ARSENIC RISK IN SOUTHWEST ENGLAND

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It is estimated that around 4000 km$^2$ of land in the UK has been contaminated to some extent due to past mining and smelting activities, The Wolfson Geochemical Atlas of England & Wales, using stream sediment data, identified extensive arsenic contamination in south-west England, and around 700 km$^2$ of land is thought to be affected.

As well as from stream sediments, data have been collected using samples of minewastes and spoils; soils, including contaminated, garden and agricultural; and dusts from houses and roads. Arsenic has also been determined in water, foodstuffs grown in the area and in human urine and hair. Arsenic concentrations in soils from a number of areas are shown in the Table.

<table>
<thead>
<tr>
<th>Location</th>
<th>Type</th>
<th>Concentration (µg/g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roseworthy</td>
<td>S</td>
<td>815-161000</td>
</tr>
<tr>
<td>Poldice</td>
<td>M/S</td>
<td>1060-74900</td>
</tr>
<tr>
<td>Levant</td>
<td>M/S</td>
<td>178-4540</td>
</tr>
<tr>
<td>Bottallack</td>
<td>M/S</td>
<td>82-617</td>
</tr>
<tr>
<td>Tamar Valley</td>
<td>A</td>
<td>4-14000</td>
</tr>
<tr>
<td>Ledestown</td>
<td>V</td>
<td>233-630</td>
</tr>
<tr>
<td>Portreath control</td>
<td>V</td>
<td>27-41</td>
</tr>
<tr>
<td>Devon Great Consols</td>
<td>M/S</td>
<td>120-52000</td>
</tr>
<tr>
<td>New Mill Farm</td>
<td>S</td>
<td>210-925</td>
</tr>
<tr>
<td>Ransley</td>
<td>M</td>
<td>77-</td>
</tr>
<tr>
<td>Fraddam</td>
<td>M</td>
<td>443-4600</td>
</tr>
<tr>
<td>Cargreen control</td>
<td>V</td>
<td>16-198</td>
</tr>
<tr>
<td>Wadebridge control</td>
<td>V</td>
<td>15-18</td>
</tr>
</tbody>
</table>

S = old smelter, M = old mine, A = agricultural, V = village

The exposure to arsenic of populations living in the area and the possible risks to health have been assessed. The results are presented using a Geographical Information System with the aim of producing a decision support system for local authorities in the area.
BIOMARKERS OF ALTERATIONS IN CARDIOVASCULAR HEALTH AND EXPOSURE TO ARSENIC IN DRINKING WATER IN CHILE

Andres Gomez-Caminero, Irva Hertz-Picciotto, James Pankow, University of North Carolina, Chapel Hill, N; Claudia Hopenhayn, University of Kentucky, Lexington, KY; Catterina Ferreccio, Catholic University, Santiago, Chile.

From a prospective study of about 900 pregnant women, a subset was enrolled for the purpose of examining biomarkers of cardiovascular health. This group consisted of 200 pregnant women, half from the exposed town of Antofagasta (~45 ug/L) and half from the unexposed town (<1 ug/L) of Valparaiso. Between 24 and 32 weeks of pregnancy, the women were approached, informed of the purpose of the study, and if they consented they were asked to complete questionnaire and donate a blood specimen. The specimens were assayed for: fibrinogen, C-reactive protein, fibrinogen degradation by-products, glycosylated hemoglobin, and von Willebrand factor. Sampling and processing were performed according to a strict protocol that was identical for the two towns, and for each measurement, all specimens were assayed in a single laboratory in Chile by technicians blinded to the origin of the specimens.

The women from the two towns did not differ with respect to smoking, age, calcium intake, history of pregnancy-induced hypertension, body mass index, or length of pregnancy at the time of enrollment. The women from Valparaiso were slightly less educated, less likely to take vitamins, and of lower gravidity, but had higher folate consumption. With regard to the biomarkers of interest, glycosylated hemoglobin was higher among the exposed women, while von Willebrand factor was lower. These findings held up after adjustment for numerous potential confounding factors. No differences were seen for the other factors. If these associations are causal, endothelial damage may be the common pathway.

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CARDIOVASCULAR DISEASE AND ENDOCRINE DISORDERS IN RELATION TO ARSENIC EXPOSURE

Irva Hertz-Picciotto, University of California, Davis

Numerous studies suggest that arsenic exposure may cause cardiovascular damage and increase the risk of diabetes. Both human and animal studies provide evidence that arsenic affects the cardiovascular system, possibly via several mechanisms. Animal studies show associations with stroke volume and vasoreactivity. The human studies have included both occupational cohorts for which exposure is primarily by inhalation, and communities for which exposure is primarily via drinking water, and cover a range of exposure levels. Both morbidity and mortality have been addressed in these investigations, which have been conducted around the world, including: Taiwan, Denmark, Germany, Sweden, Bangladesh, Japan, the U.S. and Chile. Besides peripheral vascular disease, which is well established at high exposure levels, nonfatal endpoints associated with arsenic exposure have included hypertension, ischemic heart disease, cerebrovascular disease, electrocardiographic abnormalities, von Willebrand factor, and vasospastic tendencies. Although some of the reports have not adequately controlled for confounding, several are characterized by strong methodology. Overall, there is substantial consistency across these studies, suggesting that the associations may be causal.

Similarly, there is a growing body of literature that supports a role of arsenic in the etiology of diabetes. Glucosuria, alterations in glycosylated hemoglobin, incidence of diabetes, and mortality from diabetes have all been observed to be elevated in relation to arsenic exposures. Biologic mechanisms need to be investigated, based on the suggestions from epidemiologic data.

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A RE-EXAMINATION OF THE SW TAIWAN BLADDER CANCER MORTALITY STUDIES

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Background: Historically, the health data from the blackfoot-disease (BFD) endemic area of southwest Taiwan has been examined for drinking water relationships using villages grouped either on the basis of their source of drinking water supply or the level of arsenic in their drinking water supply. It has been known for decades that its well water supply, particularly its artesian well water supply, has been contaminated with arsenic from the local rocks and soils. The arsenic levels in its drinking water were among the highest known in the world, and the villages had used these water sources for decades. A 1985 study demonstrated that bladder cancer was associated with prior use of the artesian wells, a 1989 study demonstrated that bladder cancer was associated with categorical levels of arsenic, and a 2000 study demonstrated that bladder cancer was associated with arsenic exposure as a direct measure. Study Design: We have examined the data underlying the 2000 study in order to examine the bladder cancer risk differences according to water source and then to identify the additional information that was learned from examining the specific arsenic levels with in the water source groups. Results: We found that the bladder cancer mortality risk was not associated with the arsenic level in villages that used either only shallow wells as their drinking water source or both shallow and artesian wells as their drinking water source.

We found that only for the artesian wells did the bladder cancer mortality increase with increasing level of arsenic. Conclusion: We propose that some other constituent of the artesian well water consumed may have acted as a co-factor or such to account for the observed pattern in the relationship between drinking water arsenic and bladder cancer mortality risk in the 42 villages of the BFD area of southwest Taiwan.
HEALTH EFFECT LEVELS FOR CHILDHOOD EXPOSURE TO ARSENIC

By Joyce S. Tsuji, Ph.D., Exponent, Robert Benson, Ph.D., U.S. EPA Region 8, Rosalind A. Schoof, Ph.D., Gradient, Michael J. Kosnett, M.D., M.P.H., University of Colorado Health Sciences Center, and Gene C. Hook, M.S., Denver Department of Environmental Health.

Health risks from short-term exposure to chemicals in childhood have become a recent regulatory focus in the United States. This study reviews arsenic doses resulting in adverse effects following acute to subchronic exposure in young children. Acute/subacute exposures (< 1 year) and health effects are described by case reports of arsenic poisoning from water or food and by studies of medicinal arsenic treatment (primarily adults). Several epidemiological studies report subchronic arsenic exposures and health effects in children primarily from drinking water in developing countries. Information is also available from long-term follow-up studies of medicinal arsenic use. Acute health effects typically reported include gastrointestinal, neurological, and skin, and in a few cases, facial edema and cardiac arrhythmia. Dermatoses were the subchronic effects most consistently reported in both adults and children, with pigmentation changes reported at the lowest exposure levels. At the lowest exposures causing effects, the prevalence and severity of disease generally increases with age (i.e., length of exposure) and exposure level. The available data collectively indicate a lowest-observed-adverse-effect level around 0.05 mg/kg-day for both acute and subchronic studies. At these lowest-effect levels, children do not appear to be more sensitive than adults on a dose per body weight basis, although data for acute exposures are limited. Based on these data, U.S. EPA Region 8 and ATSDR have estimated no-effect levels of 0.005–0.02 mg/kg-day and 0.005 mg/kg-day, respectively.

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ARSENIC AND HEALTH: A NEW PERSPECTIVE?

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Arsenic exposure and health have received increasing attention from academia, consulting groups, associations/foundations, and governmental entities over the last decade. The goal has been to increase the research literature and health protection through funded studies and appropriate legislation.

In 1993 at the International Arsenic Symposium, a review was presented of eleven population studies concerning arsenic exposure through drinking water and health effects. The review covered a time period of approximately 20 years and represented efforts in the U.S. and Canada. Fewer reports have been located for population studies since 1993. Thus studies of latent/chronic health effects due to drinking water exposure, either new efforts or those attributed to follow-ups, have been few. Most efforts have been focused in other countries where larger numbers of persons are exposed to greatly elevated arsenic concentrations.

New legislation has been established to limit arsenic exposure through drinking water to 10 ppb. However, there seems to be a lack of studies for exposure at such low concentrations.

The report here presented is to review these recent population health assessments on arsenic exposure and human health in North America with comparisons to the more recent studies in other nations. From these studies an assessment of the likelihood of developing sound protective technologies and legislation to minimize ill health will be considered.

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THE PRESENT SITUATION OF ARSENICOSIS AND THE GOVERNMENT POLICY IN CHINA

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Since arsenicosis was first found in the mainland of China in 1983, it has been considered as the main health problem by the government of China due to its serious influences. All sorts of measures had been taken to control this disease during this two decades. In July 1992, arsenicosis was officially regarded as one of the eight endemic diseases which are administrated by the National Endemic Disease Office. Up to now, it has been estimated that over 300 million people are under exposure to arsenic, and the diagnosed patients have reached 30,000 persons. The epidemic areas mainly involved 8 provinces and 37 counties.

In order to organize effective investigation, carry out deep researches, and make cooperation with international organization and foreign experts, the Fluoride and Arsenic Society of China (FASC) was founded in 1996. An Expert Consultative Committee was set up simultaneously. The standard of arsenicosis diagnosis had been established by the committee. A lot of medical groups and researchers had been sent to the epidemic areas in the recent years, and special-purpose funds had been allocated by the government to prevent and control the disease. Pan-Asia Pacific Conference on Fluoride and Arsenic Research was held in 1999 by the support of the Ministry of Public Health. From the beginning of 2001, a research programme on the situation of arsenicosis in other areas besides the known epidemic areas and the areas with emphasis has been carrying out. It is estimated that this programme will be finished in two years. The State Council has provided 75 million for the water mitigation in the epidemic areas up to now.

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ARSENIC AND RESPIRATORY EFFECTS IN BANGLADESH

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A cross-sectional survey involving 218 male and female participants of all ages was conducted in an arsenic-affected region during health awareness campaign program. The study was focused on keratoses and pigmentation alterations and also collected limited information concerning respiratory system signs and symptoms, including cough, chest sounds, and shortness of breath, which were assessed.

Participants were clinically examined, and the arsenic content in their current tubewell water was measured; ranged from 136 µg/L to 1000 µg/L (mean 614µg/L). Unexposed subjects were randomly selected from other villages, where tubewells were not contaminated with arsenic. There were few smokers (N=51) and analyses were confined to non-smokers.

The crude overall prevalence ratios (or risk) for chronic bronchitis among the exposed subjects amounted to 2.9 (95% CI1.6-5.4). After adjusting for sex the risk was slightly higher. Age appeared as a negative confounder for chronic bronchitis. The risk for chronic bronchitis was also analyzed separately for men and women. Interestingly, women had six times higher risk than men, although all participants lived in the same environment. The overall crude prevalence ratio for chronic coughs amounted to 2.9 (95% CI 1.5-5.4). After adjusting for sex, the risk for both sexes was almost same, although women had a ten-time higher risk than men. The dose-response trend was indicated for both the conditions by increasing exposure (p<0.1).

These results add to the evidence that long-term ingestion of inorganic arsenic can cause respiratory effects, which are more marked among female participants. A possible explanation for this markedly increased occurrence of respiratory signs and symptoms in women related to the presence of weakness.

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HEALTH RISK ASSESSMENT OF ARSENIC AND HEAVY METALS IN THE ABANDONED METAL MINE AREA, KOREA

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In order to assess the risk of adverse health effects on human exposure to toxic heavy metals influenced by past mining activity, environmental geochemical survey was undertaken in the abandoned metal mine area. After appropriate sample preparation, tailings, soils, crop plants and waters were analyzed for As, Cd, Cu, Pb and Zn by ICP-AES and ICP-MS. Also, the SBET (simple bioavailability extraction test) method was used to determine the bioavailability of toxic heavy metals in soils. Health risk assessment of toxic heavy metals has been performed with the results of SBET for soils and chemical analytical data for vegetables and groundwaters.

Elevated levels of 8,780 mg As $kg^{-1}$, 8.3 mg Cd $kg^{-1}$, 490 mg Cu $kg^{-1}$, 3,640 mg Pb $kg^{-1}$ and 920 mg Zn $kg^{-1}$ were found in tailings from the Daduk Au-Pb-Zn mine. These significant concentrations can impact on soils and waters around the tailing files. Mean concentrations of 110 mg As $kg^{-1}$, 1.9 mg Cd $kg^{-1}$, 170 mg Pb $kg^{-1}$ and 460 mg Zn $kg^{-1}$ were highly elevated in paddy soils. Risk assessment modeling is subdivided into four stages, i.e. hazard identification (data collection and evaluation), exposure assessment, toxicity (dose-response) assessment and risk characterization. In order to assess exposure it is necessary to calculate the average daily dose (ADD) of contaminant via the three identified pathways (soil, groundwater and food pathways). Dose concentration of As is the highest via a pathway of rice intake, and those of Cd and Zn via a pathway of chinese cabbage intake. Human hazards deriving from mine site either constitute a toxic risk or a carcinogenic risk. Toxic risks are indicated in terms of a Hazard Quotient (H.Q.) and this risk exists for H.Q.$>$1. The H.Q. values for As, Cd and Zn are 20.8, 4.2 and 2.2, respectively, and toxic risk for As is the highest in this mine area. Carcinogenic hazards differ from systemic toxic hazards in that there is no lower limit for the existence of cancer risk. Individual excess risk is an estimate of the probability that an individual will get cancer from an exposure, not the probability of dying from it. The carcinogenic risk for As from contaminated rice consumption is five in a thousand ($4.8 \times 10^{-3}$) in the Daduk mine area. This risk level is greater than ranging from 1 in 10,000 to 1 in 1,000,000 required to perform remediation. Thus, a significant health risk is present from the consumption of locally grown rice in this mine area.
COMPARISON OF TWO ARSENIC EXPOSURE ASSESSMENT PROTOCOLS IN A CHRONICALLY EXPOSED POPULATION

Edward E. Hudgens, B.Sc., Dina M. Schreinemachers, Dr.P.H., Rebecca L. Calderon, Ph.D., Epidemiology and Biomarkers Branch/HSD, NHEERL/US EPA; David J. Thomas, Ph.D., Pharmacokinetics Branch/ETD, NHEERL/US EPA; X. Chris Le, Ph.D., University of Alberta

Consistent with the US EPA 1997 Arsenic Research Plan’s emphasis on studies in US populations, two studies were conducted in Millard County, Utah; the first in 1997 and a second in 1999. In the 1997 study, analysis of 24-hour time course urine samples confirmed that the first morning void was a representative sample when corrected by creatinine. A positive relationship was found between total urinary arsenic and the arsenic concentration in the water source. These individuals showed stable metabolite profiles consistent with chronic exposure as described in other studies in the U.S.: As(III) = 11.1 ± 4.3%, As(V) = 3.9 ± 3.6%, MMA = 14.0 ± 4.1%, DMA = 71.0 ± 7.9%.

The results of a mixed model regression analysis of the 1997 data showed that the number of urine samples required to give a good estimate of arsenic exposure could be reduced. To validate this result, 16 subjects from the 1997 study were asked to give two urine samples on consecutive days in April 1999. The metabolite profile was consistent with the profile found in the earlier study. A similar relationship between the total urinary arsenic and the concentration of inorganic arsenic in the drinking water source was found. Reducing the number of required samples and removing the restrictions on the timing of sample collections did not affect the exposure assessment for this group of chronically exposed individuals. Larger, potentially more powerful, population based studies can be done for a reasonable cost through the use of this shorter protocol.

This is an abstract of a proposed presentation and does not necessarily reflect EPA policy.

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COMPARISON OF SECULAR TREND OF MORTALITY FROM INTERNAL CANCERS IN SOUTHWESTERN AND NORTHEASTERN ARSENIAISIS-ENDEMIC AREAS IN TAIWAN: IMPACT OF IMPLEMENTAION OF TAP WATER SUPPLY SYSTEM

Yung-Po Liaw, Ph. D., Chung Shan Medical University; Wen-Chung Lee, Ph.D., Chien-Jen Chen, Sc.D., National Taiwan University

Residents in the southwestern arseniasis-endemic area in Taiwan had been using high-arsenic artesian well water from early 1910s to late 1970s, the arsenic concentration in well water was mostly above 100µg/L. Most residents in the northeastern arseniasis-area have been using shallow well water with arsenic concentration mostly between 10 and 100µg since late 1940s. This study was conducted to compare the secular change of mortality from internal cancers among residents in arseniasis-endemic and non-endemic areas in Taiwan.

Age-adjusted mortality rates of cancers of the lung, bladder, kidney and prostate were calculated for two periods, i.e., 1971-1985 and 1986-2000. The age-period-cohort analysis for mortality from cancers of the lung, bladder and kidney combined was also carried out.

The percent changes in mortality were strikingly different in three comparison areas for various internal cancers. The increase in mortality followed the order of highest in northeastern arseniasis-endemic area, moderate in non-endemic areas, and lowest in southwestern arseniasis-endemic area. There was even a decreasing trend in mortality from bladder cancer of both males and females and lung cancer of females among residents in the southwestern arseniasis-endemic area. The age-period-cohort analysis showed similar increasing period effect in northeastern arseniasis-endemic area and non-endemic areas, especially striking in the northeastern arseniasis-endemic area; and a decreasing period effect in the southwestern arseniasis-endemic area. There was an increasing combined cancer risk for birth cohort born after 1941 in northeastern arseniasis-endemic area, and a decreasing risk was observed for the same birth cohort in the southwestern arseniasis-endemic area. The implementation of tap water supply system in southwestern endemic area seems to decrease the risk of internal cancers.

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HEALTH CONSEQUENCES OF ARSENIC POISONING
SITUATION OF TWO UPAZILAS IN BANGLADESH

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Estimates suggest that 95% of the population relies on groundwater for drinking purposes and over a quarter of Bangladesh is affected by this new problem. This means that about 30 million people are potential at risk of arsenic poisoning. Around 7000 arsenicosis patients have been identified so far in the country. Such a huge population being affected by drinking water is unparalleled elsewhere in the world. It is not a simple health problem. It is much beyond that. It is development problem as well.

BRAC in collaboration with Department of Public Health Engineering (DPHE) and UNICEF tried to find out, in some extent, the distribution and risk of arsenicosis of the exposed people. A very terrible and alarming picture came to light through this action research project implemented recently in Sonargaon and Jhikorgachha upazilas of the country.

A total of 252 patients were identified in Sonargaon and 151 in Jhikorgachha. From the very beginning of the identification of the arsenicosis patients BRAC ensured the supply of arsenic safe water and later provided carocet tablets (anti-oxidants) and salicylic acid ointment for the severe patients. At the end of the project period i.e. after two years, BRAC conducted a survey to assess the perception of the patients about BARC support and their present status of improvement. A physician re-visited the patients to assess their status. According to the physician’s survey it was observed that almost all the patients improved their physical status significantly. This paper discusses the findings in details.

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ARSENIC EXPOSURE, HEALTH PROBLEMS, AND BODY MASS INDEX OF HOSPITAL PATIENTS IN BANGLADESH

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The aim of this study was to evaluate the health effects of arsenic poisoning, and correlate the disease duration and severity with the arsenic exposure dose and the nutritional status of the patients attending the Dermatology Outpatient Department of a teaching hospital in southern Bangladesh. The mean ± SD (range) arsenic concentration of 150 water samples was 0.50 ± 0.21 mg/L (0.07 – 1.70 mg/L). Thirty-one percent of the samples had arsenic levels 10-fold higher than the permissible limit of 0.05 mg/L in Bangladesh, and 50-fold higher than the WHO-recommended limit of 0.01 mg/L. All the 150 patients presented with characteristic raindrop skin pigmentation, and more than 80% had hyperkeratosis with or without nodular warty lesions in palms and soles. Sites of the skin lesions, in order of frequency, were the trunk (38%), hands only (18%), both hands and feet (15%), feet only (13%), and the chest (11%). Twenty patients (13%) had high blood pressure and depression or anxiety. Ten patients (7%) were admitted with complications, and one died. Disease severity was significantly associated with arsenic concentration in water. Disease duration correlated inversely with body mass index, after controlling for age ($r = -0.298, p = 0.013$). Immediate public health measures are needed to curve the arsenic exposure, improve public awareness of the problem, and improve the nutritional status of the people in rural Bangladesh.

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5-YEAR FOLLOW-UP OF CHRONIC ARSENIC TOXICITY PATIENTS
IN SOUTHERN BANGLADESH

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Sharmeen S. Murshid, MSS, Brotee, a center for people’s participation

The purpose of the study was to observe cancer occurrence and arsenic
related awareness in chronic arsenic toxicity patients.

A total of 150 patients (mean age 29.35 years) who were cancer free were
observed for a period of five years. These patients were from various parts of
Southern Bangladesh and were registered with the dermatology clinic in SBMC
hospital, Barisal in 1996. Diagnosis was made clinically supported by water test
of the source of drinking water (shallow tube wells). Information dissemination
and awareness raising work was conducted by the workers of Brotee to motivate
patients to stop drinking water from contaminated wells. These patients come
from the rural areas neighboring Barisal town. Majority of them are from very
poor socio-economic background. Mean and standard deviation of duration of
drinking (in years) and arsenic concentration (mg/L) in water were 15.76+- 6.20+-
, .49+- .20+- respectively. By end of five years three patients (2%) developed
squamous cell carcinoma of skin. Regarding impact of awareness raising and
motivational process, initial (in the first year) high response was observed but at
the end of study period it was found that 25% patients still drank the contaminated
water. The study shows the need for close medical monitoring together with an
intense door to door communication campaign over considerable period to contain
the existing trend.

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PREVALENCE OF SKIN LESION IN SOME ARSENIC AFFECTED AREAS OF BANGLADESH

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Groundwater based water supply programs that provided ‘safe’ drinking water in order to control diseases like diarrhoea, dysentry, typhoid, cholera and hepatitis have exposed population to arsenic related health problems in Bangladesh. The presence of arsenic in groundwater in concentrations exceeding acceptable level has been found in most areas formed by recent alluvial sediments. The depressed areas having longer retention of floodwater are found to be worst affected. This paper presents an analysis of situation of arsenic contamination of groundwater and arsenic related diseases based on the information available from the studies conducted in Bangladesh.

The populations exposed to high arsenic contents in drinking water exceeding Bangladesh Drinking Water Standard of 50 µg/L and WHO Guideline value of 10 µg/L are 29 million and 49 million respectively. Bangladesh Arsenic Mitigation Water Supply Project under the national screening program has preliminarily identified visible arsenic related skin lesion in about 0.11 % population in 39 Upazilas (Sub-districts), which may turn into skin cancer at a later stage. The UNICEF screening program in Bangladesh has shown a skin lesion prevalence rate of 0.06% in five Upazilas. The rate of incidence of arsenicosis in the Upazilas screened so far is lower than the rate of excess lifetime skin cancer estimated by using the USEPA model for the present level of arsenic contamination of drinking water. Limited data suggest that either the excess skin cancer risk predicted by the model is on the higher side or arsenic related health effects in Bangladesh are in the preliminary stage and the cumulative effects corresponding to present level of contamination are yet to occur. No strong correlation between prevalence of skin lesion and average arsenic content of drinking water of the areas screened so far was found.

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ARSENIC EXPOSURE IN BANGLADESH POPULATION: RESULTS OF A HOUSEHOLD SURVEY


We investigated the distribution and magnitude of arsenic exposure among Bangladesh population and their awareness of the arsenic problem, and possible remediation options. Through house to house survey, we surveyed and analyzed 6,000 contiguous tube-wells and interviewed their users in three unions of Araihazar, Bangladesh. Nearly half of the 60,000 residents in these three unions were found to be drinking water with arsenic concentration more than 50 µg/L. Majority (57%) of the people interviewed were aware of the health risks of arsenic and 88% of them associated it with skin related symptoms. Higher socioeconomic status was associated with higher awareness of health consequences associated with arsenic exposure. Almost every respondent (98%) was found to be willing to take steps to overcome this problem and a solution based on existing tube wells was most popular (77%), either by switching to a safer well (45%) or by modifying and treating its water (32%).

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LIFETIME EXCESS RISK OF INTERNAL CANCERS DUE TO ARSENIC EXPOSURE FROM DRINKING WATER AMONG BANGLADESH POPULATION


The purpose of the study is to estimate the excess mortality from internal cancers (liver, bladder, and lung cancer) due to drinking arsenic-contaminated water among Bangladesh population.

As part of a large cohort study, we have analyzed 5,000 tube-well water samples and surveyed their owners to ascertain exposure distribution of 55,456 residents in a defined geographic area. Using published data, excess lifetime risk of deaths for different levels of arsenic exposure (<50, 50-99, 100-299, 300-599, and 599+ µg/L) among Bangladesh population were estimated by multiplying gender-specific, age-adjusted excess relative risks from Taiwan with the corresponding category-specific background lifetime risks for each cancer in Bangladesh. Based on the arsenic exposure distribution in our study population, these estimates were weighted to derive the overall excess risk estimate.

The excess lifetime risks (per 100,000) of mortality for liver, bladder, and lung cancer attributable to arsenic in drinking water were 0.91, 22.1, and 179.5 in males, and 3.39, 2.18, and 48.71 in females, respectively. These estimates translated into an overall excess risk of 128.37 per 100,000 for both genders (as compared to the background risk of 103.5 per 100,000).

Assuming that our study population is representative of the country’s population and that they experience similar health effects of arsenic as Taiwanese, these estimates indicate that the lifetime excess risk of deaths due to internal cancers among Bangladesh population would be doubled. Clearly, measures for reducing arsenic exposure and for early diagnosis and treatment of arsenic induced cancers among Bangladesh population are urgently needed.

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MORTALITY RATES OF CHURCHILL COUNTY, RURAL NEVADA, AND NEVADA STATE

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A comparison of mortality rates from certain underlying causes of death in Churchill County (local water content of arsenic is among the highest in the country, >50 ppb) to baseline rates from the State of Nevada and similar rural counties has been made between years 1980 to 2000. During the past two decades, Nevada has experienced significant population growth; 1.72, 2.51 and 3.0 fold for Churchill County, the State of Nevada and similar rural counties, respectively. Mortality rates are age adjusted and stratified for gender, and race/ethnicity. Mortality rates for 15 leading causes of death were analyzed including cancer (prostrate, liver, lung, bladder, etc) and noncancer (heart disease, diabetes, cardiovascular diseases, accidents, etc). Preliminary overall trends for death rates, particular for males, are higher in Churchill County than rates found for the State of Nevada or other rural Nevada counties. Lower but analogues trends were found for noncancer death rates but not for total cancer death rates. Ongoing analysis will provide further information regarding the relationship of death rates for Churchill County to specific cancer and noncancer endpoints, adjusting for confounding factors. This is an abstract of a proposed presentation and does not necessarily reflect U.S. EPA policy

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RISK ASSESSMENT OF ARSENIC IN DRINKING WATER FOR THE CALIFORNIA PUBLIC HEALTH GOAL

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Arsenic is known to be carcinogenic, atherogenic, genotoxic, and teratogenic, and may cause other adverse developmental effects in children. OEHHA has conducted a risk assessment of arsenic to support a public health goal for drinking water. Both cancer and noncancer endpoints were evaluated. Heavy reliance was placed on human data in this assessment.

The cancer risk estimate for arsenic in drinking water was based on mortality of arsenic-induced lung and urinary bladder cancers in studies of populations in Taiwan, Chile, and Argentina. For lung and bladder tumors, the proposed unit risk estimate is $2.7 \times 10^{-4} \text{ (µg/L)}^{-1}$ based on a linear extrapolation of relative risks. The mode of carcinogenic action is not fully understood, but actual risks of low-level exposure are unlikely to exceed this value but could be lower or even zero. For noncancer effects, a health protective value of 0.3 µg/L is proposed, based on a human study of cerebrovascular disease (Chiou et al., 1997). A benchmark dose approach was used with an uncertainty factor of 30 to account for interindividual variation and extrapolation from the lower bound on effect levels to negligible effect levels.

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ESTIMATING GROUND WATER ARSENIC CONCENTRATIONS FOR EXPOSURE ASSESSMENT IN CANCER EPIDEMIOLOGY


The National Cancer Institute (NCI), in collaboration with the State Departments of Health in Maine, New Hampshire, and Vermont, is conducting a large population-based case-control study of bladder cancer in northern New England to determine the reasons for the elevated bladder-cancer incidence and mortality rates in men and women. One hypothesis is that environmental exposure to arsenic in drinking water may be related to risk of bladder cancer.

A recent USGS and NCI ecological study suggested that bladder-cancer mortality in New England may be associated with private groundwater use, which supports including water source and consumption information in the case-control study. Because of the long latency period associated with bladder cancer, a key problem is assessing past exposure to water contaminants in private wells. Thus, lifetime residential histories will be collected from each subject. The USGS will then sample wells at the former residences for arsenic and other contaminants.

A USGS/NCI/Dartmouth College pilot study showed that exposure histories for many participants cannot totally rely on the sampling of former wells because wells will not be locatable, may be destroyed, or are outside of the study region. Therefore, the USGS and NCI are developing a statistical model to estimate groundwater arsenic concentrations based on geologic, hydrologic, and land-use data.

The model will account for spatial and temporal aspects of arsenic contamination and will incorporate geochemical explanatory terms (deterministic models), GIS techniques, and spatial statistics. Groundwater arsenic-concentration data, statewide geologic data, hydrologic data, and anthropogenic factors will be included. By integrating GIS tools with model, arsenic concentrations can be estimated for participants with incomplete addresses.

RELATIONSHIP BETWEEN ARSENIC EXPOSURE THROUGH DRINKING WATER AND SKIN DISORDERS IN HUHHOT, INNER MONGOLIA

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The data set includes a total of 3,140 individuals. Their arsenic exposure estimates were based on their use of the wells with measured arsenic levels. The study population was categorized into six arsenic concentration groups, 343 for <10 ppb group, 747 for 10-49 ppb, 1,032 for 50-99 ppb, 689 for 100-199 ppb, 185 for 200-499 ppb, 144 for ≥500 ppb.

The skin disorders were diagnosed by the Chinese physicians during the survey using their established clinical criteria. Hyperkeratoses was the most prevalent skin disease in the study population (5.03%), and dyspigmentation was second (3.60%). Combined hyperkeratoses and dyspigmentation had a prevalence (2.77%). Skin cancer had a prevalence (0.25%). All skin cancer had both hyperkeratoses and dyspigmentation. A linear trend in proportion test was highly significant for each of the four examined outcomes (all p<0.01). Although hyperkeratoses and dyspigmentation or both combined were observed in all exposure groups, 98% of those cases had an exposure of arsenic concentration of more than 100ppb groups. In contrast, skin cancer cases were observed only in the highest arsenic concentration group (= or >500 ppb).

The Inner Mongolia data demonstrate that both hyperkeratoses and dyspigmentation are observed at lower arsenic exposure levels than is skin cancer. The dose-response curve for skin cancer is best described with respect to arsenic concentration by a linear model with a threshold at or near 500 ppb arsenic. These results are not consistent with the analysis of the Taiwan data set which showed a threshold at about 120 ppb.

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CLINICAL STAGES OF ARSENISM IN RELATION TO ARSENIC CONCENTRATION IN HAIR AND DRINKING WATER OF A RURAL COMMUNITY OF INNER MONGOLIA, CHINA

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Peter W. Williams, Ph.D., and Peter J. Peterson, Professor, MARC, King's College London, University of London

The clinical skin lesions of arsenism in men and women in Bayinmaodao rural district in Inner Mongolia, People's Republic of China, have been examined by doctors, and their hair and drinking water samples analysed for arsenic by hydride generation and ICP-AES. Altogether 311 arsenism patients with a 15.53% occurrence rate for the district were recorded. The disease incidence rate was positively related to population age and their exposure to elevated arsenic concentrations in the drinking water dating from 1983 when new wells were dug and drinking of surface water was abandoned. Hyperkeratosis was the most common skin lesion followed by depigmentation and pigmentation in decreasing order. With increasing severity of the disease, ranging from skin lesion with single hyperkeratosis 1 to hyperkeratosis 3 with depigmentation 3 and pigmentation 3 the results showed that arsenic concentrations in head hair increased from 1.97µg/g to 4.46µg/g. Arsenic concentrations in hair were positively correlated with the arsenic concentrations in drinking water obtained from local wells.

Key Words: Arsenic, arsenism, China, Inner Mongolia, clinical stages, hair, skin lesions, drinking water

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RISK ASSESSMENT OF SKIN LESIONS POSED BY HIGH- ARSENIC WELL WATER IN SHANXI, CHINA

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Abstract: It has been 7 years since 1994 when we found the high-arsenic well water area (as concentration in well water ranges from 0.00 to 4.435 mg/L) located in 147 villages at Datong and Jingzhong basin belt which covered about 2000 km² and about 550,000 people are living within that ranges. Of them, about 100,000 people drink high-arsenic well water (arsenic concentration higher than 0.05 mg/L). The overall investigation has been conducted for 5 years by researchers included epidemiologists, clinic doctors and health technicians. So far we have found 806 high-arsenic wells, diagnosed 5,897 patients, of which light, moderate and serious skin lesions included skin hyperpigmentation and depigmentation, palmoplantar hyperkeratosis makes up 76.53%, 15.48% and 7.07% of total respectively, hyperpigmentation, depigmentation and hyperkeratosis composed 68.49%, 39.97% and 18.42% respectively.

We done the study on the different effect posed by arsenic exposure on different population. The result suggested: arsenic exposure has more severe effect on children, than on female adults, and than male adults. Come to synergistic effect of smoking, we found there are greater effect during the lower dosage than higher one. But it has no statistic significance in the logistic regression equation when we introduced it as a covariable.

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DOSE-RESPONSE RELATIONSHIP BETWEEN INGESTED ARSENIC AND RISK OF CHRONIC OBSTRUCTIVE PULMONARY DISEASE AND LUNG FUNCTION IMPAIRMENT IN TAIWAN

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In a cohort study on 8,086 residents in an arseniasis-endemic area in northeastern Taiwan, individual exposure to ingested arsenic was estimated through questionnaire interview and examination of arsenic concentration in well water. The deaths from chronic obstructive pulmonary disease (ICD9: 490-492 and 494-496) of cohort members were ascertained through data linkage with the national death certification profile between 1991 and 2000. The relative risks of dying from chronic obstructive pulmonary disease were 0.97, 4.21, and 4.04 for those who consumed well water with an arsenic concentration of 10.0–49.9, 50.0–149.9, and ≥150.0 μg/L, respectively, compared with the referent level of <10.0 μg/L after adjustment for age, sex, and cigarette smoking in the Cox’s proportional hazards regression analysis.

In another prevalence survey of impaired pulmonary function among 834 residents in an arseniasis-endemic area in southwestern Taiwan, the lung function was measured by computerized spirometer. The impaired pulmonary function was defined as a forced vital capacity (FVC) <80% of predicted value and/or a ratio of forced expiratory volume in one second (FEV1) to FVC <70%. The prevalence odds ratio of impaired pulmonary function was 2.7 for those who consumed well water with an average arsenic concentration of ≥10.0 μg/L compared with the referent level of <10.0 μg/L after adjustment for age, sex, and cigarette smoking through logistic regression analysis.

The findings suggest long-term exposure to ingested arsenic may result in impaired pulmonary function and mortality from chronic obstructive pulmonary disease. However, the etiological mechanisms need further elucidation.

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WATER USAGE, KNOWLEDGE AND INDICATORS OF ARSENICOSIS IN BANGLADESH: Results of a National Survey

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This paper reports on two national surveys carried out in Bangladesh in 2000: a census of 9,174 tubewells and a survey of tubewell use and arsenicosis in 3,780 households containing 20,260 individuals. The sample was a subsample of the 1996/7 Bangladesh Demographic and Health Survey, with a sample of 15 villages drawn from each of the country’s six divisions, and 42 households selected from the BDHS household listings. Among males, 47.5% had heard that something may be wrong with tubewell water, compared to 39.6% of females. A much lower proportion (20.6% males, 11.3% females) had heard that the water contained a poison called arsenic. Only about 1.5% of the entire population had stopped using tubewell water. Of survey respondents, 0.5% of males and 0.4% of females reported symptoms consistent with chronic arsenicosis.

Overall, the study found that the tubewell revolution has been promoted not only by health considerations, but also by the demand for a household water facility and the desire by women to reduce workloads associated with using surface water. Because of this, and because the population had absorbed the message about safe tubewell water, it is argued that the movement away from the use of tubewell water should be as limited as possible, even if this means using safe tubewells which are often found in the neighbourhood.

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THE ASSOCIATION BETWEEN ARSENIC EXPOSURE, PLASMA HOMOCYSTEINE AND RISK OF CAROTID ATHEROSCLEROSIS

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The specific aim of this study is to evaluate the association between arsenic exposure and Plasma Homocysteine(hcy) on the risk of carotid atherosclerosis. A total of 163 residents whose age were greater than and equal to 40 year-old participated he heath examination plan for arsenic in drinking water in Lanyang Basin were randomly selected as cases based on their heath examination reports with IMT>0.8 or plaque score>1 and proved by trained neurologist, another 163 examinees matched their blood draw date with cases were also recruited as the control group. Plasma hcy was detected by HPLC and plasma folate and vitamin B_{12} were applied with radioimmunoassay.

The results showed that case group has proven to be higher with age, blood pressure, total cholesterol, LDL-cholesterol, arsenic concentration in drinking water and hcy concentration. Total cholesterol(OR=1.8), LDL-cholesterol(OR=2.2), hcy concentration(OR=0.9) and arsenic exposure(arsenic concentration in well water: OR=2.2; cumulative arsenic exposure: OR=2.8) all have significant higher risks for the development of carotid atherosclerosis after adjustment for many risk factors. Furthermore, high arsenic exposure, hcy concentrations and low vitamin status(low folic acid and low vitamin B_{12} concentration) have significant higher risks of carotid atherosclerosis than low arsenic exposure and hcy concentration as the referent group( arsenic concentration in well water: OR=5.3, 95% CI=1.4-20.6; cumulative arsenic exposure: OR=6.9, 95% CI=1.6-29.0). This study has shown a significant synergistic effects on carotid atherosclerosis with arsenic exposure, plasma hcy, folic acid and vitamin B_{12}.

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GEOCHEMICAL MEDIATION OF *MYCOBACTERIUM ULCERANS* INFECTION IN GHANA

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West Africa has experienced a sharp increase in the incidence of human skin ulceration caused by *Mycobacterium ulcerans*. The resulting disease, Buruli Ulcer, often necessitates limb amputation and can be fatal. In 1998 it was recognized by the World Health Organization as the third most prevalent disease, but mechanisms leading to infection remain unclear. In the west African country of Ghana there have been >2000 reported cases of *Mycobacterium ulcerans* infection in the last ten years. Outbreaks have occurred in 35 of the country’s 110 administrative districts, with the Amansie West District one of the worst affected.

Ghana is richly-endowed with gold mineralization and the country has large gold-mining sector. Several gold deposits are presently exploited on an industrial scale; many more are worked on an artisanal scale. Spatial analysis of part of the Amansie West District indicates a relation between *Mycobacterium ulcerans* infection and mining.

Gold in Ghana occurs as native gold and in the iron sulfide minerals pyrite and arsenopyrite. Exploitation exposes these sulfide minerals to subaerial oxidation with the liberation into solution of their elemental constituents, including arsenic. As a result, some of this arsenic enters neighboring natural drainage systems, upon which many poor rural communities rely for potable water and foodcrop cultivation. Concentrations of arsenic in stream sediments of the Amansie West District range from background levels of 10-50 ppm As to anomalous locations with 100-400 ppm As. Increased incidence of *Mycobacterium ulcerans* infection exhibits a spatial association with these arsenic anomalies.

Elsewhere in the world, arsenicosis is implicated in skin diseases such as blackfoot disease and skin cancer. The spatial evidence from the Amansie West District suggests that arsenic, mobilized by mining, may also play a role in *Mycobacterium ulcerans* infection.

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CYTOSINE METHYLATION PATTERN OF PROMOTER OF GENE P-53 IN CHRONIC ARSENIC EXPOSED PEOPLE WITH AND WITHOUT MALIGNANCY

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Arsenic (As) is a known human carcinogen. It is detoxified via methylation using a methyltransferase (MTase) and S-adenosylmethionine (SAM), as methyl donor. It has been hypothesized on the basis of study in cell culture medium exposed to arsenic that As could involve MTase/SAM dependent DNA methylation of tumor suppressor gene P-53. We have examined the hypothesis by studying P-53 methylation in human subjects exposed to various doses of arsenic with or without cancer and compared the results with non As related cancer.

Materials & Methods: Blood and cancer tissue samples were collected from As exposed and unexposed people and were categorized into 6 groups; (control or < 50 ppb/L, N₁=24; 50-250 ppb/L N₂=18; 250-500 ppb/L N₃=23; 500-1100 ppb/L, N₄=28; Arsenic induced cancer N₅= 18; Non Arsenic cancer N₆=17). DNA was isolated from collected samples and degree of methylation was studied in promoter region of the tumor suppressor gene P53. For this, a 341 bp fragment in the promoter region of P53 gene, containing two sites for the restriction enzyme MspI was chosen. The fragment was amplified by PCR from genomic DNA after digestion with MspI or HpaII (methylsensitive isoschizomer of MspI) or none, using αP32 dCTP to label the products. After amplification the products were electrophoresed on 2% agarose gel and the bands of proper size (341 bp) were excised and counted in liquid scintillation counter. The ratio of radioactive incorporation in the products of HpaII, MspI digested DNA was considered as indicator of degree of methylation.

Results: With gradual increase of As exposure the degree of methylation increases gradually. Degree of hypermethylation in 2nd, 3rd, 4th & 5th group is significantly higher (P<0.05 in 2nd group; P< 0.001 in 3rd, 4th, 5th gr) than the control group (1st group). There is a positive correlation between As exposure and degree of methylation (r=0.9611). Methylation is also significantly higher (P< 0.01) in As induced cancer group than non As cancer. Significant hypomethylation was also observed in 3rd (P< 0.05) & 4th group (P< 0.05) than control group.

Conclusion: The results of the present study highlights the role of methylation in As induced human cancer as hypermethylation is significantly higher in As induced cancer compared to non As induced cancer. Further, there is a dose response relationship of alteration of methylation with increasing dose of As exposure.

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BLOOD METHIONINE, SELENIUM, AND BETA-CAROTENE LEVELS IN CASES WITH ARSENIC-INDUCED SKIN LESIONS

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To examine the relationship between skin lesion occurrence caused by ingestion of arsenic via drinking water, and the blood micronutrients, methionine, selenium and β-carotene, a cross-sectional investigation was conducted in Chiu Chiu, Chile. Because of its dry desert environment, all residents shared a drinking water supply contaminated with high levels of arsenic (735-762 ug/l). All 11 families in the village that met selection criteria, which included ≥ 20 years of residence by one parent, ≥ 10 years by the other parent, and life-long residence by the children, agreed to participate. Each family consisted of father, mother, and two children. Of 44 participants, 5 cases had arsenic-induced skin lesions (4 fathers, 1 daughter). Blood samples were assayed for micronutrients and biochemical indicators. The average concentrations were similar between 4 adult male cases and 7 adult male non-cases for all blood nutrient indicators. We present findings for methionine (involved in arsenic methylation), selenium (potentially antagonistic to arsenic), and β-carotene. Methionine was 26.5 umol/l for cases vs. 26.5 for non-cases; selenium was 1.53 vs. 1.67 umol/l, respectively; β-carotene was 166 vs. 128 ug/dl. β-carotene levels are higher in this population than the U.S. reference (2-80 ug/dl) since their livelihood is based on carrot production. We compared the levels of the blood nutrient indicators between families with a case (n=16; 4 families) and families with no case (n=28; 7 families). Methionine, selenium, and β-carotene do not differ between cases and non-cases, nor between case families and non-case families. Arsenic-induced skin lesions are found in persons with adequate blood methionine and selenium concentrations, and in persons with high blood β-carotene levels.

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OPERATIONAL CASE DEFINITION OF ARSENICOSIS AND SKIN EXAMINATION FOR USE IN EPIDEMIOLOGICAL STUDIES

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Arsenicosis is a chronic condition due to prolonged exposure to inorganic arsenic and manifested by characteristic skin lesions, involving changes in pigmentation and hyperkeratisation. A WHO workshop held in Dhaka, Bangladesh in January 2002 developed a clinical definition and flow chart to aid doctors in the clinical diagnosis of this condition. In epidemiological studies it is important to use consistent operational definitions when measuring the prevalence of arsenicosis, to be able to make meaningful comparisons between findings from different studies. Skin examinations need to be conducted, and findings recorded, in a standardised way to reduce measurement error.

This paper describes the development of a standardised data recording form for skin examinations undertaken as part of an epidemiological study in Bangladesh, aiming to validate the prevalence of arsenicosis found in a previous self-report prevalence survey. This skin examination requires the recording of details of the type, distribution and severity of both melanosis and hyperkeratisation. There is also scope to record clinical signs consistent with other relevant skin changes, such as those of non-melanotic skin cancer. Once the skin examination is completed, the data form requires the collection of information from the subject about any relevant exclusion criteria, such as skin changes being present since birth, occupational causes or drug-induced changes.

There is also a confidence scale related to the opinion on the likelihood of the subject having arsenicosis, and a three category severity index, which can be used for later sensitivity analyses. This information can also be combined with arsenic exposure data to explore dose-response relationships.

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THE INFLUENCE OF ENVIRONMENTAL POLLUTION WITH ARSENIC ON HUMAN HEALTH

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In search area are developed geological and mining activities concerning extraction and processing of ores containing Pb, Cu, Zn as major compounds. Also, there are minor and tracers compounds of As, Mn, Co, Cd, Au, Ag. Mineralogical speaking, there are rich conglomerations of metals and non-metals minerals, the major occurrence having polimetalic sulfur that contains Cu, Pb, Zn, Fe, Se. Rear, is finder As minerals: realgar AsS, mispickel FeAsS and proustit Ag₃AsS₃.

Extraction of minerals, their up-grading and processing of concentrates, determined pollution of environment with powders that contains different concentrations of elements existing in ores.

Estimation of pollution level of environment with As has been made by collecting sedimentable powders samples from air, from different points, especially from crowded areas. The samples have been dissolute and analyzed using Inductively Coupled Plasma Atomic Emission Spectrometry (ICP-AES).

The As concentration in 10 analyzed samples belong to range 80 – 10520 ppm.

The soil samples, collected from city area and neighborhoods, have been aerated at 60°C and transformed in fine powders, with granularity about 500 μm. These have been dissolved and analyzed with Perkin Elmer Atomic Absorption Spectrometer. The As concentrations in 40 analyzed samples were in range 20 – 1580 ppm.

Together with others pollutants, As affects the human health, the morbidity being with more than 70% higher in polluted areas, comparatively with non-polluted areas. Also, heart diseases are more frequent with 90%, and bronchial colds with more than 65%. About cancer, along of 4 years have been recorded more than 1500 situations, predominant being uterine malignant tumor, bronchial ways and lung malignant tumor and breast malignant tumor. Comparative with non-pollutant areas, in search area, the number and types of cancers are three time more frequency.

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A STUDY ON THE CORRELATIVE RELATION BETWEEN ARSENIC EXPOSURE THROUGH DRINKING WATER AND LUNG CANCER

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In order to study the relationship between arsenic exposure through drinking water and the mortality from lung cancer, 2,140 residents who have been made the retrospective cohort study in 3 villages of Tumote of Huhhot. The study subjects were divided into < 50 ppb group, 50-499 ppb group and ≥ 500 ppb group. Based of a total of 44,174.05 person-years as well as 29 lung cancer.

The results showed that the relative risk of lung cancer in arsenic exposure ≥500 ppb group was 27.50 for arsenic exposure 50-499 ppb group and 20.38 for arsenic exposure < 50ppb group, the attributable risk percent of lung cancer was 96.36% and 95.09%, respectively, for males; and 10.46 for arsenic exposure 50-499 ppb group and 14.68 for arsenic exposure < 50ppb group, the attributable risk percent of lung cancer was 90.44% and 93.19%, respectively, for females. The risk factors significantly associated with lung cancer mortality included arsenic- related skin disease, arsenic content in drinking water and the total arsenic ingested. After analyzing for multiple risk factors, arsenic content in drinking water and the total arsenic ingested were an important risk factors for lung cancer.

A significant relationship was observed between arsenic exposure of drinking water and mortality rate of lung cancer. The results associated oneself with outcomes of the cause and effect relationship between arsenic exposure of drinking water and lung cancer.

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PRELIMINARY STUDY ON HUMAN HEALTH RISK ASSESSMENT OF MAE MOH COAL-FIRED POWER PLANT BY RISK*ASSISTANT

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Mae Moh coal-fired power plant is the largest source of electricity generation in Thailand with an approximate production of 2,625 mega-watts. It’s 13 machine towers daily consume 40,000 tons of lignite coal and generate around 10,000 tons of fly ash as a by-product. An estimated 50 million tons of fly ash is present at the disposal site which is located in the vicinity of a valley in a somewhat higher elevation and surrounded by deciduous forests. Runoff from the disposal site from precipitation is accumulated down in the area of operating plants and thus drained to nearby water basins and natural canals wherein many communities reside. However, fly ash by nature contains high amount of inorganic arsenic that is soluble while the runoff is leaching its way through.

In this experiment, a number of soil, fly ash, and water samples in various locations have been measured for total arsenic concentration using graphite furnace atomic absorption spectrophotometry (GFAAS). Information on water consumption patterns and working manner at the disposal site, along with other geological parameters, are also acquired.

The objective of this paper aims at evaluating the human health risk assessment resulted from the plant operation. Based on the United States Environmental Protection Agency’s standards, the software ‘RISK*ASSISTANT,’ a widely applied analytical tool and databases, is used to estimate health risk from arsenic in the environment in particular settings that are correspondingly simulated. The assessment helps predict number and degree of seriousness of people affected due to both potential toxic and non-toxic effects. The result of the preliminary study will call for further research, remediation, treatment and/or suitable management.

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EVIDENCE FOR A ROLE OF OXIDATIVE STRESS IN ARSENIC DEVELOPMENTAL TOXICITY

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Inorganic arsenicals have been described as potent developmental toxicants but the mechanism by which they produce dysmorphogenesis is not known. Since reactive oxygen species (ROS) have been proposed to be involved in the general toxicity of these compounds, we evaluated the potential for ROS to mediate arsenical-induced dysmorphogenesis in mouse whole embryo culture. The role of oxidative stress in arsenite (AsIII) or arsenate (AsV) developmental toxicity was studied by modulating AsIII or AsV-induced embryopathy by either addition of exogenous antioxidants to the culture medium, or depletion of endogenous antioxidant reserves by suppressing glutathione synthesis.

Addition of hydrophobic or lipophylic antioxidants (glutathione peroxidase, superoxide dismutase, and alpha-tocopherol) ameliorated dysmorphogenesis, while addition of a glutathione synthesis inhibitor (buthionine sulfoximine) aggravated the dysmorphic effect. The protective effect of antioxidants was more pronounced in the AsIII than in AsV-treated embryos.

The findings point to involvement of free radicals in developmental toxicity of inorganic arsenicals. The extent of the pathogenic role of ROS depends on the oxidation state of arsenic. It is suggested that inorganic arsenic compounds induce oxidative stress by decreasing endogenous antioxidant levels and enhancing free radical generation.

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