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Prevalence of disability in an arsenic exposure area in Inner Mongolia, China

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ABSTRACT

Long term exposure to arsenic can cause adverse health effects and lead to different levels of disability. The prevalence of arsenical dermatosis is as high as 40% in the Hetao Plain area of Inner Mongolia, but the association between exposure to arsenic in drinking water and the occurrence of disability has not yet been fully examined. The aim of this study was to investigate the prevalence of disability in arsenic-affected villages in Inner Mongolia, China.

Methods: A cross-sectional study was performed to examine the prevalence of disability. A total of 320 villagers in the age range of 20–39 years were interviewed and examined for disability and arsenical skin lesions. The subjects were classified into a high arsenic group ($\geqslant 50\ \mu g\ L^{-1}$) and a low arsenic group ($<50\ \mu g\ L^{-1}$). The relationship between levels of arsenic in drinking water and disability was analyzed using multivariate logistic regression models to estimate the odds ratios and 95% confidence intervals.

Results: The prevalence of disability was 6.88% in the arsenic affected area of Inner Mongolia and 24.72% in the arsenic group $\geqslant 50\ \mu g\ L^{-1}$. A strong correlation was found between disability and arsenical skin lesions (OR = 86.39, 95%CI: 25.45–293.20).

Conclusion: This suggests that the level of arsenic exposure is a major risk factor for disability. Further research is needed to place the results in a wider context and to determine the exact relationship between arsenic exposure and disability.

1. Introduction

Chronic arsenic poisoning from drinking contaminated water is a major problem in many places in the world (WHO, 2001). In Inner Mongolia, China, it is estimated that more than 300 000 people are potentially exposed to arsenic poisoning in drinking water in the Hetao Plain area (Guo et al., 2003). Chronic ingestion of arsenic is known to cause adverse health effects in humans. Sufferers of arsenic poisoning may develop cardiovascular, hepatic, renal, gastrointestinal, neurological, reproductive problems and malignancies (Yu et al., 2007). Long term exposure to arsenic can cause different levels of disability (Tseng, 2009), which can impact the patients' quality of life, working ability, economic status and consequently influence local economic development (Hassan et al., 2005). The current assessment ranks arsenic in drinking water as a risk comparable to second-hand tobacco smoke and indoor radon gas, causing severe social calamity in many cases (Chowdhury et al., 2006; Nahar et al., 2008). Therefore it is important from a socio-economic point of view to explore the harm done by arsenic poisoning in drinking water. Elsewhere we have reported that the prevalence of arsenical dermatosis was as high as 40% in the Hetao Plain area of Inner Mongolia (Guo et al., 2001), but the association between the exposure to arsenic in drinking water and the occurrence of disability has not yet been fully examined. The aim of this study was to investigate the prevalence of disability in arsenic-affected villages in Inner Mongolia, China.

2. Materials and methods

2.1. Study area and population

The study area was selected in a township of Wuyuan County located in the middle of the Hetao Plain. Based on the data from a previous field survey of wells from 1993 to 1995, 66 arsenic-affected villages (water arsenic >50 $\mu g\ L^{-1}$) were found out of a total of 679 villages in Wuyuan County (Ma, 1996). We selected one of these villages to carry out the study in 2008. In this area there is no industry or mining, the main industry being agriculture, and all irrigation water is drawn from the Yellow River. Public open-type

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wells (depth about 3–5 m) were used as a drinking water source in the 1970s, but most of the villagers began to use private tube-type wells (depth about 15–30 m) for household use from the 1980s onwards.

The villagers who were present at the time of the interview were invited to participate in the study. Given that agriculture is the major occupation and most of the farming work is done by middle-aged people, 320 villagers in the age range of 20–39 years (both genders) were recruited into the present study with their informed consent. In addition to farmers (over 70% of the total), workers and shopkeepers were also involved in the study. They shared similar socio-economic status, living environment, lifestyles, dietary patterns, and health service facilities.

2.2. Study design

A total of 149 well water samples were collected from all households using drinking water wells in the arsenic affected area during the home interview. Water samples were analyzed for inorganic arsenic concentration using Ag-DDC analysis at the Institute for Water Research in Bayannaoer League, Inner Mongolia.

A cross-sectional study was performed to examine the prevalence of disability in 2008. Firstly, each subject was informed about the aim of the study, using a formatted questionnaire to obtain verbal information (as most of the inhabitants were illiterate), including demographic and lifestyle characteristics such as duration of living in the areas under investigation, sources of drinking water, well depth, physical activities and disease history. Secondly, a careful examination for disability and arsenical skin lesions was carried out. Investigators included staff from the Center for Disease Control in Wuyuan and one dermatologist from Inner Mongolia Medical College. They were not informed about the level of arsenic concentrations so as to keep the study blind. The disabling conditions were classified in accordance with the six classes of disability listed (Table 1) by the World Health Organization (Murray, 1994). Considering the level of education and cognitive capability of the inhabitants, we combined Class 1 and Class 2, Class 3 and Class 4, Class 5 and Class 6 into three different degrees of disability to define the disabling conditions, i.e. mild disability, moderate disability, and severe disability, respectively. These are defined as (1) Mild disability: limited ability to perform most activities in one of the following areas: recreation, education, procreation or occupation. (2) Moderate disability: limited ability to perform most activities in all of the following areas: recreation, education, procreation or occupation; (3) severe disability: needs assistance with daily activities such as eating, personal hygiene and toilet use.

Table 1
Definitions of disability.

Class	Description	Weight
Class 1	Limited ability to perform at least one activity in one of the following areas: recreation, education, procreation or occupation	0.096
Class 2	Limited ability to perform most activities in one of the following areas: recreation, education, procreation or occupation	0.22
Class 3	Limited ability to perform activities in two or more of the following areas: recreation, education, procreation or occupation	0.4
Class 4	Limited ability to perform most activities in all of the following areas: recreation, education, procreation or occupation	0.6
Class 5	Needs assistance with instrumental activities of daily living such as meal preparation, shopping or housework.	0.81
Class 6	Needs assistance with activities of daily living such as eating, personal hygiene or toilet use.	0.92

2.3. Statistical analysis

The subjects were classified into a high arsenic group ($\geqslant 50\ \mu g\ L^{-1}$) and a low arsenic group ($<50\ \mu g\ L^{-1}$) in accordance with the Chinese potable water standard for arsenic concentrations. A Mann–Whitney rank-sum test and Chi-square test were performed to compare the basic characteristics such as age, gender, occupation, arsenic concentration, duration of well water drinking and depth of tube-wells between the two groups. In order to investigate the association between the basic characteristics and disability prevalence, we evenly categorized age, gender, occupation, depth of tube-well and duration of well water drinking using multivariate logistic regression models to estimate odds ratios and 95% confidence intervals. Based on the World Health Organization's (WHO) recommended maximum of $10\ \mu g\ L^{-1}$ for arsenic in drinking water and China's $50\ \mu g\ L^{-1}$, the level of arsenic was categorized evenly into three groups: $<10\ \mu g\ L^{-1}$, $10–49\ \mu g\ L^{-1}$, $\geqslant 50\ \mu g\ L^{-1}$ in order to analyze the relationship between levels of arsenic in drinking water and degrees of disability. In addition, the relationship between the prevalence of disability and arsenical skin lesions was also measured in the arsenic affected areas using a logistic regression model.

All data analyzes were carried out using SPSS 10.0 (SPSS Inc., Chicago, Illinois, USA) and all statistical tests were 2-tailed with $p < 0.05$ considered statistically significant.

3. Results

The characteristics of the subjects according to their area of residence are shown in Table 2. Except for the median concentration of arsenic in well water ($p < 0.001$) and the depth of tube-wells ($p = 0.008$), no significant different were found for age, gender, occupation and average number years using well water between the high arsenic group and the low arsenic group.

A multivariate logistic regression analysis was used to explore the prevalence of disability on different variables. The results show that the prevalence of disability among workers and shopkeepers (1.20%) is lower than that for farmers (8.90%) in the study area. The odds ratio is 0.10 (95%CI: 0.01, 0.87) after adjusting for age, gender, time exposed to arsenic in drinking water, depth of tube-well and arsenic concentration in well water ($p = 0.036$). Furthermore, no significant difference was found for age, gender, depth

Table 2
The characteristics of the subjects in the present study.

Variables	High arsenic group ($n = 89$)	Low arsenic group ($n = 231$)	p values[b]
Age, years[a]	27.00 (23.00–33.00)	29.00 (23.00–35.00)	0.257
Gender			
Men	52 (58.4)	112 (48.5)	0.111
Women	37 (41.6)	119 (51.5)	
Occupation			
Farmer	70 (78.7)	167 (72.3)	0.245
Non-farmer	19 (21.3)	64 (27.7)	
Arsenic concentration ($\mu g\ L^{-1}$[a])	80 (70–100)	20 (20–30)	<0.001
Duration of well water drinking, years[a]	18.00 (8.00–24.00)	20.00 (12.00–26.00)	0.102
Tube-well depth, m[a]	18.00 (15.00–23.00)	17.00 (15.00–20.00)	0.008

[a] Data are median (Q1–Q3);
[b] A Mann–Whitney rank-sum test was performed for age, arsenic concentration, duration of well water drinking and tube-well depth. A Chi-square test was used for gender and occupation.