 30.61 | 40. | 60 | 41. | 88.97 | 42. | 26 |
| 43. | 0.97 | 44. | 93 | 45. | 32.42 | 46. | 59 | 47. | 89.94 | 48. | 25 |
| 49. | 1.18 | 50. | 92 | 51. | 34.25 | 52. | 58 | 53. | 90.83 | 54. | 24 |
| 55. | 1.42 | 56. | 91 | 57. | 36.15 | 58. | 57 | 59. | 91.67 | 60. | 23 |
| 61. | 1.68 | 62. | 90 | 63. | 38.06 | 64. | 56 | 65. | 92.45 | 66. | 22 |
| 67. | 1.96 | 68. | 89 | 69. | 40.01 | 70. | 55 | 71. | 93.19 | 72. | 21 |
| 73. | 2.28 | 74. | 88 | 75. | 41.97 | 76. | 54 | 77. | 93.86 | 78. | 20 |
| 79. | 2.69 | 80. | 87 | 81. | 43.97 | 82. | 53 | 83. | 94.49 | 84. | 19 |
| 85. | 3.01 | 86. | 86 | 87. | 45.97 | 88. | 52 | 89. | 95.08 | 90. | 18 |
| 91. | 3.43 | 92. | 85 | 93. | 47.98 | 94. | 51 | 95. | 95.62 | 96. | 17 |
| 97. | 3.89 | 98. | 84 | 99. | 50.00 | 100. | 50 | 101. | 96.11 | 102. | 16 |
| 103. | 4.38 | 104. | 83 | 105. | 52.02 | 106. | 49 | 107. | 96.57 | 108. | 15 |
| 109. | 4.92 | 110. | 82 | 111. | 54.03 | 112. | 48 | 113. | 96.99 | 114. | 14 |
| 115. | 5.51 | 116. | 81 | 117. | 56.03 | 118. | 47 | 119. | 97.37 | 120. | 13 |
| 121. | 6.14 | 122. | 80 | 123. | 58.03 | 124. | 46 | 125. | 97.72 | 126. | 12 |
| 127. | 6.81 | 128. | 79 | 129. | 59.99 | 130. | 45 | 131. | 98.04 | 132. | 11 |
| 133. | 7.55 | 134. | 78 | 135. | 61.94 | 136. | 44 | 137. | 98.32 | 138. | 10 |
| 139. | 8.33 | 140. | 77 | 141. | 63.85 | 142. | 43 | 143. | 98.58 | 144. | 9 |
| 145. | 9.17 | 146. | 76 | 147. | 65.75 | 148. | 42 | 149. | 98.82 | 150. | 8 |
| 151. | 10.06 | 152. | 75 | 153. | 67.48 | 154. | 41 | 155. | 99.03 | 156. | 7 |
| 157. | 11.03 | 158. | 74 | 159. | 69.39 | 160. | 40 | 161. | 99.22 | 162. | 6 |
| 163. | 12.04 | 164. | 73 | 165. | 71.14 | 166. | 39 | 167. | 99.39 | 168. | 5 |
| 169. | 13.11 | 170. | 72 | 171. | 72.85 | 172. | 38 | 173. | 99.55 | 174. | 4 |
| 175. | 14.25 | 176. | 71 | 177. | 74.52 | 178. | 37 | 179. | 99.68 | 180. | 3 |
| 181. | 15.44 | 182. | 70 | 183. | 76.12 | 184. | 36 | 185. | 99.80 | 186. | 2 |
| 187. | 16.69 | 188. | 69 | 189. | 77.68 | 190. | 35 | 191. | 99.91 | 192. | 1 |
| 193. | 18.01 | 194. | 68 | 195. | 79.17 | 196. | 34 | 197. | 100.00 | 198. | 0 |
| 199. | 19.39 | 200. | 67 | 201. | 80.61 | 202. | 33 | 203. | | 204. | |
| 205. | 20.93 | 206. | 66 | 207. | 81.99 | 208. | 32 | 209. | | 210. | |

**Source:** Henry, E. Garret's, Statistics in Psychology and Education, Feffer and Simans Private Limited, 1969, p.329.

**Table 2.** Ranking of Challenges faced by the Respondents

| Issues Types | Challenges | Ranks Given by the Respondent | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th | 9th | 10th |
| Health Issues | Physical Health problems | 71 | 48 | 32 | 16 | 13 | 9 | 4 | 2 | 1 | 0 |
| | Mental Health problems (Stress, Depression etc.) | 13 | 16 | 18 | 23 | 26 | 31 | 25 | 17 | 15 | 12 |
| Social Issues | Social Isolation | 3 | 4 | 8 | 5 | 12 | 14 | 32 | 38 | 34 | 46 |
| | Disturbances in Daily Activities | 6 | 11 | 12 | 15 | 14 | 19 | 29 | 32 | 31 | 27 |
| | Problems within the Family | 3 | 5 | 4 | 7 | 13 | 11 | 23 | 35 | 40 | 55 |
| | Relationship Issue | 4 | 6 | 5 | 8 | 10 | 14 | 26 | 36 | 51 | 36 |
| Financial Issues | Economic Problems | 34 | 39 | 43 | 27 | 18 | 12 | 8 | 7 | 5 | 3 |
| Institutional Issues | Access to Healthcare | 26 | 28 | 31 | 41 | 21 | 23 | 13 | 7 | 4 | 2 |
| | Access to Safe Water | 17 | 23 | 22 | 28 | 37 | 34 | 15 | 9 | 6 | 5 |
| | No Proper Treatment | 19 | 16 | 21 | 26 | 32 | 29 | 21 | 13 | 9 | 10 |

Source: Field Survey, 2023

**Table 3.** Percent Position and their corresponding Garret Value

| Sl No | Percent Position [1000 (Rij-0.5)/Nj] | Calculated Value | Garret Value |
|---|---|---|---|
| 1 | 100 (1 – 0.5)/ 10 | 5 | 82 |
| 2 | 100 (2 – 0.5)/ 10 | 15 | 70 |
| 3 | 100 (3 – 0.5)/ 10 | 25 | 63 |
| 4 | 100 (4 – 0.5)/ 10 | 35 | 58 |
| 5 | 100 (5 – 0.5)/ 10 | 45 | 52 |
| 6 | 100 (6 – 0.5)/ 10 | 55 | 48 |
| 7 | 100 (7 – 0.5)/ 10 | 65 | 42 |
| 8 | 100 (8 – 0.5)/ 10 | 75 | 37 |
| 9 | 100 (9 – 0.5)/ 10 | 85 | 29 |
| 10 | 100 (10 – 0.5)/ 10 | 95 | 18 |

Table 4. Calculation of Garret Value and Ranking

| Description | Individual Total Score of Different Challenges and Their Rank | | | | | | | | | | Total | Average | Overall Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th | 9th | 10th | | | |
| Physical Health problems | 5822 | 3360 | 2016 | 928 | 676 | 432 | 168 | 74 | 29 | 0 | 13505 | 68.9031 | 1 |
| Mental Health problems (Stress, Depression etc.) | 1066 | 1120 | 1134 | 1334 | 1352 | 1488 | 1050 | 629 | 435 | 216 | 9824 | 50.1224 | 6 |
| Social Isolation | 246 | 280 | 504 | 290 | 624 | 672 | 1344 | 1406 | 986 | 828 | 7180 | 36.6327 | 9 |
| Disturbances in Daily Activities | 492 | 770 | 756 | 870 | 728 | 912 | 1218 | 1184 | 899 | 486 | 8315 | 42.4235 | 7 |
| Problems within the Family | 246 | 350 | 252 | 406 | 676 | 528 | 966 | 1295 | 1160 | 990 | 6869 | 35.0459 | 10 |
| Relationship Issue | 328 | 420 | 315 | 464 | 520 | 672 | 1092 | 1332 | 1479 | 648 | 7270 | 37.0918 | 8 |
| Economic Problems | 2788 | 2730 | 2709 | 1566 | 936 | 576 | 336 | 259 | 145 | 54 | 12099 | 61.7296 | 2 |
| Access to Healthcare | 2132 | 1960 | 1953 | 2378 | 1092 | 1104 | 546 | 259 | 116 | 36 | 11576 | 59.0612 | 3 |
| Access to Safe Water | 1394 | 1610 | 1386 | 1624 | 1924 | 1632 | 630 | 333 | 174 | 90 | 10797 | 55.0867 | 4 |
| No Proper Treatment | 1558 | 1120 | 1323 | 1508 | 1664 | 1392 | 882 | 481 | 261 | 180 | 10369 | 52.9031 | 5 |

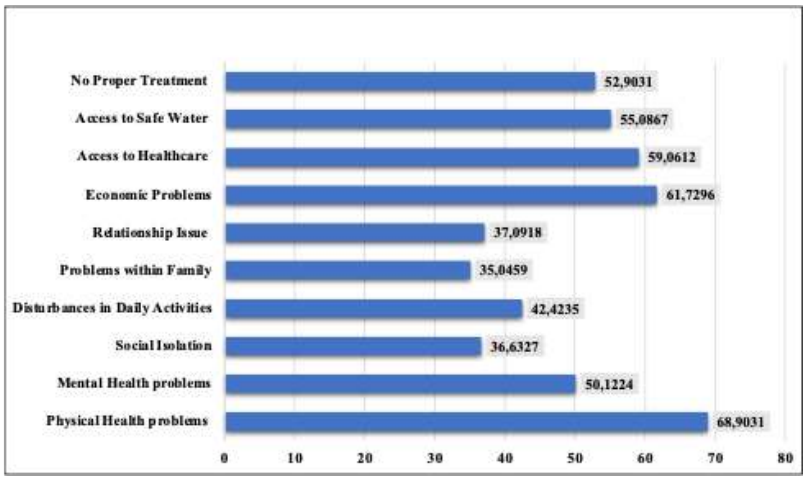


Figure 1. Respondent's Ratings over Different Problems using Garret Mean Score

From Table 4 and Figure 1 revealed that 'Physical Health problems' constitute the primary concern among arsenicosis patients, with a Garrett score of 13505 and an average score of 68.9031. This finding study is not unexpected because physical health problems frequently serve as the foundational root of other difficulties.

***Preference for Alternative Mitigation Options***

Understanding consumer preferences is essential for designing effective mitigation strategies, especially in arsenic-affected areas. Despite the availability of multiple technologies, most households are familiar with or use only one or two options. To address this, respondents were provided with a detailed briefing on five selected technologies, outlining their advantages and drawbacks. Respondents were asked to rank the technologies based on their preferences. This exercise aimed to capture a clearer picture of what households value most when it comes to alternative water sources.

**Table 5.** Frequency of Households Preference for Alternative Mitigation Options

| Options | No. of households reported their preference | | | | |
|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 4th | 5th |
| ATU | 55 | 108 | 139 | 278 | 200 |
| Dugwell | 17 | 41 | 63 | 240 | 419 |
| Deep Tubewell | 94 | 158 | 296 | 141 | 91 |
| Swajaldhara | 136 | 264 | 221 | 98 | 61 |
| PWSS | 478 | 209 | 61 | 23 | 9 |

**Table 6.** Calculation of Individual Scores of Different Mitigation Options

| Options | Individual scores of different mitigation options | | | | |
|---|---|---|---|---|---|
| | 1st | 2nd | 3rd | 4th | 5th |
| ATU | 4125 | 6480 | 6950 | 11120 | 4800 |
| Dugwell | 1275 | 2460 | 3150 | 9600 | 10056 |
| Deep Tubewell | 7050 | 9480 | 14800 | 5640 | 2184 |
| Swajaldhara | 10200 | 15840 | 11050 | 3920 | 1464 |
| PWSS | 35850 | 12540 | 3050 | 920 | 216 |

**Table 7.** Ranking of the alternative mitigation options

| Options | Calculated Value | Garett Value | Total Score | Average Score | Overall Rank |
|---|---|---|---|---|---|
| ATU | 10 | 75 | 33475 | 42.92 | 4 |
| Dugwell | 30 | 60 | 26541 | 34.03 | 5 |
| Deep Tubewell | 50 | 50 | 39154 | 50.20 | 3 |
| Swajaldhara | 70 | 40 | 42474 | 54.45 | 2 |
| PWSS | 90 | 24 | 52576 | 67.41 | 1 |

The above analysis revealed that 'PWSS' constitute the primary preference among the study area household with a total Garrett score of 52576 and an average score of 67.41 (see Table 5, Table 6, Table 7). This suggests that PWSS is widely regarded as the most reliable and effective solution for safe water supply.

'Arsenic Treatment Units (ATUs),' on the other hand, seem to have fallen out of favour, with an average score of 42.92 and a fourth-place ranking. This is a bit disappointing, considering they are designed specifically to tackle arsenic contamination. This could be attributed to frequent technical issues, limited technical expertise among locals, high maintenance requirements or reduced efficiency over time (see Figure 2).

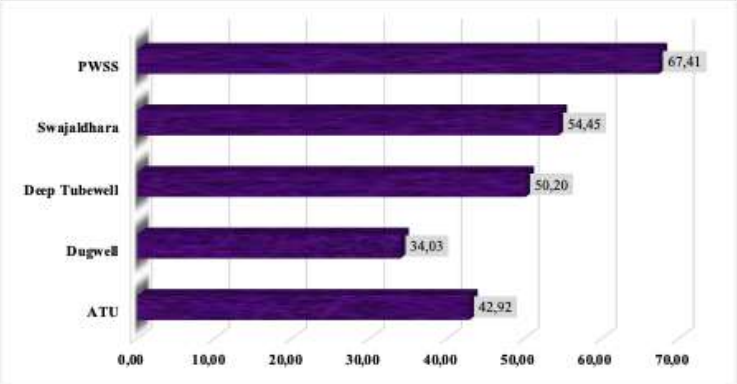


**Figure 2.** Respondent's Preference over Different Mitigation Options

## Discussion

Arsenic exposure weakens the body, causing visible symptoms like skin lesions and black spots, which dull a person's appearance and lead to social disapproval and loneliness. Kabir et al. (25) also noted that arsenicosis leads to visible dermatological abnormalities, including skin pigmentation changes and corn-like protrusions on the hands and feet. These physical markers not only contribute to pain and disfigurement but also influence social perceptions and lay diagnoses, often resulting in stigma and exclusion (25). These visible symptoms trigger mental health issues, including depression and anxiety. Additionally, the patient experiences financial difficulties as a result of their diminished capacity to work due to their physical impairment. Medical costs associated with the disease further deteriorate their existing economic conditions. Studies have highlighted that afflicted individuals can work only three hours per day compared to healthy individuals who can work up to eight hours, while the poor spend nearly 60% of their income on hospitalization (20,26). This financial burden has a detrimental impact on the person's social standing and family ties. Cultural perceptions of the disease can also lead to discrimination, worsening the patient's overall well-being. Physical health problems therefore have a domino effect, resulting in interrelated mental, economic, and cultural difficulties that significantly lower the quality of life for those with arsenicosis.

Subsequently, 'Economic Problems' ranked second, garnering a Garrett score of 12099 and an average score of 61.7296 (see Table 4 & Figure 1). The NITI Aayog has identified Murshidabad as one of the most backward districts in India currently receiving funds from the Backward Regions Grant Fund Programme (BRGF). The district's per capita income is lower than both state and national averages, and exposure to arsenicosis further reduces the work capacity of affected individuals. This makes it extremely difficult for patients to manage their daily expenses and medical costs, placing economic hardship as a top concern.

Access to Healthcare ranked third, with an average score of 59.06, slightly above Access to Safe Water, which ranked fourth with an average score of 55.09 (see Table 4 & Figure 1). The lack of specialised arsenicosis diagnosis and treatment in nearby medical institutions, inadequate transportation infrastructure, and a general lack of knowledge about potential treatment options are the main causes of the healthcare issues. In addition, patients also face the economic burden of seeking healthcare in distant centres, including high travel and diagnostic costs. At the same time, recent government programs like Har Ghar Jal, the West Bengal Drinking Water Sector Improvement Project, and the National Rural Drinking Water Programme (NRDWP) have attempted to increase access to safe drinking water, consequently, study participants were more concerned about medical facilities. This suggests that even with advancements in water safety,

people with arsenicosis still have a greater need for easily available and reasonably priced healthcare.

In contrast, issues like Relationship Problems, Social Isolation, and Problems within the Family were ranked lowest, with average scores of 37.09, 36.63, and 35.05, respectively (see Table 4 & Figure 1). One possible explanation for this lower position is the population's increasing literacy and awareness, which lessens some of the negative effects of arsenicosis on families and society. These observations are in conformity with Singha and Sikdar (27), who noted that poor public awareness and lack of government-based initiatives are two prime causes of the severity of such conditions. They further mention that without an increase in public understanding of arsenic contamination risks, mitigation efforts stand little chance of succeeding. Therefore, increasing public knowledge through health and environmental education becomes crucial in fostering a proactive approach to addressing this issue.

Remarkably, the difference between the average scores for the first and second ranks is 7.17, significantly higher than the average difference of 3.39 across all ten challenges (Table 3). However, the differences between the scores for the second to sixth ranks show minimal variance, while there is a sharp drop in the average scores between the sixth and seventh ranks, and again between the seventh and eighth ranks. The analysis emphasises that although sociocultural factors are evident, institutional infrastructure issues particularly those pertaining to healthcare and access to potable water are the main worries of arsenicosis patients in the study area. Furthermore, the overwhelming development of physical health problems remains a dominant issue for these patients, which emphasises the need for efficient interventions.

Recognizing PWSS as a safe water supplay, the Public Health Engineering Department (PHED), Government of West Bengal, in collaboration with the Arsenic Task Force, introduced an Arsenic Master Plan in 2018 to address arsenic contamination by implementing strategic measures, such as the construction of tube wells and the expansion of Public Water Supply Systems (PWSS), to ensure safe drinking water for affected communities (28). Although this option has some issues but it is the most easily accessible and available within household premises compared to other sources and is generally considered the cleanest and safest. Subsequently, 'Swajaldhara Schemes' ranked second, garnering a total Garrett score of 42474 and an average score of 54.45. Although the scheme is not as popular as PWSS but continues to be important in addressing the water needs of the community, likely owing to its water quality, relative affordability and availability in certain areas. The crucial aspect of the community-based approach is that it has been more successful in practice than the publicly managed utility schemes (29). The decentralized character of the Swajaldhara Schemes permits greater local engagement and accountability, thus enhancing the chances of good maintenance and sustainability features in the concerned project. However, its reach and efficiency may still be limited in comparison to larger-scale water supply systems. Deep tube wells ranked third with an average score of 50.20 indicating a moderate level of preference among respondents. This option is appreciated for its relatively easy and cost-effective installation process, particularly in the study area. The entire district is part of the Gangetic plain and is composed of deep alluvial soils. Therefore, tubewell installation can be done anywhere in the district without much effort and at a low cost. However, concerns about potential contamination including arsenic, made the source not among the top preferences of the respondents. This concern is substantiated by findings from Rahaman et al. (30), who analyzed 29,612 hand tube well water samples from both contaminated and non-contaminated areas. Their study revealed that 26% of tube wells contained arsenic levels exceeding 50 mg/L, while 53.8% had concentrations above 10 mg/L, indicating a widespread contamination risk (30).

The limitations of ATUs are further highlighted by studies indicating that 11 out of 12 ATUs examined failed to produce water that met arsenic-safe standards, exposing the shortcomings of existing mitigation strategies. Additionally, the annual arsenic removal efficiency of the 12 studied plants was found to range between 35.2% and 82.6%, with an average efficiency of 62%, underscoring the inconsistent and often inadequate performance of these treatment systems. Such findings suggest that without significant technological improvements and better maintenance frameworks, ATUs may continue to be perceived as an unreliable solution for arsenic mitigation (28,31). At the bottom of the list, we find ‘dug wells’ with the lowest average score of 34.03 (see Figure 2). This might be explained by poor water quality, limited functionality and the physical difficulties of collecting water from dug wells. Moreover, the decline in the use of dug wells is closely linked to the widespread adoption of tube wells, which have been perceived as a more convenient and bacteriologically safer alternative (31). As a result, the cultural practice

of relying on dug wells has gradually diminished, further reinforcing their position at the bottom of the preference hierarchy.

## Conclusion

Arsenicosis resulting from arsenic contamination is not just a public health crisis but a deep-rooted socio-economic issue that requires a multi-sectoral and community-inclusive approach. The findings of the study revealed that health problems had become a serious concern as arsenic exposure directly impacts the health of an individual and subsequent deterioration of the overall quality of life. Subsequently, economic challenges surfaced as a pressing concern with impacted persons experiencing job loss, reduced earning potential, and heightened medical costs further complicating matters. Limited access to health services turned out to be another challenge, making it harder for patients to get even a proper diagnosis, treatment, and medical attention owing to poor healthcare infrastructure and financial constraints. Despite ongoing efforts to enhance access to safe drinking water, the study revealed that many individuals still encounter substantial obstacles in obtaining arsenic-free water sources. It also draws attention to the psychosocial aspects of arsenicosis: mental health conditions, social stigma, and family-related issues that keep affected individuals isolated and away from opportunities for economic and social stability. Regarding mitigation strategies, the study shows that communities prefer Public Water Supply Schemes (PWSS) and Swajaldhara schemes, as they provide the most feasible and sustainable solutions for accessing arsenic-free water. Dug wells, deep tube wells and arsenic treatment units remain other options, but often the technical constraints and maintenance make them less feasible. To solve these problems, efforts from government agencies, healthcare providers, research institutions and local communities should work together to ensure arsenicosis-affected individuals receive the necessary support for a healthier and more dignified life. By identifying and ranking the core issues through the Garrett Ranking Approach, this study provides a data-driven roadmap for targeted interventions, paving the way for more effective mitigation and long-term resilience against arsenic contamination.

## Declaration

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