



ORIGINAL ARTICLE

Disability adjusted life years among arsenicosis patients in an arsenic-affected area of southern Bangladesh

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Abstract

Disability adjusted life years (DALY) is the sum of the present value of future years of lifetime lost through premature mortality, and the present value of years of future life-time adjusted for the average severity of any mental or physical disability caused by a disease or injury. As a method for estimating the global burden of disease, DALY was first introduced in the World Development Report in 1993 by the World Bank. The aim of this study was to estimate DALY among arsenicosis patients. DALY was calculated for 104 arsenicosis patients from an arsenic-affected rural area of southern Bangladesh using the estimated years they lived with disability (YLD). The mean (SD) of cumulative arsenic exposure level was 5.0 (3.2) mg/l-years. Among the patients, 64% reported reduction in working ability. The portion of the patients with disability for more than 50 years was as high as 58.7%. The mean (SD) of YLD and DALY was 54.0 (9.8) and 9.2 (1.5), respectively. A total of 5621 YLD equivalent to 961.7 DALY was lost due to arsenicosis (when life expectancy at birth according to Bangladesh Bureau of Statistics was applied, the YLD and DALY were 3899.2 and 868.9, respectively). There was significant relationship of YLD with education of the patients ($p < 0.05$). There was significant relationship between DALY and education of the patients ($p < 0.05$). There was also significant relationship between DALY and reduction in working ability of the patients ($p < 0.05$). The findings of the study justify for the policy makers to adopt adequate measures such as prevention, treatment and rehabilitation to alleviate the sufferings of the arsenicosis patients.

Key words: Disability adjusted life years, years lived with disability, arsenicosis patients, Bangladesh

Introduction

Arsenic contamination of groundwater is of grave concern in many developing countries including Bangladesh. Millions of

people in Bangladesh are at risk of drinking arsenic-contaminated water and many thousands of them have been suffering

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from arsenicosis as well as complications of arsenicosis. Besides physical health problems, arsenicosis patients face widespread problems, relating to psychological, social relationship and environment aspects.

Arsenicosis is a chronic disease with long duration of onset and remission and an important obstacle for management of arsenicosis is unavailability of specific remedy and the disease does not show immediate improvement even after abiding all instructions provided by the health care providers. Mitigation interventions in terms of public awareness, arsenic safe water supply and management of arsenicosis patients were undertaken but with limited success. Arsenic exposure affects the lives of the victims by reducing their quality of life. It results in disability of the victims in the long run and affects individual and subsequently the family earnings. Usually it affects the poor more. There are other less tangible impacts as well as the loss of manpower making society poorer by the loss.

It is estimated that of the 125 million inhabitants of Bangladesh between 35 million and 77 million are at risk of arsenic contamination in drinking water.^{1,2} A recent report from the World Bank has estimated that 20 million inhabitants of Bangladesh may be drinking arsenic-contaminated water.³ In a survey including 200 villages by the Rapid Action Program, 1802 of 469424 people were found to have arsenic-induced skin lesions and during the same period a more detailed study of four villages with arsenic-contaminated tube-wells was conducted, and 1481 adults were interviewed and examined.⁴ Of these, 430 were found to have skin lesions. The evidence that has accumulated since 1997 has confirmed that this is a public health threat of great magnitude of arsenic poisoning in Bangladesh.⁵

The 1993 World Development Report, "Investing in Health", used the disability adjusted life years (DALY) to measure the state of health of a population. The DALY is

the only quantitative indicator of burden of disease that reflects the total amount of healthy life lost to all causes, whether from premature mortality or from some degree disability during a period of time. A few studies on DALY of arsenicosis patients are reported.^{6,7} It was estimated in a sample of 168 arsenicosis patients that 47% of the arsenicosis patients would be living with disability for more than 51 years and a total of 7930 years lived with disability (YLD) were lost due to arsenicosis.⁶ It is imperative to estimate the burden of arsenicosis in terms of DALY and to assess arsenic exposure dose response relationship among arsenicosis patients. Unfortunately, only one such study estimating YLD of arsenicosis patients and no study assessing arsenic exposure dose response relationship with YLD among arsenicosis patients is available in the context of Bangladesh.

The aim of the present study was to estimate DALY using YLD among arsenicosis patients as well as to assess the dose-response relationship between arsenic exposure levels and YLD and DALY of the patients.

Materials and Method

Type of study

The data assessing DALY of arsenicosis patients were collected with a cross-sectional study carried out with the objective of determining quality of life.⁸

Place and time of study

Information about the location of arsenic-affected (two villages, namely Banglaish and Sonua in Comilla district) rural area available from the Department of Occupational and Environmental Health, National Institute of Preventive and Social Medicine (NIPSOM), Dhaka facilitated the selection of the place of study. The data collection period was from March to June 2008.

Study population

The study population consisted of both male and female arsenic-exposed individuals with arsenicosis. The selection criteria were i) age of the respondents between 18 and 50 years; ii) a history of exposure to arsenic

through arsenic-contaminated tube-well water for drinking water for minimum 6 months; and iii) the patients had definite signs of arsenicosis (melanosis and/ or keratosis). The total eligible population of the villages according to the mentioned selection criteria was 470 arsenicosis patients. An approval for this study involving the population was obtained from the Review Board of NIPSOM, Dhaka.

Sample size

The sample size was selected according to World Health Organization Guideline⁹ for sample size determination for study containing multiple groups of respondents. The formula used for the calculation of the sample size for each group is:

$$n = z^2 \times V / d^2$$

where

n = required sample size for each group

$z = 1.96$ for 95% confidence level

Anticipated population proportions, P_1 and $P_2 = 50\%$ and 50% or 0.50 and 0.50

Intermediate value, $V = P_1 (1 - P_1) + P_2 (1 - P_2) = 0.50 (1 - 0.50) + 0.50 (1 - 0.50) = 0.50$

Absolute precision, $d = 15\%$ or 0.15

Considering $d = 15\%$ or 0.15 and $V = 0.50$, a sample size of 86 was estimated. However, extra 20% (18) of the sample was interviewed considering the possibilities of missing of the necessary number of respondents for the study. Thus the sample size was 86 and 18 i.e., 104 arsenicosis patients.

Sampling of the respondents

On the day before the data collection, the probable respondents were requested to come to a selected spot in the study area on the following day. The persons eligible according to selection criteria and willing to participate in the study were considered as prospective subjects for the study and the number up to the calculated sample size for each group was selected one by one. Before the interview, informed consent to participate in the study was taken from all the participants.

Data collection procedure

Questionnaire-Based Face-to-Face Interview

Before data collection, the patients were briefed about the purpose of the study prior to questionnaire based face-to-face interviews conducted by the first author. None of the selected patients refused to participate in the study. Data collection was done from 8:00 to 16:00 on weekdays.

Collection of Water Sample

Water samples, 100 mL each, were collected in plastic pots by the first author from the contaminated tube-wells from which the respondents are currently using or used water in the past for drinking or cooking purpose. The samples were acidified and preserved in a refrigerator as per laboratory procedure until tested for arsenic level in the laboratory of the Department of Pharmacology, Bongobondhu Sheikh Mujib Medical University, Bangladesh. For quality control measure, 5% duplicate samples were tested.

Data processing and analysis

Water samples were analyzed to detect arsenic level using atomic fluorescence spectrometry¹⁰ and different arsenic exposure levels^{11,12} such as cumulative arsenic exposure levels (mg/L-years), lifetime exposure considering daily intake of tube-well water (mg/L-days), and time-weighted daily exposure (mg/L-day) were calculated. All data were entered and saved using Statistical Package for Social Sciences (SPSS) version 11.5 for Windows.¹³ Percentages, means, and standard deviations were calculated where necessary. Statistical analysis was carried out using chi-square test/ Fisher's exact test as applicable to find out the existence of any association.

Calculation of YLD and DALY

YLD and DALY were calculated for the patients according to Murray and Lopez.^{14,15} YLD measurement requires defining the potential limit of life. For this, the standard has been chosen to match the highest national life expectancy observed for Japanese people: life expectancy at birth for male = 80 years and life expectancy at birth for female = 82 years.

Age at the onset of disease was calculated by subtracting the duration of the disease from the current age of the patients. As arsenicosis is more or less a lifelong disease and it was assumed that the individual patient would survive up to the right life expectancy. So, lifelong YLD was calculated by subtracting the age at the onset from the right life expectancy.

Each health problem results in four possible outcomes: death, disability before death, permanent disability and full recovery. In case of arsenicosis no effective treatment is yet available and the disease leads to more or less permanent disability. In this study, the DALY is an indicator of the time lived with disability due to arsenicosis. If the person lives up to the maximum of his life expectancy with disability, we need to add up the total number of DALY lost from the onset of disability (a) to the age of death (a+L). An example of calculation of DALY for arsenicosis using YLD is:

$$\text{DALY} = D \left\{ \frac{K C e^{ra}}{(r+B)^2} \times (e^{-(r+B)(L+a)} - (r+B)(L+a) - 1) - e^{-(r+B)a} (-(r+B)a - 1) \right\} + \left(\frac{1-K}{r} \right) (1 - e^{-rL})$$

Where,

K = constant, 1

a = age at the onset of the disease

D = disability weight for arsenicosis, 0.30

r = discount rate, 0.03

C = constant for age- weights; e.g. C = 0.1658

B = age weighting parameter constant, 0.04

L = Duration of the disease derived from life expectancy

e (exponential) = 2.72 (approximately)

Replacing the values, the formula in Microsoft Excel is:

$$\text{DALY} = 0.3 * (1 * 0.1658 * \text{EXP}(0.03 * a) / (0.03 + 0.04)^2) * (\text{EXP}(-1 * (0.03 + 0.04) * (L + a)) * (-(0.03 + 0.04) * (L + a) - 1) - \text{EXP}(-1 * (0.03 + 0.04) * a) * (-(0.03 + 0.04) * a - 1)) + ((1 - 1) / 0.03) * (1 - \text{EXP}(-1 * 0.03 * L))$$

Results

Table 1 shows different characteristics of the arsenicosis patients. Of the patients, 89% and 11% were diagnosed by physicians and trained paramedical persons, respectively; 13% had melanosis, 48% leukomelanosis, and 39% melanosis and keratosis; 75% had

problems/ complains in addition to arsenicosis; 67% were getting treatment for arsenicosis; and 64% reported a reduction in working ability. The mean (SD) duration of suffering due to arsenicosis was 6.2 (4.0) years. The mean (SD) duration of treatment for arsenicosis was 1.1 (0.4) years. The mean (SD) of YLD and DALY was 54.0 (9.8) and 9.2 (1.5), respectively. A total of 5621 YLD equivalent to 961.7 DALY were lost due to arsenicosis (when life expectancy at birth according to Bangladesh Bureau of Statistics, 2006 was applied, the YLD and DALY were 3899.2 and 868.9, respectively) (not shown in the Table 1).

Table 2 shows the cross tabulation on YLD and DALY and education of the patients. The proportion of the patients would be living with disability more than 50 years was as high as 58.7%. There was significant relationship between YLD and education of the patients ($p < 0.05$). There was significant relationship between DALY and education of the patients ($p < 0.01$).

Table 3 shows the cross tabulation on YLD and DALY with occupation of the patients. There was no significant relationship of YLD and DALY with occupation of the patients.

Table 4 shows the cross tabulation on YLD and DALY with change in working ability of the patients due to arsenicosis. The proportion of the patients with reduction in working ability due to arsenicosis was 64.4%. There was significant relationship of the reduction in working ability of the patients due to arsenicosis with DALY ($p < 0.05$), but not with YLD.

Table 5 shows the YLD and DALY of the patients according to their cumulative arsenic exposure levels. The difference in YLD or DALY among the groups with cumulative arsenic exposure level <1 , $>1- \leq 5$ and ≥ 5 mg/l-years was not statistically significant.

Discussion

A cross sectional descriptive study was designed and conducted with the objective of assessing DALY among arsenicosis

Table 1. Characteristics of the patients Characteristics

Characteristics	Arsenicosis patients (n = 104)
Age (years)	33.1±10.0
Male respondents	58 (55.8)
Married	72 (69.2)
Illiterate (no schooling)	37 (35.6)
Agricultural worker	37 (35.6)
Smokers (tobacco smoking for at least 6 months)	29 (27.9)
Monthly family income (Taka ^a)	6699±717
Housing (roof and walls made of tin)	98 (94.4)
Diagnosis done by Physicians	89%
Trained paramedical persons	11%
Cumulative arsenic exposure level (mg/l-years) ^b	5.0±3.2
Life time exposure considering daily intake of tube-well water (mg/l-days) ^{bc}	9167.0±5890.6
Time weighted daily exposure (mg/l-day) ^{bc}	1.02±0.57
Age at onset of arsenicosis (years)	26.8±9.8
Patients with melanosis	13%
Patients with leukomelanosis	48%
Patients with melanosis and keratosis	39%
Patients with problems/complains in addition to arsenicosis	75%
Reported a reduction in working ability	64%
Duration of arsenicosis (years)	6.2±4.0
Getting treatment for arsenicosis	70(67)
Duration of treatment (years)	1.1±0.4
Years lived with disability (YLD)	54.0±9.8
Disability adjusted life years (DALY)	9.2±1.5
YLD ^d	37.5±9.8
DALY ^d	8.4±1.8

n = number of patients. Data represent mean ± SD (SE for monthly family income) or numbers (%). ^aUS\$1 = 70 Taka. ^bThe number of patients was 93 because water sampling from some tube-wells could not be done as the options were not working during sample collection; thus, the related patients were excluded. ^cDaily intake of tube-well water 3 l/day for patients aged ≥ 18-<20 years and 4 l/day for patients aged ≥20 years was considered.¹⁶ ^dWhen life expectancy at birth for men (63.4 years) and women (65.5 years) of rural Bangladesh for the year 2004 (Bangladesh Bureau of Statistics, 2006) was considered.

Table 2. Cross tabulation on YLD and DALY with education of the patients

Characteristics	Education				Total n = 104	%	p value	
	Illiterate	Primary	Secondary	Above				
	n = 37	n = 28	n = 31	n = 8				
YLD	35-≤40	6	0	3	1	10	9.6	Fisher's exact test, $p < 0.05$
	>40-≤50	15	13	4	1	33	31.7	
	>50	16	15	24	6	61	58.7	
DALY	6-<9	24	14	7	2	47	45.2	Fisher's exact test, $p < 0.01$
	≤9-<10	6	5	4	2	17	16.3	
	≥10	7	9	20	4	40	38.5	

YLD, years lived with disability; DALY, disability adjusted life years; n, number.

Table 3. Cross tabulation on YLD and DALY with occupation of the patients

Characteristics	Occupation					Total n = 104	%	p value	
	Agricultural labor	Business	Service	Housewife	Others				
	n = 37	n = 9	n = 4	n = 39	n = 15				
YLD	35-≤40	4	0	1	3	2	10	9.6	Fisher's exact test, $p > 0.05$
	>40-≤50	13	5	0	13	2	33	31.7	
	>50	20	4	3	23	11	61	58.7	
DALY	6-<9	17	5	1	20	4	47	45.2	Fisher's exact test, $p > 0.05$
	≥9-<10	5	1	2	8	1	17	16.3	
	≥10	15	3	1	11	10	40	38.5	

YLD, years lived with disability; DALY, disability adjusted life years; n, number.

Table 4. Cross tabulation on YLD and DALY with the change in working ability of the patients due to arsenicosis

Characteristics	Working ability		Total n = 104	%	p value	
	Not reduced	Reduced				
	n = 37	n = 67				
YLD	35-≤40	1	9	10	9.6	Fisher's exact test, $p > 0.05$
	>40-≤50	9	24	33	31.7	
	>50	27	34	61	58.7	
DALY	6-<9	11	36	47	45.2	χ^2 test, $p < 0.05$
	≥9-<10	6	11	17	16.3	
	≥10	20	20	40	38.5	

YLD, years lived with disability; DALY, disability adjusted life years; n, number.

Table 5. YLD and DALY of the patients according to their cumulative arsenic exposure levels

Variable	Cumulative arsenic exposure level (mg/l-years)		
	<1	>1-≤5	≥5
	n = 6	n = 52	n = 35
YLD	52.7±12.8	56.7±9.3	52.0±9.2
DALY	9.1±2.2	9.7±1.3	8.9±1.5

n, number; YLD, years lived with disability; DALY, disability adjusted life years. Data are Mean±SD.

patients. A total of 104 arsenicosis patients were interviewed. Non-probability purposive sampling method was adopted and the sample was selected from those meeting selection criteria such as, age between 18-50 years. YLD and DALY of the patient group were also calculated.

The mean (SD) duration of suffering due to arsenicosis was 6.2 (4.0) years which supports the findings of other studies.^{6,17,18} The finding of this study that the housewives and agricultural labour suffered more from arsenicosis, similar to a study by Molla et al.⁶ The mean (SD) duration of treatment for arsenicosis was 1.1 (0.4) years. The mean (SD) of cumulative arsenic exposure level was 5.0 (3.2) mg/l-years among patients. Proportions of the patients having melanosis and leukomelanosis, and melanosis and keratosis were 61% and 39% respectively. Of the patients, 75% had problems/complains other than arsenicosis. There was reduction in working ability in 64% of the patients due to arsenicosis. In 1999, Ahmad et al. found that among the arsenicosis patients, melanosis was 99.5% followed by, keratosis (68.9%) and leukomelanosis (42.7%).¹⁶ The mean (SD) of YLD and DALY was 54.0 (9.8) and 9.2 (1.5), respectively. Age at onset of arsenicosis was significantly related with education and occupation of the patients. The proportion of the patients would be living with disability more than 50 years was as high as 58.7%. Education of the patients was significantly related with YLD and DALY. DALY also related with

reduction in working ability due to arsenicosis. A total of 5621 YLD equivalent to 961.7 DALY were lost due to arsenicosis. Molla et al.⁶ estimated DALY of arsenicosis patients in a sample of 168 arsenicosis patients and found that 47% of the arsenicosis patients would be living with disability for more than 51 years and a total of 7930 YLD and 1980 DALY (calculated using the YLD) were lost due to arsenicosis.

From the present and other^{6,19} studies estimating YLD and DALY, it is understandable that the burden of arsenicosis is high, and the present study further revealed that arsenicosis has a great impact on lowering the patients' quality of life as supported by the dose-response relationship that higher levels of cumulative arsenic exposure revealed lower levels of physical health domain and overall scores as well as the percentage values.⁸ Chen et al. found a significant dose-response relationship between ingested inorganic arsenic level and risk of ischemic heart disease.²⁰ It has been reported that the prevalence of arsenicosis was associated with age, sex, education and the economic status of the patients, and multivariate analysis identified age and economic status as significant predictors of arsenicosis controlling for education and gender.²¹ Distance of safe water source was a primary reason for knowingly use of arsenic contaminated water.²² The issues of financial burden seem to be significant in terms of health care access for the victims.²²

Socio-cultural values make it difficult for women to attend health needs and to travel to service providers.²² It was found that arsenic-affected people are barred from social activities and often face rejection even by their immediate family members, and women with visible arsenicosis symptoms are unable to get married and some affected housewives are divorced by their husbands, and also children with symptoms are not sent to school in an effort to hide the problem.²³ It was also found that patients' experiences reveal severe negative social impacts, and a sharp difference of perceptions about arsenic and social issues between arsenicosis patients and unaffected people.²² The dose-response relationship for YLD and DALY of the patients could not be established in this study. A possible reason may be that the variables may not be suitable as they depend on the age at onset of the disease, which may vary widely. It is also peculiar that people who drink from the same contaminated tube-well do not develop the disease equally as a result the causal relationship of having the disease with the drinking of the contaminated water is not clearly evident to the people.²² Therefore, this may provide many scopes among the public to flourish misbeliefs and misconceptions about the disease, and these and many socio-cultural issues need to be addressed in addition to considerations of many technical issues linked with the problem, which are thought to be of immense importance in the achievement of a successful mitigation of the problem.

The findings of the study might be helpful to understand humane aspects of the problem and justify for the policy makers to adopt adequate measures and allocate sufficient funds to alleviate the sufferings through prevention, treatment and rehabilitation of the arsenicosis patients and serve as a basis for further studies.

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