

Groundwater Arsenic Contamination in the Indo-Gangetic Plain of Bihar: The Psychological Well-being and Quality of Life of its Diseased Inhabitants

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ABSTRACT

The health impacts of groundwater arsenic contamination are only partially known until the arsenic menace is deciphered from a psychological standpoint. Arsenic toxicity's psychological health and well-being perspective is warranted to attain sustainable development goal 3 of the United Nations towards good health and well-being for all. This study assesses psychological well-being and its substantial effect on the quality of life of the arsenic-affected diseased inhabitants of Bihar who reside in the middle Indo-Gangetic plain. Cross-sectional correlational survey research was done on a sample of 382 inhabitants drawn through purposive sampling. T-test, correlation, and regression analysis were employed for the purpose. The psychological well-being of the arsenic-affected diseased inhabitants was poor compared to that of their healthy counterparts. Further, the quality of life of this population is strongly associated with and affected by their psychological well-being. Findings call for immediate attention and intervention from mental health professionals and policymakers. Knowledge generation about the psychological health impacts of groundwater arsenic contamination paves a path to improved human resources and well-being for sustainable development.

Key words: Psychological well-being, Quality of life, Groundwater Arsenic contamination, Indo-Gangetic plain, Health impact

INTRODUCTION

One term for arsenic is “silent toxin.” (Roy et al. 2014). Its combination of metallic and non-metallic properties led to its classification as a metalloid in the past. However, toxicology now views it as a poisonous metal that is tasteless, odorless, and colorless. Arsenic combines with elements like sulfur, iron, chlorine, and oxygen in nature and the human body to produce inorganic arsenic and with hydrogen and carbon to produce organic arsenic (Jomova et al. 2011). Although the molecules of organic arsenic are less deadly, inorganic arsenic poses a greater risk (Shaji et al. 2021) to human health and well-being. It has been discovered that even deficient levels of arsenic may harm humans (Xu et al. 2021). The global scenario of arsenic contamination has shown notable growth, with several newly impacted places recorded in the last ten years (Shaji et al. 2020). Sun et al. (2019) estimated that around 500 million people worldwide are impacted by groundwater poisoning by arsenic. In India, presently 20 states, namely - West Bengal, Jharkhand, Bihar, Uttar Pradesh, Assam, Gujarat, Haryana, Madhya Pradesh, Panjab, Arunachal

Pradesh, Karnataka, Tamil Nadu, Himachal Pradesh, Telangana, Andhra Pradesh, Orissa, Nagaland, Tripura, Manipur, Chhattisgarh and 4 union territories - Delhi, Daman and Diu, Puducherry, Jammu, and Kashmir are affected by groundwater arsenic poisoning (Shaji et al. 2021). Arsenic poisoning from natural and manmade sources can have substantial repercussions from an environmental psychology standpoint. Drinking groundwater contaminated with arsenic is the most prevalent method humans are exposed to (Yu et al. 2018).

The UN Sustainable Development goal-3 calls for action to ensure healthy living and promote well-being. Still, this goal shall remain unmet without research findings deciphering the arsenic menace from a psycho-social well-being perspective. Extensive literature is available that establishes the impact of arsenic on health from a physiological/biomedical perspective.

Long-term exposure to arsenic (As) has increased its toxicity many times more, making people more susceptible to fatal illnesses like cancer (Kumar et al. 2021) in the middle Gangatic plain of Bihar. Residents of twenty-two districts of Bihar consume

drinking water with As levels above the threshold of 10 $\mu\text{g/L}$ as prescribed in the WHO's provisional guideline (Chakraborti et al. 2018). Increased As level in water while cooking and naturally high total As in grains and potatoes could contribute to higher total As concentrations in food. Based on the consumption of rice, wheat, and potatoes, the overall amount of inorganic As exposure from food was nearly equivalent to drinking water (Mondal et al. 2021).

Arsenicosis is the term for the disease that results from long-term exposure to arsenic. According to the WHO, arsenicosis is a chronic illness caused by consuming excessive amounts of arsenic for at least six months. It typically presents as keratosis or melanosis on the skin, either with or without internal organ involvement (Shaji et al. 2020). Consuming water with high As contamination is the primary source of cancers of the skin, lungs, bladder, and kidneys, along with other harmful health like neurological effects, gastrointestinal issues, infertility, and hormone disruption, (Ahmed et al. 2006, Argos et al. 2010). Human health impacts from excessive arsenic exposure include effects on the skin, heart, lungs, digestive system, nervous system, reproduction, and development (Chakraborti et al. 2018, 2019). Low-level As exposure has been linked to alterations in executive functioning and the causal morphological and functional brain substrate in developing children and adolescents (Vaidya et al. 2023). Along with a host of other adverse health impacts, it impairs children's health, including malnourishment and cognitive problems, and ultimately disrupts both intra- and intergenerational relationships (Chakraborti et al. 2018, 2019).

Chronic arsenic poisoning not only has negative health impacts but also leads to a host of social issues and financial loss. However, the requisite body of knowledge regarding arsenicosis's economic and societal ramifications is conspicuously lacking (Majumdar et al. 2018). Arsenicosis patients experience severe psychological distress, social rejection, and hate from others (Chakraborti et al. 2018). According to studies, those who have been exposed to arsenic poisoning have a higher probability of developing mental health disorders (Brinkel et al. 2009, Milione et al. 2016). The irony is that there is now no treatment for chronic arsenic

poisoning. As a precautionary step, only water safe from arsenic exposure and wholesome food that includes vitamins are advised.

Psychological well-being could be conceptualized as to what extent one's life is going well. It is a blend of feeling good and operating well. However, psychological well-being is jeopardized when unpleasant emotions are acute or chronic, which interferes with a person's capacity to perform efficiently in everyday life (Huppert 2009). People's happiness and longevity are enhanced by a higher level of psychological well-being. They are also more likely to have a higher quality of life (Kubzansky et al. 2018).

Quality of life is a concept that seeks to capture the well-being of a population or individual in terms of both positive and negative factors throughout their lifetime at a certain point in time (Teoli and Bhardwaj 2023). Quality of life is described as an individual's sense of their place in life within the framework of the culture and value system in which they live, as well as their objectives, expectations, standards, and concerns. It is an expansive notion influenced in a complex way by the person's physical health, psychological state, level of independence, social ties, and relationship to prominent aspects of their surroundings (Fayers 2003).

The present study aimed to investigate the psychological well-being and its substantial impact on the quality of life of the diseased inhabitants from arsenic-affected middle Indo-Gangetic plain area of Bihar.

MATERIALS AND METHODS

We proposed the following hypotheses:

H1: The psychological well-being of arsenic-affected diseased inhabitants would be poor compared to their healthy comparative counterparts.

H2: There would be a significant association between quality of life and psychological well-being of arsenic-affected diseased inhabitants.

H3: Psychological well-being will strongly impact the quality of life of these diseased inhabitants.

We used cross-sectional correlational survey research design for the present study. The total samples comprised 382 ($N=382$) individuals drawn with purposive sampling method from the arsenic-

Table 1. Inclusion and exclusion criteria for the clinical group (diseased inhabitants) of the study sample

| Inclusion criteria | Exclusion criteria |
|---|--|
| Individuals residing in As affected region of Bihar for more than 10 years | Individuals residing in the As affected regions of Bihar for less than 10 years |
| Must be a diseased inhabitant, suffering from any one chronic disease as per their medical-clinical profile | Individuals who do not suffer from any chronic disease and also who do not volunteer to participate in the study |
| Within the age range of 20-60 years | Individuals of age below 20 years and above 60 years |
| With no severe mental disorder or comorbidity | Individuals with severe mental illnesses |

endemic regions of Bihar in the middle Indo-Gangetic plains. Among the total sample, 202 individuals were the diseased inhabitants ($n_1=202$) who suffered from at least one chronic disease and 180 were healthy counterparts ($n_2=180$) as reference. The selection of the sample was based on the inclusion and exclusion criteria given in Table 1.

Tools and measures

Socio-demographic and clinical data sheet: A socio-demographic and clinical data sheet that was semi-structured was designed for the current study. It helped collect data on important sociodemographic details like age, gender, residential area, etc. It also includes information regarding their health and illness profile.

Psychological Well-being Scale (Ryff 2010): It is an 18-item questionnaire (short form) assessing 6 domains of PWB (environmental mastery, autonomy, personal growth, purpose in life, positive relations with others, and self-acceptance). The scale has a good fit, and the internal homology using Cronbach's alpha in 6 domains of self-acceptance, environmental mastery, positive relation with others, purpose in life, personal growth, and autonomy were, respectively, 0.52, 0.76, 0.75, 0.52, 0.73, 0.72 and for the total scale it is 0.71.

WHO Quality of Life Scale-Brief (Anonymous 1998): This 26-item scale assesses QOL in four domains of life- physical health, psychological health, social relationships, and environmental health. With a high Cronbach's alpha coefficient of 0.896, this scale was found to be good in internal reliability and test-retest reliability as well. The scale is cross-culturally sensitive.

Procedure

The participants of the study were sampled from the arsenic-affected endemic regions of Bihar, which included 6 districts of Bihar, namely, Bhojpur, Buxar, Lakhisarai, Patna, Samastipur, and Saran. The data collection processes were initiated by establishing rapport and obtaining informed consent from the participants for volunteer participation. The data collection for the study was done in two phases. In the first phase, 202 inhabitants suffering from various chronic diseases due to arsenic poisoning and residing in the arsenic-affected endemic regions were identified. The participants were selected by following the exclusion-inclusion criteria set for the purpose. Factors such as detailed records, type, and severity of their illnesses were also considered. In the second phase, 180 healthy comparative counterparts residing in the same arsenic-affected area were identified. The PWB and QoL of the participants were measured on the psychological well-being scale and WHO QoL Brief Scale, respectively. The ethical guidelines of APA were strictly followed during working with the participants. Data handling and analysis were done with the Statistical Package for Social Sciences version 25 (SPSS-25).

RESULTS

The diseased inhabitants of arsenic-affected Gangetic Plain reported significantly poor psychological well-being than their healthy comparative counterparts in five dimensions namely autonomy ($t=13.31, p\leq 0.01$), environmental mastery ($t=25.06, p\leq 0.01$), personal growth ($t=27.51, p\leq 0.01$), self-acceptance ($t=30.38, p\leq 0.05$) and

Table 2. Descriptive statistics (mean + S.D) and t-ratio comparing diseased inhabitants with their healthy counterparts on dimensions of psychological well-being (N=380)

| Psychological well-being dimensions | Health conditions | N | Mean | SD | t-ratio | Significance |
|-------------------------------------|-------------------|-----|-------|------|---------|--------------|
| Autonomy | Healthy | 180 | 14.04 | 1.77 | 13.31 | 0.01 |
| | Diseased | 200 | 10.81 | 2.80 | | |
| Environmental mastery | Healthy | 180 | 14.34 | 2.24 | 25.06 | 0.01 |
| | Diseased | 200 | 7.88 | 2.73 | | |
| Personal growth | Healthy | 180 | 17.09 | 2.53 | 27.51 | 0.01 |
| | Diseased | 200 | 9.01 | 2.13 | | |
| Positive relations with others | Healthy | 180 | 15.41 | 2.57 | 19.37 | 0.01 |
| | Diseased | 200 | 9.69 | 3.12 | | |
| Purpose in life | Healthy | 180 | 11.43 | 2.35 | 10.90 | 0.71 |
| | Diseased | 200 | 14.11 | 2.45 | | |
| Self-acceptance | Healthy | 180 | 16.62 | 2.32 | 30.38 | 0.01 |
| | Diseased | 200 | 7.83 | 3.19 | | |

positive relations with others ($t=19.37$, $p\leq 0.05$) (Table 2). Thus, the findings support of hypothesis H1.

The five dimensions of PWB and QoL in four domains of the diseased group were found to be significantly positively associated (Table 3) supporting hypothesis H2.

Table 4 presents the predictive power of the dimensions of PWB for the QoL of the arsenic-affected diseased population. As per the linear regression analysis, PWB significantly predicted the QoL of arsenic-affected diseased inhabitants. The self-acceptance dimension of PWB could explain and contribute to the QoL in the domain of physical (27.8 % of total variance; $R^2=0.278$) and psychological health 1 (34 % of total variance; $R^2=0.340$), social relations 1 (32.6 % of total variance; $R^2=0.326$) and environment 1 (35.5 % of total variance; $R^2=0.355$).

Positive relations with others were a significant predictor for QoL in the domains of physical (35.6% of total variance; $R^2=0.356$) and psychological health (39.9% of total variance; $R^2=0.399$) along with social relationship (35.8% of total variance; $R^2=0.358$). While environmental mastery strongly predicted variance in physical health (34 %; $R^2=0.340$) and social relationship (28%; $R^2=0.280$) scores among the population. Physical health (37.2%) and psychological (43.6%) domains of QoL were strongly predicted by the autonomy dimension of

PWB. Social relationship (37.2%) and environment (39.3%) were the two domains of QoL significantly predicted by the personal growth dimension of PWB. The findings stand in support of hypothesis H3.

DISCUSSION

The present study found a significant disparity in the psychological well-being of arsenic-affected diseased inhabitants compared to their healthy counterparts in the arsenic-affected middle Indo-Gangetic Plain of Bihar. This disparity highlights the grave impact of arsenic poisoning on the mental health of the diseased inhabitants of this region. This population's poor PWB has far-reaching consequences for their entire QoL. The correlation between physical and psychological health in impacted areas is shown by the documented influence on quality of life. The psychological suffering brought on by arsenic poisoning may have a direct effect on people's relationships, everyday activities, and sense of purpose, which could be one explanation for this correlation. For instance, people with mental health problems could find it challenging to have a positive outlook on life, pursue meaningful hobbies, or communicate with others - all essential elements of a high quality of life. A study from Bangladesh concluded that the patients afflicted by arsenic had much worse QoL and mental health than non-patients

Table 3. Correlation coefficient between PWB and QOL of arsenic-affected diseased inhabitants (N=200)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---------------------------------|--------|--------|-------|-------|-------|-------|-------|-------|-------|----|
| 1 Physical Health | | | | | | | | | | |
| 2 Psychological Health | .843** | | | | | | | | | |
| 3 Social Relationships | .537** | .531** | | | | | | | | |
| 4 Environmental Health | .67** | .72** | .52** | | | | | | | |
| 5 Autonomy | .30** | .33** | .30** | .23** | | | | | | |
| 6 Environmental Mastery | .49** | .50** | .53** | .46** | .37** | | | | | |
| 7 Personal Growth | .41** | .43** | .46** | .42** | .36** | .58** | | | | |
| 8 Positive relation with Others | .43** | .47** | .48** | .40** | .16* | .59** | .55** | | | |
| 9 Purpose in Life | -0.06 | -0.08 | 0.09 | -0.04 | 0.04 | -0.03 | 0.01 | 0.01 | | |
| 10 Self-Acceptance | .53** | .58** | .47** | .60** | .22** | .54** | .40** | .43** | -0.02 | |

** . Correlation is significant at the 0.01 level (2-tailed); * . Correlation is significant at the 0.05 level (2-tailed).

Table 4. Results of step-wise linear regression analysis using dimensions of PWB as predictor variables (IV) and domains of QOL as criterion variable (DV) among arsenic-affected diseased population (N=200)

| Predictors | R | R Square | R square | Beta | F change | Sig. of F |
|---|--------------------|----------|----------|------|----------|-----------|
| Criterion Variable: Physical Health | | | | | | |
| Self-acceptance | 0.527 ^a | 0.278 | 0.278 | 0.33 | 77.07 | 0.01 |
| Environmental mastery | 0.583 ^b | 0.340 | 0.062 | 0.15 | 18.59 | 0.01 |
| Positive relations with others | 0.597 ^c | 0.356 | 0.016 | 0.17 | 4.95 | 0.02 |
| Autonomy | 0.610 ^d | 0.372 | 0.016 | 0.13 | 5.11 | 0.02 |
| Criterion Variable: Psychological Health | | | | | | |
| Self-acceptance | 0.583 ^a | 0.340 | 0.340 | 0.43 | 102.99 | 0.01 |
| Positive relations with others | 0.632 ^b | 0.399 | 0.059 | 0.25 | 19.63 | 0.01 |
| Autonomy | 0.660 ^c | 0.436 | 0.037 | 0.19 | 12.81 | 0.01 |
| Criterion Variable: Social Relationships | | | | | | |
| Environmental mastery | 0.529 ^a | 0.280 | 0.280 | 0.22 | 77.71 | 0.01 |
| Self-acceptance | 0.571 ^b | 0.326 | 0.047 | 0.21 | 13.76 | 0.01 |
| Positive relations with others | 0.598 ^c | 0.358 | 0.032 | 0.17 | 9.75 | 0.01 |
| Personal growth | 0.610 ^d | 0.372 | 0.014 | 0.15 | 4.49 | 0.03 |
| Criterion Variable: Environment | | | | | | |
| Self-acceptance | 0.596 ^a | 0.355 | 0.355 | 0.51 | 110.07 | 0.01 |
| Personal growth | 0.627 ^b | 0.393 | 0.038 | 0.21 | 12.50 | 0.01 |

(Syed et al. 2012). The observed drop in psychological well-being is consistent with previous research associating arsenic exposure with poor mental health outcomes (Kumar et al. 2022).

Furthermore, those who are impacted by arsenic may face various social challenges, such as stigma and discrimination, which can worsen their psychological anguish and lower their quality of life.

Social disengagement, loneliness, and low self-esteem are all consequences of the fear of rejection or judgment, and they all harm psychological health. Prolonged exposure to arsenic can have detrimental effects on sufferers and their families, like marital issues, social instability, discrimination, and rejection by the community and families (Brinkel et al. 2009). Discrimination and social stigmatization are common

for arsenic-affected people. Unaffected people typically avoid and isolate arsenic victims out of fear of contracting arsenicosis (Chowdhary et al. 2006). A study from Bangladesh noted that since most villagers don't have adequate knowledge about arsenic, they believe it to be God's curse. For a long time, it has been observed that participation in any social program is prohibited for those impacted by arsenic. Due to the apparent signs of arsenicosis, they are excluded from the community and cannot interact with other people (Ahmed et al. 2011).

Neurotoxicity caused by arsenic may have an impact on mental health problems. Previous research has highlighted the neurotoxic consequences of arsenic, which impair neurotransmitter activities and neuroendocrine modulation (Rosado 2007, Tylor and Allan 2014). Such changes are suspected to contribute to arsenic-affected beings' increased vulnerability to mental health issues and decreased well-being. Psychosocial stresses, such as low socioeconomic level, difficulty coping with inadequate care, and debilitating illnesses linked to arsenic poisoning, were considered to be the risk factors for psychological breakdown and worsened quality of life among those affected. Many medical ailments can result from drinking contaminated groundwater with arsenic, and those who are impacted frequently experience persistent fatigue, sluggishness, and weakness. Therefore, as they cannot work properly, these populations frequently experience social rejection, job loss, difficulty finding new employment, and significant financial troubles (Khan et al 2006). This demographic is believed to be more susceptible to psychological issues because of their lower socioeconomic status, negative body image, illnesses connected with arsenic poisoning, and low self-esteem (Tylor and Allan 2014).

Environmental mastery is the ability to effectively manage one's life as well as the surrounding world (Ryff and Keyes 1995). It is considered an important psychological resource. Environmental mastery bears a major influence on the QoL of those who are afflicted and impacted by arsenic. Because of the environmental risk that groundwater contaminated with arsenic poses, these people are having difficulty managing their lives. Research showing the connection between environmental exposures and

detrimental effects on mental health has also significantly increased recently (Baker et al. 2024, Sloboden and Sosik 2012). People who are exposed to arsenic regularly face challenges that negatively affect their quality of life because they live in a place where access to safe drinking water is restricted. In addition to having an impact on their physical health, not being able to alter their surroundings to guarantee access to clean water also makes them feel helpless, frustrated, and like they have no control over their life. The environment has a separate impact on a person's QoL (Chang et al. 2020). The ongoing possibility of coming into contact with arsenic exacerbates depression, anxiety, stress, and a feeling of vulnerability, which further lowers their standard of living (Kumar and Bharti 2023).

The social problems are exacerbated by beliefs, prejudices, and fairy tales that portray arsenicosis as "an act of the devil/impure air," "a curse of God," or "the work of evil spirits" (Chowdhury et al. 2006). It is reported that thirty to eighty percent of the patients in a Bangladeshi hamlet impacted by arsenic did not obtain treatment because of these misconceptions and prejudices. Increasing public knowledge of the psychological effects of environmental contaminants like arsenic may result in improved resources and support networks for impacted communities. To avert further incidents and enhance the health of those impacted, it is imperative to treat the underlying cause of arsenic exposure through enhanced water sources and environmental remediation. A very limited sample size, from only 6 districts of Bihar state, which could be seen as a disadvantage of this study. This might have limited the ability to extrapolate the results to a larger population.

CONCLUSIONS

Poor psychological well-being was found in arsenic-affected diseased inhabitants of the arsenic-endemic middle Indo-Gangetic Plain of Bihar when compared with their healthy counterparts. The results highlight the urgent need for focused initiatives to address the mental health aspects of this environmental health hazard of great public health concern. Significant associations were found between QoL and PWB of the diseased population. The QoL was found to be

significantly impacted and predicted by the poor PWB of the diseased population.

To increase public understanding and acceptance of the psychological effects of arsenic pollution, community-based counseling services, and educational initiatives are advised. To accomplish UNSDG 3 effective initiatives that address both physical and psychological aspects require coordination between environmental scientists, public health officials, and mental health specialists.

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