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Prevalence, associated factors, treatment, and control of hypertension among adults in rural Sylhet district of Bangladesh

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Abstract:

Objectives: All low- and middle-income countries are undergoing epidemiological transition, however, the progression is varied. Bangladesh is simultaneously experiencing a continuing burden of communicable diseases and an emerging burden of non-communicable diseases (NCDs). For effective use of limited resources, an increased understanding of the shifting burden and better characterization of risk factors of NCDs including hypertension is needed to develop scalable public health programs. This study provides data on prevalence, awareness, control of and associated factors of hypertension among males and females of 35 years and older in rural Bangladesh.

Methods:

This is a population based cross-sectional study conducted in Zakiganj and Kanaighat sub-districts of Sylhet district of Bangladesh. Blood pressure was measured and data on risk factors were collected using STEPS instrument from 864 males and 946 females aged 35 years and older between August 2017 and January 2018. Bivariate and multivariate analyses were performed to identify factors associated with hypertension.

Results: The prevalence of hypertension was 18.9% and 18.0% in adult males and females, respectively. Among those who were hypertensive, the prevalence of controlled, uncontrolled and unaware/newly identified hypertension were 23.3%, 25.8% and 50.9%, respectively among males and 39.4%, 24.1% and 36.5%, respectively among females. Another 22.2% males and 18.9% females had pre-hypertension. Increasing age and higher waist circumference (≥80 cm) were positively associated with hypertension both in males and females.

Conclusions: In view of the high burden of hypertension and pre-hypertension, a scalable public health program including behavior change, identification and management of hypertension needs to be developed and implemented.

Strengths and limitations of this study

- This is a study of prevalence and associated factors of hypertension in a representative population-based sample of adult males and females aged 35 years and older in a rural district of Bangladesh. To our knowledge, this study is the first to provide precise estimates of hypertension and associated factors for a rural district in Bangladesh.
- Blood pressure was measured using a standardized method and data on factors associated with hypertension was collected using WHO STEPs questionnaire.
- The cross-sectional nature of the study limits the ability to establish causal relationship between the observed factors and hypertension.
- Blood pressure was measured at the field level, not in a clinic setting. However, our workers were adequately trained and had years of experience measuring blood pressure in the field setting.

Keywords: Hypertension, Bangladesh, Cross sectional study.

INTRODUCTION

Each year an estimated 41 million people die from non-communicable diseases (NCDs) accounting for about 70% of all deaths globally [1]. Hypertension is one of the most common NCDs. According to the Global Burden of Disease (GBD) reports, there has been a shift in disease burden between 1990 and 2010 from communicable diseases to NCDs [1 2]. This was most notable in South Asia and sub-Saharan Africa regions, where a substantial proportion of the world's population reside and where high blood pressure has had a particularly large effect on disease burden [2]. Globally, high blood pressure was the 4th leading risk factor for GBD in 1990, as quantified by disability adjusted life years (DALYs); it ranked as the leading risk factor in 2010 [2]. About one out of four adults around the world have hypertension and it is projected to increase to 29.2% by 2025, which will be more than 1.5 billion people worldwide[3-5].

Uncontrolled hypertension increases the risks of cardiovascular disease, strokes, and end-stage renal failure [6]. It accounts for about 45% of deaths due to ischemic heart disease and 52% of deaths due to stroke [6]. Older age, high body mass index (BMI), unhealthy diet, lack of physical exercise, smoking tobacco products, and family history of hypertension are major risk factors for hypertension [7 8].

The prevalence of hypertension is increasing, primarily in low- and middle-income countries (LMICs) and remain steady or decreasing in high-income countries (HICs) [3]. In South Asia, the prevalence of hypertension is approximately 33% among people aged 18 years and older with a secular trend documenting that the burden of hypertension is increasing over time [9]. South Asia region accounts for 23% (or an estimated 258 million) of global hypertension burden [9]. An increase in hypertension prevalence in South Asia including Bangladesh could be attributed largely to modifiable behavioral risk factors such as unhealthy diet, sedentary lifestyle, excess weight, tobacco consumption, alcohol abuse, and chronic stress including aging and urbanization [10-12].

Bangladesh, like many other LMICs, is undergoing an epidemiologic transition and an increased understanding of the burden and risk factors of hypertension is necessary to combat the increasing burden [13]. However, data on burden and risk factors of hypertension from Bangladesh is limited. A nationally representative survey conducted in 2011 suggests that the prevalence of hypertension including undiagnosed and uncontrolled hypertension in Bangladeshi adults is high [14-18]. The available data is not adequate to provide regional or district level estimates. In view of the increasing burden of NCDs, we have conducted this study in a rural district of Bangladesh where we have been working for about two decades to develop scalable public health programs by identifying priority health problems and by designing and testing interventions. Our work on newborn and reproductive health have influenced national and global policies [19-22].

The study was designed to provide data on prevalence, awareness, control of and associated factors of hypertension among adults 35 years and older in our population with the aim of developing public health programs to prevent and control hypertension for a low resource setting with weak health system like Bangladesh.

METHODS

Study design and setting

This was a population-based cross-sectional study conducted between August 2017 and January 2018 in an established field research site in Zakiganj and Kanaighat sub-districts of Sylhet district of Bangladesh. The site is maintained by a research partnership of the Johns Hopkins University, Baltimore, Maryland, USA, the Bangladesh Ministry of Health and Family Welfare, and Bangladeshi non-governmental organizations. The study area is in the north-east part of Bangladesh adjacent to the Indian states of Assam and Meghalaya. The study site is about 300 kilometers away from Dhaka, the capital city of Bangladesh. Every village and household in the area are numbered. All married women of reproductive age have two numbers, a current identification number (CID) to locate the individual on the ground and a permanent identification number (PID) allowing longitudinal linkages. We maintain a basic demographic surveillance system which has been described previously [23-25]. The database of all individuals including their date of birth and sex constituted the sampling frame.

Sample Size

Sample size was estimated to measure the prevalence of hypertension separately for adult males and females 35 years and older in the study population. Conservatively assuming a hypertension prevalence of 10% in both males and females, a ± 2% precision, and a significance level of 5%, the estimated sample size was 865 in each group. The sample size was inflated to 1,020 in each group to account for a 15% refusal or absence. This sample size allows us to detect a 5% difference in the prevalence of hypertension between males and females.

Study Population and implementation

Individuals either a male or female aged 35 year and older with a PID were eligible to participate in the study. Pregnant women were excluded. Participants were randomly selected from the database using automated procedures. They were visited in their homes by trained community health workers (CHWs) with a minimum of 10th grade education, who were already collecting routine surveillance and other study specific data, including blood pressure measurement of pregnant women [26 27]. Given cultural sensitivities, two male CHWs were recruited to collect data from male participants. All CHWs received study specific training.

Upon obtaining informed consent, CHWs administered an adapted version of the WHO's expanded STEP instrument at the participant's home [28 29]. The instrument contained questions on NCD behavioral risk factors, including dietary habit, tobacco consumption, and physical activity. Data on other co-variates (e.g., household socio-economic status, education, occupation) were collected.

After completing the household survey, CHWs measured blood pressure (BP) in mm Hg using digital BP machine (OMRON 5 Series®, model: BP742N). The digital machines were calibrated fortnightly by a physician against a gold standard mercury sphygmomanometer. Three measurements of both systolic and diastolic blood pressure were taken at approximately 5-minute intervals. All measurements were recorded in a data form and the average of the three measurements was used for this analysis. During measurements, the study participant remained seated with legs uncrossed and back and arm supported. The cuff was placed above the left elbow at the level of chest. In addition, CHWs obtained measurements of weight (in kilograms), height (in centimeter), waist circumference (in centimeter), hip circumference (in centimeter) and mid upper arm circumference (MUAC, in centimeter) of the study participants using standardized methods.

Measurements

Blood pressure was classified as normal, pre-hypertension, or hypertension, based on criteria used in the World Health Organization-International Society of Hypertension (WHO-ISH) [30]. A participant was considered to have normal blood pressure if systolic blood pressure (SBP) was

<120 mm Hg and the diastolic blood pressure (DBP) <80 mm Hg and not taking antihypertensive drugs. An SBP of 120-139 mmHg or a DBP of 80-89 mmHg with no history of taking antihypertensive medication during survey was classified as prehypertension. A participant was considered having hypertension if the SBP was ≥140 mmHg or DBP was ≥90 mmHg or the blood pressure was below these cut-offs, but the study participant reported taking antihypertensive medication. Controlled hypertension was defined as an SBP <140 mmHg and a DBP <90 mmHg and reported use of antihypertensive medication during survey. A SBP of ≥140 mmHg or a DBP ≥90 mmHg in a study participant taking antihypertensive medication was considered as uncontrolled hypertension. An individual with SBP ≥140 mm Hg or DBP ≥90 mm Hg with no history of taking antihypertensive medication was considered as newly identified or unaware of hypertension. The participants with high measured BP were referred to the hospital for further evaluation and care.

Participants' were categorized based on age into four groups (35-44, 45-54, 55-64, and ≥65 years old). We calculated body mass index (BMI) as the ratio of weight in kilograms to height in meters squared (weight in kg/height in m^2) and categorized using the WHO-recommended cutoff points: underweight (<18.5 kg/m^2), normal (18.5 – 24.9 kg/m^2), and obese/overweight (≥25.0 kg/m^2) [31]. Household wealth scores were created using a principal components analysis of individual housing materials and household possessions [32] and categorized into wealth tertiles. We used STEPS instrument to collect data on risk and protective factors. The data on fruits and vegetables intake were combined and categorized into <2 servings per day, 2-4 servings per day and ≥5 servings per day. Participants were defined as a current smoker if they reported smoking cigarettes, cigars, or pipes during the survey. Similarly, participants were defined as a current smokeless tobacco user if reported using smokeless tobacco products such as snuff, chewing tobacco leaf, *goul*, *noshi* or *zarda* at the time of the survey. Based on participants' reported work related vigorous and moderate activities including duration of the activities, we categorized these variables into; no vigorous/moderate physical activity, <30 min vigorous/moderate physical activity and >=30 min vigorous/moderate physical activity.

Data analysis

We presented percent distribution of selected sociodemographic and other factors including median and interquartile range for continuous variables for the total sample as well as separately for males and females. We calculated the prevalence and 95% confidence intervals (CI) of hypertension, pre-hypertension, controlled, uncontrolled and unaware or newly identified hypertension using WHO-ISH guidelines [30]. Bivariate and multivariable logistic regression were used to identify factors significantly associated with hypertension separately for males and females. First, we conducted bivariate logistic regression analysis. Variables with a p-value of <0.1 in the bivariate analyses were included in the multivariable logistic regression model. As a priori, we included smoking, fruits and vegetables and physical activities variables in the multivariable model for females even they were not significant in the bivariate model. Data was analyzed using Stata version 15 (StataCorp 2015).

We obtained approval from the National Research Ethics Committee of the Bangladesh Medical Research Council (BMRC) and the Institutional Review Board (IRB) of the Johns Hopkins Bloomberg School of Public Health, USA to conduct the research.

RESULTS

We approached 1,020 males and 1,019 females aged 35 years or older (total of 2,039) for study participation. Among the 1,020 males, 29 (2.8%) refused participation, 49 (4.8%) were absent and 76 (7.5%) were excluded for other reasons. Among the 1,019 females, 7 (0.7%) refused, 7 (0.7%) were absent, 14 (1.4%) were excluded because they were pregnant, and 45 (4.4%) were excluded for other reasons. Of the 1,810 participants who completed the survey, 864 were male and 946 were female. Distributions of sociodemographic and lifestyle characteristics of male, female and all participants are presented in Table 1.

Table 1: Socio-demographic and lifestyle characteristics among adult males and females in Sylhet district of Bangladesh

Characteristics	Males (N=864)	Females (N=946)	Total (N=1,810)
	n (%)[1]	n (%)[1]	n (%)[1]
Age (years)			
35-44	260 (30.1)	357 (37.7)	617 (34.1)
45-54	259 (30.0)	290 (30.7)	549 (30.3)
55-64	167 (19.3)	139 (14.7)	306 (16.9)
65+	178 (20.6)	160 (16.9)	338 (18.7)
Median (IQR)	50 (42,60)	47 (40, 57)	48 (41, 59)
Education (years of schooling)			
No education	99 (11.5)	234 (24.7)	333 (18.4)
1-5 years	522 (60.4)	604 (63.9)	1,126 (62.2)
6-10 years	243 (28.1)	108 (11.4)	351 (19.4)
Median (IQR)	5 (1, 7)	1 (1, 5)	2 (1, 5)
Wealth status			
Lowest tertile	293 (33.9)	317 (33.5)	610 (33.7)
Middle tertile	288 (33.3)	323 (34.1)	611 (33.8)
Highest tertile	283 (32.8)	306 (32.4)	589 (32.5)
Body mass index (BMI)			
Underweight (<18.5 kg/m2)	247 (28.6)	282 (29.8)	529 (29.2)
Normal (18.5-24.9 kg/m2)	518 (60.0)	501 (53.0)	1,019 (56.3)
Overweight/obese (>=25 kg/m2)	99 (11.5)	163 (17.2)	262 (14.5)
Median (IQR)	20.1 (18.2, 22.5)	20.5 (18.0, 23.3)	20.3 (18.1, 22.9)
Waist circumference (cm)			
<80 cm	546 (63.2)	542 (57.3)	1,088 (60.1)
≥80 cm	318 (36.8)	404 (42.7)	722 (40.0)
Median (IQR)	76.4 (70.5, 84.2)	77.3 (69.2, 85.5)	77.0 (69.7, 84.8)

Characteristics	Males (N=864)	Females (N=946)	Total (N=1,810)
Current smoker			
No	318 (36.8)	910 (96.2)	1,228 (67.9)
Yes	546 (63.2)	36 (3.8)	582 (32.2)
Current smokeless tobacco user			
No	82 (9.5)	137 (14.5)	219 (12.1)
Yes	782 (90.5)	809 (85.5)	1,591 (87.9)
Number of servings of fruits and vegetables/day			
<2 serving	456 (52.8)	432 (45.7)	888 (49.1)
2-4 servings	283 (32.8)	415 (43.9)	698 (38.6)
>=5 servings	125 (14.5)	99 (10.5)	224 (12.4)
Median (IQR)	0 (0, 1)	1 (0, 1)	1 (0, 1)
Vigorous-intensity activities (in minutes)			
0 min	521 (60.3)	884 (93.5)	1,405 (77.6)
<30 min	195 (22.8)	34 (3.6)	229 (12.7)
>=30 min	148 (17.1)	28 (3.0)	176 (9.7)
Moderate-intensity activities (in minutes)			
0 min	298 (34.5)	554 (58.7)	852 (47.1)
<30 min	106 (12.3)	238 (25.2)	344 (19.0)
>=30 min	460 (53.2)	154 (16.3)	614 (33.9)

224 [1]: column percentage; IQR: interquartile range

225 The median ages of male and female participants were 50 (IQR 42, 60) years and 47 (IQR 40, 57) years, respectively. The median BMI of males and females were 20.1 (IQR 18.2, 22.5) and 20.5 (IQR 18.0, 23.3) kg/m^2, respectively. Among females, 17.2% were overweight/obese and 42.7% had high waist circumference (≥80 cm). Majority of the males (63.2%) reported smoking currently compared to 3.8% of the females who did so. About 14.5% males and 10.5% females reported intake of >=5 servings of fruits and vegetables per day. Among males, 17.1% reported >=30 min work related vigorous-intense activities compared to 3.0% females who reported the same. About half (53.2%) of males and 16.3% females reported >=30 min work related moderate-intense activities (Table 1).

234 The prevalence of hypertension was 18.9% in males and 18.0% in females (Table 2). Among those with hypertension, the prevalence of controlled, uncontrolled and unaware/newly

identified hypertension was 23.3%, 25.8% and 50.9%, respectively among males and 39.4%, 24.1% and 36.5%, respectively among females (Table 2 and figure 1). Another 22.2% of the males and 18.9% of the females were pre-hypertensive.

Table 2: Distribution of blood pressure levels in males and females in rural Bangladesh

Blood pressure categories	Males N= 864	Females N=946	Total N=1,810
	%, 95% CI	**%, 95% CI**	**%, 95% CI**
Normal blood pressure[1]	58.8, 55.6-62.2	63.1, 60.0-66.1	61.0, 58.8-63.3
Pre-hypertension[2]	22.2, 19.6 –25.1	18.9, 16.5-21.5	20.5, 18.7-22.4
Hypertension[3]	18.8, 16.0-22.0	18.0, 16.0-21.0	18.4, 17.0-20.0
	n= 163	**n=170**	**n=333**
Controlled[4]	23.3, 17.1-30.6	39.4, 32.0-47.2	31.5, 26.6-36.8
Uncontrolled[5]	25.8, 19.2-33.1	24.1, 17.9-31.3	24.9, 20.4-29.9
Newly identified[6]	50.9, 43.0-58.8	36.5, 29.2-44.2	43.5, 38.1-49.1

Note: [1]SBP <120 mm Hg and DBP <80 mm Hg and not taking antihypertensive medication; [2]SBP 120-139 mm Hg or DBP 80-89 mm Hg and not taking antihypertensive medication; [3]SBP ≥140 mm Hg or DBP ≥ 90 mm Hg or taking antihypertensive medication; [4]SBP <140 mm Hg and DBP < 90 mm Hg but taking antihypertensive medication; [5]SBP ≥140 mm Hg or DBP ≥ 90 mm Hg and taking antihypertensive medication; [6]SBP ≥140 mm Hg or DBP ≥ 90 mm Hg and not taking antihypertensive medication.

Simple and multivariable logistic regression analyses to investigate factors associated with hypertension are presented in Table 3.

Table 3: Factors associated with hypertension among males and females in rural Bangladesh

Characteristics	Males		Females	
	Unadjusted OR, 95% CI	**Adjusted OR, 95% CI**	**Unadjusted OR, 95% CI**	**Adjusted OR, 95% CI**
Age (years)				
35-44	Ref		Ref	Ref
45-54	1.7, 1.0-2.9*	1.7, 1.0-3.0*	2.1, 1.3- 3.4**	2.3, 1.4-3.7**
55-64	3.2, 1.9-5.5***	2.9, 1.6-5.2***	2.5, 1.5- 4.3**	3.0, 1.7-5.4***
65+	3.7, 2.2-6.2***	3.1, 1.7-5.4***	4.8, 3.0- 7.8***	6.0, 3.5-10.3***
Education (years)				
No education	Ref	------------	Ref	----
1-5 years	1.2, 0.7- 2.2		1.1, 0.7- 1.6	
≥ 6 years	1.6, 0.9- 3.0		1.0, 0.6- 1.9	
Wealth status				
Lowest tertile	Ref	Ref	Ref	Ref
Middle tertile	1.1, 0.7-1.8	1.0, 0.6-1.6	1.7, 1.1-2.7*	1.7, 1.0-2.7*

Characteristics	Males		Females	
	Unadjusted OR, 95% CI	**Adjusted OR, 95% CI**	**Unadjusted OR, 95% CI**	**Adjusted OR, 95% CI**
Highest tertile	1.9, 1.2-2.9**	1.0, 0.6-1.6	2.5, 1.6-3.9***	2.2, 1.4-3.6**
Body mass index (BMI)				
Underweight (<18.5 kg/m^2)	0.4, 0.3-0.7**	-------------	0.4, 0.3- 0.7***	------------
Normal (18.5 - <25 kg/m^2)	Ref		Ref	
Overweight (>=25 kg/m^2)	3.0, 1.9-4.7***		1.6, 1.1- 2.4*	
Waist circumference (cm)				
< 80 cm	Ref			
≥80 cm	4.3, 3.0-6.1***	3.7, 2.5-5.6***	3.0, 2.1- 4.2***	2.9, 2.0-4.2***
Current smoker				
No	Ref	Ref	Ref	Ref
Yes	0.5, 0.4- 0.7***	0.9, 0.6-1.3	1.3, 0.6- 2.9	1.0, 0.4-2.3
Current smokeless tobacco users				
No	Ref	Ref	Ref	Ref
Yes	0.5, 0.3- 0.9*	0.6, 0.4-1.1	1.1, 0.7-1.8	0.9, 0.5-1.6
Number of fruits and vegetables servings/day				
0	Ref	Ref	Ref	Ref
2-4 servings	1.4, 0.9-2.0	1.1, 0.7-1.7	0.9, 0.6-1.3	0.8, 0.5-1.1
>5 servings	1.6, 1.0-2.6*	1.3, 0.7-2.2	1.3, 0.8-2.2	1.0, 0.6-1.9
Vigorous-intense activities				
0 minute	Ref	Ref	Ref	Ref
1-30 minutes	0.4, 0.2-0.6***	0.7, 0.4-1.3	1.2, 0.5-2.8	1.9, 0.8-4.7
>=30 minutes	0.2, 0.1-0.4***	0.4, 0.2-0.8*	1.6, 0.6-3.7	1.8, 0.7-4.9
Moderate-intense activities				
0 minute	Ref	Ref	Ref	Ref
1-30 minutes	0.8, 0.5-1.4	0.8, 0.5-1.4	0.8, 0.5-1.1	1.1, 0.7-1.8
>=30 minutes	0.4, 0.3- 0.6***	0.7, 0.4-1.1	0.8, 0.5- 1.2	1.2, 0.7-2.1

Notes: OR: odds ratio, CI: confidence interval, *: p<0.05, **: p<0.01, ***: p<0.001

In unadjusted logistic regression, among both in males and females, compared to the reference groups, those who were older than 45 years, overweight/obese, or had a waist circumference ≥80 cm had higher odds of hypertension. The odds of hypertension were lower in both males and females who were underweight. Among males, those who belonged to the highest wealth tertile and among females who belonged to the middle and highest wealth tertiles had significantly higher odds of hypertension in unadjusted logistic regression. Vigorously or moderately-intense activities were associated with lower prevalence of hypertension among males but not among females (Table 3).

In the adjusted logistic regression model, we included waist circumference but not BMI because they were highly correlated (r = .83). In the adjusted analysis, among males, age older than 45 years and waist circumference ≥80 cm was positively and reported vigorous-intensity activities was inversely related to risk of hypertension. Among females, older age, higher socioeconomic status and waist circumference ≥80 cm was positively related with risk of hypertension (table 3). The odds of hypertension were increasing significantly as the age was increasing both in males (45-55 y: adjusted odds ratio [aOR] 1.7, 95% CI: 1.0-3.0; 55-64 y: aOR 2.9, 95% CI 1.6-5.2, 65+ y: aOR 3.1, 95% CI 1.7-5.4) and in females (45-55 y: aOR 2.3, 95% CI 1.4-3.7, 55-64 y: aOR 3.0, 95% CI 1.7-5.4, 65+ y: aOR 6.0, 95% CI 3.5-10.3). The odds of hypertension were three-folds higher among both males (aOR 3.7, 95% CI 2.5-5.6) and females (aOR 2.9, 95% CI 2.0-4.2) with the waist circumference ≥80 cm. In a subsequent adjusted model, we replaced waist circumference by BMI; overweight/obese was significantly associated with greater odds of hypertension in both males (aOR 2.7, 95% CI 1.7-4.7) and females (aOR 1.8, 95% CI: 1.2-2.9) (data not shown).

DISCUSSION

In this population-based cross-sectional study in rural Bangladesh, the prevalence of hypertension was high among both males (18.8%) and females (18.0%). The prevalence of pre-hypertension was also high at 22.2% among males and 18.9% among females. Among those who had hypertension, more than half of the males and about a third of the females were not aware of it. Additionally, about a quarter of the hypertensive males and females had uncontrolled hypertension. Compared to males, a higher proportion of females had controlled hypertension.

The data on prevalence of and risk factors for hypertension in Bangladesh is limited. The Bangladesh Demographic and Health Survey 2011 (BDHS-2011) measured blood pressure in a nationally representative sample of adult males and females [16]. The BDHS estimates of hypertension prevalence for Sylhet division were similar to our finding among males but was higher (25.2%) among females. However, the BDHS Sylhet prevalence rate for females was based on 232 women with a wide confidence interval (19.6-31.1). BDHS documented a substantial urban versus rural and regional variations. The urban sample had a much higher prevalence than the rural sample (40.2% vs 29.4%). Among eight divisions (regions) of Bangladesh, Sylhet division where the current study was conducted, had the lowest prevalence (25.2%) [16]. Our findings of prevalence of hypertension in females is similar (18.4% vs 18.0%) but higher in males (13.5% vs 18.8%) in a study conducted in a rural area in Bangladesh [33].

Our findings of positive associations between hypertension and potential risk factors such as age, BMI, and waist circumference are consistent with several studies from Bangladesh and elsewhere [17 18 34]. A dose response relationship was observed between the risk of hypertension and age, the risk increased with the increase of age; highest risk was observed in the oldest age groups among both males and females [18 35].

High BMI is an established risk factor for hypertension [15]; several studies found that overweight/obesity had the strongest association with hypertension [33 36 37]. Body weight is the balance between consumption and expenditure of energy. One would expect higher calorie consumption among higher SES group. Adult males and females with a waist circumference of ≥80 cm had 4 and 3 folds higher risks of hypertension, respectively compared to those with a waist circumference <80 cm. Both BMI and waist circumference are established risk factors for hypertension. In our study, we analyzed them separately but presented waist circumference data instead of BMI because several studies suggested that abdominal fat deposition is generally a stronger predictor of hypertension than BMI-based association [38 39]. Moreover, we chose waist circumference in our model instead of BMI because it can be easily measured and programs can use it for screening.

Several studies observed an association between hypertension and higher socio-economic status [33 40]. In our study, we observed a positive association of hypertension among females; women who belonged to higher wealth groups were twice as likely to have hypertension compared to those who belonged to the poorest wealth group. Recent interventional studies showed beneficial effects of exercise on blood pressure reduction[41 42]. We observed a lower risk among males who reported vigorous intense activities for ≥30 minutes. The odds of having hypertension was 60.0% less among males those who had reported vigorous-intense activities.

We did not see a protective effect of fruit or vegetable consumptions on hypertension in our population. In this poor agrarian community most people consume vegetables every day, the quantity might be low. Fruit consumption is low among rural Bangladeshi people. Seasonal fruits are grown in abundance but are not popular because people do not consider them as good fruit [43]. Imported fruits are costly and remain unaffordable to many people leading to a very low consumption of fruit [43]. The benefit of fruits and vegetable consumption is primarily through increased intake of potassium [44 45]. All vegetables may not contain high level of potassium and washing, and cooking may reduce potassium level [46]. In this study, we did not see a higher risk among smokers. Not seeing a benefit of fruit and vegetable consumptions or not seeing an increased risk among smokers could be due to reverse causation i.e., those with hypertension might have modified their behavior but that is unlikely because about half of those hypertensive were newly diagnosed.

The study has several limitations. The cross-sectional nature of the study limits the ability to establish causal relationship between the observed risk factors and hypertension. Also, the study was conducted in one region of Bangladesh and may not be generalizable for the entire country. We could not measure or collect data on all variables associated with hypertension. We defined hypertension by measuring blood pressure levels at the field level, not in a clinic setting. However, our workers were adequately trained and had years of experience measuring blood pressure in the field setting. We calibrated the blood pressure machines fortnightly against mercury sphygmomanometer. This survey used standard and pre-tested STEPs questionnaire to collect data from study participants.

Our finding of high levels of hypertension in this rural area is important because the risk of CVDs is about 16 folds higher among those with hypertension compared to those with a SBP of <115 and DBP of <75 [47]. However, the risk of CVDs is higher for all individuals with a SBP >115 or DBP >75 [47-49]. For every 10 mm increase in BP, the risk almost doubles. Although the risk is lower in the so-called normal BP groups compared to those with hypertension, since there are many more individuals in these BP categories, the burden of CVD related to hypertension among them is substantial. Therefore, efforts need to be made to identify and control hypertension and adopt strategies to reduce blood pressure of the entire population and prevent rise of BP with age.

Our results show a high prevalence of hypertension and pre-hypertension in the surveyed population. In addition, high prevalence of newly diagnosed and uncontrolled hypertension despite the availability of low cost and safe drugs for hypertension is a major public health concern. Apart from age, the most important risk factor of hypertension is behavioral and potentially modifiable. For example, inappropriate diet and physical inactivity – resulting in high body mass index, raises blood pressure and unfavorable blood lipids – together with tobacco use, explain at least 75% of cardiovascular disease. Addressing behavioral risk factors, particularly unhealthy diet and physical inactivity can prevent hypertension. Salt reduction initiatives can make a major contribution to prevention and control of high blood pressure. However, vertical programs focusing on hypertension control alone are not cost effective [50]. Integrated context specific program including behavior change, identification and management of hypertension needs to be designed implemented at scale through a primary health care approach. That will be an affordable and sustainable approach for countries to tackle the increasing burden of hypertension [50].

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AUTHOR CONTRIBUTIONS

The study was designed, and analysis was conceptualized by Rasheda Khanam **(**RK) and Abdullah H. Baqui (AHB). RK, AHB, Salahuddin Ahmed and Sayedur Rahman implemented the study. Syed Jafar Raza Rizvi and Sayed Mamun Ibne Moin managed the data. RK and

Malathi Ram conducted data analysis. RK drafted the manuscript with support from AHB. All authors reviewed and provided feedback on the draft and approved the final manuscript.

COMPETING INTERESTS

All authors declare that they have no conflict of interest

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Figure 1: Distribution of blood pressure categories by age, sex, BMI and waist circumference, Sylhet, Bangladesh

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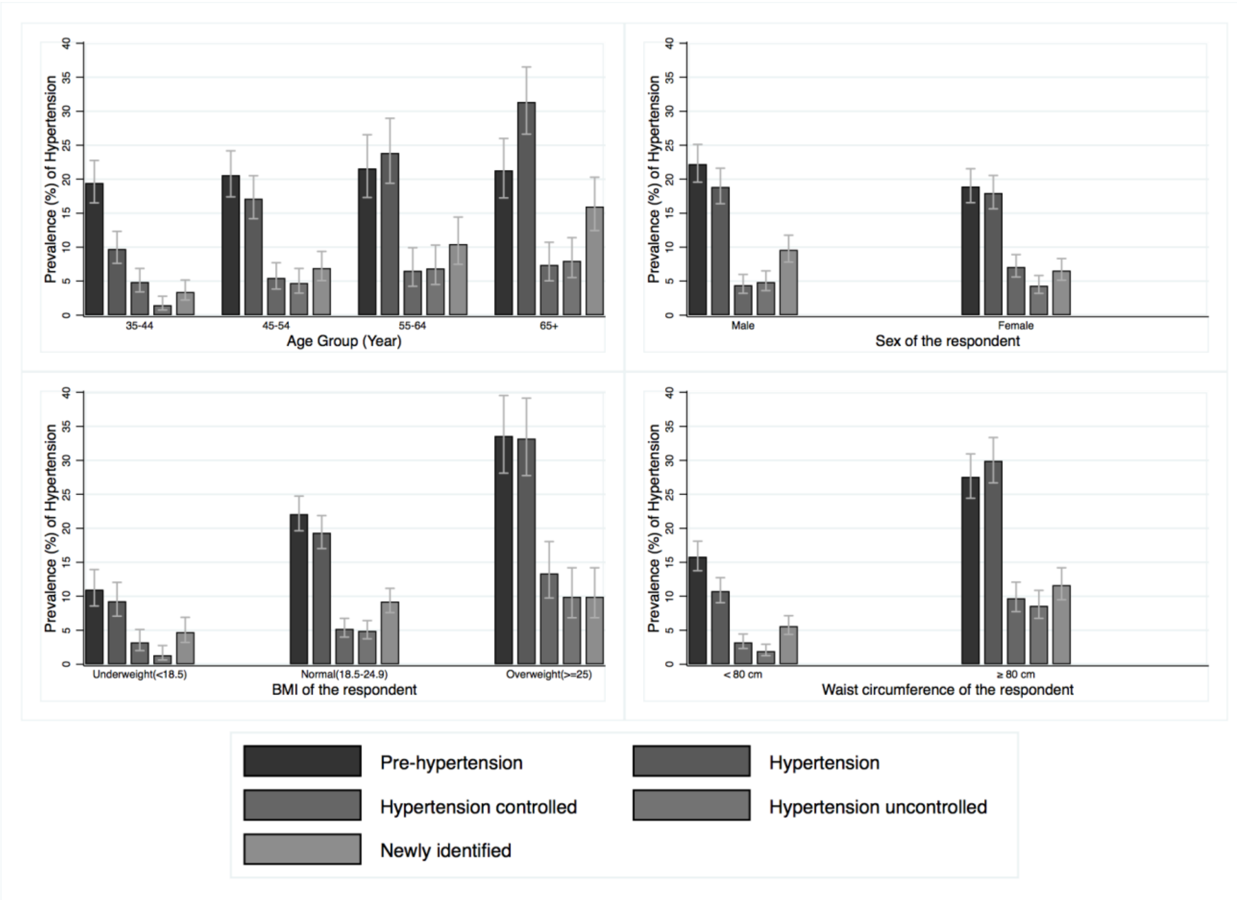

Figure 1: Distribution of blood pressure categories by age, sex, BMI and waist circumference, Sylhet, Bangladesh

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	In abstract, page 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 4 and 5
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 5
Methods			
Study design	4	Present key elements of study design early in the paper	Page 5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 5, 6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Page 6, 7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 7, 8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 7-9
Bias	9	Describe any efforts to address potential sources of bias	Page 7
Study size	10	Explain how the study size was arrived at	Page 6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Page 9
		(*b*) Describe any methods used to examine subgroups and interactions	Page 9
		(*c*) Explain how missing data were addressed	Data were missing in 11.2%, page 10
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	We assumed 15%

			refusal, page6
		(*e*) Describe any sensitivity analyses	Not applicable
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Page 10
		(b) Give reasons for non-participation at each stage	Page 10
		(c) Consider use of a flow diagram	Not considered necessary
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Text, page 11 Table, page 10, 11
		(b) Indicate number of participants with missing data for each variable of interest	Not applicable
Outcome data	15*	Report numbers of outcome events or summary measures	Text, page 11,12 Table, page 12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Text, page 13 Table, page 12, 13
		(*b*) Report category boundaries when continuous variables were categorized	Text, page 7-9 Table 10, 11
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Text, page 11, 12 Figure 1
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 17
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 15-18
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 17
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 19

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Prevalence and factors associated with hypertension among adults in rural Sylhet district of Bangladesh: A cross-sectional study

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Prevalence and factors associated with hypertension among adults in rural Sylhet district of Bangladesh: A cross-sectional study

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Figure:1

Abstract:

Objectives: All low- and middle-income countries are undergoing epidemiological transition, however, the progression is varied. Bangladesh is simultaneously experiencing a continuing burden of communicable diseases and an emerging burden of non-communicable diseases (NCDs). For effective use of limited resources, an increased understanding of the shifting burden and better characterization of risk factors of NCDs including hypertension is needed to develop scalable public health programs. This study provides data on prevalence and factors associated with hypertension among males and females 35 years and older in rural Bangladesh.

Methods:

This is a population based cross-sectional study conducted in Zakiganj and Kanaighat sub-districts of Sylhet district of Bangladesh. Blood pressure was measured and data on risk factors were collected using STEPS instrument from 864 males and 946 females aged 35 years and older between August 2017 and January 2018. Individuals with systolic blood pressure of ≥140 mmHg or diastolic blood pressure of ≥90 mmHg or taking antihypertensive drugs were considered hypertensive. Bivariate and multivariate analyses were performed to identify factors associated with hypertension.

Results: The prevalence and 95% confidence interval (CI) of hypertension was 18.8% (16.3-21.5) and 18.7% (16.3-21.3) in adult males and females, respectively. Among those who were hypertensive, the prevalence of controlled, uncontrolled and unaware/newly identified hypertension were 23.5%, 25.9% and 50.6%, respectively among males and 38.4%, 22.6% and 39.0%, respectively among females. Another 22.7% males and 17.8% females had pre-hypertension. Increasing age and higher waist circumference (≥90 cm for males and ≥80 cm for females) were positively associated with hypertension both in males and females.

Conclusions: In view of the high burden of hypertension and pre-hypertension, a context-specific scalable public health program including behavior change communications as well as identification and management of hypertension needs to be developed and implemented.

Strengths and limitations of this study

- The study provides primary data on prevalence and risk factors of hypertension for adult males and females from community-based samples of a low resource setting.
- We used standard and validated STEPS instrument which is used widely allowing comparison of our data with data from other studies.
- The cross-sectional nature of the study limits the ability to establish causal relationship between the observed factors and hypertension.
- We could not measure all the potential risk factors for hypertension which could have enhanced the interpretation.

Keywords: Hypertension, Bangladesh, Cross sectional study.

INTRODUCTION

Each year an estimated 41 million people die from non-communicable diseases (NCDs) accounting for about 70% of all deaths globally [1]. Hypertension is one of the most common NCDs. According to the Global Burden of Disease (GBD) reports, between 1990 and 2010, there has been a shift in disease burden from communicable diseases to NCDs [1 2]. This was most notable in South Asia and sub-Saharan Africa regions, where a substantial proportion of the world's population reside and where high blood pressure has had a particularly large effect on disease burden [2]. Globally, high blood pressure was the 4th leading risk factor for GBD in 1990, as quantified by disability adjusted life years (DALYs); it ranked as the leading risk factor in 2010 [2]. About one out of four adults around the world have hypertension and it is projected to increase to 29.2% by 2025, which will be more than 1.5 billion people worldwide[3-5].

Uncontrolled hypertension increases the risks of cardiovascular disease, strokes, and end-stage renal failure [6]. It accounts for about 45% of deaths due to ischemic heart disease and 52% of deaths due to stroke [6]. Older age, overweight/obesity, unhealthy diet, lack of physical exercise, smoking tobacco products, and family history of hypertension are major risk factors for hypertension [7 8].

The prevalence of hypertension is increasing, primarily in low- and middle-income countries (LMICs) and remain steady or decreasing in high-income countries (HICs) [3]. In South Asia, the prevalence of hypertension is approximately 33% among people aged 18 years and older with a secular trend documenting that the burden of hypertension is increasing over time [9]. South Asia region accounts for 23% (or an estimated 258 million) of global hypertension burden[9]. An increase in hypertension prevalence in South Asia including Bangladesh could be attributed largely to modifiable behavioral risk factors such as unhealthy diet, sedentary lifestyle, excess weight, tobacco consumption, alcohol abuse, and chronic stress including aging and urbanization [10-12].

Bangladesh, like many other LMICs, is undergoing an epidemiologic transition and an increased understanding of the burden and risk factors of hypertension is necessary to combat the increasing burden [13]. A nationally representative survey conducted in 2011 (BDHS-2011) suggests that the prevalence of hypertension including undiagnosed and uncontrolled hypertension in Bangladeshi adults is high [14-18].However, the available data is not adequate to provide regional or district level estimates. We have conducted this study among adults 35 years and older in a rural district of Bangladesh where we have been working for about two decades to develop and implement a scalable intervention for hypertension.

METHODS

Study design and setting

This was a population-based cross-sectional study conducted between August 2017 and January 2018 in an established field research site in Zakiganj and Kanaighat sub-districts of Sylhet district of Bangladesh. The site is maintained by a research partnership of the Johns Hopkins University, Baltimore, Maryland, USA, the Bangladesh Ministry of Health and Family Welfare, and Bangladeshi non-governmental organizations. The study site is located in the north-east part of Bangladesh adjacent to the Indian states of Assam and Meghalaya, about 300 kilometers away from Dhaka, the capital city of Bangladesh. Every village and household in the area are numbered. All married women of reproductive age have two numbers, a current identification number (CID) to locate the individual on the ground and a permanent identification number (PID) allowing longitudinal linkages. We maintain a basic demographic surveillance in our study area which include periodic census and updating of vital events (births, deaths and movements) by 2 monthly home visits [19-21]. The database of all individuals including their date of birth and sex, constituted the sampling frame.

Sample Size

Sample size was estimated to measure the prevalence of hypertension separately for adult males and females 35 years and older in the study population. Conservatively assuming a hypertension prevalence of 10% in both males and females, a ± 2% precision, and a significance level of 5%, the estimated sample size was 865 in each group. Assuming a 15% refusal or absence, we selected 1,020 individuals in each group. This sample size allows us to detect a 5% difference in the prevalence of hypertension between males and females.

Study Population and implementation

Individuals, either a male or female aged 35 year and older were eligible to participate in the study. Pregnant women were excluded. We recruited the study participants from the database using computer generated random numbers. They were visited in their homes by trained community health workers (CHWs) with a minimum of 10th grade education, who were already collecting routine surveillance and other study specific data, including blood pressure measurement of pregnant women [22 23]. Given cultural sensitivities, two male CHWs were recruited to collect data from male participants. All CHWs received study specific training.

Upon obtaining informed consent, CHWs administered an adapted version of the WHO's expanded STEP instrument at the participant's home [24 25]. The instrument contained questions on NCD behavioral risk factors, including dietary habit, tobacco consumption, and physical activity. Data on other co-variates (e.g., household socio-economic status, education, occupation) were collected.

After completing the household survey, CHWs measured blood pressure (BP) in mmHg using digital BP machine (OMRON 5 Series®, model: BP742N). The digital machines were calibrated fortnightly by a physician against a gold standard mercury sphygmomanometer. We measured both systolic and diastolic blood pressure three times at approximately 10-minute intervals between measurements [16]. All measurements were recorded in a data form and the average of the last two measurements were used for this analysis. During measurements, the study participant remained seated with legs uncrossed and back and arm supported. We used two different cuff sizes based on mid-upper arm circumference (MUAC) measurement. For participants with a MUAC of <22 cm, we used small cuff and for those with a MUAC of >22 cm, we used a medium cuff. The cuff was placed above the left elbow at the level of chest. In addition, CHWs obtained measurements of weight (in kilograms), height (in centimeter), waist circumference (in centimeter), hip circumference (in centimeter) and mid upper arm circumference (MUAC, in centimeter) of the study participants using standardized methods.

Measurements

Blood pressure was classified as normal, pre-hypertension, or hypertension, based on criteria used in the World Health Organization-International Society of Hypertension (WHO-ISH) [26]. A participant was considered to have normal blood pressure if systolic blood pressure (SBP) was <120 mmHg and the diastolic blood pressure (DBP) <80 mmHg and not taking antihypertensive drugs. An SBP of 120-139 mmHg or a DBP of 80-89 mmHg with no history of taking antihypertensive medication during survey was classified as prehypertension[27]. A participant was considered having hypertension if the SBP was ≥140 mmHg or DBP was ≥90 mmHg or the blood pressure was below these cut-offs, but the study participant reported taking antihypertensive medication. Controlled hypertension was defined as an SBP <140 mmHg and a DBP <90 mmHg and reported use of antihypertensive medication during survey. A SBP of ≥140 mmHg or a DBP ≥90 mmHg in a study participant taking antihypertensive medication was considered as uncontrolled hypertension. An individual with SBP ≥140 mmHg or DBP ≥90 mmHg with no history of taking antihypertensive medication was considered as newly identified or unaware of hypertension. The participants with high measured BP were referred to the hospital for further evaluation and care.

Participants' were categorized based on age into four groups (35-44, 45-54, 55-64, and ≥65 years old). We calculated body mass index (BMI) as the ratio of weight in kilograms to height in meters squared (weight in kg/height in m^2) and categorized using the WHO-recommended cutoff points: underweight (<18.5 kg/m^2), normal (18.5 – 24.9 kg/m^2), and obese/overweight (≥25.0 kg/m^2) [28]. We categorized waist circumference into low risk (<90 cm for males and <80 cm for females) and high risk (≥90 cm for males and ≥80 cm for females). We created a household wealth score based on type of housing, source of drinking water, type of toilet, availability of electricity and household possessions as a measure of household economic status, using the Principal Component Analysis (PCA)[29 30]. The wealth index is a composite measure of a household's cumulative wealth that places individual household on a continuous scale of relative wealth. We divided the households in to wealth tertiles .

We used STEPS instrument to collect data on risk and protective factors [31]. The data on fruits and vegetables intake were combined and categorized into <2 servings per day, 2-4 servings per day and ≥5 servings per day. Participants were defined as a current smoker if they reported smoking cigarettes, cigars, or pipes during the survey. Similarly, participants were defined as a current smokeless tobacco user if reported using smokeless tobacco products such as snuff, chewing tobacco leaf, *goul*, *noshi* or *zarda* at the time of the survey. We collected data on physical activity (PA) across all domains including work, transportation (walking/biking) and leisure- time/recreational activity. Data on time spent on PA were converted into minutes per week and then we calculated metabolic equivalent task (MET)-minutes per week for all activities combined[32]. According to standard classification, a MET-minute of <600 per week is classified as low PA, 600-3000 MET-minutes is considered as moderate PA and >3000 MET-minutes is considered as high PA. In our population, there was none with high PA. Based on distribution of MET-minutes, we have categorized our population into very low PA (<300 MET-min/week), low PA (300 to <600 MET-min/week) and moderate PA (>600 MET-min/week).

Data analysis

We presented percent distribution of selected sociodemographic and other factors including median and interquartile range for continuous variables for the total sample as well as separately for males and females. We calculated the prevalence and 95% confidence intervals (CI) of hypertension, pre-hypertension, controlled, uncontrolled and unaware or newly identified hypertension using WHO-ISH guidelines [26]. Bivariate and multivariable logistic regression were used to identify factors significantly associated with hypertension separately for males and females. First, we conducted bivariate logistic regression analysis. Variables with a p-value of <0.05 in the bivariate analyses were included in the multivariable logistic regression model. In addition, we have added a few variables (smoking, consumption of fruits and vegetables and physical activity) as a priori even if those variables were not statistically associated in bivariate analysis because these variables have been shown to be associated with hypertension and there is biological basis for it. Data was analyzed using Stata version 15 (StataCorp 2015).

We obtained approval from the National Research Ethics Committee of the Bangladesh Medical Research Council (BMRC) and the Institutional Review Board (IRB) of the Johns Hopkins Bloomberg School of Public Health, USA to conduct the research.

Patient and Public Involvement: Patients or public were not involved in the design of the study. We are yet to disseminate the results.

RESULTS

We approached 1,020 males and 1,019 females aged 35 years or older (total of 2,039) for study participation. Among the 1,020 males, 29 (2.8%) refused participation, 49 (4.8%) were absent and 76 (7.5%) were excluded for other reasons. Among the 1,019 females, 7 (0.7%) refused, 7 (0.7%) were absent, 14 (1.4%) were excluded because they were pregnant, and 45 (4.4%) were excluded for other reasons. Of the 1,810 participants who completed the survey, 864 were male and 946 were female. Distributions of sociodemographic and lifestyle characteristics of male, female and all participants are presented in Table 1.

Table 1: Socio-demographic and lifestyle characteristics among adult males and females in Sylhet district of Bangladesh

Characteristics	Males (N=864)	Females (N=946)	Total (N=1,810)
	n (%)[1]	n (%)[1]	n (%)[1]
Age (years)			
35-44	260 (30.1)	357 (37.7)	617 (34.1)
45-54	259 (30.0)	290 (30.7)	549 (30.3)
55-64	167 (19.3)	139 (14.7)	306 (16.9)
65+	178 (20.6)	160 (16.9)	338 (18.7)
Median (IQR)	50 (42,60)	47 (40, 57)	48 (41, 59)
Education (years of schooling)			
No education	99 (11.5)	234 (24.7)	333 (18.4)

Characteristics	Males (N=864)	Females (N=946)	Total (N=1,810)
1-5 years	522 (60.4)	604 (63.9)	1,126 (62.2)
6-10 years	243 (28.1)	108 (11.4)	351 (19.4)
Median (IQR)	5 (1, 7)	1 (1, 5)	2 (1, 5)
Wealth status			
Lowest tertile	293 (33.9)	317 (33.5)	610 (33.7)
Middle tertile	288 (33.3)	323 (34.1)	611 (33.8)
Highest tertile	283 (32.8)	306 (32.4)	589 (32.5)
Body mass index (BMI)			
Underweight (<18.5 kg/m2)	248 (28.7)	283 (29.9)	531 (29.3)
Normal (18.5-24.9 kg/m2)	523 (60.5)	503 (53.2)	1,026 (56.7)
Overweight/obese (>=25 kg/m2)	93 (10.8)	160 (16.9)	253 (14.0)
Median (IQR)	20.1 (18.2, 22.5)	20.5 (18.0, 23.3)	20.3 (18.1, 22.9)
[2]Waist circumference (cm)			
Low risk	746 (86.3)	544 (57.5)	1,290 (71.3)
High risk	118 (13.7)	402 (42.5)	520 (28.7)
Median (IQR)	76.4 (70.5, 84.2)	77.3 (69.2, 85.5)	77.0 (69.7, 84.8)
Current smoker			
No	318 (36.8)	910 (96.2)	1,228 (67.9)
Yes	546 (63.2)	36 (3.8)	582 (32.2)
Current smokeless tobacco user			
No	82 (9.5)	137 (14.5)	219 (12.1)
Yes	782 (90.5)	809 (85.5)	1,591 (87.9)
Number of servings of fruits and vegetables/day			
<2 serving	456 (52.8)	432 (45.7)	888 (49.1)
2-4 servings	283 (32.8)	415 (43.9)	698 (38.6)
>=5 servings	125 (14.5)	99 (10.5)	224 (12.4)
Median (IQR)	0 (0, 1)	1 (0, 1)	1 (0, 1)
Physical activities (PA)			
Very low PA (<300 met min/wk)	499 (57.8)	886 (93.7)	1385 (76.5)
Low PA (300 to <600 met min/wk)	310 (35.9)	38 (4.0)	348 (19.2)
Moderate PA (>600 met min/wk)	55 (6.4)	22 (2.3)	77 (4.3)

221 [1]: column percentage; IQR: interquartile range; [2] For males, low risk is <90 cm and high risk is >=90 cm and for
222 females, low risk is <80 cm and high risk is >=80 cm

223 The median ages of male and female participants were 50 (IQR 42, 60) years and 47
224 (IQR 40, 57) years, respectively. The median BMI of males and females were 20.1 (IQR 18.2,
225 22.5) and 20.5 (IQR 18.0, 23.3) kg/m^2, respectively. Among females, 16.9% were
226 overweight/obese and 42.5% had high waist circumference (≥80 cm). Majority of the males
227 (63.2%) reported smoking currently compared to 3.8% of the females who did so. About 14.5%

males and 10.5% females reported intake of >=5 servings of fruits and vegetables per day. Majority of the males (57.8%) and most females (93.7%) reported very low PA. (Table 1).

The prevalence and 95% confidence interval of hypertension was 18.8% (16.3-21.5) in males and 18.7% (16.3-21.3) in females (Table 2). Among those with hypertension, the prevalence of controlled, uncontrolled and unaware/newly identified hypertension was 23.5%, 25.9% and 50.6%, respectively among males and 38.4%, 22.6% and 39.0%, respectively among females (Table 2 and figure 1). Another 22.7% of the males and 17.8% of the females were pre-hypertensive.

Table 2: Distribution of blood pressure levels in males and females in rural Bangladesh

Blood pressure categories	Males N= 864	Females N=946	Total N=1,810
	%, 95% CI	%, 95% CI	%, 95% CI
Normal blood pressure[1]	58.6, 55.2-61.8	63.5, 60.4-66.5	61.2, 58.9-63.4
Pre-hypertension[2]	22.7, 20.0 –25.6	17.8, 15.4-20.3	20.1, 18.3-22.0
Hypertension[3]	18.8, 16.3-21.5	18.7, 16.3-21.3	18.7, 17.0-20.6
	n= 162	n=177	n=339
Controlled[4]	23.5, 17.2-30.7	38.4, 31.2-46.0	31.3, 26.4-36.5
Uncontrolled[5]	25.9, 19.4-33.4	22.6, 16.7-29.5	24.2, 19.7-29.1
Newly identified[6]	50.6, 42.7-58.6	39.0, 31.8-46.6	44.5, 39.2-50.0

Notes: [1]SBP <120 mmHg and DBP <80 mmHg and not taking antihypertensive medication; [2]SBP 120-139 mmHg or DBP 80-89 mmHg and not taking antihypertensive medication; [3]SBP ≥140 mmHg or DBP ≥ 90 mmHg or taking antihypertensive medication; [4]SBP <140 mmHg and DBP < 90 mmHg but taking antihypertensive medication; [5]SBP ≥140 mmHg or DBP ≥ 90 mmHg and taking antihypertensive medication; [6]SBP ≥140 mmHg or DBP ≥ 90 mmHg and not taking antihypertensive medication.

Simple and multivariable logistic regression analyses to investigate factors associated with hypertension are presented in Table 3. In unadjusted logistic regression, the risk of hypertension was higher among those older than 45 years, overweight/obese, and who had high waist circumference (≥90 cm for males and ≥80 cm for females). The odds of hypertension were lower in both males and females who were underweight. Among males, those who belonged to the highest wealth tertile and among females who belonged to the middle and highest wealth tertiles had significantly higher odds of hypertension in unadjusted logistic regression. Among males, compared to those with very low PA, those with low and moderate PA had lower prevalence of hypertension (Table 3).

Table 3: Factors associated with hypertension among males and females in rural Bangladesh

Characteristics	Males		Females	
	Unadjusted OR, 95% CI	**Adjusted OR, 95% CI**	**Unadjusted OR, 95% CI**	**Adjusted OR, 95% CI**
Age (years)				
35-44	Ref		Ref	Ref
45-54	1.6, 0.9-2.7	1.3, 0.8-2.4	2.2, 1.4- 3.5**	2.3, 1.5-3.8***
55-64	3.2, 1.9-5.5***	3.0, 1.7-5.4***	2.6, 1.6- 4.5***	3.1, 1.7-5.4***
65+	3.8, 2.3-6.4***	3.5, 2.0-6.3***	4.8, 3.0- 7.8***	5.7, 3.4-9.5***
Education (years)				
No education	Ref	------------	Ref	----
1-5 years	1.3, 0.7- 2.4		1.1, 0.8- 1.7	
≥ 6 years	1.7, 0.9- 3.3		1.1, 0.6- 1.9	
Wealth status				
Lowest tertile	Ref	Ref	Ref	Ref
Middle tertile	1.1, 0.7-1.7	0.9, 0.6-1.5	1.7, 1.1-2.6*	1.7, 1.0-2.7*
Highest tertile	1.8, 1.2-2.7**	1.1, 0.7-1.7	2.6, 1.7-3.9***	2.2, 1.4-3.6**
Body mass index (BMI)				
Underweight (<18.5 kg/m^2)	0.4, 0.3-0.7**	------------	0.4, 0.3- 0.7***	------------
Normal (18.5 - <25 kg/m^2)	Ref		Ref	
Overweight (>=25 kg/m^2)	2.9, 1.8-4.6***		1.6, 1.1- 2.4*	
Waist circumference (cm)[1]				
Low risk	Ref			
High risk	4.6, 3.0-6.9***	4.0, 2.5-6.4***	2.9, 2.1- 4.1***	2.8, 2.0-4.1***
Current smoker				
No	Ref	Ref	Ref	Ref
Yes	0.5, 0.4- 0.7***	0.7, 0.5-1.0	1.1, 0.5- 2.4	0.8, 0.3-1.9
Current smokeless tobacco users				
No	Ref	Ref	Ref	Ref
Yes	0.5, 0.3- 0.9*	0.6, 0.4-1.1	1.0, 0.6-1.7	0.9, 0.5-1.5
Number of fruits and vegetables servings/day				
<2 servings	Ref	Ref	Ref	Ref
2-4 servings	1.3, 0.9-1.9	1.1, 0.7-1.6	1.0, 0.7-1.4	0.8, 0.5-1.2
>5 servings	1.6, 1.0-2.6	1.5, 0.9-2.6	1.4, 0.8-2.4	1.2, 0.7-2.1
Physical activities (PA)				
Very low PA (<300 met min/wk)	Ref	Ref	Ref	Ref
Low PA (300 to <600 met min/wk)	0.4, 0.2-0.6***	0.6, 0.4- 1.0*	0.5, 0.2- 1.4	0.5, 0.2- 1.6
Moderate PA (>600 met min/wk)	0.2, 0.1- 0.6**	0.3, 0.1- 1.0*	0.9, 0.3- 2.8	1.3, 0.4- 4.2

Notes: OR: odds ratio, CI: confidence interval, *: p<0.05, **: p<0.01, ***: p<0.001; [2] For males, low risk is <90 cm and high risk is >=90 cm and for females, low risk is <80 cm and high risk is >=80 cm

In the adjusted logistic regression model, we included waist circumference but not BMI because they were highly correlated (r = .68). In the adjusted analysis, among males, age older than 45 years and waist circumference ≥90 cm was positively and reported low and moderate PA were inversely related to risk of hypertension (Table 3). Among females, older age, higher socioeconomic status and waist circumference ≥80 cm was positively related with risk of hypertension (Table 3). The odds of hypertension were increasing as the age was increasing both in males (45-55 y: adjusted odds ratio [aOR] 1.3, 95% CI: 0.8-2.4; 55-64 y: aOR 3.0, 95% CI 1.7-5.4, 65+ y: aOR 3.5, 95% CI 2.0-6.3) and in females (45-55 y: aOR 2.3, 95% CI 1.5-3.8, 55-64 y: aOR 3.1, 95% CI 1.7-5.4, 65+ y: aOR 5.7, 95% CI 3.4-9.5). The odds of hypertension were four-folds higher among males (aOR 4.0, 95% CI 2.5-6.4) and three-folds higher among females (aOR 2.9, 95% CI 2.1-4.1) with high waist circumference (≥90 cm in males and ≥80 cm in females). In a subsequent adjusted model, we replaced waist circumference by BMI; overweight/obese was significantly associated with greater odds of hypertension in both males (aOR 3.1, 95% CI 1.8-5.3) and females (aOR 1.9, 95% CI: 1.2-2.9) (data not shown).

DISCUSSION

In this population-based cross-sectional study in rural Bangladesh, the prevalence of hypertension was high among both males (18.8%) and females (18.7%). The prevalence of pre-hypertension was also high at 22.7% among males and 17.8% among females. Among those who had hypertension, more than half of the males and about a third of the females were not aware of it. Additionally, about a quarter of the hypertensive males and females had uncontrolled hypertension. Compared to males, a higher proportion of females had controlled hypertension.

The data on prevalence of and risk factors for hypertension in Bangladesh is limited. The Bangladesh Demographic and Health Survey 2011 (BDHS-2011) measured blood pressure in a nationally representative sample of adult males and females [16]. The BDHS estimates of hypertension prevalence for Sylhet division were similar to our finding among males but was higher (25.2%) among females. However, the BDHS Sylhet prevalence rate for females was based on 232 women with a wide confidence interval (19.6-31.1). BDHS documented a substantial urban versus rural and regional variations. The urban sample had a much higher prevalence than the rural sample (40.2% vs 29.4%). Among eight divisions (regions) of Bangladesh, Sylhet division where the current study was conducted, had the lowest prevalence (25.2%) [16]. Our findings of prevalence of hypertension is similar in females (18.4% vs 18.7%) but higher in males (13.5% vs 18.8%) than in a study conducted among adults 25 years and older in 2005 in three rural areas of Bangladesh[33].

Our findings of positive associations between hypertension and potential risk factors such as age, BMI, and waist circumference are consistent with several studies from Bangladesh and elsewhere [17 18 34]. A dose response relationship was observed between the risk of hypertension and age, the risk increased with the increase of age; highest risk was observed in the oldest age groups among both males and females [18 35].

High BMI is an established risk factor for hypertension [15]; several studies found that overweight/obesity had the strongest association with hypertension [33 36 37]. Body weight is the balance between consumption and expenditure of energy. One would expect higher calorie consumption among higher SES group. Adult males and females with a higher waist circumference had four- and three-fold higher risks of hypertension, respectively. Both BMI and waist circumference are established risk factors for hypertension. In our study, we analyzed them separately but presented waist circumference data instead of BMI because several studies suggested that abdominal fat deposition is generally a stronger predictor of hypertension than BMI-based association [38 39]. Moreover, we chose waist circumference in our model instead of BMI because it can be easily measured, and programs can use it for screening provided training is adequate.

Compared to those who belonged to the poorest wealth group, we observed about a two-fold higher risk of hypertension among females but not among males who belonged to higher wealth groups. The association of socio-economic status with hypertension is not consistent across studies; some studies observed higher rate of hypertension among higher socioeconomic group and yet, other studies observed higher rate among the poor[33 40 41]. A recent review reported an overall increased risk of hypertension among the lowest SES, particularly in high-income countries[41].

Association between PA and risk of hypertension are well documented. Interventional studies showed beneficial effects of PA on blood pressure reduction[42 43]. Recreational PA is uncommon in our population (<1%). We observed a lower risk among males who reported PA for ≥300 MET minutes per week. Compared to those with very low PA, the odds of having hypertension was 40.0% and 70.0% less among males who had reported low and moderate PA respectively.

We did not see a protective effect of fruit or vegetable consumptions on hypertension in our population. In this poor agrarian community most people consume vegetables every day, the quantity might be low. Fruit consumption is low among rural Bangladeshi people. Seasonal fruits are grown in abundance but are not popular because people do not consider them as good fruit [44]. Imported fruits are costly and remain unaffordable to many people leading to a very low consumption of fruit [44]. The benefit of fruits and vegetable consumption is primarily through increased intake of potassium [45 46]. All vegetables may not contain high level of potassium and washing, and cooking may reduce potassium level [47]. In this study, we did not see a higher risk among smokers. Not seeing a benefit of fruit and vegetable consumptions or not seeing an increased risk among smokers could be due to reverse causation i.e., those with hypertension might have modified their behavior but that is unlikely because about half of those hypertensive were newly diagnosed.

The study has several limitations. The cross-sectional nature of the study limits the ability to establish causal relationship between the observed risk factors and hypertension. Also, the study was conducted in one region of Bangladesh and may not be generalizable for the entire country. The sample size is small, which limited risk factor analysis. We could not measure or collect data on all variables associated with hypertension. We defined hypertension by measuring blood pressure levels at the field level, not in a clinic setting. However, our workers were adequately trained and had years of experience measuring blood pressure in the field setting. We calibrated the blood pressure machines fortnightly against mercury sphygmomanometer. This survey used standard and pre-tested STEPs questionnaire to collect data from study participants which is used widely allowing comparison of our data with data from other studies.

Our finding of high rates of hypertension in this rural area is important because the risk of CVDs is about 16 folds higher among those with hypertension compared to those with a SBP of <115 and DBP of <75 [48]. However, the risk of CVDs is higher for all individuals with a SBP >115 or DBP >75 [48-50]. For every 10 mm increase in BP, the risk almost doubles. Although the risk is lower in the so-called normal BP groups compared to those with hypertension, since there are many more individuals in these BP categories, the burden of CVD related to hypertension among them is substantial. Therefore, efforts need to be made to identify and control hypertension and adopt strategies to reduce blood pressure of the entire population and prevent rise of BP with age.

Our results show a high prevalence of hypertension and pre-hypertension in the surveyed population. In addition, high prevalence of newly diagnosed and uncontrolled hypertension despite the availability of low cost and safe drugs for hypertension is a major public health concern. Apart from age, the most important risk factor of hypertension is behavioral and potentially modifiable. For example, inappropriate diet and inadequate physical inactivity lead to overweight/obesity, raises blood pressure and increases unfavorable blood lipids. These factors together with tobacco use, explain at least 75% of cardiovascular disease. Addressing behavioral risk factors, particularly unhealthy diet and physical inactivity can prevent hypertension. Salt reduction initiatives can make a major contribution to prevention and control of high blood pressure. However, vertical programs focusing on hypertension control alone are not cost effective [51]. Integrated context specific program including behavior change and identification and management of hypertension needs to be designed and implemented at scale through a primary health care approach. That will be an affordable and sustainable approach for countries to tackle the increasing burden of hypertension [51].

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AUTHOR CONTRIBUTIONS

The study was designed, and analysis was conceptualized by Rasheda Khanam **(**RK) and Abdullah H. Baqui (AHB). RK, AHB, Salahuddin Ahmed, Sayedur Rahman, and Ahad Khan implemented the study. Syed Jafar Raza Rizvi and Syed Mamun Ibne Moin managed the data. RK, Gulam Muhammed Al Kibria and Malathi Ram conducted data analysis. George Pariyo and Dustin Gibson contributed to the study design and data interpretation. RK drafted the manuscript with support from AHB. All authors reviewed and provided feedback on the draft and approved the final manuscript.

COMPETING INTERESTS

All authors declare that they have no conflict of interest

DATA SHARING STATEMENT:

No additional data available.

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Figure 1: Distribution of blood pressure categories by age, sex, BMI and waist circumference, Sylhet, Bangladesh

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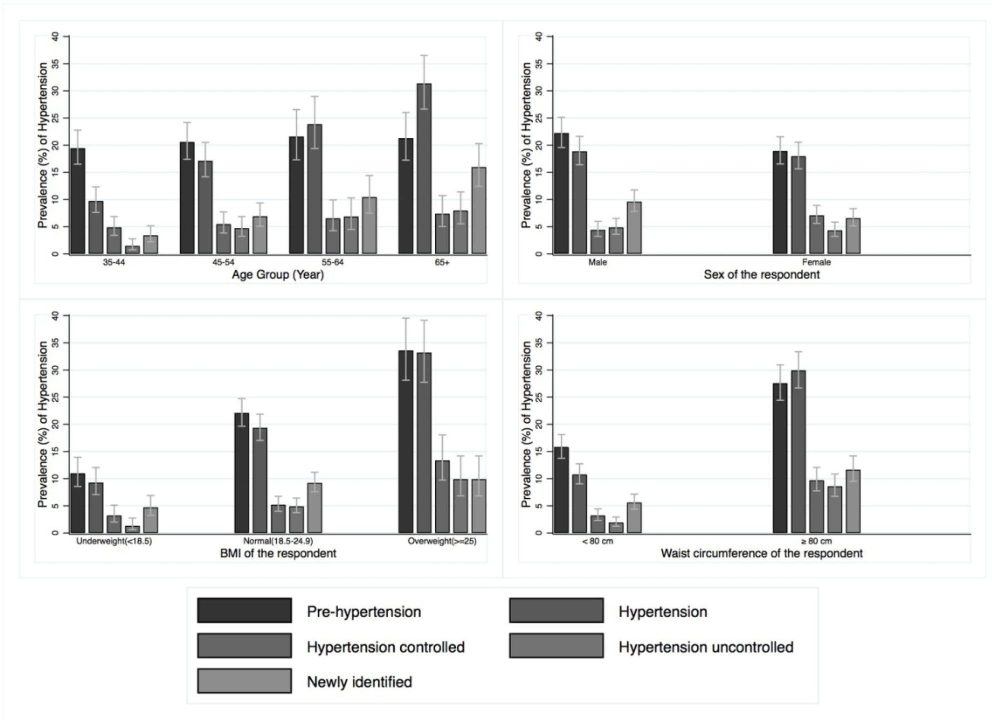

Figure 1: Distribution of blood pressure categories by age, sex, BMI and waist circumference, Sylhet, Bangladesh

123x90mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	In Title and also in abstract, page 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 4 and 5
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 5
Methods			
Study design	4	Present key elements of study design early in the paper	Page 5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 5, 6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Page 6, 7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 7, 8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 7-9
Bias	9	Describe any efforts to address potential sources of bias	Page 7
Study size	10	Explain how the study size was arrived at	Page 6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Page 9, 10
		(*b*) Describe any methods used to examine subgroups and interactions	Page 9, 10
		(*c*) Explain how missing data were addressed	Data were missing in 11.2%, page 11

		(*d*) If applicable, describe analytical methods taking account of sampling strategy	We assumed 15% refusal, page6
		(*e*) Describe any sensitivity analyses	Not applicable
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Page 10
		(b) Give reasons for non-participation at each stage	Page 10
		(c) Consider use of a flow diagram	Not considered necessary
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Text, page 11 Table, page 10, 11
		(b) Indicate number of participants with missing data for each variable of interest	Not applicable
Outcome data	15*	Report numbers of outcome events or summary measures	Text, page 13 Table, page 13
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Text, page 14-15 Table, page 14-16
		(*b*) Report category boundaries when continuous variables were categorized	Text, page 7-9 Table 11-15
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Text, page 11, 12 Figure 1
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 19
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 16-20
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 19-20
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 21

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Prevalence and factors associated with hypertension among adults in rural Sylhet district of Bangladesh: A cross-sectional study

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Abstract:

Objectives: Low- and middle-income countries are undergoing epidemiological transition, however, progression is varied. Bangladesh is simultaneously experiencing continuing burden of communicable diseases and emerging burden of non-communicable diseases (NCDs). For effective use of limited resources, an increased understanding of the shifting burden and better characterization of risk factors of NCDs, including hypertension is needed. This study provides data on prevalence and factors associated with hypertension among males and females 35 years and older in rural Bangladesh.

Methods:

This is a population based cross-sectional study conducted in Zakiganj and Kanaighat sub-districts of Sylhet district of Bangladesh. Blood pressure was measured and data on risk factors were collected using STEPS instrument from 864 males and 946 females aged 35 years and older between August 2017 and January 2018. Individuals with systolic blood pressure of ≥140 mmHg or diastolic blood pressure of ≥90 mmHg or taking antihypertensive drugs were considered hypertensive. Bivariate and multivariate analyses were performed to identify factors associated with hypertension.

Results: The prevalence of hypertension was 18.8% (95% CI: 16.3-21.5) and 18.7% (95% CI: 16.3-21.3) in adult males and females, respectively. Among those who were hypertensive, the prevalence of controlled, uncontrolled and unaware/newly identified hypertension was 23.5%, 25.9% and 50.6%, respectively among males and 38.4%, 22.6% and 39.0%, respectively among females. Another 22.7% males and 17.8% females had pre-hypertension. Increasing age and higher waist circumference (≥90 cm for males and ≥80 cm for females) were positively associated with hypertension both in males (OR, 95% CI: 4.0, 2.5-6.4) and females (OR, 95% CI: 2.8, 2.0-4.1).

Conclusions: In view of the high burden of hypertension and pre-hypertension, a context-specific scalable public health program including behavior change communications, particularly to increase physical activity and consumption of healthy diet, as well as identification and management of hypertension needs to be developed and implemented.

Strengths and limitations of this study

- The study provides primary data on prevalence and associated factors of hypertension for adult males and females from community-based samples of a low resource setting.
- We used standard and validated STEPS instrument which is used widely allowing comparison of our data with data from other studies.
- The cross-sectional nature of the study limits the ability to establish causal relationship between the observed factors and hypertension.
- We could not measure all the potential risk factors for hypertension which could have enhanced the interpretation.

Keywords: Hypertension, Bangladesh, Cross sectional study.

INTRODUCTION

Each year an estimated 41 million people die from non-communicable diseases (NCDs) accounting for about 70% of all deaths globally [1]. Hypertension is one of the most common NCDs. According to the Global Burden of Disease (GBD) reports, between 1990 and 2010, there has been a shift in disease burden from communicable diseases to NCDs [1 2]. This was most notable in South Asia and sub-Saharan Africa regions, where a substantial proportion of the world's population reside and where high blood pressure has had a particularly large effect on disease burden [2]. Globally, high blood pressure was the 4th leading risk factor for GBD in 1990, as quantified by disability adjusted life years (DALYs); it ranked as the leading risk factor in 2010 [2]. About one out of four adults around the world have hypertension and it is projected to increase to 29.2% by 2025, which will be more than 1.5 billion people worldwide[3-5].

Uncontrolled hypertension increases the risks of cardiovascular disease, strokes, and end-stage renal failure [6]. It accounts for about 45% of deaths due to ischemic heart disease and 52% of deaths due to stroke [6]. Older age, overweight/obesity, unhealthy diet, lack of physical exercise, smoking tobacco products, and family history of hypertension are major risk factors for hypertension [7 8].

The prevalence of hypertension is increasing, primarily in low- and middle-income countries (LMICs) and remain steady or decreasing in high-income countries (HICs) [3]. In South Asia, the prevalence of hypertension is approximately 33% among people aged 18 years and older with a secular trend documenting that the burden of hypertension is increasing over time [9]. South Asia region accounts for 23% (or an estimated 258 million) of global hypertension burden[9]. An increase in hypertension prevalence in South Asia including Bangladesh could be attributed largely to modifiable behavioral risk factors such as unhealthy diet, sedentary lifestyle, excess weight, tobacco consumption, alcohol abuse, and chronic stress including aging and urbanization [10-12].

Bangladesh, like many other LMICs, is undergoing an epidemiologic transition and an increased understanding of the burden and risk factors of hypertension is necessary to combat the increasing burden [13]. A nationally representative survey conducted in 2011 (BDHS-2011) suggests that the prevalence of hypertension including undiagnosed and uncontrolled hypertension in Bangladeshi adults is high [14-18].However, the available data is not adequate to provide regional or district level estimates. We have conducted this study among adults 35 years and older in a rural district of Bangladesh where we have been working for about two decades to develop and implement a scalable intervention for hypertension.

METHODS

Study design and setting

This was a population-based cross-sectional study conducted between August 2017 and January 2018 in an established field research site in Zakiganj and Kanaighat sub-districts of Sylhet district of Bangladesh. The site is maintained by a research partnership of the Johns Hopkins University, Baltimore, Maryland, USA, the Bangladesh Ministry of Health and Family Welfare, and Bangladeshi non-governmental organizations. The study site is located in the north-east part of Bangladesh adjacent to the Indian states of Assam and Meghalaya, about 300 kilometers away from Dhaka, the capital city of Bangladesh. Every village and household in the study area are numbered. We conduct periodic census of the study area. We also maintain a surveillance through 2-monthly home visits to update vital events (births, deaths and movements) in women of child-bearing age and <5 children[19-21] (19-21) but do not update adult population. We used 2016 census database to select the study sample.

Sample Size

Sample size was estimated to measure the prevalence of hypertension separately for adult males and females 35 years and older in the study population. Conservatively assuming a hypertension prevalence of 10% in both males and females, a ± 2% precision, and a significance level of 5%, the estimated sample size was 865 in each group. Assuming a 15% refusal or absence, we selected 1,020 individuals in each group. This sample size allows us to detect a 5% difference in the prevalence of hypertension between males and females.

Study Population and implementation

Individuals, either a male or female aged 35 year and older were eligible to participate in the study. Pregnant women were excluded. We recruited the study participants from the database using computer generated random numbers. They were visited in their homes by trained community health workers (CHWs) with a minimum of 10th grade education, who were already collecting routine surveillance and other study specific data, including blood pressure measurement of pregnant women [22 23]. Given cultural sensitivities, two male CHWs were recruited to collect data from male participants. All CHWs received study specific training.

Upon obtaining informed consent, CHWs administered an adapted version of the WHO's expanded STEP instrument at the participant's home [24 25]. The instrument contained questions on NCD behavioral risk factors, including dietary habit, tobacco consumption, and physical activity. Data on other co-variates (e.g., household socio-economic status, education, occupation) were collected.

After completing the household survey, CHWs measured blood pressure (BP) in mmHg using digital BP machine (OMRON 5 Series®, model: BP742N). The digital machines were calibrated fortnightly by a physician against a gold standard mercury sphygmomanometer. We measured both systolic and diastolic blood pressure three times at approximately 10-minute intervals between measurements [16]. All measurements were recorded in a data form and the average of the last two measurements were used for this analysis. During measurements, the study participant remained seated with legs uncrossed and back and arm supported. We used two different cuff sizes based on mid-upper arm circumference (MUAC) measurement. For participants with a MUAC of <22 cm, we used small cuff and for those with a MUAC of >22 cm, we used a medium cuff. The cuff was placed above the left elbow at the level of chest. In addition, CHWs obtained measurements of weight (in kilograms), height (in centimeter), waist circumference (in centimeter), hip circumference (in centimeter) and mid upper arm circumference (MUAC, in centimeter) of the study participants using standardized methods.

Measurements

Blood pressure was classified as normal, pre-hypertension, or hypertension, based on criteria used in the World Health Organization-International Society of Hypertension (WHO-ISH) [26]. A participant was considered to have normal blood pressure if systolic blood pressure (SBP) was <120 mmHg and the diastolic blood pressure (DBP) <80 mmHg and not taking antihypertensive drugs. An SBP of 120-139 mmHg or a DBP of 80-89 mmHg with no history of taking antihypertensive medication during survey was classified as prehypertension[27]. A participant was considered having hypertension if the SBP was ≥140 mmHg or DBP was ≥90 mmHg or the blood pressure was below these cut-offs, but the study participant reported taking antihypertensive medication[16]. Controlled hypertension was defined as an SBP <140 mmHg and a DBP <90 mmHg and reported use of antihypertensive medication during survey[16]. A SBP of ≥140 mmHg or a DBP ≥90 mmHg in a study participant taking antihypertensive medication was considered as uncontrolled hypertension. An individual with SBP ≥140 mmHg or DBP ≥90 mmHg with no history of taking antihypertensive medication was considered as newly identified or unaware of hypertension[28 29]. The participants with high measured BP were referred to the hospital for further evaluation and care.

Participants' were categorized based on age into four groups (35-44, 45-54, 55-64, and ≥65 years old). We calculated body mass index (BMI) as the ratio of weight in kilograms to height in meters squared (weight in kg/height in m^2) and categorized using the WHO-recommended cutoff points: underweight (<18.5 kg/m^2), normal (18.5 – 24.9 kg/m^2), and obese/overweight (≥25.0 kg/m^2) [30]. We categorized waist circumference into low risk (<90 cm for males and <80 cm for females) and high risk (≥90 cm for males and ≥80 cm for females). We created a household wealth score based on type of housing, source of drinking water, type of toilet, availability of electricity and household possessions as a measure of household economic status, using the Principal Component Analysis (PCA)[31 32]. The wealth index is a composite measure of a household's cumulative wealth that places individual household on a continuous scale of relative wealth. We divided the households in to wealth tertiles .

We used STEPS instrument to collect data on risk and protective factors [33]. The data on fruits and vegetables intake were combined and categorized into <2 servings per day, 2-4 servings per day and ≥5 servings per day. Participants were defined as a current smoker if they reported smoking cigarettes, cigars, or pipes during the survey. Similarly, participants were defined as a current smokeless tobacco user if reported using smokeless tobacco products such as snuff, chewing tobacco leaf, *goul*, *noshi* or *zarda* at the time of the survey. We collected data on physical activity (PA) across all domains including work, transportation (walking/biking) and leisure- time/recreational activity. Data on time spent on PA were converted into minutes per week and then we calculated metabolic equivalent task (MET)-minutes per week for all activities combined[34]. According to standard classification, a MET-minute of <600 per week is classified as low PA, 600-3000 MET-minutes is considered as moderate PA and >3000 MET-minutes is considered as high PA. In our population, there was none with high PA. Based on distribution of MET-minutes, we have categorized our population into very low PA (<300 MET-min/week), low PA (300 to <600 MET-min/week) and moderate PA (>600 MET-min/week).

Data analysis

We presented percent distribution of selected sociodemographic and other factors including median and interquartile range for continuous variables for the total sample as well as separately for males and females. We calculated the prevalence and 95% confidence intervals (CI) of hypertension, pre-hypertension, controlled, uncontrolled and unaware or newly identified hypertension using WHO-ISH guidelines [26]. Bivariate and multivariable logistic regression were used to identify factors significantly associated with hypertension separately for males and females. First, we conducted bivariate logistic regression analysis. Variables with a p-value of <0.05 in the bivariate analyses were included in the multivariable logistic regression model. In addition, we have added a few variables (smoking, consumption of fruits and vegetables and physical activity) as a priori even if those variables were not statistically associated in bivariate analysis because these variables have been shown to be associated with hypertension and there is biological basis for it. Data was analyzed using Stata version 15 (StataCorp 2015).

We obtained approval from the National Research Ethics Committee of the Bangladesh Medical Research Council (BMRC) and the Institutional Review Board (IRB) of the Johns Hopkins Bloomberg School of Public Health, USA to conduct the research.

Patient and Public Involvement: Patients or public were not involved in the design of the study. We are yet to disseminate the results.

RESULTS

We approached 1,020 males and 1,019 females aged 35 years or older (total of 2,039) for study participation. Among the 1,020 males, 29 (2.8%) refused participation, 49 (4.8%) were absent, 48 (4.7%) migrated out, and 28 (2.7%) died. Among the 1,019 females, 7 (0.7%) refused, 7 (0.7%) were absent, 28 (2.7%) migrated out, 14 (1.4%) died, and 14 (1.4%) were excluded because they were pregnant. Of the 1,810 participants who completed the survey, 864 were male and 946 were female. Distributions of sociodemographic and lifestyle characteristics of male, female and all participants are presented in Table 1.

Table 1: Socio-demographic and lifestyle characteristics among adult males and females in Sylhet district of Bangladesh

Characteristics	**Males (N=864)**	**Females (N=946)**	**Total (N=1,810)**
	n (%)[1]	n (%)[1]	n (%)[1]
Age (years)			
35-44	260 (30.1)	357 (37.7)	617 (34.1)
45-54	259 (30.0)	290 (30.7)	549 (30.3)
55-64	167 (19.3)	139 (14.7)	306 (16.9)
65+	178 (20.6)	160 (16.9)	338 (18.7)
Median (IQR)	50 (42,60)	47 (40, 57)	48 (41, 59)
Education (years of schooling)			
No education	99 (11.5)	234 (24.7)	333 (18.4)
1-5 years	522 (60.4)	604 (63.9)	1,126 (62.2)
≥ 6 years	243 (28.1)	108 (11.4)	351 (19.4)
Median (IQR)	5 (1, 7)	1 (1, 5)	2 (1, 5)
Wealth status			

Characteristics	Males (N=864)	Females (N=946)	Total (N=1,810)
Lowest tertile	293 (33.9)	317 (33.5)	610 (33.7)
Middle tertile	288 (33.3)	323 (34.1)	611 (33.8)
Highest tertile	283 (32.8)	306 (32.4)	589 (32.5)
Body mass index (BMI)			
Underweight (<18.5 kg/m2)	248 (28.7)	283 (29.9)	531 (29.3)
Normal (18.5-24.9 kg/m2)	523 (60.5)	503 (53.2)	1,026 (56.7)
Overweight/obese (>=25 kg/m2)	93 (10.8)	160 (16.9)	253 (14.0)
Median (IQR)	20.1 (18.2, 22.5)	20.5 (18.0, 23.3)	20.3 (18.1, 22.9)
[2]Waist circumference (cm)			
Low risk	746 (86.3)	544 (57.5)	1,290 (71.3)
High risk	118 (13.7)	402 (42.5)	520 (28.7)
Median (IQR)	76.4 (70.5, 84.2)	77.3 (69.2, 85.5)	77.0 (69.7, 84.8)
Current smoker			
No	318 (36.8)	910 (96.2)	1,228 (67.9)
Yes	546 (63.2)	36 (3.8)	582 (32.2)
Current smokeless tobacco user			
No	82 (9.5)	137 (14.5)	219 (12.1)
Yes	782 (90.5)	809 (85.5)	1,591 (87.9)
Number of servings of fruits and vegetables/day			
<2 serving	456 (52.8)	432 (45.7)	888 (49.1)
2-4 servings	283 (32.8)	415 (43.9)	698 (38.6)
>=5 servings	125 (14.5)	99 (10.5)	224 (12.4)
Median (IQR)	0 (0, 1)	1 (0, 1)	1 (0, 1)
Physical activities (PA)			
Very low PA (<300 met min/wk)	499 (57.8)	886 (93.7)	1385 (76.5)
Low PA (300 to <600 met min/wk)	310 (35.9)	38 (4.0)	348 (19.2)
Moderate PA (>600 met min/wk)	55 (6.4)	22 (2.3)	77 (4.3)

[1]: column percentage; IQR: interquartile range; [2] For males, low risk is <90 cm and high risk is >=90 cm and for females, low risk is <80 cm and high risk is >=80 cm

The median ages of male and female participants were 50 (IQR 42, 60) years and 47 (IQR 40, 57) years, respectively. The median BMI of males and females were 20.1 (IQR 18.2, 22.5) and 20.5 (IQR 18.0, 23.3) kg/m^2, respectively. Among females, 16.9% were overweight/obese and 42.5% had high waist circumference (≥80 cm). Majority of the males (63.2%) reported smoking currently compared to 3.8% of the females who did so. About 14.5% males and 10.5% females reported intake of >=5 servings of fruits and vegetables per day. Majority of the males (57.8%) and most females (93.7%) reported very low PA. (Table 1).

The prevalence and 95% confidence interval of hypertension was 18.8% (16.3-21.5) in males and 18.7% (16.3-21.3) in females (Table 2). Among those with hypertension, the prevalence of controlled, uncontrolled and unaware/newly identified hypertension was 23.5%, 25.9% and 50.6%, respectively among males and 38.4%, 22.6% and 39.0%, respectively among females (Table 2 and figure 1). Another 22.7% of the males and 17.8% of the females were pre-hypertensive.

Table 2: Distribution of blood pressure levels in males and females in rural Bangladesh

Blood pressure categories	Males N= 864	Females N=946	Total N=1,810
	%, 95% CI	%, 95% CI	%, 95% CI
Normal blood pressure[1]	58.6, 55.2-61.8	63.5, 60.4-66.5	61.2, 58.9-63.4
Pre-hypertension[2]	22.7, 20.0 –25.6	17.8, 15.4-20.3	20.1, 18.3-22.0
Hypertension[3]	18.8, 16.3-21.5	18.7, 16.3-21.3	18.7, 17.0-20.6
	n= 162	n=177	n=339
Controlled[4]	23.5, 17.2-30.7	38.4, 31.2-46.0	31.3, 26.4-36.5
Uncontrolled[5]	25.9, 19.4-33.4	22.6, 16.7-29.5	24.2, 19.7-29.1
Newly identified[6]	50.6, 42.7-58.6	39.0, 31.8-46.6	44.5, 39.2-50.0

Notes: [1]SBP <120 mmHg and DBP <80 mmHg and not taking antihypertensive medication; [2]SBP 120-139 mmHg or DBP 80-89 mmHg and not taking antihypertensive medication; [3]SBP ≥140 mmHg or DBP ≥ 90 mmHg or taking antihypertensive medication; [4]SBP <140 mmHg and DBP < 90 mmHg but taking antihypertensive medication; [5]SBP ≥140 mmHg or DBP ≥ 90 mmHg and taking antihypertensive medication; [6]SBP ≥140 mmHg or DBP ≥ 90 mmHg and not taking antihypertensive medication.

Simple and multivariable logistic regression analyses to investigate factors associated with hypertension are presented in Table 3. In unadjusted logistic regression, the risk of hypertension was higher among those older than 45 years, overweight/obese, and who had high waist circumference (≥90 cm for males and ≥80 cm for females). The odds of hypertension were lower in both males and females who were underweight. Among males, those who belonged to the highest wealth tertile and among females who belonged to the middle and highest wealth tertiles had significantly higher odds of hypertension in unadjusted logistic regression. Among males, compared to those with very low PA, those with low and moderate PA had lower prevalence of hypertension (Table 3).

Table 3: Factors associated with hypertension among males and females in rural Bangladesh

Characteristics	Males		Females	
	Unadjusted OR, 95% CI	**Adjusted OR, 95% CI**	**Unadjusted OR, 95% CI**	**Adjusted OR, 95% CI**
Age (years)				
35-44	Ref		Ref	Ref
45-54	1.6, 0.9-2.7	1.3, 0.8-2.4	2.2, 1.4- 3.5**	2.3, 1.5-3.8***
55-64	3.2, 1.9-5.5***	3.0, 1.7-5.4***	2.6, 1.6- 4.5***	3.1, 1.7-5.4***
65+	3.8, 2.3-6.4***	3.5, 2.0-6.3***	4.8, 3.0- 7.8***	5.7, 3.4-9.5***
Education (years)				
No education	Ref	------------	Ref	----
1-5 years	1.3, 0.7- 2.4		1.1, 0.8- 1.7	
≥ 6 years	1.7, 0.9- 3.3		1.1, 0.6- 1.9	
Wealth status				
Lowest tertile	Ref	Ref	Ref	Ref
Middle tertile	1.1, 0.7-1.7	0.9, 0.6-1.5	1.7, 1.1-2.6*	1.7, 1.0-2.7*
Highest tertile	1.8, 1.2-2.7**	1.1, 0.7-1.7	2.6, 1.7-3.9***	2.2, 1.4-3.6**
Body mass index (BMI)				
Underweight (<18.5 kg/m^2)	0.4, 0.3-0.7**	-------------	0.4, 0.3- 0.7***	------------
Normal (18.5 - <25 kg/m^2)	Ref		Ref	
Overweight (>=25 kg/m^2)	2.9, 1.8-4.6***		1.6, 1.1- 2.4*	
Waist circumference (cm)[1]				
Low risk	Ref			
High risk	4.6, 3.0-6.9***	4.0, 2.5-6.4***	2.9, 2.1- 4.1***	2.8, 2.0-4.1***
Current smoker				
No	Ref	Ref	Ref	Ref
Yes	0.5, 0.4- 0.7***	0.7, 0.5-1.0	1.1, 0.5- 2.4	0.8, 0.3-1.9
Current smokeless tobacco users				
No	Ref	Ref	Ref	Ref
Yes	0.5, 0.3- 0.9*	0.6, 0.4-1.1	1.0, 0.6-1.7	0.9, 0.5-1.5
Number of fruits and vegetables servings/day				
<2 servings	Ref	Ref	Ref	Ref
2-4 servings	1.3, 0.9-1.9	1.1, 0.7-1.6	1.0, 0.7-1.4	0.8, 0.5-1.2
>5 servings	1.6, 1.0-2.6	1.5, 0.9-2.6	1.4, 0.8-2.4	1.2, 0.7-2.1
Physical activities (PA)				
Very low PA (<300 met min/wk)	Ref	Ref	Ref	Ref
Low PA (300 to <600 met min/wk)	0.4, 0.2-0.6***	0.6, 0.4- 1.0*	0.5, 0.2- 1.4	0.5, 0.2- 1.6
Moderate PA (>600 met min/wk)	0.2, 0.1- 0.6**	0.3, 0.1- 1.0*	0.9, 0.3- 2.8	1.3, 0.4- 4.2

Notes: OR: odds ratio, CI: confidence interval, *: p<0.05, **: p<0.01, ***: p<0.001; [2] For males, low risk is <90 cm and high risk is >=90 cm and for females, low risk is <80 cm and high risk is >=80 cm

In the adjusted logistic regression model, we included waist circumference but not BMI because they were highly correlated (r = .68). In the adjusted analysis, among males, age older than 45 years and waist circumference ≥90 cm was positively and reported low and moderate PA were inversely related to risk of hypertension (Table 3). Among females, older age, higher socioeconomic status and waist circumference ≥80 cm was positively related with risk of hypertension (Table 3). The odds of hypertension were increasing as the age was increasing both in males (45-55 y: adjusted odds ratio [aOR] 1.3, 95% CI: 0.8-2.4; 55-64 y: aOR 3.0, 95% CI 1.7-5.4, 65+ y: aOR 3.5, 95% CI 2.0-6.3) and in females (45-55 y: aOR 2.3, 95% CI 1.5-3.8, 55-64 y: aOR 3.1, 95% CI 1.7-5.4, 65+ y: aOR 5.7, 95% CI 3.4-9.5). The odds of hypertension were four-folds higher among males (aOR 4.0, 95% CI 2.5-6.4) and three-folds higher among females (aOR 2.9, 95% CI 2.1-4.1) with high waist circumference (≥90 cm in males and ≥80 cm in females). In a subsequent adjusted model, we replaced waist circumference by BMI; overweight/obese was significantly associated with greater odds of hypertension in both males (aOR 3.1, 95% CI 1.8-5.3) and females (aOR 1.9, 95% CI: 1.2-2.9) (data not shown).

DISCUSSION

In this population-based cross-sectional study in rural Bangladesh, the prevalence of hypertension was high among both males (18.8%) and females (18.7%). The prevalence of pre-hypertension was also high at 22.7% among males and 17.8% among females. Among those who had hypertension, more than half of the males and about a third of the females were not aware of it. Additionally, about a quarter of the hypertensive males and females had uncontrolled hypertension. Compared to males, a higher proportion of females had controlled hypertension.

The data on prevalence of and risk factors for hypertension in Bangladesh is limited. The Bangladesh Demographic and Health Survey 2011 (BDHS-2011) measured blood pressure in a nationally representative sample of adult males and females [16]. The BDHS estimates of hypertension prevalence for Sylhet division were similar to our finding among males but was higher (25.2%) among females. However, the BDHS Sylhet prevalence rate for females was based on 232 women with a wide confidence interval (19.6-31.1). BDHS documented a substantial urban versus rural and regional variations. The urban sample had a much higher prevalence than the rural sample (40.2% vs 29.4%). Among eight divisions (regions) of Bangladesh, Sylhet division where the current study was conducted, had the lowest prevalence (25.2%) [16]. Our findings of prevalence of hypertension is similar in females (18.4% vs 18.7%) but higher in males (13.5% vs 18.8%) than in a study conducted among adults 25 years and older in 2005 in three rural areas of Bangladesh[35].

Our findings of positive associations between hypertension and potential risk factors such as age, BMI, and waist circumference are consistent with several studies from Bangladesh and elsewhere [17 18 36]. A dose response relationship was observed between the risk of hypertension and age, the risk increased with the increase of age; highest risk was observed in the oldest age groups among both males and females [18 37].

High BMI is an established risk factor for hypertension [15]; several studies found that overweight/obesity had the strongest association with hypertension [35 38 39]. Body weight is the balance between consumption and expenditure of energy. One would expect higher calorie consumption among higher SES group. Adult males and females with a higher waist circumference had four- and three-fold higher risks of hypertension, respectively. Both BMI and waist circumference are established risk factors for hypertension. In our study, we analyzed them separately but presented waist circumference data instead of BMI because several studies suggested that abdominal fat deposition is generally a stronger predictor of hypertension than BMI-based association [40,41]. Moreover, we chose waist circumference in our model instead of BMI because it can be easily measured, and programs can use it for screening provided training is adequate.

Compared to those who belonged to the poorest wealth group, we observed about a two-fold higher risk of hypertension among females but not among males who belonged to higher wealth groups. The association of socio-economic status with hypertension is not consistent across studies; some studies observed higher rate of hypertension among higher socioeconomic group and yet, other studies observed higher rate among the poor[35,42,43]. A recent review reported an overall increased risk of hypertension among the lowest SES, particularly in high-income countries[43].

Association between PA and risk of hypertension are well documented. Interventional studies showed beneficial effects of PA on blood pressure reduction[44,45]. Recreational PA is uncommon in our population (<1%). We observed a lower risk among males who reported PA for ≥300 MET minutes per week. Compared to those with very low PA, the odds of having hypertension was 40.0% and 70.0% less among males who had reported low and moderate PA respectively.

We did not see a protective effect of fruit or vegetable consumptions on hypertension in our population. In this poor agrarian community most people consume vegetables every day, the quantity might be low. Fruit consumption is low among rural Bangladeshi people. Seasonal fruits are grown in abundance but are not popular because people do not consider them as good fruit [46]. Imported fruits are costly and remain unaffordable to many people leading to a very low consumption of fruit [46]. The benefit of fruits and vegetable consumption is primarily through increased intake of potassium [47 48]. All vegetables may not contain high level of potassium and washing, and cooking may reduce potassium level [49]. In this study, we did not see a higher risk among smokers. Not seeing a benefit of fruit and vegetable consumptions or not seeing an increased risk among smokers could be due to reverse causation i.e., those with hypertension might have modified their behavior but that is unlikely because about half of those hypertensive were newly diagnosed.

The study has several limitations. The cross-sectional nature of the study limits the ability to establish causal relationship between the observed risk factors and hypertension. Also, the study was conducted in one region of Bangladesh and may not be generalizable for the entire country. The sample size is small, which limited risk factor analysis. We did not collect data on a number of important factors that may be associated with hypertension including family history, life style and salt intake. We defined hypertension by measuring blood pressure levels at the field level, not in a clinic setting. However, our workers were adequately trained and had years of experience measuring blood pressure in the field setting. We calibrated the blood pressure machines fortnightly against mercury sphygmomanometer. This survey used standard and pre-tested STEPs questionnaire to collect data from study participants which is used widely allowing comparison of our data with data from other studies.

Our finding of high rates of hypertension in this rural area is important because the risk of CVDs is about 16 folds higher among those with hypertension compared to those with a SBP of <115 and DBP of <75 [50]. However, the risk of CVDs is higher for all individuals with a SBP >115 or DBP >75 [50-52]. For every 10 mm increase in BP, the risk almost doubles. Although the risk is lower in the so-called normal BP groups compared to those with hypertension, since there are many more individuals in these BP categories, the burden of CVD related to hypertension among them is substantial. Therefore, efforts need to be made to identify and control hypertension and adopt strategies to reduce blood pressure of the entire population and prevent rise of BP with age.

Our results show a high prevalence of hypertension and pre-hypertension in the surveyed population. In addition, high prevalence of newly diagnosed and uncontrolled hypertension despite the availability of low cost and safe drugs for hypertension is a major public health concern. Apart from age, the most important risk factor of hypertension is behavioral and potentially modifiable. For example, inappropriate diet and inadequate physical inactivity lead to overweight/obesity, raises blood pressure and increases unfavorable blood lipids. These factors together with tobacco use, explain at least 75% of cardiovascular disease. Addressing behavioral risk factors, particularly unhealthy diet and physical inactivity can prevent hypertension. Salt reduction initiatives can make a major contribution to prevention and control of high blood pressure. However, vertical programs focusing on hypertension control alone are not cost effective [53]. Integrated context specific program including behavior change and identification and management of hypertension needs to be designed and implemented at scale through a primary health care approach. That will be an affordable and sustainable approach for countries to tackle the increasing burden of hypertension [53].

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AUTHOR CONTRIBUTIONS

The study was designed, and analysis was conceptualized by Rasheda Khanam (RK) and Abdullah H. Baqui (AHB). RK, AHB, Salahuddin Ahmed, Sayedur Rahman, and Ahad Khan implemented the study. Syed Jafar Raza Rizvi and Syed Mamun Ibne Moin managed the data. RK, Gulam Muhammed Al Kibria and Malathi Ram conducted data analysis. George Pariyo and Dustin Gibson contributed to the study design and data interpretation. RK drafted the manuscript with support from AHB. All authors reviewed and provided feedback on the draft and approved the final manuscript.

COMPETING INTERESTS

All authors declare that they have no conflict of interest

DATA SHARING STATEMENT:

All data relevant to the study are included in the article or uploaded as supplementary information.

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Figure 1: Distribution of blood pressure categories by age, sex, BMI and waist circumference, Sylhet, Bangladesh

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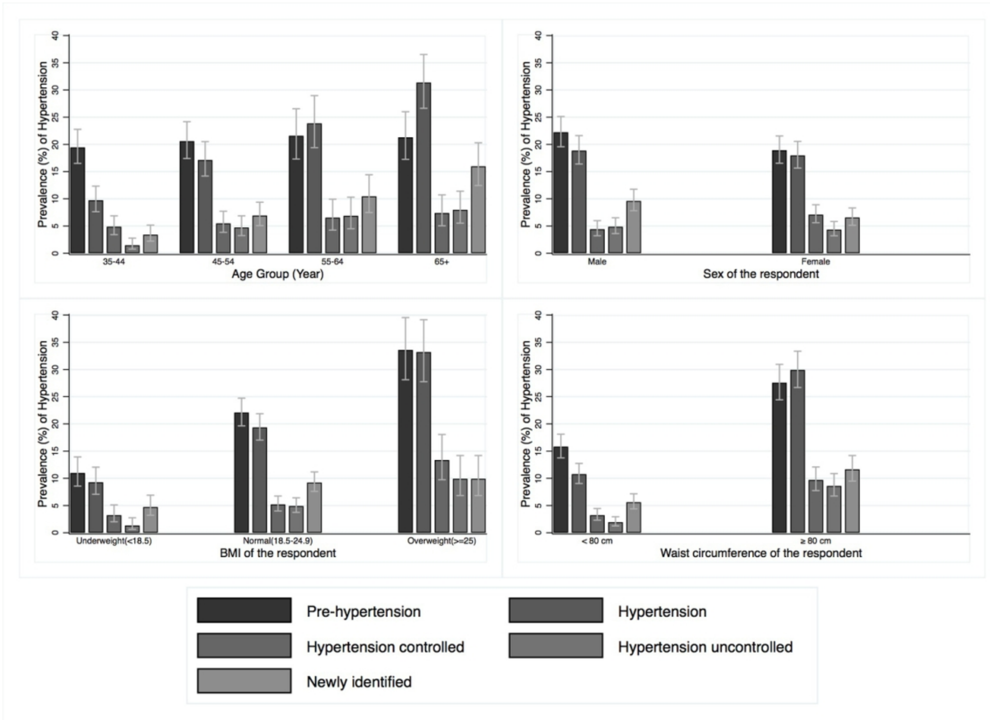

Figure 1: Distribution of blood pressure categories by age, sex, BMI and waist circumference, Sylhet, Bangladesh

123x90mm (300 x 300 DPI)

STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	In Title and also in abstract, page 2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Page 2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 4 and 5
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 5
Methods			
Study design	4	Present key elements of study design early in the paper	Page 5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 5, 6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Page 6, 7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 7, 8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 7-9
Bias	9	Describe any efforts to address potential sources of bias	Page 7
Study size	10	Explain how the study size was arrived at	Page 6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Page 9
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Page 9, 10
		(*b*) Describe any methods used to examine subgroups and interactions	Page 9, 10
		(*c*) Explain how missing data were addressed	Data were missing in 11.2%, page 11

		(*d*) If applicable, describe analytical methods taking account of sampling strategy	We assumed 15% refusal, page6
		(*e*) Describe any sensitivity analyses	Not applicable
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Page 10
		(b) Give reasons for non-participation at each stage	Page 10
		(c) Consider use of a flow diagram	Not considered necessary
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Text, page 11 Table, page 10, 11
		(b) Indicate number of participants with missing data for each variable of interest	Not applicable
Outcome data	15*	Report numbers of outcome events or summary measures	Text, page 13 Table, page 13
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Text, page 14-15 Table, page 14-16
		(*b*) Report category boundaries when continuous variables were categorized	Text, page 7-9 Table 11-15
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Text, page 11, 12 Figure 1
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 16
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 19
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Page 16-20
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 19-20
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 21

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.