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Salt intake across the hypertension care cascade in the Bangladeshi adult population: a nationally representative cross-sectional study

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ABSTRACT

Objectives This study aimed to examine the distribution of daily salt intake across the hypertension care cascade and assess the proportional distribution of these care cascade categories across various salt consumption level.

Design A population-based national cross-sectional study.

Settings Data from the Bangladesh STEPS 2018 survey were used, encompassing both urban and rural strata within all eight divisions. National estimates were generated from weighted data.

Participants A diverse population of 6754 men and women aged 18–69 years was included in the study.

Outcome measures Daily salt consumption was estimated using the spot urine sodium concentration following Tanaka equation. Distribution of salt intake among different categories of hypertension care cascade, including hypertensives, aware of hypertension status, on treatment and under control, was assessed.

Results Individuals with hypertension consume more salt on average (9.18 g/day, 95% CI 9.02 to 9.33) than those without hypertension (8.95 g/day, 95% CI 8.84 to 9.05) (p<0.02). No significant differences were found in salt intake when comparing aware versus unaware, treated versus untreated and controlled versus uncontrolled hypertension. In the overall population, 2.7% (95% CI 2.1% to 3.6%) of individuals without hypertension adhered to the recommended salt intake (<5 g/day) while 1.6% (95% CI 1.0% to 2.4%) with hypertension did so (p<0.03). Among individuals with hypertension, 2.4% (95% CI 1.4% to 4.0%) of those aware followed the guideline while only 0.8% (95% CI 0.4% to 1.9%) of those unaware adhered (p<0.03). Additionally, no significant differences were observed in adherence between the treated versus untreated and controlled versus uncontrolled hypertension.

Conclusions Individuals with hypertension consume significantly more salt than those without, with no significant variations in salt intake based on aware, treated and controlled hypertension. Adhering to WHO salt intake guidelines aids better blood pressure management. By addressing salt consumption across hypertension care cascade, substantial progress can be made in better blood pressure control.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ Reported the distribution of salt consumption across the hypertension care cascade.
- ⇒ Used a large-scale nationally representative sample, providing robust findings.
- ⇒ The lack of drug treatment stability data in the secondary dataset limited the analysis of diuretic impact on natriuresis and sodium estimation.
- ⇒ The cross-sectional study design limited the ability to establish causal relationships between salt intake and hypertension.
- ⇒ Laboratory measurements for blood and urinalysis were unavailable for all participants.

INTRODUCTION

The estimated global prevalence of high blood pressure has doubled since 1990, reaching a staggering 1.3 billion individuals worldwide and is regarded as the top risk factor for cardiovascular disease, stroke and other non-communicable diseases (NCDs).[1] Hypertension poses a significant burden in Bangladesh, affecting approximately 21% of adults aged 18 and above.[2] Furthermore, there has been a remarkable increase in hypertension prevalence among individuals aged 35 and above within a span of just 6 years (2011–2017), rising from 26% to 39%.[3 4] One of the important modifiable risk factors for hypertension is salt consumption, and it has been estimated that reducing dietary sodium intake might possibly prevent roughly 9 million lives globally each year.[5] Two key targets of the WHO global action plan for NCD reduction are to reduce the burden of hypertension in the population and achieve a minimum 30% relative reduction in the mean population intake of salt or sodium by 2025, compared with the levels observed in 2010.[6]

Literatures suggest that the estimated daily average salt intake in Bangladesh is approximately 10 g which is double the

WHO-recommended limit of 5 g per day to avoid hypertension.[7–9] Recognising the detrimental effects of high salt intake, Bangladesh has already incorporated salt reduction strategies into its multisectoral action plan.[10] These initiatives aim to raise awareness about the adverse health consequences of excessive salt consumption and promote behavioural changes to reduce daily salt intake.[10] However, the effectiveness of interventions for Individuals with hypertension relies on their adherence to recommended salt reduction practices. The hypertension cascade of care serves as a framework to identify gaps in the continuum of care for hypertension, encompassing screening, diagnosis or awareness, treatment and achieving control.[2–4 11] Information regarding the distribution of salt intake among different hypertension care cascade groups is limited. Analysing salt intake patterns across this care cascade can provide insights into the diverse range of salt consumption habits, thereby facilitating the development of an effective strategy for controlling hypertension in the population. Thus, this study aimed to explore the variation of average salt intake across hypertension cascade of care and assess the proportional distribution of these care cascade categories across various salt consumption levels using the nationally representative WHO STEPS 2018 survey data.

METHODOLOGY

Study design, setting and sampling

We analysed dataset of Bangladesh STEPS 2018 survey conducted from February to May 2018.[12] This was a nationally representative, cross-sectional study that aimed to provide updated information on NCD-related indicators. The survey used a two-stage stratified cluster sampling technique, selecting 496 primary sampling units (PSUs) from urban and rural areas across all 8 administrative divisions of Bangladesh. One PSU was excluded due to inaccessibility, leading to a total of 495 PSUs selected for the final survey. From each PSU, a fixed number of households (n=20) were selected through systematic random sampling, and one eligible adult aged between 18 and 69 years was randomly chosen for the survey. To prevent bias, no substitutions or modifications to the initially selected households were permitted during the implementation stage. Physical measurements, such as height, weight, waist and hip circumference, and blood pressure, were taken for 7208 respondents. Both blood and urine samples were provided by 6901 respondents.[2] However, in this study, 6754 participants were included who had completed records of all observations (online supplemental figure 1).

Patient and public involvement

Patients and/or the public were not involved in the design, conduct, reporting or dissemination plans of this research.

Data collection

A standardised questionnaire, based on the WHO STEPS questionnaire (V.3.2), was used for data collection. The data collection process comprised three steps. The first step (STEP-1) involved face-to-face interviews with participants to gather information on background characteristics and behavioural risk factors such as diet, salt intake, physical activity, tobacco and alcohol use. Despite using carefully designed interview techniques, some degree of recall bias might be inherent in self-reported data. In the second step (STEP-2), physical measurements and blood pressure were taken. Finally, in the third and most critical step (STEP-3), blood and urine samples were collected from participants using aseptic precautions to ensure the highest level of accuracy and reliability of laboratory data. They were instructed to fast overnight for 12 hours and diabetic participants were required to bring their medication with them and take it after providing a blood sample. Detailed methodological procedure was described in the report of STEPS Bangladesh 2018.[2 9]

Blood pressure measurements

Blood pressure measurements were conducted using the digital automated monitor ‘BP–BOSO–Medicus Control with universal cuff’, validated according to the German Hypertension League (Deutsche Hochdruckliga) Quality Seal Protocol.[2 13] After taking rest for about 15 min with uncrossed legs, participants were measured systolic and diastolic blood pressure three times with a 3 min interval between each reading. The average of the second and third readings was calculated.[2]

Spot urine samples

In this study, urine samples were collected from all participants aged 18–69 who gave their consent for the STEP 3-biochemical measures component of the survey. Exclusion criteria included pregnancy, fasting prior to urine sample collection and contaminated urine samples with blood. Participants were instructed to self-collect their urine sample on the night of the survey interview at home. They were provided with urine containers and instructed to fill half of the container, record the time of collection, and store the sample in a cool, dark place without direct sunlight before bringing it to the collection centre the next morning during their scheduled appointment for blood sample collection.[2]

Biochemical analysis

Urine sodium and creatinine were analysed at the laboratory of NIPSOM using the reagent Easylyte plus 400 mL solution pack with the analyser Easylyte plus Na/K/Cl analyser manufactured by Medica Corporation, USA. The sodium data obtained were reported in units of mmol/L, while the creatinine data were reported in mg/dL.[2]

STUDY VARIABLES

Hypertension care cascade

According to the STEPS 2018 Bangladesh survey report by WHO, hypertension was defined as having systolic blood pressure ≥140 mm Hg and/or diastolic blood pressure ≥90 mm Hg during the study, or normotensive at the time of survey but currently taking medications to control blood pressure. The concept of aware or diagnosed regarding hypertension was operationally defined as the manifestation of self-reported acknowledgement of having prior diagnosis of hypertension by a healthcare professional within the subset of individuals identified as having hypertension. On treatment of hypertension was defined as the self-reported use of medication for managing hypertension within the last 14 days. Hypertension under control was defined as the pharmacologically treated hypertension and accompanied by systolic and diastolic BP within the normal range (<140 mm Hg and <90 mm Hg).[2 11 14–16]

WHO recommended level of salt intake

WHO recommended <5 g/day salt to reduce blood pressure and risk of cardiovascular disease, stroke and coronary heart disease in adults.[8] Consumption of ≥5 g salt/day counted as high salt consumers in this paper.

Daily salt intake estimation

The widely accepted Tanaka equation was used to estimate daily salt intake in the population as follows–

Tanaka equation

$$21.98 \times \left(\frac{Naspot(\frac{mmo}{L})}{(Crspot\ (\frac{mg}{dL})\times 10)} \times PrUCr24h\ (mg/\ day) \right)^{0.392}$$

$$\mathrm{PrUCr24}h = 14.89 \times \mathrm{Weight(kg)} + 16.14 \times \mathrm{Height(cm)} 2.04 \times \mathrm{Age(year)} 2244.45$$

The estimated sodium excretion (mmol/day) from spot urine samples was calculated using the provided equation, which incorporates predicted 24-hour urinary creatinine (*PrUCr24h*), spot urinary sodium (*Naspot*) and spot urinary creatinine (*Crspot*). To further estimate salt intake using specific equations, additional information such as respondent weight, height, age and sex was required. The equations use this information to calculate 24-hour sodium intake, which was subsequently converted to salt intake by dividing it by 17.1.[2 7]

Statistical analysis

The WHO STEPS 2018 dataset was analysed as a survey dataset using STATA V.17 (STATA) and sample weight was used during the analyses. We initially performed descriptive statistics, calculating the means and 95% CIs for the daily average salt intake in line with the hypertension care cascade framework. We employed the adjusted Wald test to compare mean differences between groups. Proportional distribution of hypertension care cascade across various salt consumption levels was estimated and their association was tested by Pearson's χ^2 test. Additionally, stepwise design adjusted logistic regression was performed to investigate the association between salt intake and hypertension after adjusting for potential confounding factors, such as age, sex, sociodemographic variables (such as urban/rural residence, education level, occupation), lifestyle factors (smoking and tobacco chewing), and metabolic risk factors (body mass index (BMI) and diabetes status) (online supplemental table 1). At first, the outcome variables were dichotomised into two categories, and then independent variables were included in the model according to suggestions from the literatures,[3 4 9 11 17] as deemed appropriate. Results were presented graphically using ORs with 95% CIs to exhibit the association. All statistical tests were two tailed, and a p<0.05 was considered statistically significant for the main effect and <0.001 for the interaction effect. The presence of multicollinearity was checked by the variance inflation factor with a cut-off of five was considered to be an indication of multicollinearity.

RESULTS

In figure 1, the hypertension care cascade reveals important insights into the prevalence to control of hypertension within Bangladeshi population. Statistical analysis indicates that the estimated prevalence of hypertension among this population stands at 22%. Among individuals with hypertension, we observed that approximately 46.3% were aware of their hypertensive status. However, the subsequent stages of hypertension management exhibit concerning disparities. Only 27.3% of those hypertensives were receiving treatment, highlighting a substantial gap in access to healthcare services. Furthermore, the data showed that merely 10.9% of individuals with hypertension successfully maintained their blood pressure within recommended levels (figure 1).

The findings from table 1 indicate that the overall mean salt intake in Bangladesh was 9.18 g per day (95% CI 9.02 to 9.33) among individuals with hypertension, which was significantly higher (p<0.02) compared with those without hypertension who consumed an average of 8.95 g per day (95% CI 8.84 to 9.05). In the male category, the difference was also significant (p<0.05). Within the group diagnosed with hypertension, there was no significant difference in salt intake based on whether they were aware of their hypertension status or not. This was the case for both genders and overall. Among those aware of their hypertension, individuals receiving treatment consumed less salt on average, at 9.13 g per day (95% CI 8.88 to 9.38), compared with untreated Individuals with hypertension, who had a mean intake of 9.24 g per day (95% CI 8.89 to 9.59), although this difference was not statistically significant. Furthermore, the results indicated that among those undergoing treatment, individuals who had their blood pressure under control had a slightly lower mean salt intake, measuring 9.10 g per day (95% CI 8.68 to 9.53), compared with those with uncontrolled blood pressure, measuring 9.14 g per day (95% CI 8.83 to 9.47). However, this difference was also not statistically significant (table 1).

Figure 2 presents the proportional distribution of the hypertension care cascade concerning adherence to the WHO recommended salt intake level of less than 5 g per day. In the overall population, 2.7% (95% CI 2.1% to 3.6%) Individuals without hypertension adhered to the recommended salt intake level (<5 g/day), while only

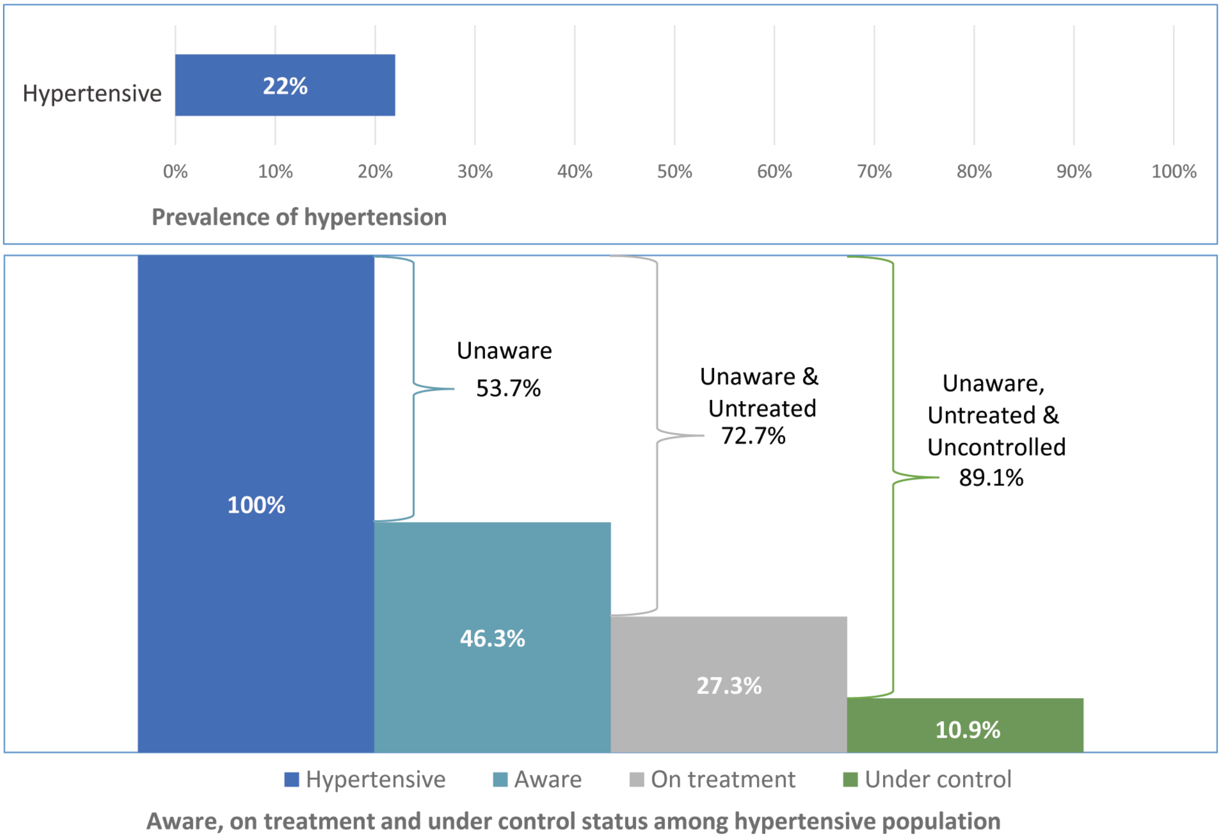


Figure 1 Hypertension cascade framework in Bangladesh.

1.6% (95% CI 1.0% to 2.4%) Individuals with hypertension complied. The proportional difference was statistically significant (p<0.03). Among individuals with hypertension, those aware of their condition adhered to the recommended salt intake level at a significantly higher rate (2.4%, 95% CI 1.4% to 4.0%) compared with their unaware counterparts (0.8%, 95% CI 0.4% to 1.9%) (p<0.03). Among those aware of their hypertension, 3.5% (95% CI 2.1% to 5.9%) on treatment adhered to recommended salt intake, compared with 0.8% (95% CI 0.2% to 4.2%) of untreated individuals. However, no significant difference in salt intake was observed between the two groups. Additionally, 3.2% (95% CI 1.4% to 7.4%) of those on treatment achieved blood pressure control while following recommended salt intake, compared with 3.7% (95% CI 1.9% to 7.1%) of those with uncontrolled blood pressure adhered to the recommended salt intake, with no statistically significant difference (figure 2).

As depicted in figure 3, a positive association between high salt consumption and hypertension was observed. Initially adjusted for age and sex, the OR for hypertension when comparing high salt intake to the WHO recommended levels was found to be 2.13 (95% CI 1.14 to 3.97). Further adjustments were made for other sociodemographic factors (such as residence, education and occupation), lifestyle factors (such as smoking and chewable tobacco) and metabolic factors (such as BMI and diabetes). The ORs minimally changed to 2.21 (95% CI 1.15 to 4.25), 2.09 (95% CI 1.14 to 3.81) and 2.12 (95% CI 1.12 to 4.03), respectively, after accounting for these additional variables. The step-by-step adjustments for potential confounders consistently indicate an association between salt consumption and hypertension, which is suggestive of a relationship. However, it is important to note that due to the cross-sectional nature of this study, it cannot establish causation, but these findings highlight a significant association between salt intake and hypertension (figure 3).

DISCUSSION

The Hypertension care cascade provides a valuable framework for understanding the sequential steps that individuals with hypertension must navigate to achieve optimal blood pressure control, as described in prior studies.[16 18] In this regard, this study found a high hypertension prevalence of 22%, aligning with the global trend, particularly pronounced in low-income and middle-income countries.[19] However, it is worth noting that our results slightly differ from the Bangladesh STEPS 2018 report,[2] possibly due to variations in sample size. Notably, below half of Individuals with hypertension were aware of their condition, indicating substantial awareness but leaving over half undiagnosed. Bridging this awareness gap is crucial for early management. Yet, more striking disparities emerged downstream, as only 27.3% Individuals with hypertension received treatment, indicating a considerable access

Table 1 Average daily salt intake (grams/day) across the hypertensive cascade framework by gender

Hypertension subgroups (n, %)		Female Mean (95% CI)	Male Mean (95% CI)	Overall Mean (95% CI)
Hypertension (overall)	Without hypertension (n=5016, 78.0%)	8.99 (8.87 to 9.11)	8.91 (8.78 to 9.05)	8.95 (8.84 to 9.05)
	With hypertension (n=1738, 22.0%)	9.17 (8.98 to 9.36)	9.19 (8.96 to 9.42)	9.18 (9.02 to 9.33)
		p=0.0896	**p<0.05**	**p<0.02**
Aware or diagnosed hypertension	Aware (n=867, 46.3%)	9.15 (8.87 to 9.43)	9.22 (8.90 to 9.55)	9.18 (8.96 to 9.39)
	Unaware (n=871, 53.7%)	9.19 (8.96 to 9.41)	9.15 (8.83 to 9.48)	9.18 (8.98 to 9.37)
		p=0.8233	p=0.7671	p=0.9972
Treated among diagnosed hypertension	On treatment (n=554, 59.0%)	9.18 (8.85 to 9.52)	9.03 (8.59 to 9.47)	9.13 (8.88 to 9.38)
	Untreated (n=313, 41.0%)	9.10 (8.65 to 9.55)	9.51 (9.08 to 9.95)	9.24 (8.89 to 9.59)
		p=0.7779	p=1227	p=0.6064
BP Controlled among treated hypertension	Control (n=239, 39.9%)	9.38 (8.81 to 9.95)	8.73*	9.10 (8.68 to 9.53)
	Uncontrolled (n=315, 60.1%)	9.08 (8.68 to 9.48)	9.32*	9.14 (8.83 to 9.47)
		p=0.3916	P value*	p=0.8770

n=sample size, %=weighted percentage.
p<0.05 in bold are considered as significant. p values obtained by adjusted Wald test.
Mean: weighted mean (g/day).
*95%CI and p value missing due to stratum with single sample unit.
BP, blood pressure.

gap. Identifying and addressing these access barriers must be a priority in healthcare policy. Furthermore, just 11% achieved recommended blood pressure levels, underscoring the challenge of control. Comprehensive approaches encompassing medication adherence, lifestyle factors and healthcare system improvements are

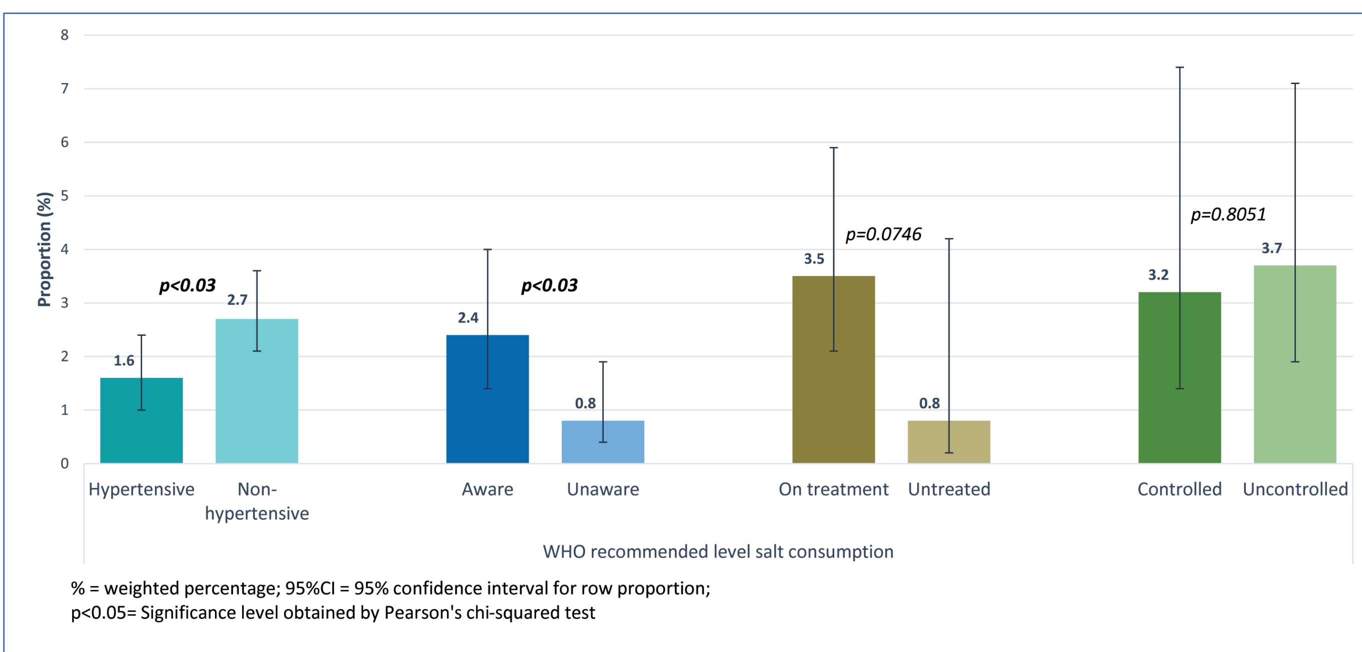
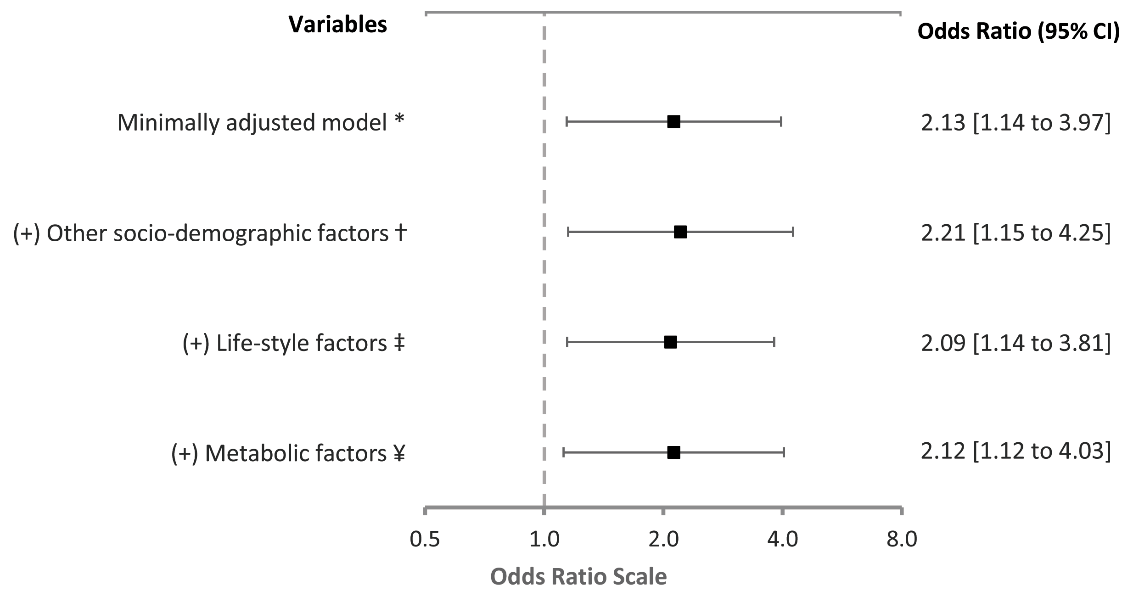


Figure 2 Proportion of adherence to WHO recommended salt intake in the hypertension care cascade.



ORs, odds ratios are adjusted, as appropriate, for age, sex, socio-demographic, lifestyle and metabolic factors
** Minimally adjusted model (adjusted for age, sex)*
† Other socio-demographic factors (residence, education, occupation)
‡ Lifestyle factors (smoking, chewable tobacco)
¥ Metabolic factors (BMI, diabetes)
Significant level for main effect P<0.05 and for interaction P<0.001
(n=6,754, strata:16, PSU: 495 population size:92,865,655)

Figure 3 Association between high salt consumption and hypertension in compare to WHO recommended level.

imperative to enhance hypertension management and control rates.

Salt intake can affect each category of the hypertension care cascade, potentially hindering optimal blood pressure control and increasing the risk of complications associated with hypertension.[20] This study revealed persistent challenges in achieving optimal blood pressure control and reducing salt intake among individuals with hypertension. Despite established salt reduction strategies in health promotion and healthcare advice,[8 10 21] study findings indicated that salt consumption remains high, emphasising the need for more effective interventions. Particularly, individuals diagnosed with hypertension exhibited a higher average salt intake compared with individuals without hypertension, although the difference, while statistically significant, was relatively small. It is noteworthy that both the groups with and without hypertension demonstrated high salt intake, underscoring a universal need for dietary sodium reduction. All population segments, regardless of hypertension status, would benefit from interventions aimed at lowering salt intake. This aligns with global health recommendations and emphasising the need for broad-based dietary changes to combat hypertension and its associated health risks.[21]

Surprisingly, awareness of hypertension did not substantially influence salt intake across genders. However, among those receiving treatment for hypertension, gender-specific dietary variations emerged, with females exhibiting slightly higher salt intake than males. Conversely, untreated males had higher salt intake than untreated females. Additionally, individuals with controlled blood pressure had a slightly lower mean salt intake than those with uncontrolled blood pressure, warranting further investigation. Intriguingly, this study unveiled a concerning pattern—individuals across all hypertension care cascade subgroups consistently exceeded the WHO-recommended salt intake levels. This finding aligns with other studies conducted in neighbouring South Asian countries, indicating an average salt intake approximately two times higher than the recommended level.[22 23] Likewise, studies conducted in Bangladesh have also reported varying levels of salt intake in the population, assessed through urine sodium excretion, with measurements of 10 g/day in 2022, 17 g/day in 2009 and 6.7 g/day in 2014, all of which exceeded the recommended level.[7 23–25] These findings highlighted the influence of cultural context and dietary habits on sodium consumption in Bangladesh, where dietary salt comes from various sources such as added salt during cooking and meal, processed foods, pickles, sauces, condiments, street foods, and fast foods.[21 24 26]

This study highlights that a remarkably low proportion of the population adheres to the recommended salt intake level, with a higher percentage of Individuals without hypertension compared with those with hypertension, the difference was statistically significant. These findings were consistent with previous research indicating that a low-sodium diet, in line with WHO-recommended salt intake levels, reduces the risk of developing hypertension and lowers overall prevalence.[27] Moreover, study results suggested that individuals with hypertension who were aware of their condition exhibit significantly higher adherence rate to the recommended salt intake compared with unaware counterparts. A similar trend is observed among individuals receiving treatment and those who are untreated, though the difference does not reach statistical significance. Surprisingly, blood pressure control and uncontrolled levels appear to be nearly equivalent among those adhering to the recommended salt intake, with no statistically significant differences. This unexpected finding contradicts our initial expectations, where we anticipated a greater proportion of individuals with hypertension will follow recommended salt intake for better blood pressure control. Individuals who have received medical advice on managing hypertension from healthcare providers may have reduced their salt consumption but this practice might not be generalised among the population with hypertension. Proper diagnosis and management of hypertension, including lifestyle modifications such as dietary changes to low salt, could lead to improved blood pressure control.[28] This surprising finding emphasises the necessity for a revitalised emphasis on implementing salt reduction strategies and developing more efficacious interventions.

Importantly, this study demonstrated a statistically significant positive association between high salt consumption and hypertension, even after adjusting for age, sex, sociodemographic, lifestyle and metabolic factors. These results aligned with prior research, which has consistently demonstrated a robust correlation between salt intake and elevated blood pressure levels.[17 29–31] To effectively control blood pressure, reducing salt intake plays a crucial role in addition to antihypertensive treatments.[32] Scientific evidence confirms that reducing salt intake leads to a decrease in blood pressure in both individuals with hypertension and those with normal blood pressure, typically observed within weeks of implementing sodium restriction.[5 33 34] Even a modest reduction of 3 g per day in salt consumption is projected to result in a significant decrease in blood pressure among individuals with hypertension and those with normal blood pressure.[35] Notably, countries where people consume low-salt diets do not exhibit the age-related increase in blood pressure.[29] It was noteworthy that Bangladesh had incorporated the WHO's target of a 30% relative reduction in the mean population salt intake in its 3-year multisectoral action plan for the years 2018–2025,[10] as well as its predecessor plan.[36]

Strengths and limitations

This study reported the distribution of salt consumption across the hypertension care cascade, using the nationally representative Bangladesh STEPS 2018[12] survey for comprehensive insights. Our methodology ensured robustness and relevance, substantially enhancing the understanding of dietary impacts on hypertension and informing public health strategies in Bangladesh.

The study faced several limitations that merit consideration. First, while spot urine sodium measurements are advantageous for large-scale epidemiological research,[2 37] their accuracy in estimating individual dietary sodium intake is limited due to daily variations in sodium consumption and excretion.[7 38] This methodological concern is acknowledged within the research community and necessitates cautious interpretation of findings derived from spot urine analyses. Second, the absence of data on the duration of medication use prior to the study period restricted an in-depth evaluation of the transient physiological effects of diuretic initiation, such as the initial increase in natriuresis, which is crucial for understanding sodium intake estimations. Third, the study's applicability beyond the Bangladeshi context is limited, as its findings may not generalise to countries with different dietary, cultural and healthcare systems. This necessitates caution when extrapolating these insights to other settings. Additionally, the cross-sectional design of the study impedes the establishment of causal relationships between salt intake and hypertension. Lastly, blood and urinalysis for all participants were not available.

In conclusion, this study found that individuals with hypertension in Bangladesh consume significantly higher average salt compared with those without hypertension. Notably, awareness of hypertension status, receiving treatment and achieving blood pressure control did not exhibit significant differences in salt intake compared with their respective counterparts. Adherence to WHO recommended salt levels was associated with a lower prevalence of hypertension and greater awareness of one's hypertension status. However, unexpectedly, no association was found with those on treatment and who had controlled their hypertension. Substantial gaps persist in achieving widespread salt reduction, and addressing these issues should be a national priority in Bangladesh. Effective public health efforts aimed at reducing salt intake can profoundly impact hypertension prevention and control.

In light of these findings, Bangladesh's public health policies must urgently reorient and intensify their approach to salt reduction. Sustained, targeted public health campaigns and educational initiatives are imperative. These policies should prioritise adherence to WHO-recommended salt levels, empower informed dietary choices, and educate patients about salt's risks and benefits. Ensuring affordability and accessibility of low-sodium options is crucial to promote healthier dietary habits. A collaborative effort involving policy-makers, healthcare professionals and the public is paramount. Such concerted action can markedly enhance salt reduction and improve blood pressure management, alleviate the burden of hypertension and improve overall cardiovascular health in Bangladesh.

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Contributors SRC and MMM designed the study; MMM, SUAA and AKA conducted the statistical analysis and interpretation of the data; MMM drafted the initial manuscript; SRC, SUAA and AKA did the critical revision on the draft. SRC is the guarantor for the overall content. All authors approved the final version for publication and are committed to ensuring the work's integrity, aligning with the ICMJE authorship criteria.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval The STEPS 2018 Bangladesh study obtained ethical clearance from the Bangladesh Medical and Research Council (BMRC). Prior to the interview and specimen collection, informed written consent was obtained from each respondent. Permission to use the dataset was obtained from the NCD Microdata Repository of the World Health Organization (WHO) in March 2023. Given the use of secondary data which had already undergone ethical scrutiny and obtained the necessary consents, our study did not require further ethical approval or additional consent for publication, aligning with the ethical guidelines for secondary data analysis.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available in a public, open access repository. This study used data from datasets of STEPS 2018 Bangladesh survey, which are available from the WHO data repository website.

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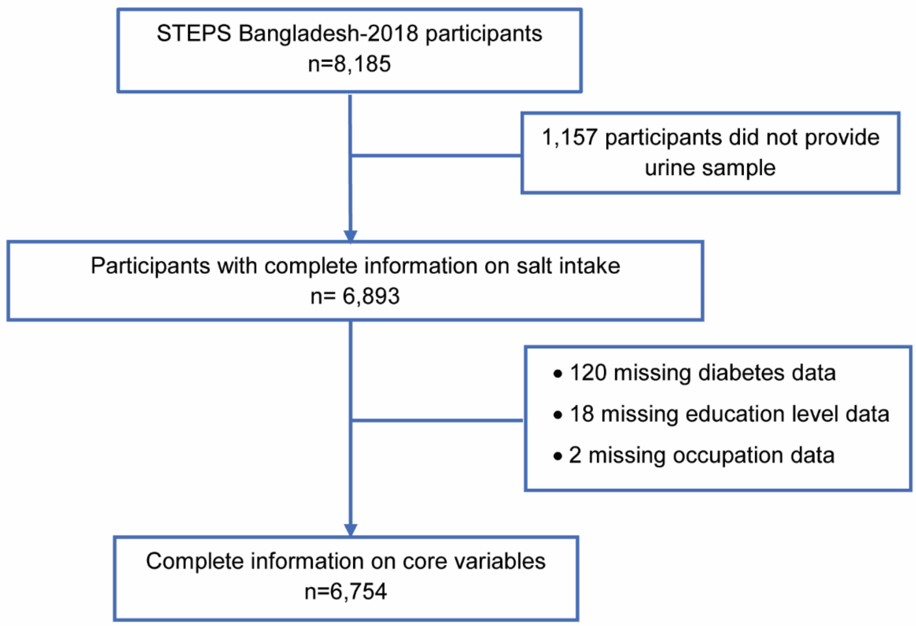
Supplementary Tables & figures



Supplementary Figure 1. Flow chart illustrating selection of eligible participants (n=6,754)

Supplementary Table 1. Characteristics of all study participants, overall and by sex (n=6,754).

Characteristics	**Male** **N= 3,161**	**Female** **N= 3,593**	**Total** **N= 6,754**
Age, median (IQR), y	35 (26,50)	34 (25,47)	35 (25,49)
Place of Residence			
Rural	1,655 (78.9%)	1,937 (81.5%)	3,592 (80.2%)
Urban	1,506 (21.1%)	1,656 (18.5%)	3,162 (19.8%)
Education			
No education	1,465 (44.4%)	1,699 (48.1%)	3,164 (46.3%)
Primary	844 (27.8%)	1,256 (34.6%)	2,100 (31.2%)
Secondary	365 (12.3%)	323 (9.7%)	688 (11.0%)
More than secondary	487 (15.5%)	315 (7.6%)	802 (11.5%)
Occupation			
Professional	1,294 (34.0%)	217 (5.2%)	1,511 (19.6%)
Manual labour	820 (26.0%)	170 (3.3%)	990 (14.6%)
Home maker	5 (0.3%)	3,080 (86.4%)	3,085 (43.4%)
Agriculture	731 (25.5%)	19 (0.5%)	750 (13.1%)
Unemployed & retired	147 (5.1%)	32 (1.5%)	179 (3.3%)
Students & others	164 (0.1%)	75 (3.1%)	239 (6.0%)
Smoking			
Never smoker	1,076 (38.7%)	3,537 (97.8%)	4,613 (68.3%)
Ever smoker	2,085 (61.3%)	56 (2.2%)	2,141 (31.7%)
Chewable tobacco users			
Never users	2,013 (68.6%)	2,312 (67.0%)	4,325 (67.8%)
Ever users	1,148 (31.4%)	1,281 (33.0%)	2,429 (32.2%)
Body mass index, mean (95%CI)	21.8 (CI:21.6-21.9)	23.4 (CI:23.1-23.7)	22.6 (CI:22.4-22.7)
Spot urinary Sodium (mmol/L)	93.0 (54.0,157.0)	100.0 (58.1,165.1)	96.0 (56.8.162.0)
Spot urinary Creatinine (mg/dL)	80 (45,145)	60 (35,105)	70 (40,125)
Predicted 24-hour urinary creatinine (mg/day)	1510.6 (1304.2,1683.6)	972.3 (887.6, 1054.1)	1106.7 (956.6,1477.6)
Diabetes			
Yes	321 (8.9%)	328 (8.0%)	649 (8.4%)
No	2.840 (91.1%)	3,265 (92.0%)	6.105 (91.6%)

*Data are presented as weighted mean (SD) for continuous variables (normally distributed), weighted median (IQR) for non-normally distributed continuous variables, and unweighted frequency and weighted percentages for categorical measures.

**Abbreviations: IQR, Interquartile range; N, number of participants; CI, 95% Confidence Interval.