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Coastal residency and its association with diagnosed hypertension based on findings from a cross-sectional study in rural Bangladesh

Ahmed Hossain[1,2]✉, Shanjida Rahman Sultana[2], Mohammad Julhas Sujan[3], Gias Uddin Ahsan[4], Mohammad Zakir Hossain[5], Mohammad Anwar Hossain[5], Heba Hijazi[1], Alounoud Salman[1] & Rajiv Chowdhury[6]

The high prevalence of hypertension in coastal regions poses a significant public health challenge due to factors such as high salt intake, air pollution, poor diets, limited healthcare access, and increased stress levels. However, disparities in diagnosed hypertension between coastal and non-coastal areas in Bangladesh remain underexplored. This study aims to investigate and address the prevalence of diagnosed hypertension among adults in both regions. In 2020–2021, a cross-sectional study was conducted in Bangladesh to assess hypertension prevalence in coastal and non-coastal regions. The study included 3917 adults from six districts, including non-coastal and coastal regions. Prevalence ratios (PRs) were determined using a modified Poisson regression model, to quantify the relationship between hypertension prevalence in the two regions. The study finds that 438 (11.2%) of the 3917 respondents [446 females [11.7%]; mean age 44.73 years] had been diagnosed with hypertension. Notably, adults residing in coastal areas had a higher prevalence of hypertension (13.4%, 95% confidence interval: 11.8%-15.0%) than their non-coastal counterparts (9.5%, 95% CI: 8.3%-10.7%). In coastal areas, the prevalence ranged from 7.8% in the 18–24 age group to 16.4% in the 55 + age group. In non-coastal areas, the prevalence ranged from 2.9% in the 18–24 age group to 15.8% in the 55 + age group. The results of the multivariable analysis revealed that adults from coastal areas were 29% more likely to have hypertension than those in non-coastal areas (aPR:1.29, 95% CI: 1.07–1.56). Moreover, age, physical activity, occupation, and body mass index (BMI) were identified as factors associated with the development of hypertension within these regions. Hypertension is a major health issue across Bangladesh, with coastal regions facing added challenges from high salinity in drinking water. While both coastal and non-coastal areas experience high rates of undiagnosed hypertension, environmental factors unique to coastal areas may intensify the issue. Targeted interventions that account for environmental and socioeconomic factors are essential to addressing this growing health concern in both regions.

Keywords Hypertension, Coastal Residency, Coastal areas, Salt intake, Bangladesh

Hypertension, a significant global health concern, exerts a widespread impact, particularly in coastal regions worldwide. This phenomenon is driven by a combination of factors, including increased salt intake, air pollution, unhealthy diets, restricted healthcare access, and elevated stress levels among coastal residents[1,2]. Associated with an estimated annual toll of 9.4 million premature deaths globally, hypertension serves as a major precursor to severe health risks such as stroke, cardiovascular diseases, and kidney failure[1–3]. Globally, hypertension is more

[1]College of Health Sciences, University of Sharjah, Sharjah, United Arab Emirates. [2]Department of Public Health, North South University, Dhaka 1229, Bangladesh. [3]Department of Research and Innovation, JBRSOFT Limited, Dhaka, Bangladesh. [4]Canadian University of Bangladesh, Dhaka, Bangladesh. [5]Rangpur Hypertension and Research Center, Rangpur, Bangladesh. [6]Global Health, Robert Stempel College of Public Health and Social Work, Florida International University, Miami, USA. ✉email: ahossain@sharjah.ac.ae

prevalent and frequently treated among individuals with multimorbidity[4]. Additionally, long-term hypertension significantly diminishes the quality of life[5].

While high-income countries witness a slight decline in hypertension prevalence, its relentless surge across low- and middle-income nations, especially in regions like South Asia and sub-Saharan Africa, casts a shadow on overachieving global health and sustainable development goals (SDG)–3[6–8]. The geographical landscape plays a pivotal role, with disparities in prevalence linked to income levels and diverse risk factors—such as elevated salt content in local diets or water sources—significantly impacting susceptibility to hypertension[9]. The World Health Organization (WHO) stresses the importance of lowering the salt content in food to a recommended level below 5-6 g per day[10]. Nevertheless, the salinity in water sources used for drinking and cooking has risen in numerous coastal regions worldwide, partly because of global climate change[8]. This heightened salinity in water for drinking and cooking purposes can amplify the likelihood of hypertension and related illnesses.

Bangladesh, a nation perched at the forefront of vulnerability to climate change, grapples with escalating saline water intrusion due to rising sea levels and intensified storms in the Bay of Bengal[11–13]. Coastal divisions like Khulna, Barishal, and Chattogram bear the brunt, hosting districts (such as Satkhira, Bagerhat, Khulna, and Barguna) highly prone to heightened water salinity, exposing inhabitants to increased hypertension risks[14–17]. Due to the infiltration of salty water triggered by environmental shifts, more than twenty million people in the Bangladesh region face a significant risk of developing high blood pressure[18]. Beyond climate change, local activities like intensive shrimp farming contribute to rising water salinity, further amplifying health hazards[19]. As a result, residents in these areas could be more vulnerable to the negative effects of heightened salinity in their drinking and cooking water.

In Bangladesh, evidence indicates a substantial variation in hypertension prevalence across regions[20]. A nationwide survey in Bangladesh (2017–2018) found that approximately 28% of the population had hypertension, including 16% undiagnosed cases and 12% diagnosed cases[21]. A study conducted in a rural district of Bangladesh found a prevalence of 6.9%, with a higher prevalence among women (8.9%) compared to men (4.5%)[22]. National surveys highlight this diversity, with rates fluctuating between urban and rural landscapes and regions like Khulna, Barisal, and Sylhet[23–25]. Studies reveal a higher prevalence in urban settings compared to rural areas, emphasizing the multifaceted influences shaping hypertension, including age, gender, education, employment status, body mass index, diabetes, socioeconomic status, and, notably, drinking water salinity[24,26–28].

However, despite existing data, a critical gap persists in understanding the diagnosed hypertension disparities between coastal and non-coastal regions within rural Bangladesh. This research endeavors to bridge this gap, aiming to meticulously scrutinize and address the prevalence of diagnosed hypertension among adults dwelling in both coastal and non-coastal domains of rural Bangladesh. Such insights could pave the way for targeted interventions, enhance healthcare strategies, and fortify resilience against the burgeoning threat of hypertension in these regions.

Methods and materials

Study design and study area

Data collection for this cross-sectional study was conducted by the Center for Natural Resource Studies (CNRS) during 2020–2021. For the purposes of this study, the survey selected a total of 3917 households from six districts of Bangladesh, including coastal (Satkhira and Khulna) and non-coastal (Sherpur, Jamalpur, Sunamganj, and Pabna). The study protocol received approval from the Bangladesh Medical Research Council, and the authorized protocol is available in the public domain: https://osf.io/ka6sj/.

Calculation of sample size

The participants from rural areas were drawn from the 14 sub-districts of the selected districts. Within sub-districts, unions are the smallest geographic tier with precise and defined areas in rural areas. A total of at least 384 households were drawn from each sub-district and it was decided that the primary sampling units (PSUs) or clusters for the rural stratum were unions (each union consists of several villages- thus forming village-based communities). The sampling frame of the clusters is given in **Supplementary Fig. S1**. The sample size of total 7000 are collected for the study and the details are given in the Supplement. The sampling frame comprised a list of rural villages as developed by the Bangladesh Bureau of Statistics, based on the 2011 census of population and housing enumeration areas. The sample size calculation for project intervention areas is given in **Supplementary Table S1**. Figure 1 illustrates the study area in rural Bangladesh, along with a flow diagram outlining the participant selection process.

Outcome

We considered self-reported known hypertension among individuals in the study. A diagnosis of hypertension was made by a healthcare professional when systolic blood pressure measurements, taken on two separate occasions, are ≥ 140 mmHg and/or diastolic blood pressure measurements are ≥ 90 mmHg on both occasions. Here in this study, hypertension was considered to be present in individuals if they met one of the following criteria:

(1) Individuals who had a documented history of taking antihypertensive medication to control high blood pressure, or (2) Individuals who had received medical advice or recommendations for controlling high blood pressure, even if they were not currently taking antihypertensive medication.

This definition suggests that individuals who either had a history of taking medication for hypertension or had received medical advice for controlling high blood pressure were classified as having hypertension for the purposes of the study. This criterion allows for a broader inclusion of individuals who may be managing their hypertension through different means, including lifestyle modifications in addition to medication.

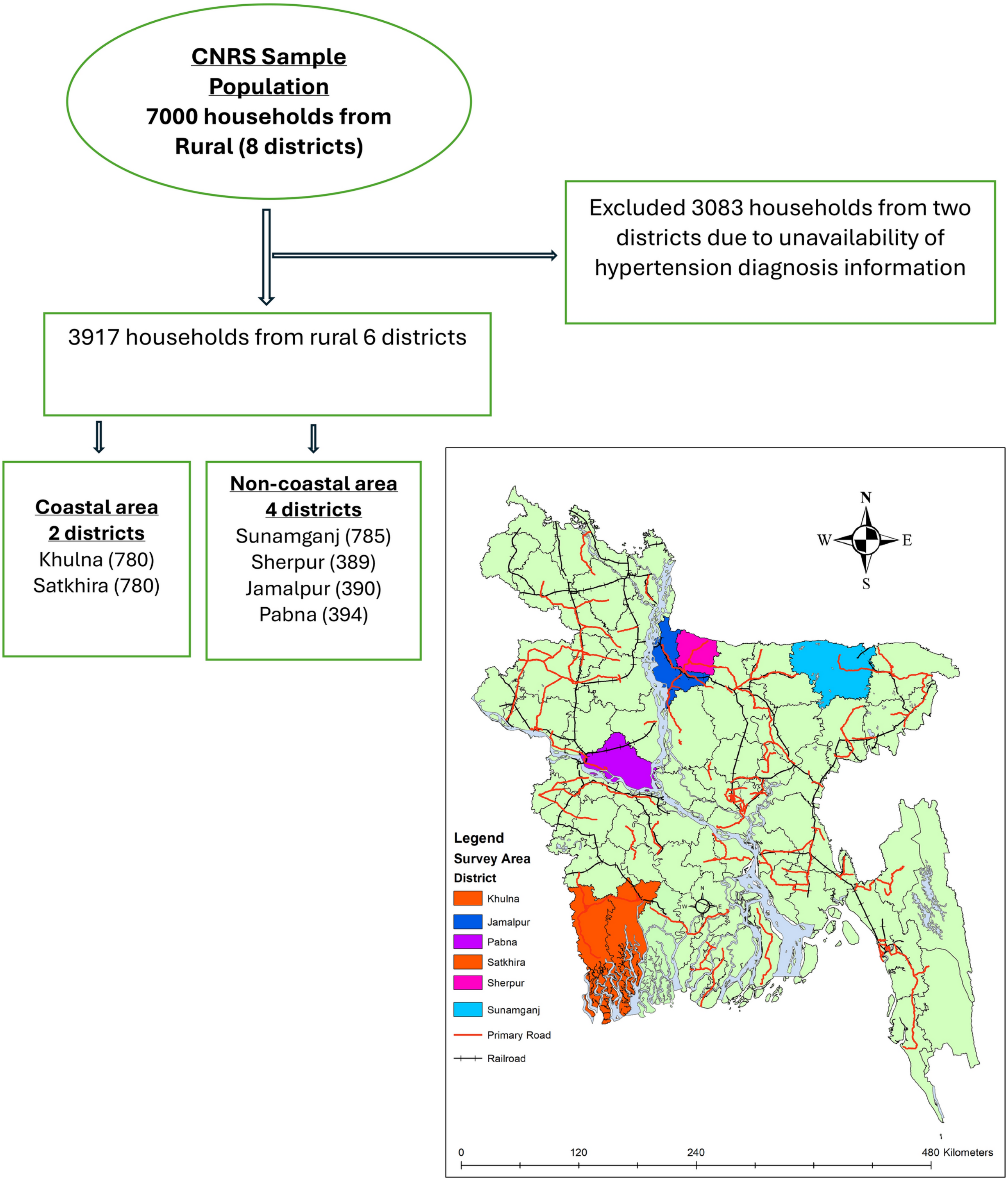

Fig. 1. The survey sites and the study design for the analysis.

Exposure

Coastal residency in Bangladesh encompasses 19 districts that are directly or indirectly impacted by the Bay of Bengal. These regions are particularly vulnerable to natural hazards such as tidal surges, cyclones, saline water intrusion, and flooding. Key coastal districts include Chittagong, Cox's Bazar, Khulna, Barisal, and Bhola. Characterized by their proximity to the sea and unique ecosystems like the Sundarbans, coastal areas are simultaneously blessed with abundant natural resources and challenged by climate-related risks.

Non-coastal Bangladesh, situated further inland, is less susceptible to the immediate threats posed by the Bay of Bengal, such as saline intrusion and tidal surges. Nevertheless, these regions may still experience flooding from riverine systems, especially during the monsoon season. Major non-coastal districts include Dhaka, Rajshahi, Sylhet, and Mymensingh.

Covariates

The analysis includes several explanatory variables such as the respondent's age (years), gender (male/female), schooling years (no/1–5 years/6–10 years/11–12 years/ ≥ 12 years), marital status (Married/ Divorced/ Widowed/ Unmarried), and occupation (Service/ Day labor/ Housewife/ Small Business/ Student/ Unemployed/ Retired). Body Mass Index (BMI), calculated from height and weight records, was categorized as normal (18.5–24.9 kg/m^2), underweight (< 18.5 kg/m^2), overweight (25–29.9 kg/m^2), and obese (> = 30 kg/m^2) (23). The World Health Organization's Global Physical Activity Questionnaire (GPAQ) was used to assess physical activity levels[29], measuring in three domains: work, transport, and leisure-time activities. It classifies physical activity by intensity using Metabolic Equivalent of Task (MET) values. Light (1–2.9 METs): Slightly increased breathing or heart rate (e.g., slow walking, light chores), Moderate (3–5.9 METs): Moderate increase in breathing or heart rate (e.g., brisk walking, leisurely cycling) and Vigorous (≥ 6 METs): Significant increase in breathing or heart rate (e.g., running, swimming). The location of residence is divided into coastal (Satkhira and Khulna) and non-coastal (Sherpur, Jamalpur, Sunamganj, and Pabna) regions. These variables are used to assess and explain various aspects of the study in relation to diagnosed hypertension.

Statistical analysis

The statistical analyses were conducted using R version 4.3.0. First, we conducted a bivariate analysis to assess the relationships between the outcome and the predictors by calculating the unadjusted prevalence ratio (PR) for each categorical predictor. The unadjusted PR is computed to assess the difference in hypertension prevalence between demographic groups. We used the robust standard errors to address potential overdispersion in the modified Poisson model and the sandwich package in R to compute robust standard errors. To preserve the statistical validity of our findings in adjusted analysis, cases with missing data were systematically excluded from the analytical process. The results of the multivariable regression analysis were presented as adjusted prevalence ratio (APR), and 95% confidence intervals (*CI*). To enhance our primary analysis, we conducted a sensitivity analysis using a machine learning approach, specifically the Random Forest (RF) method. RF offers key advantages, including the ability to model complex, nonlinear relationships and to identify important predictors even when variables are highly correlated. We implemented the RF model using the randomForest() function from the randomForest package in R. To assess the model's accuracy, we used a 70/30 data split: 70% of the data for training and 30% for testing. This method enabled us to validate the model's performance on unseen data, providing a more rigorous evaluation of its predictive capabilities.

Results

The unadjusted analysis in Table 1 reveals the relationship between socio-demographic characteristics and diagnosed hypertension in the study participants. Among the 3,917 adult participants, 438 (11.2%, 95% confidence interval, CI = 10.2%–12.1%) had been diagnosed with hypertension. The study had 2227 (56.8%) respondents from non-coastal regions, and the remaining 1690 (43.2%) were from coastal regions. Coastal adults had a higher prevalence of hypertension (13.4%, 95% CI = 11.8%–15.0%) compared to non-coastal adults (9.5%, 95% CI = 8.3%–10.7%). The unadjusted prevalence ratio indicated that coastal adults were 1.42 times more likely to have been diagnosed with hypertension than non-coastal adults (PR = 1.42, 95% CI = 1.19–1.69).

The study had 446 (11.4%) female respondents and 3471(88.6%) male respondents. Male respondents reported a 21% lower prevalence of diagnosed hypertension compared to female participants (PR = 0.79, 95% CI = 0.61–1.02), but this difference was not statistically significant in the unadjusted association analysis. Marital status did not show a significant association with hypertension prevalence.

The average age of the respondents was 44.73 years (standard deviation 13.53 years). The prevalence of diagnosed hypertension increased with age, ranging from 4.8% in the 18–24 age group to 16.1% in the 55 + age group. Approximately one-fifth of overweight or obese respondents (20.6%) were diagnosed with hypertension. Unemployed or retired participants had a higher prevalence of hypertension compared to those who were working.

The Table 2 compares various health-related characteristics between coastal residents and non-coastal residents. Coastal residents have a lower percentage of underweight individuals (17.4% vs 25.4%) and have a higher percentage of overweight (14.2% vs 8.5%) and obese (2.5% vs 1.5%) individuals. This suggests that coastal residents may have different lifestyle factors contributing to higher body mass. Coastal residents have a slightly higher rate of comorbid conditions with hypertension (11.1% vs 7.8%). Coastal residents have a lower smoking rate (34.3% vs 53.8%) but have a higher rate of chewing tobacco habit (33.8% vs 22.5%). This shift in substance use might reflect cultural preferences or availability of different tobacco forms in coastal areas. Coastal residents engage in more vigorous physical activity than non-coastal residents (19.1% vs 10.5%), possibly due to occupational demands (e.g., fishing, physical labor) or lifestyle choices influenced by their environment. Overall, the data suggests that coastal residents tend to have higher BMIs, slightly more hypertension-related comorbidities, and engage in more vigorous physical activity. They are less likely to smoke but more likely to chew tobacco compared to non-coastal residents.

The study's findings, as shown in Fig. 2, indicate a consistent pattern of higher diagnosed hypertension prevalence among respondents in coastal areas compared to those in non-coastal areas across different age groups. For instance, within the age group of 45–54 years, the prevalence of diagnosed hypertension was notably higher in coastal regions, at 16.2%, compared to 10.1% in non-coastal regions. In general, younger adults from coastal

Confirmed hypertension				
Variables	**Total n (%)**	**Yes n (%)**	**No n (%)**	**Unadjusted PR* (95%CI)**
Coastal residency (n=3917)				
No	2227(56.8%)	211(9.5%)	2016(90.5%)	1
Yes	1690(43.2%)	227(13.4%)	1463(86.6%)	**1.42(1.19–1.69)**
Age (n=3917)				
18–24 years	166(4.2%)	8(4.8%)	158(95.2%)	1
25–34 years	751(19.2%)	41(5.5%)	710(94.5%)	1.13(0.54–2.37)
35–44 years	953(24.3%)	88(9.2%)	865(90.8%)	1.92(0.94–3.88)
45–54 years	888(22.7%)	115(12.9%)	773(87.1%)	**2.69(1.33–5.39)**
≥55 years	1159(29.6%)	186(16.1%)	973(83.9%)	**3.33(1.67–6.63)**
Sex				
Female	446(11.4%)	61 (13.7%)	385(86.3%)	1
Male	3471(88.6%)	377 (10.9%)	3094(89.1%)	0.79(0.62–1.02)
Education (n=3917)				
No-schooling	1712(43.7%)	164(9.6%)	1548(90.4%)	1
1–5 years	1276(32.6%)	132(10.3%)	1144(89.7%)	1.07(0.87–1.34)
6–10 years	684(17.5%)	97(18.2%)	587(81.8%)	**1.89(1.30–2.77)**
11–12 years	143(3.7%)	26(18.6%)	117(81.4%)	**1.94(1.26–2.99)**
≥12 years	102(2.6%)	19(14.2%)	83(85.8%)	**1.48(1.17–1.48)**
Marital status (n=3917)				
Married	3664(93.5%)	410(11.2%)	3254(88.8%)	1
Divorced/ widowed	165(4.2%)	20(12.1%)	145(87.9%)	1.08(0.71–1.65)
Unmarried	88(2.3%)	8(9.1%)	80(90.9%)	0.81(0.42–1.58)
Occupation (n=3631)**				
Day labor	2233 (61.7%)	201(9.0%)	2032(91.0%)	1
Services	171 (4.7%)	21(12.3%)	150(87.7%)	1.36(0.89- 2.08)
Housewife	344(9.5%)	50(14. 5%)	294(85.5%)	**1.61(1.21- 2.15)**
Small business	674(18.6%)	96(14.2%)	578(85.8%)	**1.58(1.26- 1.98)**
Student/unemployed	73(2.0%)	7(9.6%)	66(90.4%)	1.06(0.52- 2.18)
Retired	127(3.5%)	29(22.8%)	98(77.2%)	**2.54(1.80- 3.58)**
Body mass index (BMI) (n=3725)**				
Healthy-weight	2429(65.2%)	263(10.8%)	2166(89.2%)	1
Overweight/ obese	481(12.9%)	99(20.6%)	382(79.4%)	**1.90(1.54–2.34)**
Underweight	815(21.9%)	59(7.2%)	756(92.8%)	0.67(0.51–0.88)

Table 1. Characteristics of respondents by sociodemographic factors (n=3917). *Bold faces indicate significant at 5% significance level. **Variables with missing data.

areas exhibited a higher likelihood of hypertension compared to those in non-coastal regions. A significant difference in the prevalence of diagnosed hypertension was observed between coastal and non-coastal residents in the 35–54 age group. However, as the age category increases to 55 years and above, the difference in diagnosed HTN prevalence between coastal and non-coastal adults becomes less pronounced.

To account for potential factors influencing the associations between our exposures and diagnosed hypertension, we employed a modified Poisson regression model to estimate adjusted prevalence ratios (aPRs). We previously utilized a directed acyclic graph (DAG) – a visual representation of hypothesized causal relationships – to identify confounders in these relationships. In this DAG (see **Supplementary Fig. S2**, constructed with DAGitty: http://www.dagitty.net/dags.html#), diagnosed hypertension was considered the outcome, while coastal residency was the main exposure. For the association between exposures and diagnosed hypertension, a minimal sufficient adjustment set including age, sex, BMI, physical activity and coastal residency was determined. The mosaik plot, given in **Supplementary Fig. S3**, is also investigated to understand the relationship with coastal residency and confounders.

The adjusted analysis, using a Poisson regression model with robust standard errors, revealed several significant associations between hypertension and various variables. The adjusted prevalence ratios from the multivariable analysis are given in Fig. 3.

The PR for coastal residents (compared to non-coastal residents) is 1.29, indicating that coastal residents have a 29% higher prevalence of the outcome. This association was statistically significant, with a 95% confidence interval of 1.07–1.56. Male adults were 12% less likely to be diagnosed with hypertension compared to female participants (aPR = 0.88, 95% CI = 0.51–1.51). Overweight or obese individuals were 1.69 times more likely to have been diagnosed with hypertension than those with a normal weight (aPR = 1.69, 95% CI = 1.35–2.11). The

Coastal residency		
Variables	Yes (n = 1690) n (%)	No (n=2227) n (%)
Age (mean ± sd)	46.18±13.7 years	45.21±14.59 years
BMI group (n=3725)		
Underweight	282(17.4%)	533(25.4%)
Normal weight	1072 (66.0%)	1357 (64.6%)
Overweight	231 (14.2%)	178 (8.5%)
Obese	40 (2.5%)	32 (1.5%)
Co morbid conditions with confirmed hypertension (n = 3917)		
No	1502 (88.9%)	2054 (92.2%)
Yes	188 (11.1%)	173 (7.8%)
Smoking behavior (n=3917)		
No	1110 (65.7%)	1028 (46.2%)
Yes	580 (34.3%)	1199 (53.8%)
Chewing tobacco (n=3917)		
No	1118 (66.2%)	1725 (77.5%)
Yes	572 (33.8%)	502 (22.5%)
Physical activity (n=3917)		
Light	361 (21.4%)	556 (25.0%)
Moderate	1006 (59.5%)	1437 (64.5%)
Vigorous	323 (19.1%)	234 (10.5%)

Table 2. Clinical and behavioral factors of respondents by coastal residency.

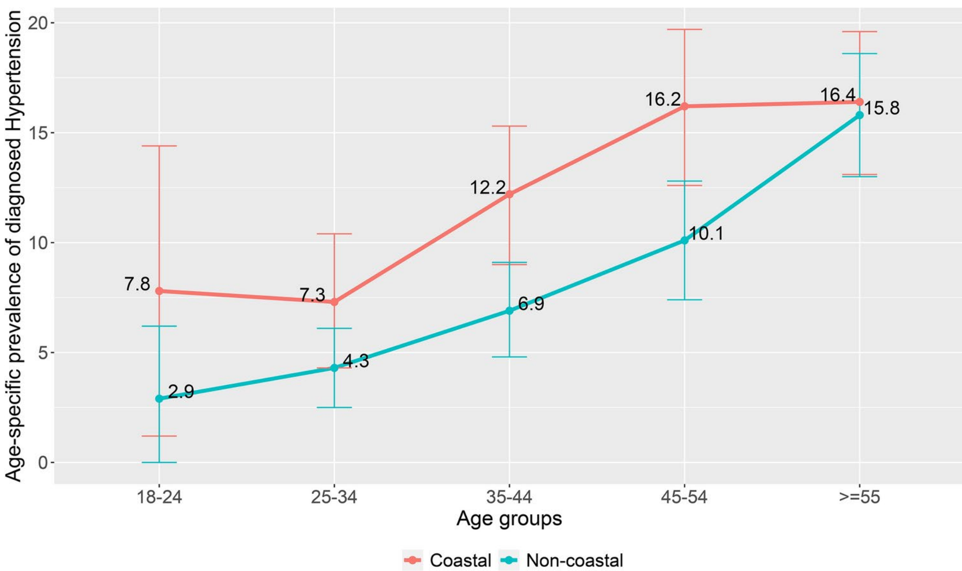

Fig. 2. Prevalence of diagnosed hypertension according to age groups and residence.

PR for the retirement group in occupation category (compared to day labor) is 1.73, indicating that individuals in this category have a 73% higher prevalence of the outcome compared to day labor (aPR = 1.73, 95% CI = 1.19–2.52). Adults in the 35–44 age group were 1.91 times more likely to have hypertension compared to those in the 18–24 age group (aPR = 1.91, 95% CI = 0.86–4.21). Additionally, individuals aged 55 years and above were 3.52 times more likely to be diagnosed with hypertension than those in the 18–24 age group. These age-related associations were statistically significant, with 95% confidence intervals of 1.62–7.66. This indicates that older individuals have a significantly higher prevalence of the outcome compared to younger individuals.

We used a random forest model to identify the top five important variables on defining diagnosed hypertension among the adult Bangladeshis in a sensitivity analysis. The values of mean decrease accuracy estimate the prediction measure of significance. If a particular variable is removed from the model, the higher it is for a predictor, the more the precision will decrease. The overall precision of the test data is 88.2 percent

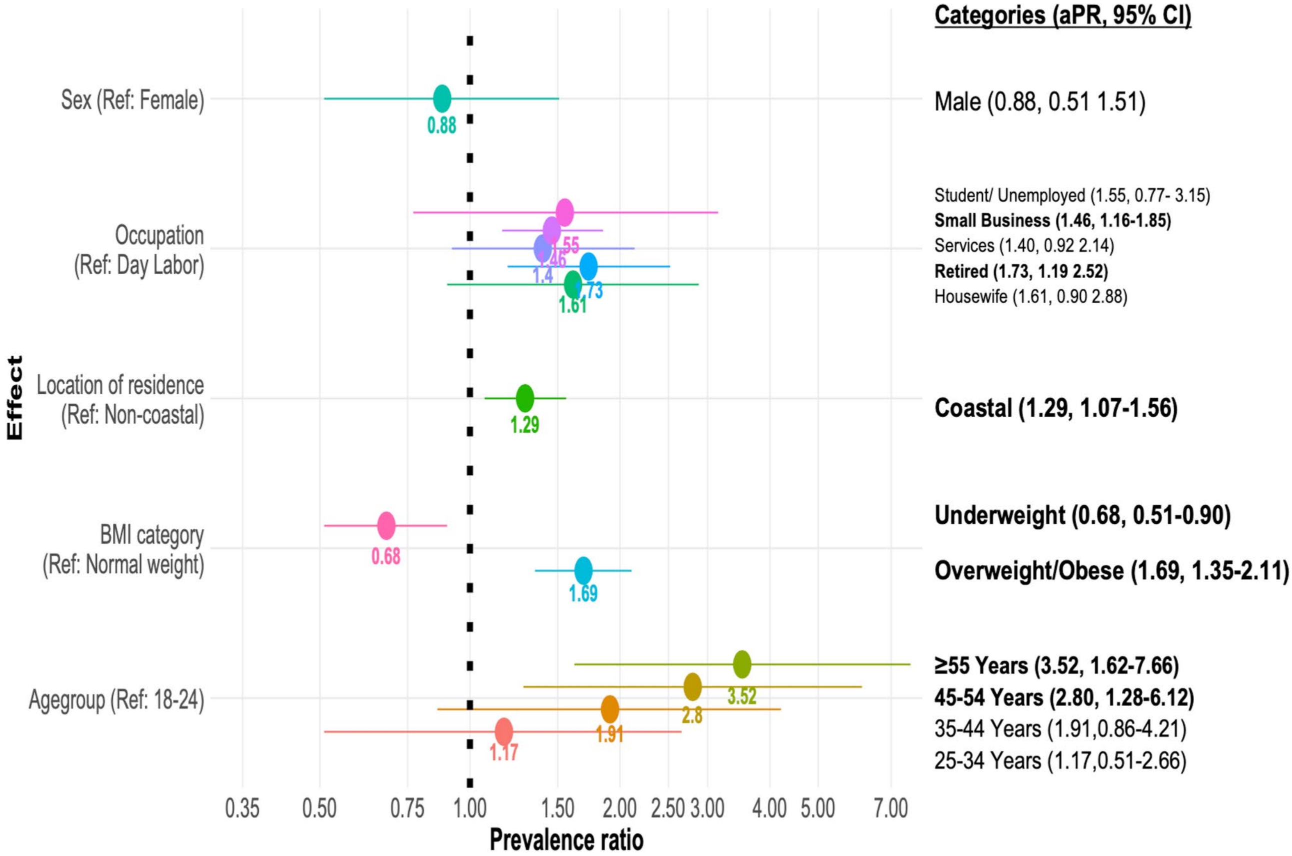

Fig. 3. Adjusted prevalence ratios from multivariable analysis.

(see **Supplementary Fig. S4**). The supplementary figure shows that, according to the measure of importance, the top 5 potential predictors are: age, sex, employment status, coastal residency, and physical activity. We also have conducted a sensitivity analysis by incorporating additional variables into the Poisson regression model to explore potential counterintuitive findings and identify aspects that may warrant further investigation. The results are given in **Supplementary Table S2**. Coastal residency was consistently found to be significant across all models, even after adjusting for confounders, highlighting its robust association with the outcome.

Discussion

The study's investigation of hypertension prevalence in adults residing in coastal and non-coastal regions provides insightful observations regarding geographic disparities. The descriptive analysis revealed a significantly elevated prevalence of diagnosed hypertension among adults in coastal areas compared to their non-coastal counterparts. This pattern persisted across diverse age groups, indicating a consistent trend of higher hypertension prevalence in coastal regions, albeit with a diminishing gap in older age brackets. These findings align with previous studies in Bangladesh, reporting hypertension prevalence ranging from 6.2% to 26.2% across different regions and demographics[30,31]. A comprehensive nationwide survey in Bangladesh conducted in 2017–2018 revealed that approximately 28% of the population had hypertension, with 16% of cases being undiagnosed and 12% diagnosed[21]. Another study with one rural district in Bangladesh, the prevalence was 6.9%, with higher rates among women (8.9%) compared to men (4.5%)[22]. Similar trends in hypertension prevalence have been observed internationally, including in regions such as China, and India[32,33]. The low prevalence of diagnosed hypertension also indicate that undiagnosed hypertension is a significant issue in Bangladesh, affecting both coastal and non-coastal rural regions. The high rates of undiagnosed cases suggest a need for improved screening and awareness programs, especially in rural and lower socioeconomic areas.

The adjusted analysis, utilizing modified Poisson regression, reaffirmed key associations in hypertension prevalence and living in coastal regions. Coastal residency emerged as a significant predictor, indicating that adults in coastal areas were more likely to have hypertension compared to their non-coastal counterparts. Gender differences were notable, with males having a lower likelihood of hypertension diagnosis than females but the difference is not independently significant. Hypertension is generally more common in males, especially in younger age groups. However, females experience a sharper increase in blood pressure from the third decade of life, leading to a higher prevalence in older age groups and it is also found in another study[34].

Factors such as BMI and age also exerted substantial influences, with overweight or obese individuals and older adults exhibiting a higher likelihood of hypertension. These findings resonate with existing research that identifies water salinity, gender, age, and lifestyle habits as substantial contributors to hypertension rates[35–37].

While both BMI and physical activity independently affect hypertension risk, they may also interact. Physical activity can help mitigate some of the hypertension risk associated with higher BMI[38]. Individuals with more schooling tend to have less active lifestyles and higher BMIs, both of which contribute to elevated blood pressure. Coastal living may further amplify these risks.

A Study has linked saline water consumption to elevated blood pressure, underscoring the potential impact of environmental factors on public health[24]. Coastal populations have a higher risk of hypertension due to the tradition of salting and drying fish, which increases salt intake in these populations. The high amount of salt used for salting fish can have an undesirable effect on blood pressure.

Our study reveals that younger adults residing in coastal regions exhibit a higher susceptibility to hypertension compared to their non-coastal counterparts. This aligns with findings from a study conducted in coastal villages of Udupi district in southern India, which observed a substantial proportion of pre-hypertensives and identified a moderate to high risk of pre-hypertensives progressing to hypertension among younger adults[39]. Certain coastal occupations, particularly those involving strenuous physical labor, can have complex effects on hypertension risk. Fish farming is considered a physically demanding occupation, with high workloads and awkward work positions for prolonged periods. Fishery workers were found to have a higher incidence of cardiometabolic diseases, which may include hypertension[40]. Younger individuals in our study may be more biologically susceptible to the effects of a high-salt diet, resulting in a more immediate impact on their health. Additionally, they may engage in other lifestyle behaviors, such as physical inactivity or poor dietary habits, that further intensify the effects of high salt intake. In contrast, older individuals might have developed a degree of adaptation or resilience over time due to prolonged exposure, making them less affected by acute changes in salt consumption.

Studies conducted in different time frames and regions consistently highlight the multifaceted nature of hypertension prevalence, underscoring the intricate interplay between geographical, environmental, cultural, and individual factors in shaping public health outcomes[38–43]. In our study, we found hypertension is influenced by lifestyle factors like smoking, tobacco use, and physical inactivity. Managing these behaviors through lifestyle modifications can be essential for both preventing and controlling high blood pressure. A study conducted among a Bangladeshi population explored the use of telemedicine as a strategy to alleviate the burden of hypertension[44]. These findings not only enhance our understanding of regional variations in hypertension but also highlight the significance of implementing tailored interventions that account for the diverse factors influencing health within specific geographic settings.

The strength of this study indicates a notably higher prevalence of diagnosed hypertension among adults in coastal areas, a pattern consistent across age groups. This disparity may be attributed to environmental factors, particularly the increased salt consumption common in coastal regions. Lifestyle elements such as physical inactivity and unhealthy habits like chewing tobacco further compound the risk of hypertension in these areas. The study also highlights the alarming issue of undiagnosed hypertension, especially in rural and low-income communities. This finding emphasizes the critical need for enhanced screening and awareness initiatives to effectively identify and manage hypertension. By comprehending the intricate relationship between geographical, environmental, and lifestyle factors, we can craft targeted interventions tailored to the specific needs of both coastal and non-coastal populations. Future studies should investigate the long-term effects of climate change on hypertension prevalence and evaluate the efficacy of various interventions in reducing the risks associated with this chronic condition.

Limitations of the study

It is crucial to recognize and address the limitations inherent in this study. Firstly, the participants were exclusively drawn from two coastal areas, which inherently restricts the generalizability of the findings to encompass all coastal regions. Consequently, caution should be exercised when extrapolating these results into a broader context. Moreover, the study refrains from endorsing the testing of causal relationships. The nature of the research design precludes the establishment of direct cause-and-effect associations, emphasizing the need for prudence in interpreting the observed correlations. The data on lifestyle factors and medical history were self-reported, which may be subject to bias. Additionally, dietary factors should be considered to better understand the complex factors contributing to developing hypertension in coastal and non-coastal regions.

Conclusion

The research indicates an increased risk of hypertension in coastal populations compared to non-coastal areas. The low prevalence of diagnosed hypertension suggests undiagnosed hypertension is a significant issue in both coastal and non-coastal rural areas of Bangladesh, highlighting the need for better screening and awareness programs, especially in rural, low-income regions. The study has highlighted the multifaceted nature of hypertension's determinants, revealing that geographical location, gender, BMI, and age all have significant impacts on the high prevalence of diagnosed hypertension among adults. Addressing these factors, particularly among younger adults in coastal regions, requires targeted interventions, including the promotion of healthy lifestyles, enhanced healthcare access, and heightened awareness of hypertension risks. These findings stress the importance of continued research into the complex interplay of these factors in hypertension to refine our understanding and improve healthcare approaches.

Data availability

The protocol, data, and questionnaire are accessible in the public domain at https://osf.io/ka6sj/.

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Author contributions

AH, GUA and SRS formulated and planned the experiments. AH devised the analytical approach and conducted the data analysis. AH, SRS, MJS, and MZH drafted the manuscript. AH, SRS, MJS, GUA, MZH, MAH, HH, RC and AS participated in editing, reviewing, and contributing to the acquisition and interpretation of data for the work. AH is accountable for the overall content as the guarantor. All authors contributed to the critical revision and endorsed the final version of the manuscript for submission.

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Declarations

Competing interests

The authors declare no competing interests.

Ethics approval and consent to participate

The study received ethical clearance from the National Research Ethics Committee, adhering to the ethical guidelines of the Bangladesh Medical Research Council (BMRC) with the reference number 25003092020. The respondents and/or their legal representatives provided written informed consent, acknowledging the study's objectives, procedures, associated risks and benefits, voluntary participation rights, the option to withdraw, and the assurance of data anonymity and confidentiality.

Additional information

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Correspondence and requests for materials should be addressed to A.H.