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Sex differences in prevalence and risk factors of hypertension and pre-hypertension in a rural district of Bangladesh

Running Title: Hypertension in rural Bangladesh

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Abstract

Objective: Prevention of CVD-related mortality through control of hypertension is a public health priority in Bangladesh. Hypertension prevalence is lower in rural areas compared to urban areas of Bangladesh. However, risk groups in rural areas should be assessed. Our objective was to assess sex differences in prevalence and risk factors of hypertension, and pre-hypertension among adults in rural Bangladesh.

Study Design: Cross-sectional

Setting and Participants: From January 2014 to December 2015, we conducted a cross-sectional study of 2600 men and women aged ≥18 years located in one rural district of Bangladesh. We collected data on demographics, behavioral factors, physical measurements, and health history.

Primary Outcome Measures: Our primary outcome was hypertension (SBP ≥ 140 or DBP ≥ 90 mmHg).

Results: Hypertension prevalence was 6.9%(95% CI: 5.9-7.9), and was significantly higher among women(8.9%) than men(4.5%). The highest prevalence of hypertension observed among women aged ≥60 years at 21.3%(95% CI: 16.6 to 26.7). A higher proportion of men with hypertension were aware of their condition(72.2%) compared to women(52.4%). Risk factors of hypertension included older age, higher education, current tobacco use, increasing body mass index, and hyperglycemia.

Conclusion: Our research suggests that hypertension prevalence may be higher among women than men in rural Bangladesh. Sex-specific interventions should be developed to inform adults of the necessary lifestyle changes that may reduce the risk of hypertension and subsequent CVDs.

Keywords: Hypertension, Bangladesh, rural, prevalence, risk factors, blood pressure

Article Summary

Strengths and Limitations of the Study

- We present novel data on the prevalence of hypertension and prehypertension in Bangladesh as we included adults aged 18 years and above, unlike prior studies which have been limited to ages ≥25 years.
- We used WHO-recommended standardized methods to measure blood pressure to limit the potential for measurement error.
- Generalizability of our results may be limited as community-level campaigns on non-communicable disease prevention and lifestyle changes that may reduce their risk of developing chronic diseases commonly took place in this village.
- Self-reported medication use may be subject to social desirability bias as participants are in regular contact with ECOH staff members through community campaigns and prior surveillance efforts.
- We were unable to measure important risk factors of hypertension such as diet, physical activity, waist circumference, family history of cardiovascular disease, and blood lipid levels.

Introduction

Globally, hypertension, also known as high or raised blood pressure, is a leading cause of disease burden and mortality [1]. Hypertension contributes to the burden of cardiovascular disease (CVDs), stroke, and kidney failure, and disproportionately affects populations living in low and middle-income countries (LMICs). Hypertension is a preventable condition through healthy diet, normal body mass, controlled salt intake, and physical activity [1]. When diagnosed at an early stage, hypertension can be successfully controlled through appropriate treatment and successful control through lifestyle changes [1]. However, the burden and mortality due to hypertension is growing globally, particularly in LMICs [1-3], where access to preventive services and treatment is limited. In Bangladesh, the prevalence of hypertension among adults has been increasing for the past several decades [4], rising from ~10% in the 90's [5] to 20% based on estimates published by the World Health Organization [6]. As such, prevention and control of hypertension is a growing public health concern and a priority of Bangladesh's public health agenda [7 8].

Although 70% of the population of Bangladesh resides in rural areas, few prior studies have investigated the burden and determinants of hypertension among adults in rural areas [9-11], Additionally, prior studies conducted in Bangladesh to assess risk factors of non-communicable diseases (NCDs), including hypertension, have concluded that the majority of the NCD burden lies in urban areas among individuals with high socioeconomic status [12]. This finding implies the epidemiological shift to a higher burden of chronic disease is of major concern in urban regions of the country rather than rural areas of Bangladesh [9]. However, high-risk groups in rural areas should be identified and provided with tailored prevention programs, such as sex-specific interventions. One recent study conducted to assess risk factors of non-communicable diseases (NCDs) among a sample of over 12,000 rural residents aged ≥30 years found that the prevalence of hypertension was 15.9% among men and 22.5% among women [11]. This finding indicates a significant difference in burden among rural men and women, with women's prevalence approaching the overall prevalence of adults residing in urban areas of Bangladesh [9 13]. Data are needed to assess determinants of high blood pressure among women in rural areas and identify any sex-based disparities on hypertension medication use. Here, we assess sex differences in prevalence and associated determinants of hypertension and prehypertension in a rural area of Bangladesh. Additionally, we assessed self-reported antihypertensive medication use among our adult and rural study population.

Methods

Data for this analysis were collected from January 2014 to December 2015 among residents, aged 18 years or older, in a rural area of Bangladesh named, Ekhlaspur village of Matlab North Sub-district. Ekhlaspur is located about 60 kilometers south-east of Dhaka city, the capital of Bangladesh. Ekhlaspur Centre of Health (ECOH), a local nongovernmental health promotion organization, conducts periodic

demographic surveys in the village[14]. ECOH was founded in 1999 (by MMZ) but it has been managed and funded by the local community.

Data included in this analysis was obtained through ECOH's routine surveillance work and biennial health checkup of all adult residents of the village. To inform the community about this survey, ECOH management organized meetings and orientations with the community leaders, schools, and union council members. This survey is part of the community's initiative to monitor their health status and to detect any hypertension, diabetes and other risk factors. ECOH provides free medicines to those who have prescriptions from doctors. Community-level campaigns have been organized to inform the people of the village about NCDs and related risk factors. Health assistants of ECOH visited all households to select eligible subjects but no more than three recall visits were done. Ethical guidelines as outlined and approved by the Bangladesh Medical Research Council were followed throughout the study. Written informed consent was obtained from the respondents in Bengali to participate in this survey.

ECOH conducted geographic surveillance to identify and compile a complete list of households with demographic information of residents. As of 2015, the village had 1036 households. Residents aged ≥18 years living in the village were the target population for this study. In total there were 4871 adults aged ≥18 years (2520 men and 2351 women). However, 4414 residents (2202 men and 2212 women) were living in the village permanently. The remaining 457 residents lived in either urban areas or outside the country to earn their livelihoods and occasionally visited the village. Therefore, permanent residents aged ≥18 years were considered eligible for the survey. Pregnant women were excluded.

Patient and Public Involvement

These data were collected as part of routine surveillance conducted by ECOH, which is managed and funded by the local community. Patients routinely attend health fairs and obtain free health care from ECOH. There was no patient or public involvement in the interpretation of analytic results.

Survey Instrument:

We administered a structured questionnaire to assess basic demographics and physical measurements of each participant. The questionnaire was administered in Bengali. We obtained details on household size and composition from the head of each household. Each participant provided information on tobacco use, salt intake, health history including history of diabetes, hypertension, stroke, heart disease and chronic respiratory illness, and physical measurements including blood pressure. History of hypertension was assessed using the following questions: (1) Have you ever been diagnosed with hypertension by a health care provider?; (2) If yes, are you receiving treatment for the condition?; and (3) If yes, where are you receiving your treatment? Treatment history of participants was confirmed by

ECOH field workers through prescription and medical charts. Blood pressure was measured by calibrated aneroid sphygmomanometer by a trained field interviewer. Blood pressure measurements were consistently taken on the right arm at level of the heart and elbow-assisted while the participant was seated. The initial measurement was performed after five minutes of rest on the right arm. After two minutes, the second measurement was taken. The Korotkoff phase I (beginning of the sound) and the phase V of Korotkoff (disappearance of the sound) was recorded as systolic and diastolic blood respectively. The mean of these two blood pressure readings was utilized as the final blood pressure for each participant.

Outcome Definition:

Our primary outcomes of interest were prevalence of hypertension and of pre-hypertension. We utilized the World Health Organization guidelines diagnostic criteria to define hypertension. An individual was considered to have hypertension if systolic blood pressure (SBP) was ≥140 mmHg (millimeters of mercury) and/or, diastolic blood pressure (DBP) ≥90 mmHg and/or currently taking any-hypertensive medication based on self-report. Prehypertension was defined as SBP ≥120 mmHg but < 140 mmHg and/or DBP ≥ 80 mmHg but <90 mmHg and not taking anti-hypertensive medication at the time of the survey.

Covariates:

The following variables were used as risk factors: sex, age, education, occupation, body mass index (BMI), diabetes and tobacco use. Education was categorized into five groups: no education, less than primary (completed ≤grade 4), primary school (completed grade 5), secondary school (completed grade 10), and higher secondary and above (completed ≥grade 12). Occupation was categorized into five groups for analysis. These groups included: professional employment (government employee, non-government employee, business owner, farmer, agricultural worker, and other self-employed), unemployed or retired, industrial worker or day laborer, housemaker and other (beggar, rickshaw puller, cook, carpenter, tailor, security guard, migrant workers and fishermen). Utilizing height (centimeters) and weight (kilograms) measurements, we calculated BMI (height/weight^2) and categorized these measurements as follows: underweight (≤18.50), normal (18.6-25), overweight (25.1-30) and obese (>30). Participants were asked if they added any additional teaspoons of salt to their food during their meals. Added salt intake was categorized based on the number of tablespoons and the assumption that 1 tablespoon was equivalent to 5 grams. Hyperglycemia was defined based on a random blood glucose measured of 11.1 or above and/or self-report of taking diabetes medication. We categorized participants

as tobacco users if they either smoked cigarettes, cigars or pipes, or if they used smokeless tobacco products such as zarda, sadapata, gul and/or snuff.

Data Analysis:

Sociodemographic variables were presented with median (interquartile range) for continuous variables and with proportion for categorical variables. The overall, sex-specific, age-specific by sex, and area-specific prevalence of hypertension were calculated. For bivariate analyses, study participants were divided by sex and into five age groups (18-29, 30-44, 45-59, and 60+ years). A chi-square test was performed to assess proportional differences in hypertension and treatment patterns across select categorical variables.

Adjusted and unadjusted Poisson regression using robust estimation of standard errors analyses were performed to identify significant predictors, or risk factors, of pre-hypertension and hypertension [15-17]. Potential risk factors were assessed using bivariate Poisson regression analysis; an arbitrary p-value of <0.10 was used as criteria to include the variable in the multivariable Poisson regression model to control for confounding effects. For multivariable Poisson regression models, crude prevalence ratios (cPR), adjusted prevalence ratios (aPR), and 95% confidence intervals (CI) for each independent variable were calculated, $p<0.05$ was used as the level of significance. Collinearity was assessed using the variance inflation factor to ensure a strong linear relationship among independent variables included in the model was not present. The outcome variable of the model to identify risk factors for hypertension was coded as "1" if the participant was found to be hypertensive based on the definition described above and the rest were coded as "0." To identify predictors of pre-hypertension, we excluded those with existing hypertension at study measurement from the binary dependent variable of pre-hypertension. Accordingly, the outcome variable was coded as "1" if the participant was found to be pre-hypertensive and the rest were coded as "0." All statistical procedures were performed using Stata/SE 15.1 (StataCorp LP, Texas, USA) software package.

Results

Background Characteristics

Overall, out of 1036 households in the sampling frame, at least one participant from 866 households agreed to participate leading to an 83.6% response rate by household. On an individual level, 58.9% (2600/4414) of village residents participated in our survey. Per household, there were an average 3.0 participants (95% CI: 2.89-3.11). In our sample, there were 1205 (46.4%) men and 1395 (53.7%) female respondents (Table 1). The age of our participants ranged from 18 to 85 years. The mean age and education level of participants were 41.6 (SD = 17.8) years and 4.9 (SD = 4.6) years, respectively. On

average, men were more educated then women, with 15.9% men pursuing above secondary education compared to 6.3% women. The majority of men were employed as either an industrial worker/day laborer (38.3%) or professional employment (39.3%), and the majority of women were either a housewife (87.2%) or unemployed (11.9%). Smoking habits varied by sex: 99% of women reported to have never used smoking tobacco such as cigarettes, however, 51.3% of men either currently or previously used smoking tobacco. More women reported to currently use smokeless tobacco compared to men (31.8% vs 21.4%). More women were overweight or obese than men (15.8% vs 7.6%). Additionally, more women were categorized as hyperglycemic compared to men (3.2% vs 2.2%).

Prevalence and Predictors of Hypertension

Overall, the prevalence of hypertension among our population of rural adults aged ≥18 years was 6.9% (95% CI: 5.9-7.9). The prevalence of hypertension was significantly higher among women (8.9%, 95% CI: 7.4-10.5) than men (4.5%, 95% CI: 3.4-5.8) (Chi-squared P = <0.001). Additionally, the prevalence of hypertension increased with age among both men and women (p <0.001), with the highest prevalence of hypertension among women aged 60 years and above (21.3%, 95% CI: 16.6-26.7) (Figure 1). For comparability to prior studies, we report the prevalence of hypertension if restricted to those aged ≥25 years (8.5%) and ≥35 years (11.3%).

Among women, the prevalence of hypertension decreased as education level increased (12.3%: no education to 2.3% above secondary education), however, among men the prevalence of hypertension increased as education level increased (3.6%: no education to 7.9%: above secondary education) (Table 2). Among overweight and obese participants, the prevalence of hypertension was significantly higher than among those with normal BMI, particularly among men (60% of obese men had hypertension). Additionally, the prevalence of hypertension was significantly higher among those with hyperglycemia or blood glucose levels approaching the diabetic limit (> 11.1 mmol/L) (Table 2).

Table 3 presents the results of multivariable Poisson regression with robust variance analyses to identify predictors of hypertension. Significant predictors of hypertension differed among men and women. Among women, those of older age, both underweight and overweight/obesity BMI, and with hyperglycemia were more likely to have hypertension. When compared to women with normal BMI, women categorized as underweight or a BMI of 18.5 and below had 1.6 times the prevalence of hypertension (95% CI: 1.1 – 2.5). Additionally, women who were overweight (aPR: 2.3, 95% CI: 1.5-3.5) and obese (aPR: 4.9, 95% CI: 2.4-10.0) had a significantly higher prevalence of hypertension when compared to women with normal BMI. After adjustment, educational status no longer appeared to have a significant relationship with hypertension prevalence although the crude analysis revealed a protective effect of higher education. Among men, those of older age, increasing educational level, being overweight

and obese, and with hyperglycemia were more likely to have hypertension. Unlike in women, among men with an educational level above secondary education, the prevalence of hypertension was 3.8 times that of men with no formal education (aPR: 3.8, 95% CI: 1.8-8.2). Hyperglycemia was a significant determinant of hypertension among both women (aPR: 2.5, 95% CI: 1.4-4.4) and men (aPR: 3.8, 95% CI: 2.0-7.0).

Awareness and Treatment of Hypertension

Overall, among those with hypertension, 58% were aware of their diagnosis (Figure 2). The proportion of those aware of their hypertension diagnosis was higher among men (72%) then women (52%). When assessed by age group, the proportion of women who were aware of their diagnosis decreased with increasing age, dropping from 55% among those aged 30-44 years to 46.5% among women aged 60 years and above. Among those who were aware of their hypertension diagnosis (n = 105), 99.1% of participants (n = 104) self-reported to take antihypertensive medication. Among those who are taking medication to control their hypertension, 55.2% had normal blood pressure (SBP: <140 mmHg and DBP: <90 mmHg). The proportion of participants with controlled hypertension did not significantly differ by sex (men: 58.9%, women: 53.0%, chi squared p = 0.55).

Prevalence and Predictors of Prehypertension

The prevalence of prehypertension among our population of rural adults was 37.7% (95% CI: 35.7-39.6). Overall, the prevalence of prehypertension was higher among men (41.4%, 95% CI: 38.6-44.3) than women (34.2%, 95% CI: 31.6 – 36.9) (Table 4). This sex difference in prevalence of prehypertension was consistent across all age groups (Figure 3). The highest prevalence of prehypertension was observed among men and women aged 60 years and above (57.9%, 50% respectively) (Figure 3).

Table 4 presents the results of multivariable Poisson regression with robust variance analyses to identify predictors of prehypertension. Among both women, predictors of prehypertension included older age (≥45 years) and being overweight or obese. Among women who were aged 45-59 years the prevalence of hypertension was 1.4 times that of the prevalence among women aged 18-29 years. Additionally, the prevalence of women aged 60 years and above was 2.3 times that of women aged 18-29 years. Women who were obese had 2 times the prevalence of hypertension compared to women with a normal body mass index. Similar predictors were identified among men: men who were obese had 1.9 times the prevalence of men with a normal BMI. Increasing age among men also led to an increase in hypertension prevalence. Hyperglycemia was not a significant determinant of prehypertension among men or women (Table 4).

Discussion

In this study of adults aged ≥18 years in one rural area of Bangladesh, the prevalence of hypertension prevalence was significantly higher among women compared to men. To our knowledge, this is the first cohort to estimate prevalence of hypertension and pre-hypertension in rural Bangladesh among adults starting from age 18 years. The determinants of hypertension were consistent across sex excluding educational level; as educational level increased, the prevalence of hypertension increased among men whereas among women hypertension prevalence decreased, indicating a potential protective effect. Women were less likely to be aware they had hypertension compared to men, particularly older women aged ≥60 years, and thus women were more likely to have uncontrolled hypertension. Among adults who were aware of their condition, we did not find any sex differences in antihypertensive medication use as almost 100% of adults who were previously diagnosed with hypertension self-reported to take antihypertensive medication. Findings from this survey may highlight the need for sex-specific tailored interventions. Additionally, results from this analysis may underscore the importance of identifying high-risk groups in rural areas, particularly elderly women as their prevalence of hypertension rivals that of urban residents in Bangladesh.

In our study, the overall prevalence of hypertension was 6.9%, which is lower than prior studies conducted in Bangladesh. Nationally representative data collected in 2010 among adults ≥25 years estimated the prevalence of hypertension and prehypertension was 20% and 43%, respectively [6]. Similar to our study's findings, the prevalence of hypertension among rural women (18.2%) was slightly higher than men (17.6%). Another nationally representative analysis conducted in 2011 among adults ≥35 years found the age-standardized prevalence of hypertension and prehypertension was 24.4% and 27.1%; the odds of having hypertension were higher among women compared to men [18] in both urban and rural regions [19]. In one study conducted in rural Bangladesh, the prevalence of hypertension was 16% and factors such as increasing age and higher BMI was positively associated with hypertension [10]. Although they found no difference in prevalence of hypertension by sex, the prevalence of pre-hypertension was higher among men (33.6%) than women (30.6%), which is similar to our findings. Another study conducted in a different rural area of Bangladesh identified a strikingly high prevalence of hypertension among over 3000 adults aged ≥30 years across both sex groups of 40% (95% CI: 38-42%)[20].

Hypertension prevalence in our study is lower than previously documented due to two reasons. First, our cohort was younger and included adults aged ≥18 years. We found hypertension prevalence among our younger participants (18-29 years) to be 0%. Second, the lower hypertension prevalence may be attributable to various public health interventions promoted by ECOH over the past several decades to lower and control blood pressure of Ekhlaspur residents. Through these public health interventions,

residents of Ekhlaspur have been advised to be more physically active, avoid tobacco and alcohol products, and reduce dietary salt intake. ECOH has provided hypertension treatment services for several years. The clinic provides patients with counselling on lifestyle changes and provides antihypertensive medications free of charge. Evidence from ECOH and Ekhlaspur shows that with dedicated services and low cost treatment options, the burden of hypertension in Bangladesh can be reduced and controlled. Despite these improvements in prevalence of hypertension in Ekhlaspur, sex differences persist in the area.

Our study demonstrates important sex differences in both prevalence, determinants, and awareness of hypertension in rural Bangladesh. Hypertension prevalence among women (8.9%) was significantly higher than among men (4.5%, $p < 0.001$). Additionally, we found that as age increases, the difference in prevalence by sex also increases drastically; among adults aged ≥60 years the difference in prevalence of hypertension is almost double (21.3% among women vs 12.3%) among men. Moreover, men were more likely to be aware of having hypertension than women, leaving almost half of women with hypertension unaware and untreated for their condition. However, when adults were aware of their condition there were no sex differences in hypertension treatment or medication use. Efforts to ensure women have equal access to preventive care as men in rural areas of Bangladesh should be prioritized.

ECOH provides accessible hypertension services at free or low cost. Prior studies have shown that barriers to seeking hypertension treatment in Bangladesh include inadequate availability of services, poor quality of existing facilities, shortage of medicine supplies, long distance to health care facilities, and cost of continued treatment once diagnosed [21 22]. In 2014, it was estimated that only 16% of health care facilities across the country (i.e. hospitals, community clinics) have the capacity to diagnose, prescribe treatment for, and manage patients with hypertension [23]. Additionally, among facilities with the capacity to offer services for hypertension management, less than one-third had essential CVD medicines readily available on-site for patients [23]. Prior studies have also mentioned the value of provider-patient relationships and the importance of continuity of care and follow-up with providers who prescribed their medication (NIPORT 2016). ECOH has been able to address these barriers by providing consistent care to the residents of Ekhlaspur and at free or low cost. As Bangladesh moves towards implementing universal health care [24], efforts should be focused on establishing clinics particularly in rural areas to make health care accessible and to support the continuity of care.

In our analysis, we found that female sex, older age, higher education, high BMI and blood glucose levels approaching the diabetic range (≥11.1) were determinants of hypertension, which is similar to prior nationally-representative studies conducted in Bangladesh [13 25 26]. These determinants were consistent across sex groups, excluding educational status. Among men, higher education led to an increase in hypertension prevalence when compared to no education. However, among women, higher

education appeared to have a protective effect when compared to no education although not statistically significant after adjustment. Higher educational attainment among women may be lead to employment, higher physical activity and active commuting, which have been shown to reduce sedentary behavior among Bangladeshi women [27].

Interestingly, we observed that normotensives had higher added salt intake (90.6%) compared to hypertensive adults (81.5%). This may be due to an ongoing dietary salt reduction campaign in Ekhlaspur village focused on high-risk patients, including hypertensive adults. Clinic based data from ECOH have clearly demonstrated a sharp decline of added salt intake among those who have hypertension, dropping from 73% at enrollment to 13% after about five months, based on self-report [28] Similarly, we observed a high proportion of hypertensive participants who previously used tobacco. Patients of ECOH with hypertension have been counseled on the harms of tobacco use, both smokeless and smoking, and as such the majority reported to use either tobacco form in the past.

This study has several strengths. First, we present novel prevalence data on hypertension and prehypertension as we included adults aged 18 years and above, whereas prior studies have started their cohorts at older ages. Additionally, we used WHO-recommended standardized methods to measure BP among our study population to limit the potential for measurement error. There are several limitations to be considered when interpreting our results. Prior to this survey, community-level campaigns took place to educate the adults on NCD prevention and lifestyle changes that may reduce their risk of developing chronic diseases. As such, they were generally more educated about public health interventions, which may limit the generalizability of our findings. Self-reported medication use may be subject to social desirability bias as participants are in regular contact with ECOH staff members through community campaigns and prior surveillance efforts. We were unable to measure important risk factors of hypertension such as diet, physical activity, waist circumference, family history of cardiovascular disease, and blood lipid levels. Finally, due to the cross-sectional nature of our study design, we were unable to assess temporality of our risk factors or establish any causal relationship with our outcome of interest.

Conclusion

In conclusion, our sex-disaggregated analysis showed a higher burden of hypertension among women compared to men in a rural area of Bangladesh. Furthermore, we found that women were less likely to be have been previously diagnosed with hypertension compared to men and thus, more women had uncontrolled hypertension. The prevalence of prehypertension was higher among men than women. An alarmingly high proportion of those aged 18-29 years had prehypertension (27.9%). A preventive community-based approach with sex-tailored educational efforts should be directed to those with prehypertension, as they are at highest risk of developing hypertension. The primary health care system of

Bangladesh is limited, particularly in rural areas, due to a shortage of trained health care providers including physicians and nurses. Efforts towards population-level prevention measures, specifically lifestyle changes, should be promoted and directed towards risk groups identified through this analysis, such as those who are overweight or obese.

Footnotes:

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Author contributions:

JYI conceptualized the manuscript, guided data analysis, interpreted critically, wrote the manuscript; MMZ conceptualized the intervention, assisted with data analysis and manuscript development; JA and SRC established methodologies, executed the campaign, supervised and monitored data collection, trained the health workers; TZ conducted clinic-based counselling, trained counsellors on counselling skills, reviewed literature and prepared citations; HK prepared questionnaires, maintained records, worked as a data manager. All authors have read and approved the submission.

Disclosure statement:

The authors have no conflicts of interest to disclose.

Ethics and consent:

To inform the community about this survey, ECOH management organized meetings and orientations with the community leaders, schools, and union council members. This survey is part of the community's initiative to monitor their health status and to detect any hypertension, diabetes and other risk factors. ECOH provides free medicines to those who have prescriptions from doctors. Community-level campaigns have been organized to inform the people of the village about NCDs and related risk factors. Health assistants of ECOH visited all households to select eligible subjects but no more than three recall visits were done. Ethical guidelines as outlined and approved by the Bangladesh Medical Research Council were followed throughout the study. Written informed consent was obtained from the respondents in Bengali to participate in this survey.

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Data collection was conducted using ECOH's own funds generated by the local community as regular surveillance. We did not receive any funding from external organizations to complete this work.

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Figures

Figure 1: Prevalence of hypertension stratified by age group and sex among rural adults in Bangladesh

Figure 2: Prevalence of awareness of hypertension diagnosis stratified by age group and sex among rural adults in Bangladesh

Figure 3: Prevalence of pre-hypertension stratified by age group and sex among rural adults in Bangladesh

Table 1: Background characteristics of participants of rural Ekhlaspur, Bangladesh (n = 2600)

	Total (n = 2600)		Women (n = 1395)		Men (n = 1205)		*P**
Characteristic	n	%	n	%	n	%	
Age (years)							
18 - 29	829	31.9	444	31.8	385	31.9	0.81
30 - 44	717	27.6	390	27.9	327	27.1	
45 - 59	530	20.4	289	20.7	241	20.0	
≥ 60	524	20.2	272	19.5	252	20.9	
Mean (SD)	41.6 (17.8)		41.3 (17.7)		41.9 (17.9)		
Educational Status							<0.001
No Education	825	31.7	463	33.2	362	30.0	
Primary Education	680	26.2	386	27.7	294	24.4	
Secondary Education	816	31.4	458	32.8	358	29.7	
Above Secondary Education	279	10.7	88	6.3	191	15.9	
Mean (SD)	4.9 (4.6)		4.5 (4.1)		5.5 (5.1)		
Occupation							<0.001
Professional employment§	485	18.7	11	0.8	474	39.3	
Unemployed/retired	312	12	166	11.9	146	12.1	
Industrial worker/Day Laborer	463	17.8	1	0.1	462	38.3	
Homemaker/Other†	1340	51.5	1217	87.2	123	10.2	
Smoking Tobacco Use							<0.001
Never	1975	75.9	1389	99.6	586	48.6	
Current Use	498	19.2	1	0.1	497	41.2	
Past Use	127	4.9	5	0.4	122	10.1	
Smokeless Tobacco Use							<0.001
Never	1804	69.4	913	65.5	891	73.9	
Current Use	702	27.0	444	31.8	258	21.4	
Past Use	94	3.6	38	2.7	56	4.7	
Added salt Intake during meal							0.084
None	256	9.9	134	9.6	122	10.1	
Less than 5 grams (1 teaspoon)	1451	55.8	755	54.1	696	57.8	
Five grams and above	893	34.3	506	36.3	387	32.1	
Body Mass Index‡							
Underweight (≤18.5)	251	9.7	184	13.2	67	5.6	<0.001
Normal (18.6 - 25)	2035	78.3	989	70.9	1046	86.8	
Overweight (25.1 - 30)	277	10.7	195	13.9	82	6.8	
Obese (>30)	37	1.4	27	1.9	10	0.8	
Capillary blood glucose level							0.121
Normal	2470	97.3	1306	96.8	1164	97.8	
Hyperglycemia‖	69	2.7	43	3.2	12	2.2	
History of stroke	9	0.4	4	0.3	5	0.4	-
History of heart disease	8	0.3	3	0.2	5	0.4	

*Fisher's exact test p-value for trend

§Professional occupation includes: Government employee, non-goverment employee, business owner

†Other occupation includes: Self-employed, home maker, student, and other

‡ Body mass index (BMI) calculated by weight in kilogram divided by height in meter squared

‖Hyperglycemia was defined as a random capillary blood glucose level greater than or equal to 11.1 mmol/L or self-reported diabetes medication use

Table 2: Prevalence of hypertension by sex and select demographic variables among rural Bangladeshi adults

	Total (n = 2600)		*P**	Women (n = 1395)		*P**	Men (n = 1205)		*P**
Characteristic	n	%		n	%		n	%	
Age (years)									
18 - 29	0	0	<0.001	0	0	<0.001	0	0	<0.001
30 - 44	28	3.9		20	5.1		8	2.5	
45 - 59	61	11.5		46	15.9		15	6.2	
≥ 60	89	16.9		58	21.3		31	12.3	
Educational Status			0.017			<0.001			0.05
No Education	70	8.5		57	12.3		13	3.6	
Primary Education	52	7.7		44	11.4		8	2.7	
Secondary Education	39	4.8		21	4.6		18	5	
Above Secondary Education	17	6.1		2	2.3		15	7.9	
Occupation			<0.001			<0.001			<0.001
Professional employment§	25	5.2		2	18.2		23	4.9	
Unemployed/retired	57	18.3		30	18.1		27	18.5	
Industrial worker/Day Laborer	5	1.1		1	100		4	0.9	
Homemaker/Other†	91	6.8		91	7.5		0	0	
Smoking Tobacco Use			<0.001			1.00			<0.001
Never	146	7.4		124	8.9		22	3.8	
Current Use	13	2.6		0	0		13	2.6	
Past Use	19	14.9		0	0		19	15.6	
Smokeless Tobacco Use			<0.001			<0.001			<0.001
Never	71	3.9		48	5.3		23	2.6	
Current Use	86	12.3		66	14.9		20	7.8	
Past Use	21	22.3		10	26.3		11	19.6	
Salt Intake			<0.001			0.017			<0.001
None	33	12.7		16	11.6		17	13.9	
Less than 5 grams (1 teaspoon)	108	7.5		77	10.3		31	4.5	
Five grams and above	37	4.1		31	6.1		6	1.6	
Body Mass Index‡			<0.001			<0.001			<0.001
Underweight (≤18.5)	27	10.8		23	12.5		4	5.9	
Normal (18.6 - 25)	97	4.8		64	6.5		33	3.2	

Overweight (25.1 - 30)	40	14.4		29	14.8		11	13.4	
Obese (>30)	14	37.8		8	29.6		6	60.0	
Blood Sugar Level			<0.001			<0.001			<0.001
Normal	147	5.9		106	8.1		41	3.5	
Hyperglycemia‖	24	35.3		14	33.3		10	38.5	

*Fisher's exact test p-value for trend

§Professional occupation includes: Government employee, non-goverment employee, business owner

†Other occupation includes: Self-employed, home maker, student, and other

‡ Body mass index (BMI) calculated by weight in kilogram divided by height in meter squared

‖Diabetes was defined as a random capillary blood glucose level greater than or equal to 11.1 mmol/L or self-reported diabetes medication use

Table 3: Predictors of hypertension by sex among rural Ekhlaspur, Bangladesh (n = 2600)

	Total (n = 2600)		Women (n = 1395)		Men (n = 1205)	
Characteristic	Crude PR (95 % CI)	Adjusted PR (95% CI)	Crude PR (95 % CI)	Adjusted PR (95% CI)	Crude PR (95 % CI)	Adjusted PR (95% CI)
Sex						
Men	Ref.	Ref.	-	-	-	-
Women	2.0 (1.5 - 2.7)	2.2 (1.6 - 3.0)	-	-	-	-
Age (years)						
Less than 55 years	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
55 years and above	4.9 (3.7 - 6.6)	5.0 (3.3 - 7.6)	4.5 (3.2 - 6.4)	3.8 (2.3 - 6.2)	6.8 (3.8 - 12.1)	6.8 (3.2 - 14.2)
Educational Status						
No Education	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Primary Education	0.9 (0.6 - 1.3)	1.4 (0.9 - 1.9)	0.9 (0.6 - 1.3)	1.4 (0.9 - 2.0)	0.8 (0.3 - 1.8)	1.1 (0.5 - 2.4)
Secondary Education	0.6 (0.4 - 0.8)	1.2 (0.8 - 1.9)	0.4 (0.2 - 0.6)	0.8 (0.5 - 1.5)	1.4 (0.7 - 2.8)	1.9 (0.9 - 3.8)
Above Secondary Education	0.7 (0.4 - 1.2)	2.4 (1.4 - 4.0)	0.2 (0.0 - 0.7)	0.6 (0.1 - 2.4)	2.2 (1.1 - 4.5)	3.8 (1.8 - 8.2)
Ever Tobacco Use*						
Never	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Currently or in the past	2.3 (1.7 - 3.2)	1.3 (0.9 - 2.0)	3.0 (2.1 - 4.2)	1.3 (0.79 - 2.0)	2.3 (1.2 - 4.1)	1.0 (0.5 - 2.2)
Body Mass Index						
Underweight (≤18.5)	2.3 (1.5 - 3.4)	1.7 (1.1 - 2.5)	1.9 (1.2 - 3.0)	1.6 (1.1 - 2.5)	1.9 (0.7 - 5.2)	1.9 (0.7 - 5.2)
Normal (18.6 - 25)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Overweight (25.1 - 30)	3.0 (2.1 - 4.3)	2.5 (1.8 - 3.6)	2.3 (1.5 - 3.5)	2.3 (1.5 - 3.5)	4.3 (2.2 - 8.1)	2.8 (1.6 - 5.2)
Obese (>30)	7.9 (5.0 - 12.5)	7.6 (4.2 - 13.8)	4.6 (2.4 - 8.6)	4.9 (2.4 - 10.0)	19.0 (10.4 - 34.9)	15.8 (5.5 - 45.4)
Blood Sugar Level						
Normal	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Hyperglycemia†	5.9 (4.1 - 8.5)	2.7 (1.8 - 4.3)	4.1 (2.6 - 6.5)	2.5 (1.4 - 4.4)	10.9 (6.2 - 19.3)	3.8 (2.0 - 7.0)

* Ever tobacco use includes ever smokeless or smoking tobacco use

†Body mass index was calculated by weight in kilogram divided by height in meter squared and included in the model as a continuous variable

‡Hyperglycemia was defined as a random capillary blood glucose level greater than or equal to 11.1 mmol/L or self-reported diabetes medication use

608

609

610

611

Table 4: Predictors of hypertension by sex among rural Ekhlaspur, Bangladesh (n = 2422)

	Total (n = 2422)			Women (n = 1271)			Men (n = 1151)		
Characteristic	Prevalence of pre-hypertension (%)	Adjusted PR	95% CI	Prevalence of pre-hypertension (%)	Adjusted PR	95% CI	Prevalence of pre-hypertension (%)	Adjusted PR	95% CI
Sex									
Men	41.4%	Ref.		-	-	-	-	-	-
Women	34.2%	0.8	0.8 - 0.9	-	-	-	-	-	-
Age (years)									
18 - 29	27.9%	Ref.		26.6%	Ref.		29.4%	Ref.	
30 - 44	36.9%	1.3	1.1 - 1.5	33.5%	1.2	0.9 - 1.5	40.8%	1.4	1.1 - 1.7
45 - 59	40.9%	1.6	1.3 - 1.9	35.4%	1.4	1.1 - 1.9	46.9%	1.7	1.4 - 2.2
≥ 60	54.0%	2.3	1.9 - 2.7	50.0%	2.3	1.7 - 3.1	57.9%	2.3	1.8 - 2.9
Educational Status									
No Education	40.0%	Ref.		37.7%	Ref.		42.7%	Ref.	
Primary Education	37.3%	1.1	0.9 - 1.2	34.5%	1.1	0.9 - 1.4	40.6%	1.1	0.9 - 1.3
Secondary Education	36.4%	1.1	0.9 - 1.3	32.9%	1.2	0.9 - 1.5	40.9%	1.1	0.9 - 1.3
Above Secondary Education	35.5%	1.2	0.9 - 1.4	23.3%	0.9	0.6 - 1. 5	41.5%	1.2	1.0 - 1.6
Ever Tobacco Use*									
Never	34.4%	Ref.		31.5%	Ref.		39.1%	Ref.	
Currently or in the past	42.6%	0.9	0.8 - 1.1	40.7%	0.9	0.8 - 1.2	43.8%	0.9	0.7 - 1.1
Body Mass Index‡									
Underweight (≤18.5)	16.9%	0.4	0.3 - 0.6	15.5%	0.4	0.3 - 0.6	20.6%	0.5	0.3 - 0.7
Normal (18.6 - 25)	37.1%	Ref.		32.9%	Ref.		40.8%	Ref.	
Overweight (25.1 - 30)	59.5%	1.7	1.5 - 1.9	56.6%	1.7	1.5 - 2.1	66.2%	1.5	1.3 - 1.9
Obese (>30)	65.2%	1.9	1.5 - 2.7	57.9%	2.0	1.3 - 3.1	100.0%	1.9	1.6 - 2.3
Blood Sugar Level									
Normal	37.7%	Ref.		34.4%	Ref.		41.2%	Ref.	
Hyperglycemia†	47.7%	1.0	0.7 - 1.4	42.9%	0.9	0.6 - 1.5	56.3%	1.0	0.7 - 1.5

Abbreviations: PR - prevalence ratio; CI - confidence interval; Ref - reference

* Ever tobacco use includes ever smokeless or smoking tobacco use

‡ Body mass index (BMI) calculated by weight in kilogram divided by height in meter squared

‡Hyperglycemia was defined as a random capillary blood glucose level greater than or equal to 11.1 mmol/L or self-reported diabetes medication use

612

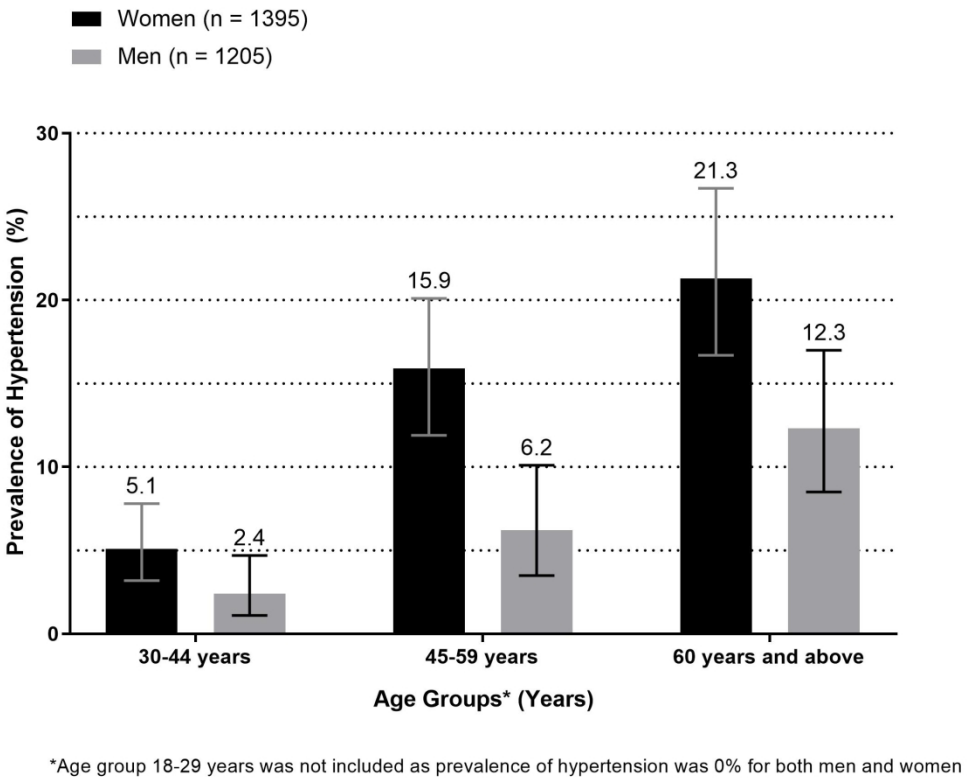

Figure 1: Prevalence of hypertension stratified by age group and sex among rural adults in Bangladesh

185x149mm (300 x 300 DPI)

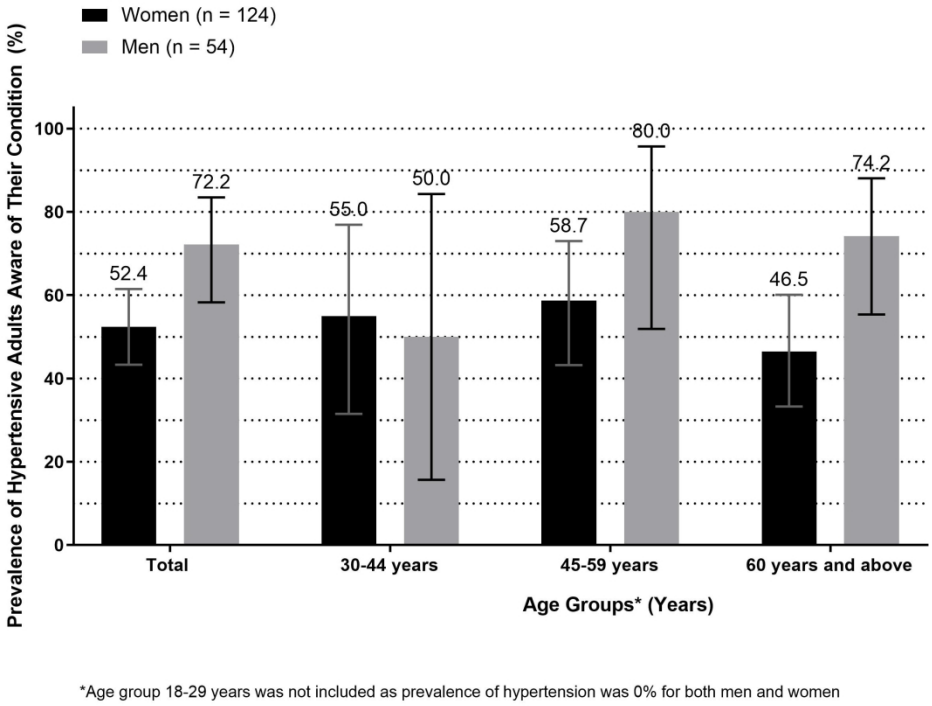

Figure 2: Prevalence of awareness of hypertension diagnosis stratified by age group and sex among rural adults in Bangladesh

213x155mm (300 x 300 DPI)

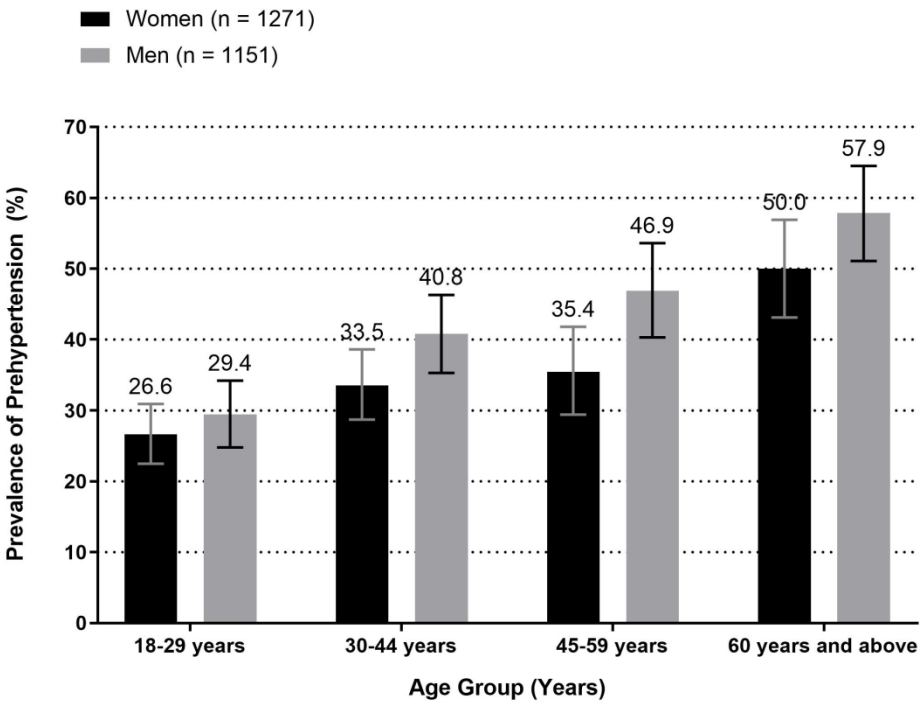

Figure 3: Prevalence of pre-hypertension stratified by age group and sex among rural adults in Bangladesh

187x137mm (300 x 300 DPI)

STROBE Statement

Checklist of items that should be included in reports of observational studies

Section/Topic	Item No	Recommendation	Reported on Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Method			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6,7
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	6,7
Bias	9	Describe any efforts to address potential sources of bias	12
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6,7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	9
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	9

Section/Topic	Item No	Recommendation	Reported on Page No
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	7,8
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7,8
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	9,10
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
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	10
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
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	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11,12
Generalisability	21	Discuss the generalisability (external validity) of the study results	13
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	15

**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

Sex differences in prevalence and determinants of hypertension among adults: a cross-sectional survey of one rural village in Bangladesh

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Keywords:	Hypertension < CARDIOLOGY, EPIDEMIOLOGY, PUBLIC HEALTH

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Sex differences in prevalence and determinants of hypertension among adults: a cross-sectional survey of one rural village in Bangladesh

Running Title: Hypertension in rural Bangladesh

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Abstract

Objective: Prevention of mortality due to cardiovascular disease (CVD) through control of hypertension is a public health priority in Bangladesh. Our objective was to assess sex differences in prevalence and risk factors of hypertension among adults in one rural area of Bangladesh.

Study Design: Cross-sectional

Setting and Participants: From January 2014 to December 2015, we conducted a cross-sectional study of 2600 men and women aged ≥18 years located in one rural district of Bangladesh. We collected data on demographics, behavioral factors, physical measurements, and health history.

Primary Outcome Measures: Our primary outcome was hypertension (SBP ≥ 140 or DBP ≥ 90 mmHg).

Results: The average age of participants was 41.6 years and 53.7% were women. Hypertension prevalence was 6.9%(95% CI: 5.9-7.9), and was significantly higher among women (8.9%) than men (4.5%). The highest prevalence of hypertension observed among women aged ≥60 years at 21.3% (95% CI: 16.6 to 26.7). A higher proportion of men with hypertension were aware of their condition (72.2%) compared to women (52.4%). Risk factors of hypertension included older age, higher education, current tobacco use, increasing body mass index, and hyperglycemia.

Conclusion: Our research suggests that hypertension prevalence is higher among women than men in rural Bangladesh. Sex-specific interventions should be developed to inform adults of the necessary lifestyle changes that may reduce the risk of hypertension and subsequent CVDs.

Keywords: Hypertension, Bangladesh, rural, prevalence, risk factors, blood pressure

Article Summary

Strengths and Limitations of the Study

- The population studied was enumerated by the Ekhlaspur Center of Health (ECOH) study staff, which allowed us to provide accurate estimates of prevalence using a well-defined denominator in a rural area of Bangladesh.
- We used WHO-recommended standardized methods to measure blood pressure to limit the potential for measurement error.
- Generalizability of our results may be limited as community-level campaigns on non-communicable disease prevention and lifestyle changes that may reduce their risk of developing chronic diseases commonly took place in this village.
- Self-reported medication use may be subject to social desirability bias as participants are in regular contact with ECOH staff members through community campaigns and prior surveillance efforts.
- We were unable to measure important risk factors of hypertension such as diet, physical activity, waist circumference, family history of cardiovascular disease, and blood lipid levels.

Introduction

Globally, hypertension, also known as high or raised blood pressure, is a leading cause of disease burden and mortality [1]. Hypertension contributes to the burden of cardiovascular disease (CVDs), stroke, and kidney failure, and disproportionately affects populations living in low and middle-income countries (LMICs). Hypertension is a preventable condition through healthy diet, normal body mass, controlled salt intake, and physical activity [1]. When diagnosed at an early stage, hypertension can be successfully controlled through appropriate treatment and successful control through lifestyle changes [1]. However, the burden and mortality due to hypertension is growing globally, particularly in LMICs [1-3], where access to preventive services and treatment is limited. In Bangladesh, the prevalence of hypertension among adults has been increasing for the past several decades [4], rising from ~10% in the 90's [5] to 20% based on estimates published by the World Health Organization [6]. As such, prevention and control of hypertension is a growing public health concern and a priority of Bangladesh's public health agenda [7 8].

Although 70% of the population of Bangladesh resides in rural areas, few prior studies have investigated the burden and determinants of hypertension among adults in rural areas [9-11], Additionally, prior studies conducted in Bangladesh to assess risk factors of non-communicable diseases (NCDs), including hypertension, have concluded that the majority of the NCD burden lies in urban areas among individuals with high socioeconomic status [12]. This finding implies the epidemiological shift to a higher burden of chronic disease is of major concern in urban regions of the country rather than rural areas of Bangladesh [9]. However, high-risk groups in rural areas should be identified and provided with tailored prevention programs, such as sex-specific interventions. One recent study conducted to assess risk factors of non-communicable diseases (NCDs) among a sample of over 12,000 rural residents aged ≥30 years found that the prevalence of hypertension was 15.9% among men and 22.5% among women [11]. This finding indicates a significant difference in burden among rural men and women, with women's prevalence approaching the overall prevalence of adults residing in urban areas of Bangladesh [9 13]. Data are needed to assess determinants of high blood pressure among women in rural areas and identify any sex-based disparities on hypertension medication use. Our objective was to evaluate differences in prevalence and associated determinants of hypertension and prehypertension in a rural area of Bangladesh. Additionally, we assessed self-reported antihypertensive medication use among our adult and rural study population.

Methods

Data for this analysis were collected from January 2014 to December 2015 among residents, aged 18 years or older, in a rural area of Bangladesh named, Ekhlaspur village of Matlab North Sub-district.

Ekhlaspur is located about 60 kilometers south-east of Dhaka city, the capital of Bangladesh. Ekhlaspur Centre of Health (ECOH), a local nongovernmental health promotion organization, conducts periodic demographic surveys in the village[14]. ECOH was founded in 1999 (by MMZ) but it has been managed and funded by the local community.

Data included in this analysis was obtained through ECOH's routine surveillance work and biennial health checkup of all adult residents of the village. To inform the community about this survey, ECOH management organized meetings and orientations with the community leaders, schools, and union council members. This survey is part of the community's initiative to monitor their health status and to detect any hypertension, diabetes and other risk factors. ECOH provides free medicines to those who have prescriptions from doctors. Community-level campaigns have been organized to inform the people of the village about NCDs and related risk factors. Health assistants of ECOH visited all households to select eligible subjects but no more than three recall visits were done. Ethical guidelines as outlined and approved by the Bangladesh Medical Research Council were followed throughout the study. Written informed consent was obtained from the respondents in Bengali to participate in this survey.

ECOH conducted geographic surveillance to identify and compile a complete list of households with demographic information of residents. As of 2015, the village had 1036 households. Residents aged ≥18 years living in the village were the target population for this study. In total there were 4871 adults aged ≥18 years (2520 men and 2351 women). However, 4414 residents (2202 men and 2212 women) were living in the village permanently. The remaining 457 residents lived in either urban areas or outside the country to earn their livelihoods and occasionally visited the village. Therefore, permanent residents aged ≥18 years were considered eligible for the survey. Pregnant women were excluded.

Patient and Public Involvement

These data were collected as part of routine surveillance conducted by ECOH, which is managed and funded by the local community. Patients routinely attend health fairs and obtain free health care from ECOH. There was no patient or public involvement in the interpretation of analytic results.

Survey Instrument:

We administered a structured questionnaire to assess basic demographics and physical measurements of each participant. The questionnaire was administered in Bengali. We obtained details on household size and composition from the head of each household. Each participant provided information on tobacco use, salt intake, health history including history of diabetes, hypertension, stroke, heart disease and chronic respiratory illness, and physical measurements including blood pressure. History of hypertension was assessed using the following questions: (1) Have you ever been diagnosed with

hypertension by a health care provider?; (2) If yes, are you receiving treatment for the condition?; and (3) If yes, where are you receiving your treatment? Treatment history of participants was confirmed by ECOH field workers through prescription and medical charts. Blood pressure was measured by calibrated aneroid sphygmomanometer by a trained field interviewer. Blood pressure measurements were consistently taken on the right arm at level of the heart and elbow-assisted while the participant was seated. After a test run, the first measurement was performed after five minutes of rest on the right arm. After three minutes, the second measurement was taken. The Korotkoff phase I (beginning of the sound) and the phase V of Korotkoff (disappearance of the sound) was recorded as systolic and diastolic blood respectively. The mean of these two blood pressure readings was utilized as the final blood pressure for each participant.

Outcome Definition:

Our primary outcomes of interest were prevalence of hypertension and of pre-hypertension. We utilized the World Health Organization guidelines diagnostic criteria to define hypertension. An individual was considered to have hypertension if systolic blood pressure (SBP) was ≥140 mmHg (millimeters of mercury) and/or, diastolic blood pressure (DBP) ≥90 mmHg and/or currently taking any-hypertensive medication based on self-report. Prehypertension was defined as SBP ≥120 mmHg but < 140 mmHg and/or DBP ≥ 80 mmHg but <90 mmHg and not taking anti-hypertensive medication at the time of the survey.

Covariates:

The following variables were used as risk factors: sex, age, education, occupation, body mass index (BMI), diabetes and tobacco use. Education was categorized into five groups: no education, less than primary (completed ≤grade 4), primary school (completed grade 5), secondary school (completed grade 10), and higher secondary and above (completed ≥grade 12). Occupation was categorized into five groups for analysis. These groups included: professional employment (government employee, non-government employee, business owner, farmer, agricultural worker, and other self-employed), unemployed or retired, industrial worker or day laborer, housemaker and other (beggar, rickshaw puller, cook, carpenter, tailor, security guard, migrant workers and fishermen). Utilizing height (centimeters) and weight (kilograms) measurements, we calculated BMI (height/weight^2) and categorized these measurements as follows: underweight (≤18.50), normal (18.6-25), overweight (25.1-30) and obese (>30). Participants were asked if they added any additional teaspoons of salt to their food during their meals. Added salt intake was categorized based on the number of tablespoons and the assumption that 1 tablespoon was equivalent to 5 grams. Hyperglycemia was defined based on a random blood glucose

measured of 11.1 or above and/or self-report of taking diabetes medication. We categorized participants as tobacco users if they either smoked cigarettes, cigars or pipes, or if they used smokeless tobacco products such as zarda, sadapata, gul and/or snuff. We defined past tobacco users as respondents who were ever users of tobacco, however, currently do not use tobacco products.

Data Analysis:

Sociodemographic variables were presented with median (interquartile range) for continuous variables and with proportion for categorical variables. The overall, sex-specific, age-specific by sex, and area-specific prevalence of hypertension were calculated. For bivariate analyses, study participants were divided by sex and into five age groups (18-29, 30-44, 45-59, and 60+ years). A chi-square test was performed to assess proportional differences in hypertension and treatment patterns across select categorical variables.

Adjusted and unadjusted Poisson regression using robust estimation of standard errors analyses were performed to identify significant predictors, or risk factors, of pre-hypertension and hypertension [15-17]. Potential risk factors were assessed using bivariate Poisson regression analysis; an arbitrary p-value of <0.10 was used as criteria to include the variable in the multivariable Poisson regression model to control for confounding effects. For multivariable Poisson regression models, crude prevalence ratios (cPR), adjusted prevalence ratios (aPR), and 95% confidence intervals (CI) for each independent variable were calculated, $p<0.05$ was used as the level of significance. Collinearity was assessed using the variance inflation factor to ensure a strong linear relationship among independent variables included in the model was not present. The outcome variable of the model to identify risk factors for hypertension was coded as "1" if the participant was found to be hypertensive based on the definition described above and the rest were coded as "0." To identify predictors of pre-hypertension, we excluded those with existing hypertension at study measurement from the binary dependent variable of pre-hypertension. Accordingly, the outcome variable was coded as "1" if the participant was found to be pre-hypertensive and the rest were coded as "0." All statistical procedures were performed using Stata/SE 15.1 (StataCorp LP, Texas, USA) software package.

Results

Background Characteristics

Overall, out of 1036 households in the sampling frame, at least one participant from 866 households agreed to participate leading to an 83.6% response rate by household. On an individual level, 58.9% (2600/4414) of village residents participated in our survey. Per household, there were an average 3.0 participants (95% CI: 2.89-3.11). In our sample, there were 1205 (46.4%) men and 1395 (53.7%)

female respondents (Table 1). The age of our participants ranged from 18 to 85 years. The mean age and education level of participants were 41.6 (SD = 17.8) years and 4.9 (SD = 4.6) years, respectively. On average, men were more educated then women, with 15.9% men pursuing above secondary education compared to 6.3% women. About one-third of men were employed as either an industrial worker/day laborer (38.3%) or professional employment (39.3%), and the majority of women were either a housewife (87.2%) or unemployed (11.9%). Smoking habits varied by sex: 99% of women reported to have never used smoking tobacco such as cigarettes, however, 51.3% of men either currently or previously used smoking tobacco. More women reported to currently use smokeless tobacco compared to men (31.8% vs 21.4%). More women were overweight or obese than men (15.8% vs 7.6%). Additionally, more women were categorized as hyperglycemic compared to men (3.2% vs 2.2%). Figure 1 provides a distribution of systolic and diastolic blood pressure by age group and sex.

Prevalence and Predictors of Hypertension

Overall, the prevalence of hypertension among our population of rural adults aged ≥18 years was 6.9% (95% CI: 5.9-7.9). The prevalence of hypertension was significantly higher among women (8.9%, 95% CI: 7.4-10.5) than men (4.5%, 95% CI: 3.4-5.8) (Chi-squared P = <0.001). Additionally, the prevalence of hypertension increased with age among both men and women (p <0.001), with the highest prevalence of hypertension among women aged 60 years and above (21.3%, 95% CI: 16.6-26.7) (Figure 2). For comparability to prior studies, we report the prevalence of hypertension if restricted to those aged ≥25 years (8.5%) and ≥35 years (11.3%).

Among women, the prevalence of hypertension decreased as education level increased (12.3%: no education to 2.3% above secondary education), however, among men the prevalence of hypertension increased as education level increased (3.6%: no education to 7.9%: above secondary education) (Table 2). Among overweight and obese participants, the prevalence of hypertension was significantly higher than among those with normal BMI, particularly among men (60% of obese men had hypertension). Additionally, the prevalence of hypertension was significantly higher among those with hyperglycemia or blood glucose levels approaching the diabetic limit (> 11.1 mmol/L) (Table 2).

Table 3 presents the results of multivariable Poisson regression with robust variance analyses to identify predictors of hypertension. Significant predictors of hypertension differed among men and women. Among women, those of older age, both underweight and overweight/obesity BMI, and with hyperglycemia were more likely to have hypertension. When compared to women with normal BMI, women categorized as underweight or a BMI of 18.5 and below had 1.6 times the prevalence of hypertension (95% CI: 1.1 – 2.5). Additionally, women who were overweight (aPR: 2.3, 95% CI: 1.5-3.5) and obese (aPR: 4.9, 95% CI: 2.4-10.0) had a significantly higher prevalence of hypertension when

compared to women with normal BMI. After adjustment, educational status no longer appeared to have a significant relationship with hypertension prevalence although the crude analysis revealed a protective effect of higher education. Among men, those of older age, increasing educational level, being overweight and obese, and with hyperglycemia were more likely to have hypertension. Unlike in women, among men with an educational level above secondary education, the prevalence of hypertension was 3.8 times that of men with no formal education (aPR: 3.8, 95% CI: 1.8-8.2). Hyperglycemia was a significant determinant of hypertension among both women (aPR: 2.5, 95% CI: 1.4-4.4) and men (aPR: 3.8, 95% CI: 2.0-7.0).

Awareness and Treatment of Hypertension

Overall, among those with hypertension, 58% were aware of their diagnosis (Figure 3). The proportion of those aware of their hypertension diagnosis was higher among men (72%) then women (52%). When assessed by age group, the proportion of women who were aware of their diagnosis decreased with increasing age, dropping from 55% among those aged 30-44 years to 46.5% among women aged 60 years and above. Among those who were aware of their hypertension diagnosis (n = 105), 99.1% of participants (n = 104) self-reported to take antihypertensive medication. Among those who are taking medication to control their hypertension, 55.2% had normal blood pressure (SBP: <140 mmHg and DBP: <90 mmHg). The proportion of participants with controlled hypertension did not significantly differ by sex (men: 58.9%, women: 53.0%, chi squared p = 0.55).

Prevalence and Predictors of Prehypertension

The prevalence of prehypertension among our population of rural adults was 37.7% (95% CI: 35.7-39.6). Overall, the prevalence of prehypertension was higher among men (41.4%, 95% CI: 38.6-44.3) than women (34.2%, 95% CI: 31.6 – 36.9) (Table 4). This sex difference in prevalence of prehypertension was consistent across all age groups (Figure 4). The highest prevalence of prehypertension was observed among men and women aged 60 years and above (57.9%, 50% respectively) (Figure 4).

Table 4 presents the results of multivariable Poisson regression with robust variance analyses to identify predictors of prehypertension. Among both women, predictors of prehypertension included older age (≥45 years) and being overweight or obese. Among women who were aged 45-59 years the prevalence of hypertension was 1.4 times that of the prevalence among women aged 18-29 years. Additionally, the prevalence of women aged 60 years and above was 2.3 times that of women aged 18-29 years. Women who were obese had 2 times the prevalence of hypertension compared to women with a normal body mass index. Similar predictors were identified among men: men who were obese had 1.9

times the prevalence of men with a normal BMI. Increasing age among men also led to an increase in hypertension prevalence. Hyperglycemia was not a significant determinant of prehypertension among men or women (Table 4).

Discussion

In this study of adults aged ≥18 years in one rural area of Bangladesh, the prevalence of hypertension prevalence was significantly higher among women compared to men. The determinants of hypertension were consistent across sex excluding educational level; as educational level increased, the prevalence of hypertension increased among men whereas among women hypertension prevalence decreased, indicating a potential protective effect. Women were less likely to be aware they had hypertension compared to men, particularly older women aged ≥60 years. Among adults who were aware of their condition, we did not find any sex differences in antihypertensive medication use as almost 100% of adults who were previously diagnosed with hypertension self-reported to take antihypertensive medication. Findings from this survey may highlight the need for sex-specific tailored interventions. Additionally, results from this analysis may underscore the importance of identifying high-risk groups in rural areas, particularly elderly women as their prevalence of hypertension rivals that of urban residents in Bangladesh.

In our study, the overall prevalence of hypertension was 6.9%, which is lower than prior studies conducted in Bangladesh. Nationally representative data, including both urban and rural residents, collected in 2010 among adults ≥25 years estimated the prevalence of hypertension and prehypertension was 20% and 43%, respectively [6]. Similar to our study's findings, the prevalence of hypertension among rural women (18.2%) was slightly higher than men (17.6%). Another nationally representative analysis conducted in 2011 among adults ≥35 years found the age-standardized prevalence of hypertension and prehypertension was 24.4% and 27.1%; the odds of having hypertension were higher among women compared to men [18] in both urban and rural regions [19]. In one study conducted in rural Bangladesh, the prevalence of hypertension was 16% and factors such as increasing age and higher BMI was positively associated with hypertension [10]. Although they found no difference in prevalence of hypertension by sex, the prevalence of pre-hypertension was higher among men (33.6%) than women (30.6%), which is similar to our findings. Another study conducted in a different rural area of Bangladesh identified a strikingly high prevalence of hypertension among over 3000 adults aged ≥30 years across both sex groups of 40% (95% CI: 38-42%)[20].

Hypertension prevalence in our study may be lower than previously documented due to two reasons. First, our cohort was younger and included adults aged ≥18 years. We found hypertension prevalence among our younger participants (18-29 years) to be 0%, although the prevalence of

prehypertension was almost 30% in both sexes. Second, the lower hypertension prevalence may be attributable to various public health interventions promoted by ECOH over the past several decades to lower and control blood pressure of Ekhlaspur residents. Through these public health interventions, residents of Ekhlaspur have been advised to be more physically active, avoid tobacco and alcohol products, and reduce dietary salt intake. ECOH has provided chronic disease preventive and treatment services for several years at low or free cost. Additionally, the clinic provides patients with counselling on lifestyle changes and provides antihypertensive medications free of charge. Free and low-cost preventive services are not widespread in rural areas of Bangladesh. In 2014, it was estimated that only 16% of health care facilities across the country (i.e. hospitals, community clinics) have the capacity to diagnose, prescribe treatment for, and manage patients with hypertension [21]. In fact, only 10% of community clinics and maternal and child welfare centers, and 17% of union level facilities, which are the most accessible providers in rural areas, provided any cardiovascular services, and the services at these facilities are limited to the measurement of blood pressure or referrals[21]. Additionally, among facilities with the capacity to offer services for hypertension management, less than one-third had essential CVD medicines readily available on-site for patients [21]. Prior studies have shown that barriers to seeking hypertension treatment in Bangladesh include inadequate availability of services, poor quality of existing facilities, shortage of medicine supplies, long distance to health care facilities, and cost of continued treatment once diagnosed [22 23]. ECOH has been able to address these barriers by providing consistent care to the residents of Ekhlaspur and at free or low cost. As Bangladesh moves towards implementing universal health care [24], efforts should be focused on establishing clinics particularly in rural areas to make health care accessible and to support the continuity of care.

Our study demonstrates important sex differences in both prevalence, determinants, and awareness of hypertension in rural Bangladesh. Hypertension prevalence among women (8.9%) was significantly higher than among men (4.5%, $p < 0.001$). Additionally, we found that as age increases, the difference in prevalence by sex also increases drastically; among adults aged ≥60 years the difference in prevalence of hypertension is almost double (21.3% among women vs 12.3%) among men. Moreover, men were more likely to be aware of having hypertension than women, leaving almost half of women with hypertension unaware and untreated for their condition. However, when adults were aware of their condition there were no sex differences in hypertension treatment or medication use. Efforts to ensure women have equal access to preventive care as men in rural areas of Bangladesh should be prioritized.

In our analysis, we found that female sex, older age, higher education, high BMI and blood glucose levels approaching the diabetic range (≥11.1) were determinants of hypertension, which is similar to prior nationally-representative studies conducted in Bangladesh [13 25 26]. These determinants were consistent across sex groups, excluding educational status. Among men, higher education led to an

increase in hypertension prevalence when compared to no education. However, among women, higher education appeared to have a protective effect when compared to no education although not statistically significant after adjustment. Higher educational attainment among women may be lead to employment, higher physical activity and active commuting, which have been shown to reduce sedentary behavior among Bangladeshi women [27].

This study has several strengths. First, we present novel prevalence data on hypertension and prehypertension as we included adults aged 18 years and above, whereas prior studies have started their cohorts at older ages. As such, these may be useful towards informing our progress towards NCD control as defined by the indicators included in the WHO's Global Monitoring Framework[28]. Additionally, we used WHO-recommended standardized methods to measure BP among our study population to limit the potential for measurement error. There are several limitations to be considered when interpreting our results. Our study is limited to one rural area of Bangladesh and may not be reflective of other areas of the country. Prior to this survey, community-level campaigns took place to educate the adults on NCD prevention and lifestyle changes that may reduce their risk of developing chronic diseases. As such, they were generally more educated about public health interventions, which may limit the generalizability of our findings. Self-reported medication use may be subject to social desirability bias as participants are in regular contact with ECOH staff members through community campaigns and prior surveillance efforts. We were unable to measure important risk factors of hypertension such as diet, physical activity, waist circumference, family history of cardiovascular disease, and blood lipid levels. Additionally, we did not repeat blood pressure readings after 4 weeks to confirm a diagnosis of hypertension. Finally, due to the cross-sectional nature of our study design, we were unable to assess temporality of our risk factors or establish any causal relationship with our outcomes of interest.

Published in 2013, the Guidelines for Management of Hypertension in Bangladesh largely recommend and focus on lifestyle measures to reduce the risk of hypertension in adults[8]. This is because Bangladesh is a low resource setting with limited availability of trained health care providers and treatment, particularly in rural areas. Affordability of treatment is an important factor all providers should consider, since costs may impact adherence and continuity of care. In our setting, we observe a low prevalence of hypertension, particularly among younger groups, and also hyperglycemia. We believe this low prevalence is due to the availability and access to preventive health care, such as physical activity and tobacco cessation campaigns. We recommend that other rural areas follow the national guidelines for hypertension management, and promote similar lifestyle changes, to achieve similar burden reduction. Interestingly, we observed that normotensives had higher added salt intake (90.6%) compared to hypertensive adults (81.5%). This may be due to an ongoing dietary salt reduction campaign in Ekhlaspur village focused on high-risk patients, including hypertensive adults. Clinic based data from ECOH have

clearly demonstrated a sharp decline of added salt intake among those who have hypertension, dropping from 73% at enrollment to 13% after about five months, based on self-report [29] Similarly, we observed a high proportion of hypertensive participants who previously used tobacco. Patients of ECOH with hypertension have been counseled on the harms of tobacco use, both smokeless and smoking, and as such the majority reported to use either tobacco form in the past.

Conclusion

In conclusion, our sex-disaggregated analysis showed a higher burden of hypertension among women compared to men in a rural area of Bangladesh. Furthermore, we found that women were less likely to be have been previously diagnosed with hypertension compared to men and thus, more women had uncontrolled hypertension. The prevalence of prehypertension was higher among men than women. An alarmingly high proportion of those aged 18-29 years had prehypertension (27.9%). A preventive community-based approach with sex-tailored educational efforts should be directed to those with prehypertension, as they are at highest risk of developing hypertension. The primary health care system of Bangladesh is limited, particularly in rural areas, due to a shortage of trained health care providers including physicians and nurses. Efforts towards population-level prevention measures, specifically lifestyle changes, should be promoted and directed towards risk groups identified through this analysis, such as those who are overweight or obese.

Footnotes:

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Author contributions: JYI conceptualized the manuscript, guided data analysis, interpreted critically, wrote the manuscript; MMZ conceptualized the intervention, assisted with data analysis and manuscript development; JA and SRC established methodologies, executed the campaign, supervised and monitored data collection, trained the health workers; TZ conducted clinic-based counselling, trained counsellors on counselling skills, reviewed literature and prepared citations; HK prepared questionnaires, maintained records, worked as a data manager. All authors have read and approved the submission.

Availability of data and materials: The de-identified participant data used and/or analyzed during the current study are available from the corresponding author on reasonable request. Please contact M. Mostafa Zaman at zamanm@who.int for further information and guidelines.

Disclosure statement: The authors have no conflicts of interest to disclose.

Ethics and consent: To inform the community about this survey, ECOH management organized meetings and orientations with the community leaders, schools, and union council members. This survey is part of the community's initiative to monitor their health status and to detect any hypertension, diabetes and other risk factors. ECOH provides free medicines to those who have prescriptions from doctors. Community-level campaigns have been organized to inform the people of the village about NCDs and related risk factors. Health assistants of ECOH visited all households to select eligible subjects but no more than three recall visits were done. Ethical guidelines as outlined and approved by the Bangladesh Medical Research Council were followed throughout the study. Written informed consent was obtained from the respondents in Bengali to participate in this survey.

Funding: Data collection was conducted using ECOH's own funds generated by the local community as regular surveillance. We did not receive any funding from external organizations to complete this work.

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Figures

Figure 1: Distribution of systolic and diastolic blood pressure by age group and sex among rural adults in Bangladesh

Figure 2: Prevalence of hypertension stratified by age group and sex among rural adults in Bangladesh

Figure 3: Prevalence of awareness of hypertension diagnosis stratified by age group and sex among rural adults in Bangladesh

Figure 4: Prevalence of pre-hypertension stratified by age group and sex among rural adults in Bangladesh

Table 1: Background characteristics of participants of rural Ekhlaspur, Bangladesh (n = 2600)

	Total (n = 2600)		Women (n = 1395)		Men (n = 1205)		*P**
Characteristic	n	%	n	%	n	%	
Age (years)							
18 - 29	829	31.9	444	31.8	385	31.9	0.81
30 - 44	717	27.6	390	27.9	327	27.1	
45 - 59	530	20.4	289	20.7	241	20.0	
≥ 60	524	20.2	272	19.5	252	20.9	
Mean (SD)	41.6 (17.8)		41.3 (17.7)		41.9 (17.9)		
Educational Status							<0.001
No Education	825	31.7	463	33.2	362	30.0	
Primary Education	680	26.2	386	27.7	294	24.4	
Secondary Education	816	31.4	458	32.8	358	29.7	
Above Secondary Education	279	10.7	88	6.3	191	15.9	
Mean (SD)	4.9 (4.6)		4.5 (4.1)		5.5 (5.1)		
Occupation							<0.001
Professional employment§	485	18.7	11	0.8	474	39.3	
Unemployed/retired	312	12	166	11.9	146	12.1	
Industrial worker/Day Laborer	463	17.8	1	0.1	462	38.3	
Homemaker/Other†	1340	51.5	1217	87.2	123	10.2	
Smoking Tobacco Use							<0.001
Never	1975	75.9	1389	99.6	586	48.6	
Current Use	498	19.2	1	0.1	497	41.2	
Past Use	127	4.9	5	0.4	122	10.1	
Smokeless Tobacco Use							<0.001
Never	1804	69.4	913	65.5	891	73.9	
Current Use	702	27.0	444	31.8	258	21.4	
Past Use	94	3.6	38	2.7	56	4.7	
Added salt intake during meal							0.084
None	256	9.9	134	9.6	122	10.1	
Less than 5 grams (1 teaspoon)	1451	55.8	755	54.1	696	57.8	
Five grams and above	893	34.3	506	36.3	387	32.1	
Body Mass Index‡							
Underweight (≤18.5)	251	9.7	184	13.2	67	5.6	<0.001
Normal (18.6 - 25)	2035	78.3	989	70.9	1046	86.8	
Overweight (25.1 - 30)	277	10.7	195	13.9	82	6.8	
Obese (>30)	37	1.4	27	1.9	10	0.8	
Capillary blood glucose level							0.121
Normal	2470	97.3	1306	96.8	1164	97.8	
Hyperglycemia‖	69	2.7	43	3.2	12	2.2	
History of stroke	9	0.4	4	0.3	5	0.4	-
History of heart disease	8	0.3	3	0.2	5	0.4	

*Fisher's exact test p-value to identify differences between men and women surveyed

§Professional occupation includes: Government employee, non-government employee, business owner

†Other occupation includes: Self-employed, home maker, student, and other

‡ Body mass index (BMI) calculated by weight in kilogram divided by height in meter squared

‖Hyperglycemia was defined as a random capillary blood glucose level greater than or equal to 11.1 mmol/L or self-reported diabetes medication use

Table 2: Prevalence of hypertension by sex and select demographic variables among rural Bangladeshi adults

	Total (n = 2600)		*P**	Women (n = 1395)		*P**	Men (n = 1205)		*P**
Characteristic	n	%		n	%		n	%	
Age (years)									
18 - 29	0	0	<0.001	0	0	<0.001	0	0	<0.001
30 - 44	28	3.9		20	5.1		8	2.5	
45 - 59	61	11.5		46	15.9		15	6.2	
≥ 60	89	16.9		58	21.3		31	12.3	
Educational Status			0.017			<0.001			0.05
No Education	70	8.5		57	12.3		13	3.6	
Primary Education	52	7.7		44	11.4		8	2.7	
Secondary Education	39	4.8		21	4.6		18	5	
Above Secondary Education	17	6.1		2	2.3		15	7.9	
Occupation			<0.001			<0.001			<0.001
Professional employment§	25	5.2		2	18.2		23	4.9	
Unemployed/retired	57	18.3		30	18.1		27	18.5	
Industrial worker/Day Laborer	5	1.1		1	100		4	0.9	
Homemaker/Other†	91	6.8		91	7.5		0	0	
Smoking Tobacco Use			<0.001			1.00			<0.001
Never	146	7.4		124	8.9		22	3.8	
Current Use	13	2.6		0	0		13	2.6	
Past Use	19	14.9		0	0		19	15.6	
Smokeless Tobacco Use			<0.001			<0.001			<0.001
Never	71	3.9		48	5.3		23	2.6	
Current Use	86	12.3		66	14.9		20	7.8	
Past Use	21	22.3		10	26.3		11	19.6	
Salt Intake			<0.001			0.017			<0.001
None	33	12.7		16	11.6		17	13.9	
Less than 5 grams (1 teaspoon)	108	7.5		77	10.3		31	4.5	
Five grams and above	37	4.1		31	6.1		6	1.6	
Body Mass Index‡			<0.001			<0.001			<0.001
Underweight (≤18.5)	27	10.8		23	12.5		4	5.9	
Normal (18.6 - 25)	97	4.8		64	6.5		33	3.2	

Overweight (25.1 - 30)	40	14.4		29	14.8		11	13.4	
Obese (>30)	14	37.8		8	29.6		6	60.0	
Blood Sugar Level			<0.001			<0.001			<0.001
Normal	147	5.9		106	8.1		41	3.5	
Hyperglycemia‖	24	35.3		14	33.3		10	38.5	

*Fisher's exact test p-value for trend

§Professional occupation includes: Government employee, non-government employee, business owner

†Other occupation includes: Self-employed, home maker, student, and other

‡ Body mass index (BMI) calculated by weight in kilogram divided by height in meter squared

‖Diabetes was defined as a random capillary blood glucose level greater than or equal to 11.1 mmol/L or self-reported diabetes medication use

Table 3: Predictors of hypertension by sex among rural Ekhlaspur, Bangladesh (n = 2600)

	Total (n = 2600)		Women (n = 1395)		Men (n = 1205)	
Characteristic	Crude PR (95 % CI)	Adjusted PR (95% CI)	Crude PR (95 % CI)	Adjusted PR (95% CI)	Crude PR (95 % CI)	Adjusted PR (95% CI)
Sex						
Men	Ref.	Ref.	-	-	-	-
Women	2.0 (1.5 - 2.7)	2.2 (1.6 - 3.0)	-	-	-	-
Age (years)						
Less than 55 years	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
55 years and above	4.9 (3.7 - 6.6)	5.0 (3.3 - 7.6)	4.5 (3.2 - 6.4)	3.8 (2.3 - 6.2)	6.8 (3.8 - 12.1)	6.8 (3.2 - 14.2)
Educational Status						
No Education	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Primary Education	0.9 (0.6 - 1.3)	1.4 (0.9 - 1.9)	0.9 (0.6 - 1.3)	1.4 (0.9 - 2.0)	0.8 (0.3 - 1.8)	1.1 (0.5 - 2.4)
Secondary Education	0.6 (0.4 - 0.8)	1.2 (0.8 - 1.9)	0.4 (0.2 - 0.6)	0.8 (0.5 - 1.5)	1.4 (0.7 - 2.8)	1.9 (0.9 - 3.8)
Above Secondary Education	0.7 (0.4 - 1.2)	2.4 (1.4 - 4.0)	0.2 (0.0 - 0.7)	0.6 (0.1 - 2.4)	2.2 (1.1 - 4.5)	3.8 (1.8 - 8.2)
Ever Tobacco Use*						
Never	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Currently or in the past	2.3 (1.7 - 3.2)	1.3 (0.9 - 2.0)	3.0 (2.1 - 4.2)	1.3 (0.79 - 2.0)	2.3 (1.2 - 4.1)	1.0 (0.5 - 2.2)
Body Mass Index						
Underweight (≤18.5)	2.3 (1.5 - 3.4)	1.7 (1.1 - 2.5)	1.9 (1.2 - 3.0)	1.6 (1.1 - 2.5)	1.9 (0.7 - 5.2)	1.9 (0.7 - 5.2)
Normal (18.6 - 25)	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Overweight (25.1 - 30)	3.0 (2.1 - 4.3)	2.5 (1.8 - 3.6)	2.3 (1.5 - 3.5)	2.3 (1.5 - 3.5)	4.3 (2.2 - 8.1)	2.8 (1.6 - 5.2)
Obese (>30)	7.9 (5.0 - 12.5)	7.6 (4.2 - 13.8)	4.6 (2.4 - 8.6)	4.9 (2.4 - 10.0)	19.0 (10.4 - 34.9)	15.8 (5.5 - 45.4)
Blood Sugar Level						
Normal	Ref.	Ref.	Ref.	Ref.	Ref.	Ref.
Hyperglycemia†	5.9 (4.1 - 8.5)	2.7 (1.8 - 4.3)	4.1 (2.6 - 6.5)	2.5 (1.4 - 4.4)	10.9 (6.2 - 19.3)	3.8 (2.0 - 7.0)

* Ever tobacco use includes ever smokeless or smoking tobacco use

†Body mass index was calculated by weight in kilogram divided by height in meter squared and included in the model as a continuous variable

‡Hyperglycemia was defined as a random capillary blood glucose level greater than or equal to 11.1 mmol/L or self-reported diabetes medication use

609

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Table 4: Predictors of pre-hypertension by sex among rural Ekhlaspur, Bangladesh (n = 2422)

	Total (n = 2422)			Women (n = 1271)			Men (n = 1151)		
Characteristic	Prevalence of pre-hypertension (%)	Adjusted PR	95% CI	Prevalence of pre-hypertension (%)	Adjusted PR	95% CI	Prevalence of pre-hypertension (%)	Adjusted PR	95% CI
Sex									
Men	41.4%	Ref.		-	-	-	-	-	-
Women	34.2%	0.8	0.8 - 0.9	-	-	-	-	-	-
Age (years)									
18 - 29	27.9%	Ref.		26.6%	Ref.		29.4%	Ref.	
30 - 44	36.9%	1.3	1.1 - 1.5	33.5%	1.2	0.9 - 1.5	40.8%	1.4	1.1 - 1.7
45 - 59	40.9%	1.6	1.3 - 1.9	35.4%	1.4	1.1 - 1.9	46.9%	1.7	1.4 - 2.2
≥ 60	54.0%	2.3	1.9 - 2.7	50.0%	2.3	1.7 - 3.1	57.9%	2.3	1.8 - 2.9
Educational Status									
No Education	40.0%	Ref.		37.7%	Ref.		42.7%	Ref.	
Primary Education	37.3%	1.1	0.9 - 1.2	34.5%	1.1	0.9 - 1.4	40.6%	1.1	0.9 - 1.3
Secondary Education	36.4%	1.1	0.9 - 1.3	32.9%	1.2	0.9 - 1.5	40.9%	1.1	0.9 - 1.3
Above Secondary Education	35.5%	1.2	0.9 - 1.4	23.3%	0.9	0.6 - 1. 5	41.5%	1.2	1.0 - 1.6
Ever Tobacco Use*									
Never	34.4%	Ref.		31.5%	Ref.		39.1%	Ref.	
Currently or in the past	42.6%	0.9	0.8 - 1.1	40.7%	0.9	0.8 - 1.2	43.8%	0.9	0.7 - 1.1
Body Mass Index‡									
Underweight (≤18.5)	16.9%	0.4	0.3 - 0.6	15.5%	0.4	0.3 - 0.6	20.6%	0.5	0.3 - 0.7
Normal (18.6 - 25)	37.1%	Ref.		32.9%	Ref.		40.8%	Ref.	
Overweight (25.1 - 30)	59.5%	1.7	1.5 - 1.9	56.6%	1.7	1.5 - 2.1	66.2%	1.5	1.3 - 1.9
Obese (>30)	65.2%	1.9	1.5 - 2.7	57.9%	2.0	1.3 - 3.1	100.0%	1.9	1.6 - 2.3
Blood Sugar Level									
Normal	37.7%	Ref.		34.4%	Ref.		41.2%	Ref.	
Hyperglycemia†	47.7%	1.0	0.7 - 1.4	42.9%	0.9	0.6 - 1.5	56.3%	1.0	0.7 - 1.5

Abbreviations: PR - prevalence ratio; CI - confidence interval; Ref - reference

* Ever tobacco use includes ever smokeless or smoking tobacco use

‡ Body mass index (BMI) calculated by weight in kilogram divided by height in meter squared

‡Hyperglycemia was defined as a random capillary blood glucose level greater than or equal to 11.1 mmol/L or self-reported diabetes medication use

613

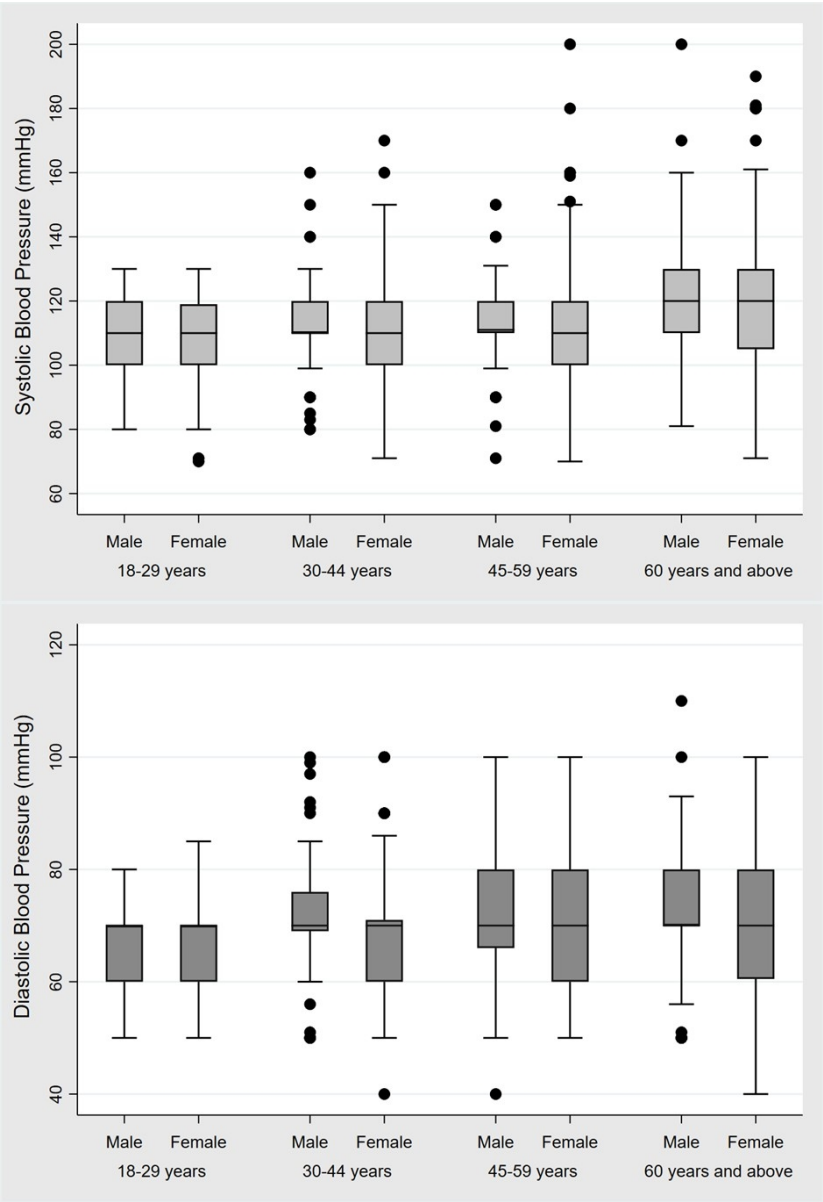

Figure 1: Distribution of systolic and diastolic blood pressure by age group and sex among rural adults in Bangladesh

159x231mm (150 x 150 DPI)

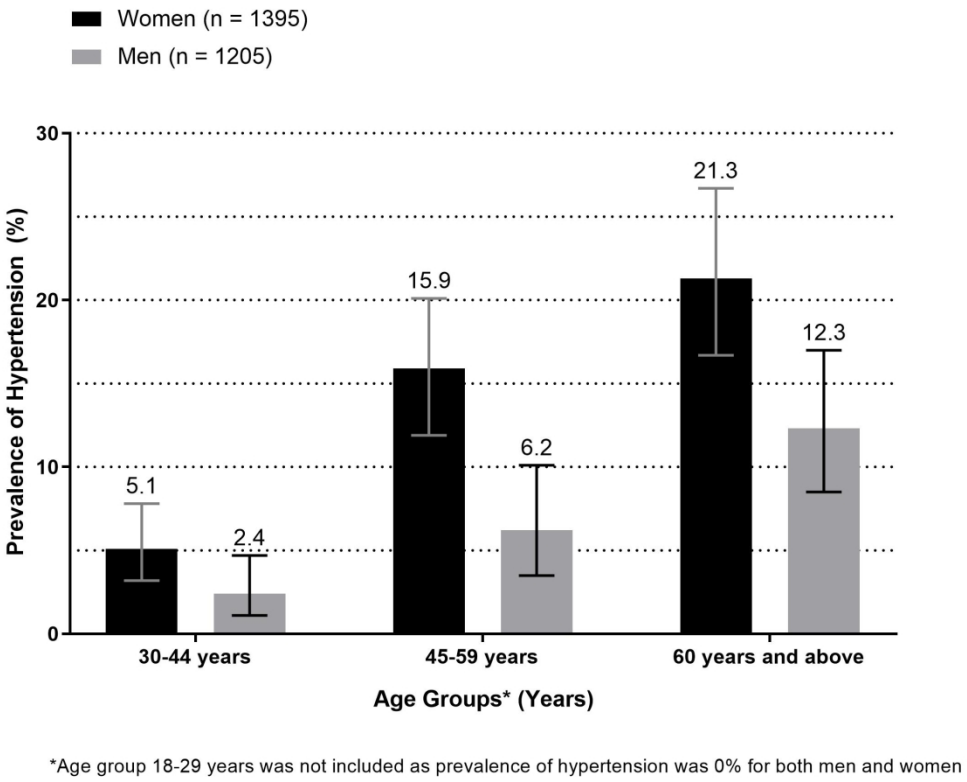

Figure 2: Prevalence of hypertension stratified by age group and sex among rural adults in Bangladesh

185x149mm (300 x 300 DPI)

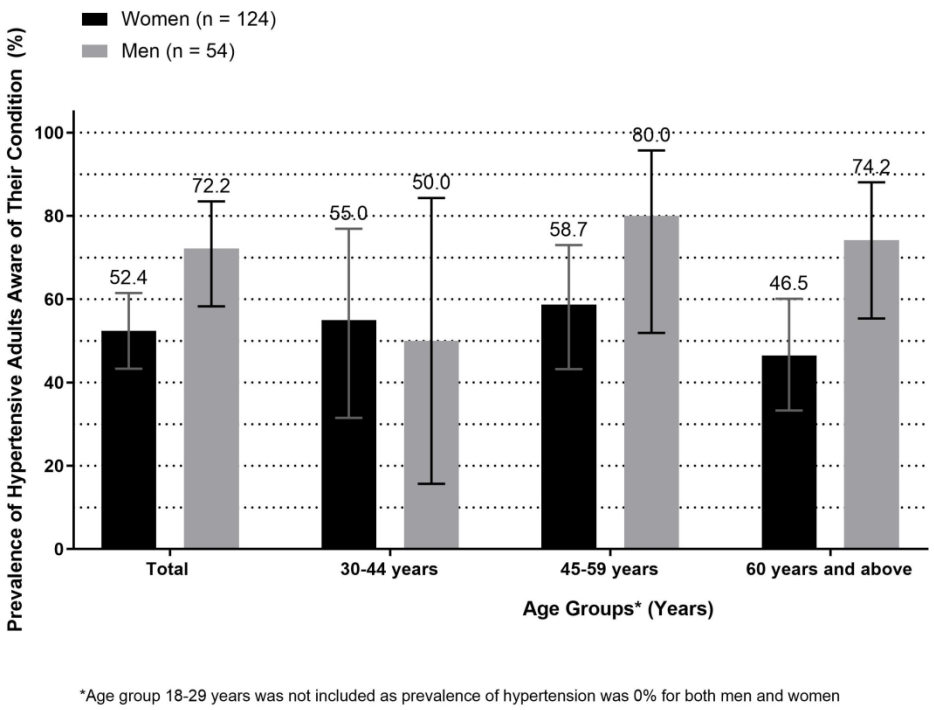

Figure 3: Prevalence of awareness of hypertension diagnosis stratified by age group and sex among rural adults in Bangladesh

213x155mm (300 x 300 DPI)

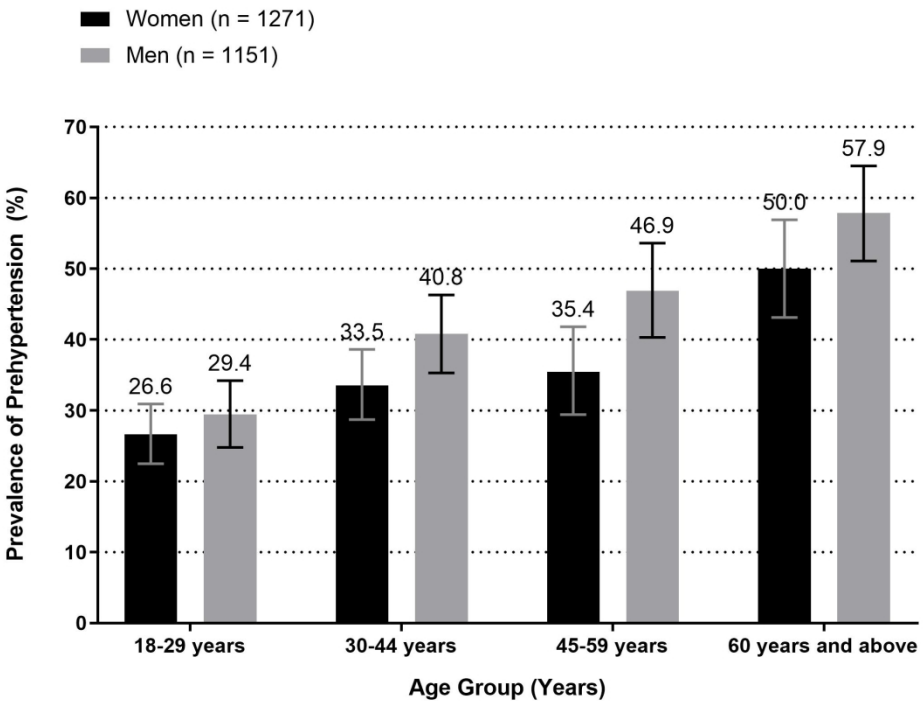

Figure 4: Prevalence of pre-hypertension stratified by age group and sex among rural adults in Bangladesh

187x137mm (300 x 300 DPI)

STROBE Statement

Checklist of items that should be included in reports of observational studies

Section/Topic	Item No	Recommendation	Reported on Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Method			
Study design	4	Present key elements of study design early in the paper	5
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5
Participants	6	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants	5
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case	
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6,7
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	6,7
Bias	9	Describe any efforts to address potential sources of bias	12
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6,7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	9
		(*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy	N/A
		(*e*) Describe any sensitivity analyses	9

Section/Topic	Item No	Recommendation	Reported on Page No
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	7,8
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7,8
		(b) Indicate number of participants with missing data for each variable of interest	
		(c) *Cohort study*—Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	*Cohort study*—Report numbers of outcome events or summary measures over time	9,10
		Case-control study—Report numbers in each exposure category, or summary measures of exposure	
		Cross-sectional study—Report numbers of outcome events or summary measures	
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	10
		(*b*) Report category boundaries when continuous variables were categorized	
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10
Discussion			
Key results	18	Summarise key results with reference to study objectives	11
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	13
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11,12
Generalisability	21	Discuss the generalisability (external validity) of the study results	13
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	15

**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.