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Arsenic in tube well water in Bangladesh: health and economic impacts and implications for arsenic mitigation

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Abstract

A national drinking water quality survey conducted in 2009 furnished data that were used to make an updated estimate of chronic arsenic exposure in Bangladesh. About 20 million and 45 million people were found to be exposed to concentrations above the national standard of 50 µg/L and the World Health Organization's guideline value of 10 µg/L, respectively. From the updated exposure data and all-cause mortality hazard ratios based on local epidemiological studies, it was estimated that arsenic exposures to concentrations > 50 µg/L and 10–50 µg/L account for an annual 24 000 and perhaps as many as 19 000 adult deaths in the country, respectively. Exposure varies widely in the 64 districts; among adults, arsenic-related deaths account for 0% to 15% of all deaths. An arsenic-related mortality rate of 1 in every 16 adult deaths could represent an economic burden of 13 billion United States dollars (US$) in lost productivity alone over the next 20 years. Arsenic mitigation should follow a two-tiered approach: (i) prioritizing provision of safe water to an estimated 5 million people exposed to > 200 µg/L arsenic, and (ii) building local arsenic testing capacity. The effectiveness of such an approach was demonstrated during the United Nations Children's Fund 2006–2011 country programme, which provided safe water to arsenic-contaminated areas at a cost of US$ 11 per capita. National scale-up of such an approach would cost a few hundred million US dollars but would improve the health and productivity of the population, especially in future generations.

Introduction

Exposure to arsenic through drinking water sourced from groundwater is a global public health problem that is particularly devastating in Bangladesh.[1,2] According to survey data from the early 2000s, an estimated 35 to 77 million people in the country have been chronically exposed to arsenic in their drinking water in what has been described as the largest mass poisoning in history.[2,3] In rural areas, 97% of the population relies on tube wells[4] installed since the 1970s to reduce disease from ingestion of pathogen-laden surface waters. Unfortunately, this has resulted in a population highly exposed to arsenic but with limited means or incentives for seeking safe water alternatives. First detected in well water in the early 1990s, arsenic is released from sediment by biogeochemical processes that promote reducing environments.[5,6] The tube wells, affordably priced at about 100 United States dollars (US$), draw the arsenic-containing groundwater from a shallow depth of 10–70 m.[3] Groundwater from depths > 150 m usually contains less arsenic[3] and can be a sustainable drinking water source.[7]

The health implications of chronic arsenic exposure in such a large population are substantial.[2] Between 2000 and 2003, 4.94 million tube wells throughout Bangladesh were tested for arsenic and marked as safe or unsafe.[8,9] Since then, well switching has partially succeeded in reducing exposure.[10] However, sustaining the behaviour change required for long-term sharing of wells is difficult. Additionally, severely affected areas have few if any safe water options and need alternative drinking water sources. Areas showing high proportions of unsafe wells (i.e. wells whose water contains arsenic in concentrations > 50 µg/L, the Bangladeshi drinking water standard) are largely the same areas experiencing the highest arsenic concentrations (often > 200 µg/L). This suggests that interventions targeting areas with the highest proportion of unsafe wells are also likely to reach the population exposed to the highest arsenic concentrations and hence at highest risk of experiencing adverse health outcomes.[11] Mitigating the problem of water containing high levels of arsenic requires a sizeable investment into the water supply infrastructure. This paper provides evidence that such investment is economically justified when the health and economic burdens of unabated arsenic exposure are considered.

Arsenic exposure from drinking water in 2009

The 2009 Bangladesh Multiple Indicator Cluster Survey (MICS) included collection of drinking water for arsenic tests from 15 000 randomized households nationwide.[11] The National Drinking Water Quality Survey report used an estimated national population of 164 million to estimate that 22 million and 5.6 million people are drinking water with arsenic concentrations > 50 µg/L and > 200 µg/L, respectively. According to preliminary census figures for 2011, the population of Bangladesh is about 142.3 million. Based on this figure, the people drinking water having arsenic concentrations > 50 µg/L and > 200 µg/L are approximately 19 million and 5 million, respectively. These estimates may be revised upwards when the final 2011 census figure is released. The proportion of water samples with arsenic in excess of permissible limits was found to be lower in the MICS survey than in previous national well surveys, which suggests important progress in mitigation (Table 1), although differences in sample collection (e.g. use of source water versus household drinking water) could also explain the difference.[11]

Modelling arsenic-related mortality

Chronic arsenic exposure is linked to a range of dose-dependent conditions, including cancers of the skin, bladder, kidney and lung,[12–14] as well as skin lesions, arterial hypertension and cardiovascular disease, pulmonary disease, peripheral vascular disease, diabetes mellitus and neuropathy.[2] In Bangladesh, the risk of dying from ingestion of arsenic in drinking water has been shown to depend on the level of arsenic exposure.[15,16] Sohel et al. analysed survival data for 1991–2000 from a health and demographic surveillance system covering 115 903 people in Matlab (Table 2). After adjusting for potential confounders such as age, sex, education and asset score (as an indicator of household wealth), they found that arsenic exposure through drinking water accounts for considerable excess mortality among adults in rural Bangladesh.[15]

The Health Effects of Arsenic Longitudinal Study (HEALS), which followed a cohort of 11 746 people in Araihazar subdistrict from October 2000 to February 2009,[16] also showed that arsenic exposure is associated with a higher risk of death (Table 3). Although both Argos et al. and Sohel et al. found this increased risk even at low exposure levels (10–50 µg/L), historical exposure to concentrations > 50 µg/L arsenic may have introduced bias.[17] To reduce the risk of bias, the population exposed to 0–10 µg/L was used as a reference group, but because of uncertainties in lifetime exposure history in both studies, the dose category may have been assigned incorrectly, especially at the lower dose. Sohel et al. attempted to construct an exposure history for each subject but was unable to do so for those already deceased. Additionally, Sohel et al. found the hazard ratio (HR) to be higher for all non-accidental deaths than for any of the three known arsenic-related causes of death – cancer, cardiovascular problems, infection – at an exposure level of 10–50 µg/L (Table 2),[15] which suggests that factors other than arsenic exposure could have influenced the findings. Although the HRs from these studies are fraught with uncertainties that bear further investigation, we used them to estimate arsenic-related mortality in Bangladesh because they were the best data available.

To assess the impact of arsenic exposure on mortality in Bangladesh, we calculated the excess deaths from the estimated risk of death (hazard) among adults in each arsenic exposure category (Table 2 and Table 3). The MICS 2009 drinking water quality survey provided the population exposure estimates.[11] From the resulting population attributable fraction (PAF) we estimated the annual number of deaths for each district by using the area's adult population (based on the census and the age distribution from the Bangladesh Demographic and Health Survey 2007)[18] and an estimate of the crude death rate. Because Bangladesh has no active vital registry system, we used a crude death rate for adults (> 15 years old) of 8.5 deaths per 1000 population, a figure based on WHO mortality estimates[19] and consistent with ICDDR,B Health and Demographic Surveillance System observations in Matlab and with crude death rates in other countries of southern Asia.

Using Sohel et al.'s HR for non-accidental deaths, we modelled excess deaths for all districts and arrived at an annual total of nearly 43 000 deaths, representing about 5.6% of all deaths, as being attributable to chronic arsenic exposure at current exposure levels (Table 4, available at: http://www.who.int/bulletin/volumes/90/##/##-######). On the basis of Sohel's cause-specific mortality HRs, about 1 in 16 cancer deaths, 1 in 36 cardiovascular disease deaths and 1 in 19 deaths from infections is attributable to arsenic exposure. We used Sohel et al.'s HR for non-accidental deaths because Argos et al.'s HR for the 10–50 μg/L exposure level is implausible, since it is not significant at the 0.05 significance level, is higher than for the 50–150 μg/L exposure group, and predicts nearly twice as many excess deaths as Sohel et al.'s HR (Table 5). Interestingly, under either study the excess deaths among people exposed to arsenic concentrations of 10–50 μg/L (below the national standard) represent from 45% to 62% of all arsenic-related deaths. However, a proportion of the population that is currently in the 10–50 μg/L exposure group may have been exposed to higher arsenic concentrations in the past and have an increased risk of death reflective of previous rather than current exposure. In light of this, we used the total number of arsenic-attributable deaths – about 43 000 deaths per year – for our economic impact assessment, since it more accurately reflects total exposure, past and present.

Economic implications

We estimated the economic losses resulting from the arsenic-related mortality burden by calculating lost productivity in terms of per capita gross domestic product (GDP). According to estimates by the International Monetary Fund, the per capita GDP for Bangladesh in 2009 was 1465 purchasing power parity dollars. If we assume steady economic growth and an average loss of 10 years of productivity per arsenic-attributable death, over the next 20 years arsenic-related mortality in Bangladesh (1 of every 16 deaths) could lead to a loss of US$ 12.5 billion, provided arsenic exposure (> 10 µg/L) remains the same as in 2009. We made this estimate using Sohel et al.'s HRs and a discount rate of 5%.[20] Our assumption of an average loss of 10 years of productivity per arsenic-attributable death was based on lost productivity owing to deaths from types of cancer known to be arsenic-related and may be a conservative assumption because medical care capacity in Bangladesh is limited. The average person dying of cancer in the United States of America loses 15.4 years of life and, for the four types of cancer linked to arsenic exposure (skin, bladder, kidney and lung), the average loss ranges from 11 to 18 years.[2,21] Although life expectancy in the United States is higher than in Bangladesh, the proportion of time people spend working is probably higher in Bangladesh, so any loss of life in Bangladesh would translate into a greater reduction in lifetime productivity. Because the loss in GDP attributable to deaths does not take into account health costs or other costs to society, it probably underestimates the full economic burden. This burden can be expected to grow as the country develops and life expectancy rises. The morbidity burden will also increase as diagnostic tests improve and better treatment methods prolong the lives of people with chronic arsenic-related disease, and the costs of medical care will increase in tandem.

Consequences of delaying action

In Bangladesh, arsenic-related diseases and deaths will increase in the future because the latency period after exposure lasts several decades.[2] Studies on chronic arsenic exposure *in utero* and in early childhood suggest an increased risk of fetal loss, infant death, reduced birth weight and impaired cognitive function in children, as well as significantly higher risks of impaired lung function, renal cancer and death from lung cancer, lung disease and acute myocardial infarction later in life.[22–26] Since an entire generation has now grown up exposed to arsenic, some children will become "arsenic orphans" as their caretakers succumb to arsenic-related diseases. These children may also be exposed to arsenic themselves, which would perpetuate the cycle of arsenic-related disease.

It is illustrative to examine the impact of arsenic exposure on children not yet born, whose future health will be affected by the concentration of arsenic in the water they begin drinking *in utero*, as shown by several studies.[22–27] We contemplate three scenarios for population exposure to arsenic in concentrations > 50 µg/L: in the first and worst, exposure is constant beginning in 2000; in the second and best, exposure has been eliminated by 2010; in the third and most realistic, exposure is reduced to 13% by 2010 (as found in MICS 2009) and completely eliminated by 2030. How will these exposure scenarios affect today's children in the future? The proportion of eventual deaths attributable to arsenic exposure above the national standard in each year's birth cohort ranges from 0% when exposure to drinking water containing arsenic in concentrations > 50 µg/L has been eliminated by the respective year, to 5.8% if exposure level remains the same as in 2000. Overall, only 1.1% of eventual deaths in the 2000–2030 cohorts would be attributable to arsenic if exposure to concentrations > 50 µg/L had been eliminated by 2010. However, if exposure levels throughout 2000–2030 were to remain the same as in 2000, 5.8% of all eventual deaths in the 2000–2030 cohort would be attributable to arsenic. The most likely scenario will lie in between: if exposure to arsenic in concentrations > 50 µg/L is eliminated by 2030, 2.4% of the cohort's future deaths will be attributable to arsenic. In absolute terms, if about 90 million children are born between 2000 and 2030, between 1 and 5 million of their eventual deaths will be attributable to exposure to arsenic concentrations above the national standard, depending on the exposure scenario. This exercise shows that any population- level reduction in arsenic exposure will result in decreased arsenic-related morbidity and mortality among children yet to be born. Similarly, any failure to sustain progress in arsenic mitigation will result in deaths that could have been prevented among members of future generations. However, because of uncertainty and individual variation in arsenic exposure and latency period before disease onset, these analyses are qualitative and semiquantitative predictions at best.

Mitigation strategy

According to the model, Comilla is the district with the highest number of arsenic-related deaths – 3748 adult deaths in 2009. This is because many people there are exposed to high arsenic concentrations (Table 4). Resulting losses in productivity could amount to US$ 1.1 billion over the next 20 years in Comilla alone.[20] Supplying safe water to the district's population by installing water points with no more than 50 people per water point, as well as small communal piped water systems serving a few hundred households, would cost approximately US$ 44.2–49.2 million depending on the choice of water supply technology.[20] This would be a fraction of the economic losses that would result from continued arsenic exposure, and the health benefits to generations not yet born would be incalculable. Despite the considerable capital costs involved, the benefits of an immediate investment in an improved water supply system would far outweigh the costs. Sustainability and appropriateness for a given setting should drive the choice of one arsenic mitigation technology over another.[20]

The water sector in Bangladesh urgently needs to find a sustainable way to supply safe water to people in areas with high arsenic exposure and to build capacity for local arsenic testing for surveillance.[28] Because of the dose–response relationship that characterizes arsenic-related health problems, the public health benefits of new safe water supplies can be maximized by targeting grossly contaminated areas (i.e. with concentrations > 200 μg/L) first. Such areas are usually the ones having the highest proportion of wells with water having arsenic concentrations > 50 μg/L. The Department of Public Health Engineering (DPHE) of Bangladesh and the United Nations Children's Fund (UNICEF) have succeeded in increasing access to safe water in Comilla for a per capita cost of only US$ 11 by following this approach. Complete coverage of Comilla with safe water could be achieved for an additional US$ 32 million. Thanks to the provision of safe water points in communities at risk as well as public education and social mobilization, the population drinking arsenic-safe water in the intervention area in Comilla increased steadily from 75% in 2007 to 81% in 2009.[29] However, in control areas access to arsenic-safe water decreased from 93% in 2007 to 83% in 2009, perhaps because of the continued installation of new and inexpensive but contaminated shallow tube wells and because adherence to well switching has declined as memories of arsenic awareness-raising activities have begun to fade. The greatest improvements in access were achieved among the poorest population quintiles in intervention areas, which points to success in targeting people living in poverty and extreme poverty.

As these examples suggest, past achievements can be lost if arsenic mitigation efforts are not sustained. Markings on wells from previous testing campaigns have now worn off and the motivation for promoting arsenic-safe water has waned. The top-down blanket testing approach of the past left no infrastructure in place for monitoring existing wells or for testing new wells.[30] Building testing capacity locally will lead to sustained awareness in areas with high arsenic exposure and give people more control over their water supply, although instilling a social norm of periodically testing well water is essential for sustainability. Implementing a local pay-for-use testing system has already been found effective at motivating households to test wells and, in turn, has strengthened the commitment of the local population to undertake arsenic mitigation measures. By making it possible for people to know which local wells are contaminated and which ones are safe[31] and by strategically providing new water supply systems to the populations most exposed to arsenic, compliance with the national drinking water arsenic standard can be facilitated. Progress will not be even, however, since some areas will prove more challenging than others.[32] Social acceptability and sustainability are crucial factors to be considered when choosing among arsenic mitigation strategies, in addition to the costs of the technologies involved.[20] For example, technologies for removing arsenic from contaminated water would cost an average of four times as much over a span of 20 years as delivery of safe water obtainable from other sources and require high maintenance. Thus, technologies that prevent arsenic contamination, rather than remove arsenic, are more cost-effective in the long term.[33]

Conclusion

In Bangladesh, ongoing exposure to arsenic in drinking water calls for renewed and sustained mitigation efforts. Exposure to arsenic could be eliminated by 2030 if the government invested a small fraction of its annual GDP growth in providing an arsenic-safe water supply and improving water quality monitoring and surveillance activities. Reductions in arsenic-related mortality would be noted within about 40 years, as suggested by observations in similarly exposed populations in Chile and China, Taiwan (China), where arsenic-related cancer mortality started to decline gradually about 20 or 25 years after measures to reduce exposure were initiated and coronary heart disease mortality declined even faster.[24,34–37] The current generation may face the latent effects of lifetime exposure to arsenic even after switching to a safe water source, but for future generations, arsenic-attributable disease and death would be a thing of the past. If, on the other hand, population-wide chronic arsenic exposure is allowed to continue unchecked or to worsen as the population grows and installs more private tube wells, future generations will be saddled with enormous health and productivity costs. Appropriate interventions and robust investments, if undertaken now, can prevent this from happening.

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Competing interests:

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Table 1. **Arsenic concentration in drinking water and proportions exposed as determined by testing during national surveys, Bangladesh, 2011**

Arsenic concentration (µg/L)	BGS/DPHE 2000 (*n* = 3 534)		MICS 2009 (*n* = 14 442)	
	Proportion (%)	Cumulative (%)	Proportion (%)	Cumulative (%)
0–10	57.9	57.9	68.0	68.0
10.1–50	17.1	75.1	18.7	86.6
50.1–100	8.9	84.0	7.2	93.8
100.1–150	4.2	88.2	1.4	95.2
150.1–200	2.9	91.1	1.4	96.6
200.1–250	2.1	93.2	1.1	97.8
250.1–300	1.8	94.9	0.4	98.2
300+	5.1	100	1.8	100

BGS, British Geological Survey; DPHE, Department of Public Health Engineering; MICS, Multiple Indicator Cluster Survey.

Table 2. **Hazard ratios (HRs) for death from arsenic exposure, by cause of death and average arsenic concentration in drinking water, in a cohort of 115 903 people,[15] Bangladesh, 2011**

Average arsenic concentration (µg/L)	Cause of death			
	Nonaccidental HR (95% CI)	Cancer HR (95% CI)	Cardiovascular HR (95% CI)	Infection HR (95% CI)
< 10[a]	1.00	1.00	1.00	1.00
10–49	1.16 (1.06–1.26)	1.10 (0.77–1.59)	1.03 (0.82–1.29)	1.09 (0.92–1.30)
50–149	1.26 (1.18–1.36)	1.44 (1.06–1.95)	1.16 (0.96–1.40)	1.30 (1.13–1.49)
150–299	1.36 (1.27–1.47)	1.75 (1.28–2.40)	1.23 (1.01–1.51)	1.51 (1.31–1.75)
≥ 300	1.35 (1.23–1.48)	1.56 (1.06–2.30)	1.37 (1.07–1.77)	1.59 (1.33–1.91)

CI, confidence interval.

[a] Reference category.

Table 3. **Hazard ratios (HRs) for death from arsenic exposure, by cause of death and baseline arsenic concentration in drinking water, in a cohort of 11 746 people,[16] Bangladesh, 2011**

Baseline arsenic concentration (µg/L)	Cause of death	
	All-cause HR (95% CI)	Chronic disease HR (95% CI)
< 10.1	1.00	1.00
10.1–50.0	1.34 (0.99–1.82)	1.33 (0.94–1.87)
50.1–150.0	1.09 (0.81–1.47)	1.22 (0.87–1.70)
150.1–864.0	1.68 (1.26–2.23)	1.68 (1.21–2.33)

CI, confidence interval.

Table 4. **Population attributable fraction (PAF) of deaths from arsenic exposure and arsenic-attributable excess deaths (ED) per year for different arsenic concentrations in drinking water, by district, Bangladesh, 2011**

District	2011 adult population (thousands)	PAF (Sohel et al.)[15]	PAF (Argos et al.)[16]	Annual no. of arsenic-attributable ED by arsenic concentration (in μg/L) and in total (Sohel et al.)[15]					ED (Argos et al.)[16]
				10–49	50–149	150–299	≥ 300	Total deaths	
Bagerhat	931	0.036	0.045	133	103	41	8	285	361
Bandarban	244	0.013	0.024	28	0	0	0	28	51
Barguna	562	0.003	0.005	13	0	0	0	13	23
Barisal	1459	0.019	0.031	158	24	20	40	241	392
Bhola	1120	0.003	0.006	32	0	0	0	32	59
Bogra	2147	0.022	0.034	293	90	29	0	412	619
Brahamanbaria	1789	0.090	0.116	240	373	273	485	1371	1765
Chandpur[a]	1524	0.115	0.152	77	324	461	640	1503	1976
Chittagong[a]	4783	0.041	0.062	1140	383	98	72	1694	2514
Chuadanga	715	0.087	0.116	296	173	49	12	531	708
Comilla[a]	3379	0.130	0.162	356	1066	1262	1064	3748	4673
Cox's Bazar	1449	0.004	0.006	34	13	0	0	47	68
Dhaka	7564	0.020	0.026	555	435	305	0	1295	1662
Dinajpur	1892	0.007	0.013	115	0	0	0	115	212
Faridpur	1189	0.133	0.171	511	439	292	112	1354	1737
Feni	905	0.088	0.084	177	392	88	21	678	649
Gaibandha	1496	0.071	0.107	633	189	49	32	902	1364
Gazipur	2123	0.006	0.009	63	23	30	0	116	170
Gopalganj	732	0.145	0.171	223	341	267	73	904	1069
Habiganj	1312	0.089	0.115	542	356	101	0	999	1294
Jamalpur	1443	0.015	0.063	76	0	0	0	76	781
Jessore	1747	0.040	0.120	380	86	32	0	498	1785
Jhalokathi	380	0.096	0.038	552	511	303	66	1431	123
Jhenaidah	1119	0.023	0.104	65	10	0	0	75	991
Joypurhat	579	0.077	0.028	449	247	43	0	739	140
Khagrachari	387	0.002	0.003	4	3	0	0	7	8
Khulna	1461	0.056	0.076	414	214	49	19	696	952
Kishoreganj	1817	0.085	0.107	659	489	123	44	1315	1666
Kurigram	1306	0.048	0.079	446	71	23	0	540	883
Kushtia	1231	0.050	0.076	407	119	0	0	526	796

Lakshmipur	1090	0.090	0.119	343	251	77	165	835	1106
Lalmonirhat	796	0.017	0.031	113	0	0	0	113	209
Madaripur	732	0.119	0.154	246	223	212	61	742	961
Magura	582	0.083	0.104	204	157	20	30	410	515
Manikganj	878	0.093	0.116	363	275	30	30	698	870
Maulvibazar	1212	0.097	0.096	208	76	44	17	345	989
Meherpur	415	0.080	0.143	403	360	68	0	830	507
Munshiganj	905	0.066	0.073	85	221	120	85	511	561
Mymensingh	3212	0.047	0.074	1018	239	22	21	1301	2035
Naogaon	1641	0.024	0.043	322	10	0	0	332	597
Narail	455	0.092	0.111	116	136	97	10	360	432
Narayanganj	1845	0.047	0.055	160	269	306	0	735	870
Narsingdi	1403	0.052	0.066	236	217	87	85	626	788
Natore	1080	0.004	0.006	28	11	0	0	39	57
Nawabganj	1041	0.045	0.055	169	161	74	0	403	487
Netrokona	1406	0.115	0.136	570	585	188	43	1386	1636
Nilphamari	1159	0.029	0.053	288	0	0	0	288	530
Noakhali[a]	1957	0.117	0.138	415	740	441	365	1962	2305
Pabna	1591	0.042	0.059	295	144	127	0	566	795
Panchagarh	625	0.017	0.032	93	0	0	0	93	170
Patuakhali	966	0.023	0.042	188	0	0	0	188	346
Pirojpur	703	0.044	0.074	232	23	8	0	263	447
Rajbari	662	0.021	0.070	174	99	0	23	295	397
Rajshahi	1639	0.051	0.028	150	81	46	11	288	395
Rangamati	380	0.014	0.025	44	0	0	0	44	81
Rangpur	1826	0.023	0.040	333	30	0	0	364	625
Satkhira	1257	0.054	0.149	196	107	0	36	339	1604
Shariatpur	730	0.110	0.074	465	317	311	93	1186	459
Sherpur	850	0.055	0.063	718	184	18	0	920	455
Sirajganj	1957	0.039	0.085	219	37	24	0	281	1423
Sunamganj[a]	1556	0.151	0.146	659	1192	127	34	2012	1936
Sylhet	2168	0.054	0.057	370	513	90	25	999	1063
Tangail	2275	0.040	0.064	621	118	30	0	769	1236
Thakurgaon	879	0.003	0.006	26	0	0	0	26	48
Total	**90 657**	**0.056**	**0.074**	**19 140**	**13 250**	**6504**	**3823**	**42 717**	**56 425**

[a] One of five districts having the highest number of arsenic-attributable deaths per year (based on Sohel et al.'s hazard ratios).

Table 5. **Population attributable fraction of deaths and excess deaths (ED) from arsenic exposure based on hazard ratios from two published sources, Bangladesh, 2011**

Arsenic concentration (µg/L)	**Percentage exposed**	**PAF (Sohel et al.)[15]**	**PAF (Argos et al.)[16]**	**ED (Sohel et al.)[15]**	**ED (Argos et al.)[16]**
< 10	68.0	0	0	0	0
10.1–50	18.7	0.138	0.254	19 140	35 210
50.1–150	8.6	0.206	0.083	13 250	5302
150.1–300	3.0	0.265	0.405	6504	9945
> 300	1.8	0.259	0.405	3823	5969
Total	**100.0**	**0.056**	**0.074**	**42 717**	**56 425**
> 50 µg/L only	13.4	0.030	0.027	23 577	21 215