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Article

Drinking-water salinity, sodium exposure, and blood pressure among lactating mothers in coastal Bangladesh: a cross-sectional study

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Abstract: Rising sea levels linked to climate change are intensifying saltwater intrusion in coastal zones, which increases the risk of consuming saline drinking water and may have implications for maternal health. This research explored the relationship between drinking-water salinity, urinary sodium output, and blood pressure among breastfeeding mothers in coastal Bangladesh. A cross-sectional survey was carried out in Kalapara Upazila of Patuakhali District between July and December 2017. Using purposive sampling, 100 lactating mothers were enrolled. Information was gathered through structured interviews, body measurements, and blood pressure recordings. Spot urine samples were tested for sodium levels, and 24-hour sodium excretion was estimated using the Nerbass equation. Water samples from tube wells and ponds were analyzed for pH, electrical conductivity, sodium, and overall salinity. Statistical analyses, including correlation and multivariable linear regression, were applied to assess the links between water salinity, urinary sodium excretion, and systolic (SBP) as well as diastolic blood pressure (DBP). Overall, 58% of participants had estimated urinary sodium excretion above the WHO recommended level of 2 g/day (≈85 mmol/day). Mean salt concentration was significantly higher in tube-well water than in pond water (1420.67 ± 403.70 vs. 262.89 ± 794.50 mg/L; P<0.001). Water salinity was positively associated with urinary sodium excretion ($P < 0.05$). Estimated 24-h urinary sodium excretion was positively associated with SBP ($\beta = 0.29$, 95% CI: 0.17–0.36; P<0.001) and DBP ($\beta = 0.23$, 95% CI: 0.15–0.28; P<0.001). Associations remained significant after adjustment for age, education, water salinity, BMI, and MUAC (SBP: $\beta = 0.36$, 95% CI: 0.21–0.45; DBP: $\beta = 0.21$, 95% CI: 0.16–0.34; both P<0.001). Higher drinking-water salinity was associated with greater sodium exposure and higher blood pressure among lactating mothers. Improving access to low-salinity drinking water and strengthening community-based education on sodium exposure should be prioritized within maternal-health and climate-adaptation programmes in salinity-affected coastal communities.

Keywords: saltwater intrusion; maternal health; hypertension; climate change; coastal communities

1. Introduction

Climate change is increasingly acknowledged as a critical environmental factor influencing human health, especially in low- and middle-income nations where communities rely heavily on climate-sensitive resources and possess limited adaptive capacity (Abdul-Nabi *et al*., 2025). Rising global temperatures, sea-level rise, shifts in rainfall patterns, and more frequent extreme weather events are reshaping ecosystems and jeopardizing access to clean water, food security, and sustainable livelihoods (Habib *et al*., 2025). Bangladesh faces heightened vulnerability due to its low-lying deltaic terrain, extensive coastal areas, and dense populations residing in regions most exposed to climate-related risks. In the coastal belt, sea-level rise, tidal inundation, storm surges, and changes in freshwater availability have contributed to progressive saltwater intrusion into rivers, groundwater, ponds, agricultural land, and other freshwater resources (Murshed *et al*., 2022). Consequently, many coastal communities increasingly depend on saline or moderately saline water sources for drinking and domestic activities, creating an important environmental exposure with potential implications for population health (Roy *et al*., 2021; Costopoulos *et al*., 2025). Continued sea-level rise and changes in freshwater flow are expected to further intensify salinity intrusion, potentially increasing pressure on already limited freshwater resources and exacerbating associated health risks.

The health impacts of consuming saline water are becoming increasingly evident. High sodium intake is a well-established contributor to hypertension and cardiovascular disorders. To mitigate these risks, the World Health Organization advises limiting daily sodium consumption to under 2 grams, which is roughly equivalent to 5 grams of table salt (Costopoulos *et al*., 2025). Although this recommendation primarily addresses total dietary sodium intake, drinking water can represent an additional source of sodium in communities where freshwater resources are contaminated by saltwater intrusion. Evidence from coastal Bangladesh indicates that exposure to saline water can contribute substantially to daily salt intake. Individuals consuming medium- or high-salinity water have been reported to have higher odds of hypertension than those consuming lower-salinity water (Khan *et al*., 2020). Moreover, elevated drinking-water salinity has been associated with hypertension, gestational hypertension, and pre-eclampsia, as well as other health problems reported in salinity-affected coastal communities (Scheelbeek *et al*., 2016; Khan *et al*., 2021; Roy *et al*., 2022; Shamsuddoha *et al*., 2024; Pinchoff *et al*., 2025). Despite these concerns, there remains no universally established health-based threshold specifically defining a safe sodium concentration in drinking water, leaving populations dependent on saline water sources without clear guidance regarding the potential health risks of chronic exposure (Costopoulos *et al*., 2025).

The potential consequences of saline-water exposure are particularly important for maternal health. Women living in coastal communities may experience repeated exposure to saline water through drinking, cooking, food preparation, and other household activities, thereby increasing their cumulative sodium exposure (Chakraborty *et al*., 2019; Shammi *et al*., 2019; Shamsuddoha *et al*., 2024). Studies conducted in coastal Bangladesh have reported a higher burden of hypertension and hypertensive disorders among women exposed to saline drinking water, suggesting that environmental salinity may represent an important and potentially modifiable determinant of maternal cardiovascular health (Talukder *et al*., 2016; Scheelbeek *et al*., 2017; Rahman *et al*., 2023; Pinchoff *et al*., 2025). This vulnerability may be compounded by socioeconomic disadvantage, limited access to healthcare, gender-related inequalities, and inadequate awareness of the health consequences of saline-water exposure (Sultana *et al*., 2022; Rahman *et al*., 2023). In addition, limited access to alternative freshwater sources may constrain women's ability to avoid saline water, particularly in households where women are responsible for water collection and domestic activities.

Although the relationship between drinking-water salinity and hypertension has received increasing attention, limited evidence exists on the pathway linking environmental salinity, sodium exposure, and blood pressure among lactating mothers. Previous studies have mainly focused on pregnant women or general coastal populations, with comparatively little evidence for lactating women. Few studies have simultaneously assessed household water salinity, urinary sodium excretion as an objective indicator of sodium exposure, and blood pressure. Examining these factors together may clarify the relationship between saline drinking water, sodium exposure, and blood-pressure levels. This issue is particularly relevant in coastal Bangladesh, where climate-related changes are expected to intensify saltwater intrusion and further threaten freshwater availability (Costopoulos *et al*., 2025). Household water-source selection, treatment practices, access to alternative freshwater, and awareness of salinity-related health risks may influence exposure. However, evidence on these adaptation practices in relation to maternal health and sodium exposure remains limited. Understanding both physiological exposure and household responses is therefore important for developing context-specific safe-water, health-education, and climate-adaptation interventions.

Building on this context, the present study examined how drinking-water salinity relates to urinary sodium excretion and blood pressure among lactating women in Kalapara Upazila, a coastal region of Bangladesh affected by salinity intrusion. The central research questions were whether increased salinity in drinking water is linked to higher urinary sodium output and elevated systolic and diastolic blood pressure, and how households in coastal areas respond to saline-water intrusion. Our working hypothesis was that greater drinking-water salinity would correspond to increased urinary sodium excretion and higher blood pressure levels in lactating mothers. Accordingly, the study aimed to examine these relationships and document household adaptation strategies for coping with saline-water intrusion. The novelty of this study lies in linking drinking-water salinity, urinary sodium, blood pressure, and household adaptation among lactating mothers in coastal Bangladesh. The findings may support improved access to low-salinity drinking water and integration of safe-water measures into maternal-health and climate-adaptation strategies in vulnerable coastal communities.

2. Materials and Methods

2.1. Ethical considerations

This study was conducted in accordance with the ethical standards outlined in the Declaration of Helsinki and the institutional regulations governing human research. Prior to data collection, approval was granted by the Institutional Ethical Committee (IEC) of Patuakhali Science and Technology University, Bangladesh (approval no: PSTU/IEC/2017/02). All participants were fully briefed on the study objectives and provided written informed consent. They were assured of their right to withdraw participation at any stage. Measures were taken to safeguard confidentiality and anonymity, and all collected data were used exclusively for research purposes.

2.2. Study area and periods

A descriptive cross-sectional study was conducted in Kalapara Upazila, Patuakhali District, in the southern coastal region of Bangladesh, from July to December 2017 (Figure 1). The study area is located along the Bay of Bengal and is characterized by low-lying terrain, high environmental salinity, and frequent exposure to cyclones and tidal surges, making it highly vulnerable to climate-related environmental and public-health challenges.

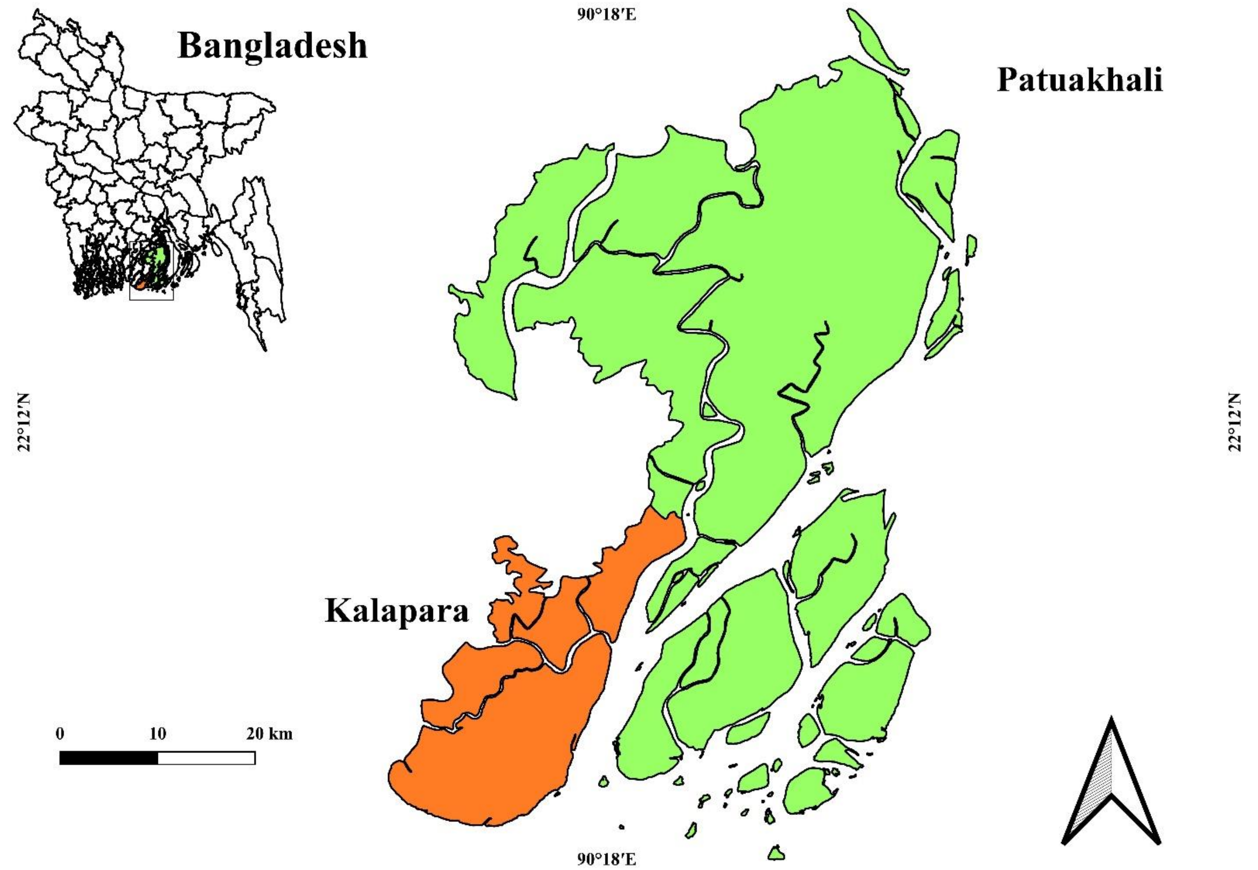

Figure 1. Location map of the study area in Kalapara Upazila, Patuakhali District, coastal Bangladesh.

2.3. Participants and water sampling

A total of 120 lactating mothers with children under 5 years of age were purposively recruited from the study area. Eligibility for participation was based on availability during the survey period and willingness to participate. All participants were informed about the study objectives before enrollment. Of the 120 recruited mothers, 100 were included in the final analysis because 20 declined to provide urine samples. In addition, 62 water samples were randomly collected from different locations within the study area, comprising 24 groundwater samples and 38 surface-water samples (Table 1).

Table 1. Distribution of study participants and water samples by sampling category.

Sampling category	Sampling source/status	Number (n)	Percentage (%)
Participants	Initially recruited lactating mothers	120	100
	Declined to provide urine sample	20	16.7
	Included in final analysis	100	83.3
Water samples	Total water samples	62	100
	Groundwater	24	38.7
	Surface water	38	61.3

Values are presented as number (n) and percentage (%). Percentages for participants are calculated from the initially recruited sample (n = 120), while percentages for water samples are calculated from the total number of collected water samples (n = 62).

2.4. Data collection and measurement

Information was gathered through direct interviews using a structured questionnaire that had been designed following a review of relevant scholarly literature. The questionnaire was reviewed by academic experts to assess its content validity and was pilot-tested among 10 participants who were not included in the final analysis to evaluate its clarity, comprehensibility, and internal consistency. The finalized questionnaire collected information on household characteristics, socioeconomic conditions, drinking-water sources, domestic water use, water-treatment practices, adaptation strategies for saline-water intrusion, and self-reported disease history during the preceding 6 months.

2.5. Anthropometric measurement

Anthropometric measurements were obtained using standardized procedures. Body weight (kg), height (m), and mid-upper arm circumference (MUAC, cm) were measured for each participant. Body mass index (BMI) was calculated as body weight (kg) divided by height squared (m^2) and used, together with MUAC, to assess maternal nutritional status. BMI was categorized as underweight (<18.50 kg/m^2), normal (18.50–24.99 kg/m^2), or overweight (≥25 kg/m^2) according to established classification criteria (Estrella-Castillo and Regil, 2019). MUAC was classified as undernourished (<22.80 cm), normal (22.80–27.10 cm), or overweight (>27.10 cm) based on previously validated cut-off values (Fakier *et al*., 2017).

2.6. Measurement of blood pressure

Blood pressure was measured twice for each participant using a calibrated digital sphygmomanometer according to standardized procedures. Participants were seated comfortably and allowed to rest before measurement. Systolic blood pressure (SBP) and DBP were recorded for each reading, and the mean of the two measurements was calculated separately for SBP and DBP for subsequent analysis. Participants were classified as hypertensive if SBP was >130 mmHg and/or DBP was >85 mmHg; otherwise, they were classified as normotensive (Bolli *et al*., 2007).

2.7. Measurement of urinary sodium

Twenty-four-hour urinary sodium excretion is considered a reference method for estimating sodium intake; however, its implementation in community-based studies is often constrained by participant burden, collection difficulties, and compliance requirements (Tanaka *et al*., 2002; Elliott and Brown, 2007). Therefore, spot urine samples were collected as a practical alternative for estimating sodium exposure. Previous studies have demonstrated significant associations between spot urinary sodium concentrations and 24-h urinary sodium excretion (Tanaka *et al*., 2002; Brown *et al.*, 2013; Mente *et al*., 2014; Nerbass *et al*., 2014). Urine samples were collected with assistance from community clinic staff and transported to Labaid Diagnostic Limited, Barishal, Bangladesh, for laboratory analysis. Urinary sodium concentration (mmol/L) was measured using the ionselective electrode (ISE) method with an automated chemistry analyzer. Estimated 24-h urinary sodium excretion (mmol/day) was calculated from spot urinary sodium concentration and body weight using the equation proposed by Nerbass *et al*. (2014),

Estimated 24-h urinary sodium excretion (mmol/day) = −68.625 + [1.824 × body weight (kg)] + [0.482 × spot urinary sodium (mmol/L)]

Based on the WHO recommendation, estimated sodium intake was categorized as low (<2 g/day; <85 mmol/day) or high (≥2 g/day; ≥85 mmol/day) (WHO, 2012).

2.8. Water salinity assessment

Drinking and household water samples, including groundwater and surface water, were randomly collected from different locations within the study area using sterile 200-mL plastic sampling bottles. Samples were transported to the Laboratory of Community Health and Hygiene at Patuakhali Science and Technology University for physicochemical analysis. The analyzed parameters included pH, electrical conductivity (EC; dS/m), sodium concentration (mg/L), and total salt concentration (mg/L). Sodium concentration was determined using atomic absorption flame photometry and a flame photometer according to standard laboratory procedures. Water salinity was assessed based on EC and corresponding salt concentration following the classification criteria of the Food and Agriculture Organization (FAO, 2018).

Based on EC and salt concentration, water samples were classified as non-saline (<0.7 dS/m; <500 mg/L), slightly saline (0.7–2.0 dS/m; 500–1500 mg/L), moderately saline (2–10 dS/m; 1500–7000 mg/L), highly saline (10–25 dS/m; 7000–15,000 mg/L), very highly saline (25–45 dS/m; 15,000–35,000 mg/L), or brine (>45 dS/m; >45,000 mg/L).These categories were used to characterize the degree of salinity across the sampled water sources and facilitate comparison between groundwater and surface-water sources.

2.9. Statistical analysis

All statistical analyses were performed using SPSS version 16.0. Data were screened for completeness and consistency before analysis. Participants' sociodemographic characteristics and key study variables were summarized using descriptive statistics. Continuous variables, including drinking-water salinity (tube-well and pond water), estimated urinary sodium excretion, and blood pressure measurements, were expressed as mean ± standard deviation (SD). Bivariate correlation analysis was performed to assess the relationship between water salinity and urinary sodium excretion. Multivariable linear regression analyses were conducted separately for SBP and DBP to examine their associations with estimated 24-h urinary sodium excretion (mmol/day). A stepwise modeling approach was used. Model 1 was an unadjusted linear regression model assessing the crude association between urinary sodium excretion and each blood pressure outcome. Model 2 was adjusted for age, education level, and water salinity. Model 3 further adjusted for anthropometric measures, including BMI and MUAC. Regression coefficients (β), 95% confidence intervals (CI), and *P*-values were reported to quantify the strength and statistical significance of the associations. A two-sided $P<0.05$ was considered statistically significant.

3. Results

3.1. Sociodemographic, nutritional, and household characteristics

Most participants had primary-level education (66%), whereas only 6% had a degree or higher level of education. The majority were housewives (85%), while 7% were teachers and 8% were engaged in other occupations. Regarding household income, most families (61%) reported a monthly income of BDT 7,000–12,000. Regarding nutritional status, 63% of participants had a normal BMI, while 14% were underweight and 23% were overweight; the mean BMI was 22.50 ± 3.70 kg/m². Based on MUAC, 67% were within the normal range, whereas 15% were classified as undernourished and 18% as overweight. A substantial proportion of participants (85%) reported adding extra salt to their meals. For household activities, pond water was the predominant source (93%), while 4% used rainwater and 3% used tube-well water (Table 2).

Table 2. Sociodemographic, nutritional, and household characteristics of the study participants (N = 100).

Variables		Frequency (N=100)	Percentage (%)
Educational status	Illiterate	9	9
	Primary	66	66
	Secondary	16	16
	higher secondary	3	3
	Degree and above	6	6

Table 2. Contd.

Variables		Frequency (N=100)	Percentage (%)
Occupation	Housewife	85	85
	Teacher	7	7
	Others job	8	8
Monthly family income (BDT)	<7000	12	12
	7000-12000	61	61
	12001-20000	15	15
	>20000	12	12
BMI (kg/m^2)	Underweight	14	14
	Normal	63	63
	Overweight	23	23
MUAC (cm)	Underweight	15	15
	Normal	67	67
	Overweight	18	18
Added salt in meals	No	15	15
	Yes	85	85
Household activities water sources	Tube-well	3	3
	Pond	93	93
	Rainwater	4	4

Values are presented as frequency (N) and percentage (%). BMI = body mass index; BDT= Bangladesh Taka; MUAC = mid-upper arm circumference. BMI categories were classified as underweight (BMI<18.50 kg/m^2), normal (BMI between 18.50 and 24.99 kg/m^2) and overweight (BMI ≥25 kg/m^2) based on the WHO guidelines. Using established MUAC cut-off points, MUAC categories were classified as under nourished (<22.80 cm), normal (22.80-27.10 cm), and overweight (>27.10 cm). Household water source refers to water used for daily domestic activities.

3.2. Characteristics of the drinking-water sources and salinity levels

Access to safe water in the study area depended largely on the availability and type of local water sources. All households (100%) reported using groundwater for drinking, while pond water was the predominant source for household activities. Participants also reported that tube wells were often located at considerable distances from their residences, potentially limiting convenient access to safe drinking-water sources.

Sodium concentration was markedly higher in tube-well water (466.80 ± 132.60 mg/L) than in pond water (86.40 ± 261 mg/L), indicating a substantially greater sodium burden in groundwater. Similarly, the mean salt concentration was more than fivefold higher in tube-well water (1420.70 ± 403.70 mg/L) than in pond water (262.90 ± 794.50 mg/L). Electrical conductivity (EC) showed a similar pattern, with higher mean values in tube-well water (2.04 ± 0.42 dS/m) than in pond water (0.94 ± 1.50 dS/m), suggesting greater dissolved mineral and salt content in groundwater. In contrast, pond-water EC showed considerable variability across sampling locations. Both water sources were slightly alkaline, although tube-well water had a higher mean pH (8.20 ± 0.25) than pond water (7.70 ± 0.29). Statistical comparison further demonstrated that tube-well water had significantly higher salinity than pond water. The mean difference in EC was 1.10 dS/m (95% CI: 0.59–1.60; $P < 0.001$), while the mean difference in salt concentration was 1157.80 mg/L (95% CI: 851.60–1464.02; $P < 0.001$) (Table 3).

Table 3. Physicochemical characteristics of tube-well and pond water in the study area.

Water quality parameter	Tube well				Pond			
	Mean	SD	Min	Max	Mean	SD	Min	Max
pH	8.20	0.25	7.70	8.60	7.70	0.29	6.60	8.20
EC (dS/m)	2.04	0.42	1.70	3.70	0.94	1.50	0.20	9.40
Na (mg/L)	466.80	132.60	297.70	825.80	86.40	261.00	6.90	1632.40
Salt (mg/L)	1420.70	403.70	905.60	2513.40	262.90	794.50	21.20	4968.20

Values are presented as mean ± standard deviation (SD) with minimum (Min) and maximum (Max) ranges. EC= electric conductivity; Na=sodium content.

3.3. Urinary sodium excretion and blood pressure profile

The mean spot urinary sodium concentration was 129.90 ± 42.70 mmol/L, with a median of 139 mmol/L and a range of 36–198 mmol/L. The estimated 24-hour urinary sodium excretion was 89.60 ± 25.70 mmol/day, with a median of 89.30 mmol/day and a range of 34.20–158.70 mmol/day, indicating substantial inter-individual variation in sodium excretion. Overall, 58% of participants had estimated 24-hour urinary sodium excretion above approximately 85mmol/day, corresponding to the WHO guideline level of 2g sodium/day. Despite this relatively high sodium exposure, the majority of participants had blood pressure within the normal range; however, 18% were classified as hypertensive according to the study criteria. The mean SBP was 112.90 ± 13.80 mmHg, while the mean DBP was 72.50 ± 10.50 mmHg (Table 4).

Table 4. Distribution of spot and estimated 24-hour urinary sodium excretion among study participants.

	Mean	SD	Median	Minimum	Maximum
Urinary Na (spot) (mmol/L)	129.9	42.7	139	36	198
Urinary Na (24 hours) (mmol/day)	89.6	25.7	89.3	34.2	158.7

Values are presented as mean ± standard deviation (SD), median, and range (minimum–maximum). Urinary sodium excretion was estimated using spot urine samples. The WHO (2012) guideline recommends a sodium intake of <2 g/day (≈85 mmol/day).

3.4. Independent association between urinary sodium excretion and blood pressure

Estimated urinary sodium excretion was positively and significantly associated with both SBP and DBP across all regression models. In the unadjusted model (model 1), urinary sodium excretion was significantly associated with SBP (β = 0.29, 95% CI: 0.17–0.36; $P < 0.001$) and DBP (β = 0.23, 95% CI: 0.15–0.28; $P < 0.001$). These associations remained statistically significant after adjustment for age, education, and drinking-water salinity (Model 2), with slightly higher regression coefficients for both SBP (β = 0.32, 95% CI: 0.20–0.39; $P < 0.001$) and DBP (β = 0.27, 95% CI: 0.16–0.30; $P < 0.001$) (Figure 2). Further adjustment for BMI and MUAC (Model 3) did not attenuate the observed associations. The association with SBP increased to β = 0.36 (95% CI: 0.21–0.45; $P < 0.001$), while the association with DBP remained statistically significant (β = 0.21, 95% CI: 0.16–0.34; $P < 0.001$) (Table 5).

Table 5. Unadjusted and multivariable linear regression models examining the association between estimated 24-hour urinary sodium excretion and blood pressure.

Model	SBP (mmHg)			DBP (mmHg)		
	β-coefficient	95% CI	p-value	β-coefficient	95% CI	p-value
Model 1 (unadjusted)	0.29	0.17–0.36	<0.001	0.23	0.15–0.28	<0.001
Model 2 (adjusted: age, education, water salinity)	0.32	0.20–0.39	<0.001	0.27	0.16–0.30	<0.001
Model 3 (Fully adjusted: Model 2 + BMI, MUAC)	0.36	0.21–0.45	<0.001	0.21	0.16–0.34	<0.001

β-coefficients represent regression estimates. CI = confidence interval; SBP = systolic blood pressure; DBP = diastolic blood pressure. Model 1: unadjusted; Model 2: adjusted for age, education, and water salinity; Model 3: adjusted for Model 2 variables plus BMI and MUAC.

Most participants with normal sodium excretion had urinary sodium levels close to the 85 mmol/day cut-off. The scatter plot indicates that several observations exceeded this threshold (Figure 2). Frequent consumption of tube-well water and added dietary salt may contribute to increased sodium exposure.

3.5. Self-reported health problems and household water-treatment practices

The most frequently reported conditions were gastritis (25%) and skin diseases (24%), followed by arthritis and headache (20% each) and hypertension (15%). Less frequently reported conditions included urinary irritation and allergies (9% each), asthma (8%), gynecological problems (7%), and cardiovascular disease (6%). Diarrhea and bleeding/miscarriage were reported by 3% of participants each, while 21% reported other miscellaneous health conditions (Figure 3). The survey also identified gaps in awareness and household water-management practices. Despite the observed prevalence of hypertension, awareness regarding the potential relationship between saline water exposure, sodium intake, and blood pressure appeared limited. Pond water was widely used for domestic activities, reflecting the limited availability of alternative water sources for household use in the study area. Regarding drinking-water treatment, 31% of participants reported that they did not treat their drinking water. Among those who reported treating their water, 65% used fitkari (alum), whereas only 1% reported boiling water as a treatment method. A commonly reported reason for not treating tube-well water was the perception that it was inherently safe for consumption.

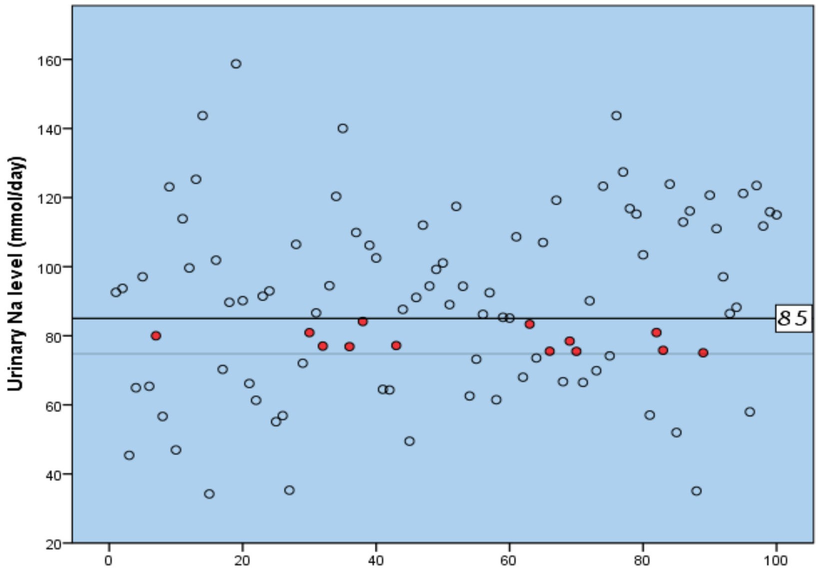

Figure 2. Scatter plot illustrating the estimated 24-hour urinary sodium excretion.

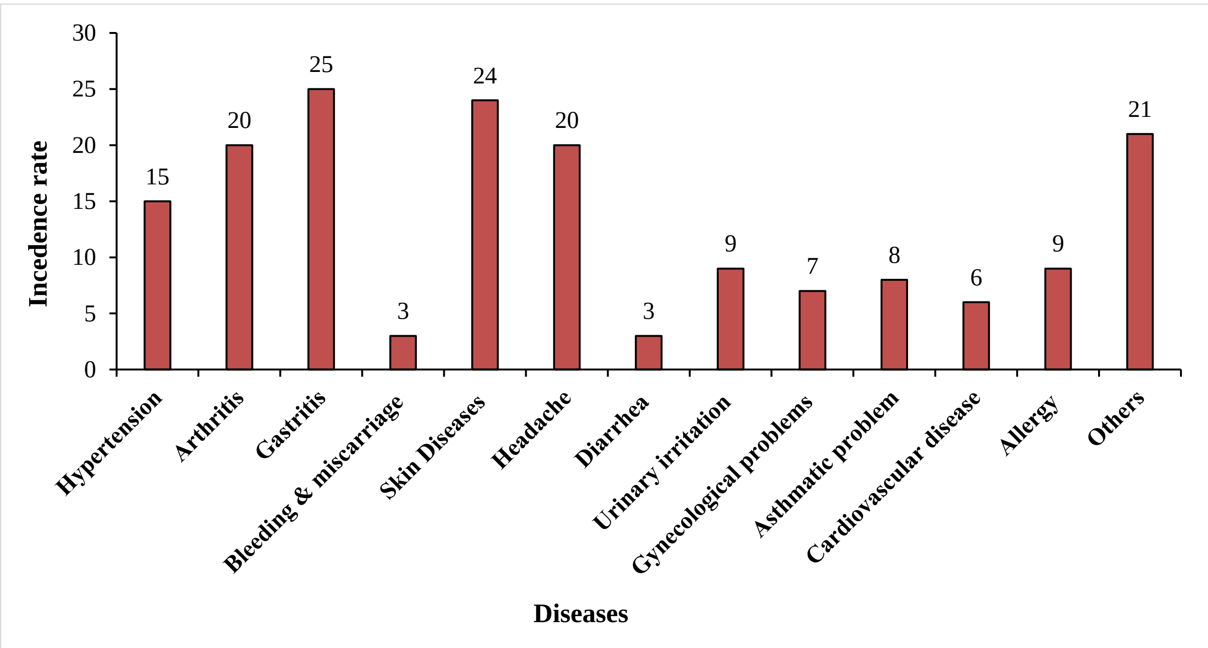

Figure 3. Distribution of self-reported health problems among study participants.

4. Discussion

The study provides important insights into the educational and nutritional status of participants. Most respondents had only primary-level education, which has been associated with higher rates of undernutrition and poorer health outcomes (Moushumi *et al*., 2024). Lower educational attainment may also limit awareness of healthy dietary practices and the risks associated with excessive salt intake, while educational status has been significantly associated with hypertension (Khan *et al*., 2020). Notably, 85% of participants reported adding extra salt to their meals, exceeding the 77% reported by Karim *et al*. (2023). Such practices may increase the risk of hypertension and other non-communicable diseases. The prevalence of underweight (14%) and overweight (23%) was also higher than the corresponding estimates of 10% and 18.90% reported among reproductive-age women in a recent BDHS analysis (Nandi *et al*., 2026). The coexistence of undernutrition and overweight reflects the persistent double burden of malnutrition in Bangladesh (Mamun and Mascie-Taylor, 2019).

Coastal communities in Bangladesh rely on both surface and groundwater, although climate change and saltwater intrusion increasingly affect the quality and availability of these sources. In the present study, most households used surface water for daily household activities, while all participants reported using groundwater for drinking, consistent with previous studies reporting similar patterns of drinking-water use in coastal Bangladesh (Benneyworth *et al*., 2016; Nahian *et al*., 2018). Tube-well water is often perceived as microbiologically safe and is therefore commonly consumed without treatment; similarly, more than 60% of coastal residents in a previous study used tube-well water because it was considered safe (Talukder *et al*., 2016). In the present study, 65% of participants reported treating surface water with fitkari (alum), whereas 31% reported using no water-treatment method. These findings are broadly consistent with earlier evidence showing that approximately 24% of households used fitkari and 51% used no water-purification method, while groundwater was generally left untreated (Benneyworth *et al*., 2016).

Most participants used pond water for domestic activities, while freshwater sources such as ponds and tube wells were commonly used for drinking, cooking, bathing, and washing in coastal Bangladesh, potentially contributing to sodium exposure (Talukder *et al*., 2016). Frequent salt addition to meals was also reported in the study area, which may further increase overall sodium intake. Limited access to nearby tube wells may compound this challenge, as nearly half of coastal residents reportedly travel 0.50–3.00 km to obtain safe drinking water (Azam and Sarker, 2012).

In this study, untreated tube-well water had a mean sodium concentration of 466.79 mg/L and salt concentration of 1420.67 mg/L, exceeding previously reported levels of 884.60 mg/L and 915 mg/L (Talukder *et al*., 2016; Nahian *et al*., 2018) and approaching concentrations above 1500 mg/L considered unusually high for drinking water (Scheelbeek *et al*., 2017). Pond-water salt concentration was considerably lower (262.89 mg/L) than previously reported levels (Talukder *et al*., 2016). A significant positive correlation was observed between water salinity and urinary sodium excretion (P = 0.029), suggesting that saline drinking water may contribute to sodium exposure. The mean EC of tube-well water was 2.04 dS/m, within the previously reported range of 0.83–2.91 dS/m for the area and above the cited 0.30 dS/m drinking-water benchmark (Haque *et al.*, 2014). Consistent with previous findings (Talukder *et al*., 2016), tube-well water showed significantly higher EC and salinity than pond water (P < 0.001).

The mean estimated 24-hour urinary sodium excretion in this study was 89.62 mmol/day, which was lower than the levels reported in 2011 (170 mmol/day) and 2016 (121 mmol/day) among coastal populations in Bangladesh (Khan *et al.*, 2011; Talukder *et al*., 2016). Nevertheless, 58% of breastfeeding mothers had urinary sodium excretion above the WHO-recommended limit of 2 g/day (approximately 85 mmol/day). This proportion was broadly comparable to previous findings from coastal Bangladesh, where 59% of adults aged ≥25 years and 53% of young adults aged 19–25 years exceeded the recommended threshold (Rasheed *et al*., 2014; Talukder *et al*., 2016). Overall, the estimated sodium intake observed in the present coastal population was lower than that reported in other populations (Inoue *et al*., 2016).

In this study, 18% of participants were hypertensive, which was lower than the 21.60% reported among coastal populations by Nahian *et al*. (2018) and the national prevalence of 26.40% reported by Chowdhury *et al*. (2016), including 20.30% among men and 32.40% among women. Previous studies have identified associations between physical activity, sedentary behavior, and blood pressure (Chowdhury *et al*., 2016; Boudreaux *et al*., 2023). The relatively active lifestyle of women in the study area may partly contribute to the lower prevalence observed, although this relationship could not be established in the present cross-sectional study. The mean SBP and DBP were 112.95 ± 13.80 mmHg and 72.45 ± 10.48 mmHg, respectively, compared with 111 ± 10 mmHg and 66 ± 9 mmHg reported by Talukder *et al*. (2016). Evidence from coastal Bangladesh has also reported SBP and DBP values of 103 ± 10 mmHg and 66.90 ± 8.90 mmHg among non-hypertensive pregnant women at ≥20 weeks of gestation, although comparisons should be interpreted cautiously because of differences in population characteristics and physiological status (Khan *et al.*, 2014).

Several studies in coastal Bangladesh have reported that increasing drinking-water salinity can increase dietary sodium exposure beyond recommended levels (Talukder *et al*., 2016). In the present study, water salinity was positively associated with urinary sodium excretion (P = 0.029), supporting the potential contribution of saline drinking water to overall sodium exposure. High sodium intake is well established as a risk factor for elevated blood pressure (Grillo *et al*., 2019), and several studies have reported associations between saline drinking water, increased sodium exposure, and hypertension (Talukder *et al*., 2016; Rasheed *et al*., 2016; Scheelbeek *et al*., 2017; Naser *et al*., 2019; Shammi *et al*., 2019; Khan *et al*., 2020; Rosinger *et al*., 2021). However, evidence specifically examining this relationship among lactating mothers remains limited. In the present study, water salinity was positively associated with both SBP and DBP, with adjusted regression coefficients of 0.609 mmHg and 0.607 mmHg, respectively, after controlling for age, education, water salinity, BMI, and MUAC. These estimates were lower than the 2 mmHg increase in SBP per 1 g increase in water salinity reported by Talukder *et al*. (2016).

Untreated saline drinking water may increase dietary sodium exposure and contribute to elevated blood pressure, hypertension, and other chronic health conditions, including cardiovascular and renal diseases (Talukder *et al*., 2016). Cardiovascular diseases accounted for approximately one-fifth of all deaths in Bangladesh between 2000 and 2012, highlighting the broader public-health significance of hypertension and related risk factors (WHO, 2014). In the present study, commonly reported health problems included gastritis, skin diseases, arthritis, headache, hypertension, urinary irritation or painful urination, gynecological problems, hemorrhage or miscarriage, cardiovascular disease, stroke, asthma, and allergies, while similar conditions, including hypertension, diarrhea, dehydration, gynecological problems, skin disorders, respiratory symptoms, chest pain, asthma, and vector-borne diseases, have been reported in other salinity-prone coastal areas of Bangladesh (Zaman, 2017). Previous research has also reported higher rates of hypertension, pre-eclampsia, acute respiratory infections, skin diseases, and urinary irritation among coastal populations exposed to higher drinking-water salinity (Talukder *et al*., 2015). With increasing saltwater intrusion and freshwater salinization, coastal populations may face greater exposure to excessive sodium, underscoring the potential health implications of climate change and sea-level rise for low-lying communities, particularly in relation to blood pressure and cardiovascular health.

5. Conclusions

Findings from this study suggest that salinity in drinking water may contribute to elevated sodium intake and increased blood pressure among lactating women in coastal Bangladesh. The observed positive relationships between water salinity, urinary sodium excretion, and blood pressure emphasize the role of saline drinking water as a potential environmental determinant of hypertension risk. Ensuring access to safe, low-salinity drinking water and improving community awareness should therefore be prioritized as part of climate adaptation and maternal health strategies. However, the small, geographically restricted cross-sectional design and reliance on spot urine and single-period water sampling limit causal inference and seasonal assessment. Larger longitudinal studies with repeated biological measurements and seasonal salinity monitoring are needed to confirm these associations and inform sustainable safe-water interventions.

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Data availability

All data supporting the findings of this study are included within the manuscript.

Conflict of interest

None to declare.

Authors’ contribution

Abu Shoeb Md. Touhiduzzaman: conceptualization, data curation, formal analysis, investigation, methodology, visualization, writing first draft of the manuscript, review and revision of the manuscript; M. M. Mehedi Hasan: investigation, visualization, review and revision of the manuscript; Sujan Kanti Mali: supervision, review and revision of the manuscript; Liton Chandra Sen: conceptualization, methodology, project administration, resources, supervision, review and revision of the manuscript. All authors have read and approved the final manuscript.

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