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The effect of drinking water salinity on blood pressure in young adults of coastal Bangladesh☆

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A B S T R A C T

More than 35 million people in coastal Bangladesh are vulnerable to increasing freshwater salinization. This will continue to affect more people and to a greater extent as climate change projections are realised in this area in the future. However the evidence for health effects of consuming high salinity water is limited. This research examined the association between drinking water salinity and blood pressure in young adults in coastal Bangladesh. We conducted a cross-sectional study during May-June 2014 in a rural coastal sub-district of Bangladesh. Data on blood pressure (BP) and salinity of potable water sources was collected from 253 participants aged 19–25 years. A linear regression method was used to examine the association between water salinity exposure categories and systolic BP (SBP) and diastolic BP (DBP) level. Sixty five percent of the study population were exposed to highly saline drinking water above the Bangladesh standard (600 mg/L and above). Multivariable linear regression analyses identified that compared to the low water salinity exposure category (<600 mg/L), those in the high water salinity category (>600 mg/L), had statistically significantly higher SBP (B 3.46, 95% CI 0.75, 6.17; $p = 0.01$) and DBP (B 2.77, 95% CI 0.31, 5.24; $p = 0.03$). Our research shows that elevated salinity in drinking water is associated with higher BP in young coastal populations. Blood pressure is an important risk factor of hypertension and cardiovascular diseases. Given the extent of salinization of freshwater in many low-lying countries including in Bangladesh, and the likely exacerbation related to climate change-induced sea level rise, implementation of preventative strategies through dietary interventions along with promotion of low saline drinking water must be a priority in these settings.

1. Introduction

Being a low-lying deltaic country, Bangladesh is highly vulnerable to climate change and its consequences. Of the climate vulnerable regions in Bangladesh, southwestern coastal areas are particularly exposed to sea level rise and seawater intrusion (Minar et al., 2013). Contamination of both surface and groundwater resources by varying levels of salinity in coastal Bangladesh has the potential to affect the health of its 35 million inhabitants (almost one-third of the total population) either through direct or indirect use (Khan et al., 2011b). A significant proportion of the population in these settings, including women, are exposed to a higher level of sodium than recommended by the World Health Organization (>2 g/day) (Khan et al., 2011a; Rasheed et al., 2014), even from early in life (Talukder et al., 2015b). The projections for climate change associated sea level rise also suggest that a growing population in coastal Bangladesh will be affected by the spread and intensity of salinity in the future (Dasgupta et al., 2014). Populations in other low-lying settings vulnerable to climate change and sea level rise (Nicholls et al., 2007) and that predominantly use untreated water sources are likely to have similar exposure to high sodium. However there is limited data on the population health effects of increasing water salinity in such contexts (Vineis et al., 2011).

The relationship between dietary sodium and rise in BP is well documented (He et al., 2013; Aburto et al., 2013), though evidence

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is mainly from studies of food consumption. Blood pressure is the largest contributor to global burden of cardiovascular diseases (CVD) (Neal et al., 2007). Globally, cardiovascular diseases (CVD) are the leading cause of death, contributing almost one third of total deaths and three-quarters of deaths in low- and middle-income countries (World Health Organization, 2015). Similarly CVD was the major cause of death in Bangladesh in 2010 (El-Saharty et al., 2013). Epidemiological data indicate that the risk of cardiovascular disease (CVD) is progressive throughout the range of BP with a threshold down to 115 mmHg for systolic blood pressure (SBP) and 75 mmHg for diastolic blood pressure (DBP) (Lewington et al., 2002; Lawes et al., 2003). Suboptimal blood pressure (SBP above 115 mmHg) is responsible for around 62% of strokes and 49% of ischemic heart disease globally (World Health Organization, 2002). Conversely, reduced sodium intake is associated with lower BP in both hypertensive and normotensive individuals (Neal et al., 2007). Moreover lowering sodium intake is also beneficial for people on antihypertensive medications achieving optimum blood pressure (Appel et al., 2009).

While food is considered as the major source of sodium, in low-lying countries like Bangladesh increasing water salinity (sodium) has been found to be associated with higher sodium consumption (Talukder et al., 2015b; Khan et al., 2011a) and high blood pressure in pregnant mothers (Khan et al., 2014). However, the existing, scanty evidence on the link between sodium consumption via drinking water and BP is not definitive (Talukder et al., 2016). Some studies in the USA, Netherlands and Israel have found a positive relationship between elevated sodium in drinking water and rise in blood pressure (Tuthill and Calabrese, 1981, 1979; Hofman et al., 1980; Pomeranz et al., 2000). However other studies in the USA and Australia did not observe any such relationship (Robertson, 1984; Armstrong et al., 1982). It is noteworthy that the concentration of sodium in drinking water in all of these studies ranged from ~100 to 405 mg/l, while in coastal Bangladesh drinking water sodium has been measured as 2–6 times higher (Talukder et al., 2015b; Khan et al., 2011a; 2014).

In this research we evaluated the effect of elevated salinity in drinking water on BP level in a young population between 19 and 25 years of age in coastal Bangladesh. This group was chosen as there is little available information about BP on healthy young adults in Bangladesh, nor from salinity affected coastal areas, and the influence of the usual risk factors for elevated BP are expected to be low in this group.

2. Methods

2.1. Study design, setting and population

We conducted a cross-sectional survey in Koyra, a rural sub-district of Khulna district in southwestern coastal Bangladesh during May-June 2014. Among 9 sub-districts in Khulna, the highest salinity concentration in surface and ground water sources has been recorded in Koyra (Abedin and Shaw, 2013). This sub-district is also prone to salinity intrusion as it is part of the exposed coastal classification (PDO-ICZMP, 2003). Koyra sub-district is also one of the WaterAid, Bangladesh water, sanitation and hygiene (WASH) development program areas, which aided the researcher to access existing data, community members and field assistants. Detailed study methods are provided elsewhere (Talukder et al., 2015b). In brief, we selected two unions (Koyra Sadar and Amadi), out of 7 in Koyra, based on the diversity of potable water uses. In these unions both surface water from ponds and ground water from tube wells were used. We randomly selected four villages, two villages from each union using a Probability Proportionate Sampling (PPS) technique.

In the selected villages trained research staff made household visits, identified and listed 418 eligible participants aged 19–25 years. Of those, 340 participants were available for interview and health assessments and we aimed to include all of them. We excluded multiple eligible participants from the same household (n = 49), pregnant women (n = 21) and participants who declined to participate (n = 4) resulting in 266 interviews and BP measurements. Of them, 253 participants (74% of the total available) with completed data including both water salinity measures and BP were included in the analyses. Ethical approval was obtained from Griffith University, Australia and the International Centre for Diarrhoeal Disease Research, Bangladesh (icddr,b) and all participants provided written consent at the beginning of data collection. The trained project staff conducted household visits for data collection and health assessment.

2.2. Outcome (blood pressure) assessment

The trained project staff recorded three measurements of blood pressure, at intervals of 10 min between each measurement, from the right arm of the seated participants after a 30-min rest period using an OMRON HEM-7111 automated sphygmomanometer following standard guidelines (Pickering et al., 2005). The mean of the last two measurements was used in the analysis.

2.3. Exposure (drinking water salinity and urinary sodium) assessment

Samples from participants' drinking water sources were collected and measured for salinity in parts per thousand (ppt) using a conductivity meter (Model: Sension5, company: HACH, origin: USA) at the internationally accredited International Centre for Diarrhoeal Disease Research, Bangladesh (icddr,b) laboratory and then converted into milligrams per liter (mg/L) (1 ppt = 1000 mg/L) for analysis purposes.

Spot urine of participants was collected and measured for urinary sodium in millimoles per liter (mmol/L) by the Ion Selective Electrode method (ISE), using Automated Chemistry Analyzer, Olympus, Model AU640, Beckman Culter International, Japan at the icddr,b laboratory. From this value the 24-h sodium level was estimated using the INTERSALT study method (Brown et al., 2013).

2.4. Covariates

Information on socio-demographic conditions, household characteristics, the sources of drinking and cooking water, years of using the water sources, family history of hypertension, previous assessment of raised blood pressure by health care providers or related use of medications, and diet of the past 7 days including consumption of rice, vegetables and fruits, fish, red meat and diary products, and tobacco use from each of the eligible participants were collected during household visits. To obtain dietary consumption we adopted the food frequency questionnaire used in the Bangladesh Integrated Household Survey. The questionnaire included 17 food items. For each food item, respondents were asked about the number of days they had consumed each food item in the past 7 days (Ahmed et al., 2013).

Weight and height of each participant were measured following standard anthropometric techniques. Weight was measured on a digital electric balance (TANITA HD 318 Digital weighing scale, 150 kg, ±0.1 kg) and height was measured using S + M height measure scale-2 m (Aaxis Pacific Healthcare, Australia).