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

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3 1 **Sex differences in prevalence and risk factors of hypertension and pre-hypertension in a rural**
4 2 **district of Bangladesh**
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8 4 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

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3 68 **Article Summary**

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5 69 **Strengths and Limitations of the Study**

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7 70 • We present novel data on the prevalence of hypertension and prehypertension in Bangladesh as
8 71 we included adults aged 18 years and above, unlike prior studies which have been limited to ages
9 72 ≥ 25 years.
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12 73 • We used WHO-recommended standardized methods to measure blood pressure to limit the
13 74 potential for measurement error.
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15 75 • Generalizability of our results may be limited as community-level campaigns on non-
16 76 communicable disease prevention and lifestyle changes that may reduce their risk of developing
17 77 chronic diseases commonly took place in this village.
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20 78 • Self-reported medication use may be subject to social desirability bias as participants are in
21 79 regular contact with ECOH staff members through community campaigns and prior surveillance
22 80 efforts.
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25 81 • We were unable to measure important risk factors of hypertension such as diet, physical activity,
26 82 waist circumference, family history of cardiovascular disease, and blood lipid levels.
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101 Introduction

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

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

130 Methods

131 Data for this analysis were collected from January 2014 to December 2015 among residents, aged
132 18 years or older, in a rural area of Bangladesh named, Ekhlaspur village of Matlab North Sub-district.
133 Ekhlaspur is located about 60 kilometers south-east of Dhaka city, the capital of Bangladesh. Ekhlaspur
134 Centre of Health (ECOH), a local nongovernmental health promotion organization, conducts periodic

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3 135 demographic surveys in the village¹⁴. ECOH was founded in 1999 (by MMZ) but it has been managed
4 136 and funded by the local community.

6 137 Data included in this analysis was obtained through ECOH's routine surveillance work and
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8 138 biennial health checkup of all adult residents of the village. To inform the community about this survey,
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10 139 ECOH management organized meetings and orientations with the community leaders, schools, and union
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12 140 council members. This survey is part of the community's initiative to monitor their health status and to
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14 141 detect any hypertension, diabetes and other risk factors. ECOH provides free medicines to those who have
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16 142 prescriptions from doctors. Community-level campaigns have been organized to inform the people of the
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18 143 village about NCDs and related risk factors. Health assistants of ECOH visited all households to select
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20 144 eligible subjects but no more than three recall visits were done. Ethical guidelines as outlined and
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22 145 approved by the Bangladesh Medical Research Council were followed throughout the study. Written
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24 146 informed consent was obtained from the respondents in Bengali to participate in this survey.

25 147 ECOH conducted geographic surveillance to identify and compile a complete list of households
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27 148 with demographic information of residents. As of 2015, the village had 1036 households. Residents aged
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29 149 ≥ 18 years living in the village were the target population for this study. In total there were 4871 adults
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31 150 aged ≥ 18 years (2520 men and 2351 women). However, 4414 residents (2202 men and 2212 women)
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33 151 were living in the village permanently. The remaining 457 residents lived in either urban areas or outside
34
35 152 the country to earn their livelihoods and occasionally visited the village. Therefore, permanent residents
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37 153 aged ≥ 18 years were considered eligible for the survey. Pregnant women were excluded.

38 154 39 155 Patient and Public Involvement

40 156 These data were collected as part of routine surveillance conducted by ECOH, which is managed
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42 157 and funded by the local community. Patients routinely attend health fairs and obtain free health care from
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44 158 ECOH. There was no patient or public involvement in the interpretation of analytic results.

45 159 46 160 Survey Instrument:

47 161 We administered a structured questionnaire to assess basic demographics and physical
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49 162 measurements of each participant. The questionnaire was administered in Bengali. We obtained details on
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51 163 household size and composition from the head of each household. Each participant provided information
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53 164 on tobacco use, salt intake, health history including history of diabetes, hypertension, stroke, heart disease
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55 165 and chronic respiratory illness, and physical measurements including blood pressure. History of
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57 166 hypertension was assessed using the following questions: (1) Have you ever been diagnosed with
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59 167 hypertension by a health care provider?; (2) If yes, are you receiving treatment for the condition?; and (3)
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168 If yes, where are you receiving your treatment? Treatment history of participants was confirmed by

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3 169 ECOH field workers through prescription and medical charts. Blood pressure was measured by calibrated
4 170 aneroid sphygmomanometer by a trained field interviewer. Blood pressure measurements were
5 171 consistently taken on the right arm at level of the heart and elbow-assisted while the participant was
6 172 seated. The initial measurement was performed after five minutes of rest on the right arm. After two
7 173 minutes, the second measurement was taken. The Korotkoff phase I (beginning of the sound) and the
8 174 phase V of Korotkoff (disappearance of the sound) was recorded as systolic and diastolic blood
9 175 respectively. The mean of these two blood pressure readings was utilized as the final blood pressure for
10 176 each participant.
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18 178 Outcome Definition:

19 179 Our primary outcomes of interest were prevalence of hypertension and of pre-hypertension. We
20 180 utilized the World Health Organization guidelines diagnostic criteria to define hypertension. An
21 181 individual was considered to have hypertension if systolic blood pressure (SBP) was ≥ 140 mmHg
22 182 (millimeters of mercury) and/or, diastolic blood pressure (DBP) ≥ 90 mmHg and/or currently taking any-
23 183 hypertensive medication based on self-report. Prehypertension was defined as SBP ≥ 120 mmHg but <
24 184 140 mmHg and/or DBP ≥ 80 mmHg but <90 mmHg and not taking anti-hypertensive medication at the
25 185 time of the survey.
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31 187 Covariates:

32 188 The following variables were used as risk factors: sex, age, education, occupation, body mass
33 189 index (BMI), diabetes and tobacco use. Education was categorized into five groups: no education, less
34 190 than primary (completed \leq grade 4), primary school (completed grade 5), secondary school (completed
35 191 grade 10), and higher secondary and above (completed \geq grade 12). Occupation was categorized into five
36 192 groups for analysis. These groups included: professional employment (government employee, non-
37 193 government employee, business owner, farmer, agricultural worker, and other self-employed),
38 194 unemployed or retired, industrial worker or day laborer, housemaker and other (beggar, rickshaw puller,
39 195 cook, carpenter, tailor, security guard, migrant workers and fishermen). Utilizing height (centimeters) and
40 196 weight (kilograms) measurements, we calculated BMI (height/weight²) and categorized these
41 197 measurements as follows: underweight (≤ 18.50), normal (18.6-25), overweight (25.1-30) and obese
42 198 (>30). Participants were asked if they added any additional teaspoons of salt to their food during their
43 199 meals. Added salt intake was categorized based on the number of tablespoons and the assumption that 1
44 200 tablespoon was equivalent to 5 grams. Hyperglycemia was defined based on a random blood glucose
45 201 measured of 11.1 or above and/or self-report of taking diabetes medication. We categorized participants
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202 as tobacco users if they either smoked cigarettes, cigars or pipes, or if they used smokeless tobacco
203 products such as zarda, sadapata, gul and/or snuff.

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205 Data Analysis:

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

212 Adjusted and unadjusted Poisson regression using robust estimation of standard errors analyses
213 were performed to identify significant predictors, or risk factors, of pre-hypertension and hypertension¹⁵⁻
214¹⁷. Potential risk factors were assessed using bivariate Poisson regression analysis; an arbitrary p-value of
215 <0.10 was used as criteria to include the variable in the multivariable Poisson regression model to control
216 for confounding effects. For multivariable Poisson regression models, crude prevalence ratios (cPR),
217 adjusted prevalence ratios (aPR), and 95% confidence intervals (CI) for each independent variable were
218 calculated, $p < 0.05$ was used as the level of significance. Collinearity was assessed using the variance
219 inflation factor to ensure a strong linear relationship among independent variables included in the model
220 was not present. The outcome variable of the model to identify risk factors for hypertension was coded as
221 "1" if the participant was found to be hypertensive based on the definition described above and the rest
222 were coded as "0." To identify predictors of pre-hypertension, we excluded those with existing
223 hypertension at study measurement from the binary dependent variable of pre-hypertension. Accordingly,
224 the outcome variable was coded as "1" if the participant was found to be pre-hypertensive and the rest
225 were coded as "0." All statistical procedures were performed using Stata/SE 15.1 (StataCorp LP, Texas,
226 USA) software package.

227

228 **Results**

229 Background Characteristics

230 Overall, out of 1036 households in the sampling frame, at least one participant from 866
231 households agreed to participate leading to an 83.6% response rate by household. On an individual level,
232 58.9% (2600/4414) of village residents participated in our survey. Per household, there were an average
233 3.0 participants (95% CI: 2.89-3.11). In our sample, there were 1205 (46.4%) men and 1395 (53.7%)
234 female respondents (Table 1). The age of our participants ranged from 18 to 85 years. The mean age and
235 education level of participants were 41.6 (SD = 17.8) years and 4.9 (SD = 4.6) years, respectively. On

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3 236 average, men were more educated than women, with 15.9% men pursuing above secondary education
4 237 compared to 6.3% women. The majority of men were employed as either an industrial worker/day laborer
5 238 (38.3%) or professional employment (39.3%), and the majority of women were either a housewife
6 239 (87.2%) or unemployed (11.9%). Smoking habits varied by sex: 99% of women reported to have never
7 240 used smoking tobacco such as cigarettes, however, 51.3% of men either currently or previously used
8 241 smoking tobacco. More women reported to currently use smokeless tobacco compared to men (31.8% vs
9 242 21.4%). More women were overweight or obese than men (15.8% vs 7.6%). Additionally, more women
10 243 were categorized as hyperglycemic compared to men (3.2% vs 2.2%).
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245 Prevalence and Predictors of Hypertension

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19 246 Overall, the prevalence of hypertension among our population of rural adults aged ≥ 18 years was
20 247 6.9% (95% CI: 5.9-7.9). The prevalence of hypertension was significantly higher among women (8.9%,
21 248 95% CI: 7.4-10.5) than men (4.5%, 95% CI: 3.4-5.8) (Chi-squared $P = <0.001$). Additionally, the
22 249 prevalence of hypertension increased with age among both men and women ($p <0.001$), with the highest
23 250 prevalence of hypertension among women aged 60 years and above (21.3%, 95% CI: 16.6-26.7) (Figure
24 251 1). For comparability to prior studies, we report the prevalence of hypertension if restricted to those aged
25 252 ≥ 25 years (8.5%) and ≥ 35 years (11.3%).
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30 253 Among women, the prevalence of hypertension decreased as education level increased (12.3%:
31 254 no education to 2.3% above secondary education), however, among men the prevalence of hypertension
32 255 increased as education level increased (3.6%: no education to 7.9%: above secondary education) (Table
33 256 2). Among overweight and obese participants, the prevalence of hypertension was significantly higher
34 257 than among those with normal BMI, particularly among men (60% of obese men had hypertension).
35 258 Additionally, the prevalence of hypertension was significantly higher among those with hyperglycemia or
36 259 blood glucose levels approaching the diabetic limit (> 11.1 mmol/L) (Table 2).
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41 260 Table 3 presents the results of multivariable Poisson regression with robust variance analyses to
42 261 identify predictors of hypertension. Significant predictors of hypertension differed among men and
43 262 women. Among women, those of older age, both underweight and overweight/obesity BMI, and with
44 263 hyperglycemia were more likely to have hypertension. When compared to women with normal BMI,
45 264 women categorized as underweight or a BMI of 18.5 and below had 1.6 times the prevalence of
46 265 hypertension (95% CI: 1.1 – 2.5). Additionally, women who were overweight (aPR: 2.3, 95% CI: 1.5-3.5)
47 266 and obese (aPR: 4.9, 95% CI: 2.4-10.0) had a significantly higher prevalence of hypertension when
48 267 compared to women with normal BMI. After adjustment, educational status no longer appeared to have a
49 268 significant relationship with hypertension prevalence although the crude analysis revealed a protective
50 269 effect of higher education. Among men, those of older age, increasing educational level, being overweight
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3 270 and obese, and with hyperglycemia were more likely to have hypertension. Unlike in women, among men
4 271 with an educational level above secondary education, the prevalence of hypertension was 3.8 times that of
5 272 men with no formal education (aPR: 3.8, 95% CI: 1.8-8.2). Hyperglycemia was a significant determinant
6 273 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).
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275 Awareness and Treatment of Hypertension

12 276 Overall, among those with hypertension, 58% were aware of their diagnosis (Figure 2). The
13 277 proportion of those aware of their hypertension diagnosis was higher among men (72%) than women
14 278 (52%). When assessed by age group, the proportion of women who were aware of their diagnosis
15 279 decreased with increasing age, dropping from 55% among those aged 30-44 years to 46.5% among
16 280 women aged 60 years and above. Among those who were aware of their hypertension diagnosis (n = 105),
17 281 99.1% of participants (n = 104) self-reported to take antihypertensive medication. Among those who are
18 282 taking medication to control their hypertension, 55.2% had normal blood pressure (SBP: <140 mmHg and
19 283 DBP: <90 mmHg). The proportion of participants with controlled hypertension did not significantly differ
20 284 by sex (men: 58.9%, women: 53.0%, chi squared p = 0.55).
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30 287 Prevalence and Predictors of Prehypertension

31 288 The prevalence of prehypertension among our population of rural adults was 37.7% (95% CI:
32 289 35.7-39.6). Overall, the prevalence of prehypertension was higher among men (41.4%, 95% CI: 38.6-
33 290 44.3) than women (34.2%, 95% CI: 31.6 – 36.9) (Table 4). This sex difference in prevalence of
34 291 prehypertension was consistent across all age groups (Figure 3). The highest prevalence of
35 292 prehypertension was observed among men and women aged 60 years and above (57.9%, 50%
36 293 respectively) (Figure 3).
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41 294 Table 4 presents the results of multivariable Poisson regression with robust variance analyses to
42 295 identify predictors of prehypertension. Among both women, predictors of prehypertension included older
43 296 age (≥ 45 years) and being overweight or obese. Among women who were aged 45-59 years the
44 297 prevalence of hypertension was 1.4 times that of the prevalence among women aged 18-29 years.
45 298 Additionally, the prevalence of women aged 60 years and above was 2.3 times that of women aged 18-29
46 299 years. Women who were obese had 2 times the prevalence of hypertension compared to women with a
47 300 normal body mass index. Similar predictors were identified among men: men who were obese had 1.9
48 301 times the prevalence of men with a normal BMI. Increasing age among men also led to an increase in
49 302 hypertension prevalence. Hyperglycemia was not a significant determinant of prehypertension among
50 303 men or women (Table 4).
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Discussion

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

320 In our study, the overall prevalence of hypertension was 6.9%, which is lower than prior studies
321 conducted in Bangladesh. Nationally representative data collected in 2010 among adults ≥ 25 years
322 estimated the prevalence of hypertension and prehypertension was 20% and 43%, respectively⁶. Similar
323 to our study's findings, the prevalence of hypertension among rural women (18.2%) was slightly higher
324 than men (17.6%). Another nationally representative analysis conducted in 2011 among adults ≥ 35 years
325 found the age-standardized prevalence of hypertension and prehypertension was 24.4% and 27.1%; the
326 odds of having hypertension were higher among women compared to men¹⁸ in both urban and rural
327 regions¹⁹. In one study conducted in rural Bangladesh, the prevalence of hypertension was 16% and
328 factors such as increasing age and higher BMI was positively associated with hypertension¹⁰. Although
329 they found no difference in prevalence of hypertension by sex, the prevalence of pre-hypertension was
330 higher among men (33.6%) than women (30.6%), which is similar to our findings. Another study
331 conducted in a different rural area of Bangladesh identified a strikingly high prevalence of hypertension
332 among over 3000 adults aged ≥ 30 years across both sex groups of 40% (95% CI: 38-42%)²⁰.

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

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3 338 residents of Ekhlaspur have been advised to be more physically active, avoid tobacco and alcohol
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5 339 products, and reduce dietary salt intake. ECOH has provided hypertension treatment services for several
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7 340 years. The clinic provides patients with counselling on lifestyle changes and provides antihypertensive
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9 341 medications free of charge. Evidence from ECOH and Ekhlaspur shows that with dedicated services and
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11 342 low cost treatment options, the burden of hypertension in Bangladesh can be reduced and controlled.
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13 343 Despite these improvements in prevalence of hypertension in Ekhlaspur, sex differences persist in the
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15 344 area.

16 345 Our study demonstrates important sex differences in both prevalence, determinants, and
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18 346 awareness of hypertension in rural Bangladesh. Hypertension prevalence among women (8.9%) was
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20 347 significantly higher than among men (4.5%, $p < 0.001$). Additionally, we found that as age increases, the
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22 348 difference in prevalence by sex also increases drastically; among adults aged ≥ 60 years the difference in
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24 349 prevalence of hypertension is almost double (21.3% among women vs 12.3%) among men. Moreover,
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26 350 men were more likely to be aware of having hypertension than women, leaving almost half of women
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28 351 with hypertension unaware and untreated for their condition. However, when adults were aware of their
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30 352 condition there were no sex differences in hypertension treatment or medication use. Efforts to ensure
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32 353 women have equal access to preventive care as men in rural areas of Bangladesh should be prioritized.

33 354 ECOH provides accessible hypertension services at free or low cost. Prior studies have shown
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35 355 that barriers to seeking hypertension treatment in Bangladesh include inadequate availability of services,
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37 356 poor quality of existing facilities, shortage of medicine supplies, long distance to health care facilities, and
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39 357 cost of continued treatment once diagnosed^{21 22}. In 2014, it was estimated that only 16% of health care
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41 358 facilities across the country (i.e. hospitals, community clinics) have the capacity to diagnose, prescribe
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43 359 treatment for, and manage patients with hypertension²³. Additionally, among facilities with the capacity
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45 360 to offer services for hypertension management, less than one-third had essential CVD medicines readily
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47 361 available on-site for patients²³. Prior studies have also mentioned the value of provider-patient
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49 362 relationships and the importance of continuity of care and follow-up with providers who prescribed their
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51 363 medication (NIPORT 2016). ECOH has been able to address these barriers by providing consistent care to
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53 364 the residents of Ekhlaspur and at free or low cost. As Bangladesh moves towards implementing universal
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55 365 health care²⁴, efforts should be focused on establishing clinics particularly in rural areas to make health
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57 366 care accessible and to support the continuity of care.

58 367 In our analysis, we found that female sex, older age, higher education, high BMI and blood
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60 368 glucose levels approaching the diabetic range (≥ 11.1) were determinants of hypertension, which is similar
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62 369 to prior nationally-representative studies conducted in Bangladesh^{13 25 26}. These determinants were
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64 370 consistent across sex groups, excluding educational status. Among men, higher education led to an
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66 371 increase in hypertension prevalence when compared to no education. However, among women, higher

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3 372 education appeared to have a protective effect when compared to no education although not statistically
4 373 significant after adjustment. Higher educational attainment among women may be lead to employment,
5 374 higher physical activity and active commuting, which have been shown to reduce sedentary behavior
6 375 among Bangladeshi women ²⁷.

9 376 Interestingly, we observed that normotensives had higher added salt intake (90.6%) compared to
11 377 hypertensive adults (81.5%). This may be due to an ongoing dietary salt reduction campaign in Ekhlaspur
12 378 village focused on high-risk patients, including hypertensive adults. Clinic based data from ECOH have
14 379 clearly demonstrated a sharp decline of added salt intake among those who have hypertension, dropping
16 380 from 73% at enrollment to 13% after about five months, based on self-report ²⁸ Similarly, we observed a
17 381 high proportion of hypertensive participants who previously used tobacco. Patients of ECOH with
19 382 hypertension have been counseled on the harms of tobacco use, both smokeless and smoking, and as such
21 383 the majority reported to use either tobacco form in the past.

22 384 This study has several strengths. First, we present novel prevalence data on hypertension and
23 385 prehypertension as we included adults aged 18 years and above, whereas prior studies have started their
25 386 cohorts at older ages. Additionally, we used WHO-recommended standardized methods to measure BP
27 387 among our study population to limit the potential for measurement error. There are several limitations to
28 388 be considered when interpreting our results. Prior to this survey, community-level campaigns took place
30 389 to educate the adults on NCD prevention and lifestyle changes that may reduce their risk of developing
32 390 chronic diseases. As such, they were generally more educated about public health interventions, which
33 391 may limit the generalizability of our findings. Self-reported medication use may be subject to social
35 392 desirability bias as participants are in regular contact with ECOH staff members through community
36 393 campaigns and prior surveillance efforts. We were unable to measure important risk factors of
38 394 hypertension such as diet, physical activity, waist circumference, family history of cardiovascular disease,
39 395 and blood lipid levels. Finally, due to the cross-sectional nature of our study design, we were unable to
41 396 assess temporality of our risk factors or establish any causal relationship with our outcome of interest.

42 397

44 398 **Conclusion**

46 399 In conclusion, our sex-disaggregated analysis showed a higher burden of hypertension among
47 400 women compared to men in a rural area of Bangladesh. Furthermore, we found that women were less
49 401 likely to be have been previously diagnosed with hypertension compared to men and thus, more women
51 402 had uncontrolled hypertension. The prevalence of prehypertension was higher among men than women.
52 403 An alarmingly high proportion of those aged 18-29 years had prehypertension (27.9%). A preventive
54 404 community-based approach with sex-tailored educational efforts should be directed to those with
55 405 prehypertension, as they are at highest risk of developing hypertension. The primary health care system of

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3 406 Bangladesh is limited, particularly in rural areas, due to a shortage of trained health care providers
4 407 including physicians and nurses. Efforts towards population-level prevention measures, specifically
5 408 lifestyle changes, should be promoted and directed towards risk groups identified through this analysis,
6 409 such as those who are overweight or obese.
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3 440 **Footnotes:**

4
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7
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13 446

14 447 **Author contributions:**

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16 448 JYI conceptualized the manuscript, guided data analysis, interpreted critically, wrote the
17 449 manuscript; MMZ conceptualized the intervention, assisted with data analysis and manuscript
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19 450 development; JA and SRC established methodologies, executed the campaign, supervised and monitored
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21 451 data collection, trained the health workers; TZ conducted clinic-based counselling, trained counsellors on
22 452 counselling skills, reviewed literature and prepared citations; HK prepared questionnaires, maintained
23
24 453 records, worked as a data manager. All authors have read and approved the submission.
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27 455 **Disclosure statement:**

28 456 The authors have no conflicts of interest to disclose.
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32 458 **Ethics and consent:**

33 459 To inform the community about this survey, ECOH management organized meetings and
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35 460 orientations with the community leaders, schools, and union council members. This survey is part of the
36
37 461 community's initiative to monitor their health status and to detect any hypertension, diabetes and other
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39 462 risk factors. ECOH provides free medicines to those who have prescriptions from doctors. Community-
40
41 463 level campaigns have been organized to inform the people of the village about NCDs and related risk
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43 464 factors. Health assistants of ECOH visited all households to select eligible subjects but no more than three
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45 465 recall visits were done. Ethical guidelines as outlined and approved by the Bangladesh Medical Research
46
47 466 Council were followed throughout the study. Written informed consent was obtained from the
48
49 467 respondents in Bengali to participate in this survey.
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51 468

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53 470 Data collection was conducted using ECOH's own funds generated by the local community as
54
55 471 regular surveillance. We did not receive any funding from external organizations to complete this work.
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474 **References**

- 475 1. WHO. A global brief on Hypertension: Silent Killer, global public health crisis. Geneva,
476 Switzerland: World Health Organization, 2013.
- 477 2. Lloyd-Sherlock P, Beard J, Minicuci N, et al. Hypertension among older adults in low- and
478 middle-income countries: prevalence, awareness and control. *International journal of*
479 *epidemiology* 2014;43(1):116-28. doi: 10.1093/ije/dyt215
- 480 3. Kearney PM, Whelton M, Reynolds K, et al. Global burden of hypertension: analysis of
481 worldwide data. *Lancet (London, England)* 2005;365(9455):217-23. doi: 10.1016/S0140-
482 6736(05)17741-1
- 483 4. Moniruzzaman TA, Rahman S Prevalence of hypertension among the Bangladeshi adult
484 population: a meta-analysis. *Reg Health Forum* 2013;17:15-19.
- 485 5. Zaman MM, Rouf MA. Prevalence of hypertension in a Bangladeshi adult population. *Journal*
486 *of human hypertension* 1999;13(8):547-9.
- 487 6. Rahman M, Zaman MM, Islam JY, et al. Prevalence, treatment patterns, and risk factors of
488 hypertension and pre-hypertension among Bangladeshi adults. *Journal of human*
489 *hypertension* 2018;32(5):334-48. doi: 10.1038/s41371-017-0018-x
- 490 7. Neupane D, McLachlan CS, Sharma R, et al. Prevalence of hypertension in member countries
491 of South Asian Association for Regional Cooperation (SAARC): systematic review and
492 meta-analysis. *Medicine* 2014;93(13):e74. doi: 10.1097/MD.0000000000000074
- 493 8. National Guidelines for Management of Hypertension in Bangladesh. Dhaka, Bangladesh:
494 WHO/SEARO/Country Office for Bangladesh and DGHS, Ministry of Health and
495 Family Welfare 2013.
- 496 9. Ahsan Karar Z, Alam N, Kim Streatfield P. Epidemiological transition in rural Bangladesh,
497 1986-2006. *Global health action* 2009;2 doi: 10.3402/gha.v2i0.1904
- 498 10. Khanam MA, Lindeboom W, Razzaque A, et al. Prevalence and determinants of pre-
499 hypertension and hypertension among the adults in rural Bangladesh: findings from a
500 community-based study. *BMC public health* 2015;15:203. doi: 10.1186/s12889-015-
501 1520-0

- 1
2
3 502 11. Fottrell E, Ahmed N, Shaha SK, et al. Distribution of diabetes, hypertension and non-
4 503 communicable disease risk factors among adults in rural Bangladesh: a cross-sectional
5 504 survey. *BMJ Glob Health* 2018;3(6):e000787. doi: 10.1136/bmjgh-2018-000787
6
7
8
9 505 12. Biswas T, Townsend N, Islam MS, et al. Association between socioeconomic status and
10 506 prevalence of non-communicable diseases risk factors and comorbidities in Bangladesh:
11 507 findings from a nationwide cross-sectional survey. *BMJ open* 2019;9(3):e025538. doi:
12 508 10.1136/bmjopen-2018-025538
13
14
15 509 13. Rahman M, Zaman MM, Islam JY, et al. Prevalence, treatment patterns, and risk factors of
16 510 hypertension and pre-hypertension among Bangladeshi adults. *Journal of human*
17 511 *hypertension* 2017 doi: 10.1038/s41371-017-0018-x
18
19
20
21 512 14. Ekhlaspur Center of Health 2018 [Available from: <http://ecohbd.org/index.php> accessed June
22 513 2018.
23
24
25 514 15. Coutinho LM, Scazufca M, Menezes PR. Methods for estimating prevalence ratios in cross-
26 515 sectional studies. *Revista de saude publica* 2008;42(6):992-8.
27
28
29 516 16. Behrens T, Taeger D, Wellmann J, et al. Different methods to calculate effect estimates in
30 517 cross-sectional studies. A comparison between prevalence odds ratio and prevalence
31 518 ratio. *Methods Inf Med* 2004;43(5):505-9.
32
33
34
35 519 17. Barros AJ, Hirakata VN. Alternatives for logistic regression in cross-sectional studies: an
36 520 empirical comparison of models that directly estimate the prevalence ratio. *BMC medical*
37 521 *research methodology* 2003;3:21. doi: 10.1186/1471-2288-3-21
38
39
40 522 18. Rahman MM, Gilmour S, Akter S, et al. Prevalence and control of hypertension in
41 523 Bangladesh: a multilevel analysis of a nationwide population-based survey. *Journal of*
42 524 *hypertension* 2015;33(3):465-72; discussion 72. doi: 10.1097/HJH.0000000000000421
43
44
45 525 19. Kibria GMA, Swasey K, Das Gupta R, et al. Differences in prevalence and determinants of
46 526 hypertension according to rural-urban place of residence among adults in Bangladesh.
47 527 *Journal of biosocial science* 2018:1-13. doi: 10.1017/S0021932018000366
48
49
50
51 528 20. Islam FM, Bhuiyan A, Chakrabarti R, et al. Undiagnosed hypertension in a rural district in
52 529 Bangladesh: The Bangladesh Population-based Diabetes and Eye Study (BPDES).
53 530 *Journal of human hypertension* 2016;30(4):252-9. doi: 10.1038/jhh.2015.65
54
55
56
57
58
59
60

- 1
2
3 531 21. Legido-Quigley H, Naheed A, de Silva HA, et al. Patients' experiences on accessing health
4 532 care services for management of hypertension in rural Bangladesh, Pakistan and Sri
5 533 Lanka: A qualitative study. *PloS one* 2019;14(1):e0211100. doi:
6 534 10.1371/journal.pone.0211100
7
8
9
10 535 22. Khatib R, Schwalm JD, Yusuf S, et al. Patient and healthcare provider barriers to
11 536 hypertension awareness, treatment and follow up: a systematic review and meta-analysis
12 537 of qualitative and quantitative studies. *PloS one* 2014;9(1):e84238. doi:
13 538 10.1371/journal.pone.0084238
14
15
16 539 23. NIPORT. Bangladesh Health Facility Survey 2014 Dhaka, Bangladesh: National Institute of
17 540 Population Research and Training (NIPORT), Associates for Community and Population
18 541 Research (ACPR), and ICF International. ; 2016 [Available from:
19 542 <https://dhsprogram.com/pubs/pdf/SPA23/SPA23.pdf> accessed 03/15 2019.
20
21
22
23 543 24. Rahman MS, Rahman MM, Gilmour S, et al. Trends in, and projections of, indicators of
24 544 universal health coverage in Bangladesh, 1995-2030: a Bayesian analysis of population-
25 545 based household data. *The Lancet Global health* 2018;6(1):e84-e94. doi: 10.1016/S2214-
26 546 109X(17)30413-8
27
28
29
30 547 25. Chowdhury MA, Uddin MJ, Haque MR, et al. Hypertension among adults in Bangladesh:
31 548 evidence from a national cross-sectional survey. *BMC cardiovascular disorders*
32 549 2016;16:22. doi: 10.1186/s12872-016-0197-3
33
34
35 550 26. Islam JY, Zaman MM, Haq SA, et al. Epidemiology of hypertension among Bangladeshi
36 551 adults using the 2017 ACC/AHA Hypertension Clinical Practice Guidelines and Joint
37 552 National Committee 7 Guidelines. *Journal of human hypertension* 2018;32(10):668-80.
38 553 doi: 10.1038/s41371-018-0087-5
39
40
41
42 554 27. Moniruzzaman M, Mostafa Zaman M, Islalm MS, et al. Physical activity levels in
43 555 Bangladeshi adults: results from STEPS survey 2010. *Public health* 2016;137:131-8. doi:
44 556 10.1016/j.puhe.2016.02.028
45
46
47 557 28. Zaman MM, Ahmed J, Choudhury SR, et al. Hypertension Clinic Service is a Good
48 558 Opportunity for Tobacco Cessation in Bangladeshi Villagers. *Cardiovascular Journal of*
49 559 *Bangladesh* 2016;9(1):19-22.
50
51 560
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563 Figures

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

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

568 Figure 3: Prevalence of pre-hypertension stratified by age group and sex among rural adults in
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Table 1: Background characteristics of participants of rural Ekhaspur, Bangladesh (n = 2600)

Characteristic	Total (n = 2600)		Women (n = 1395)		Men (n = 1205)		P*
	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 [‡]							<0.001
Underweight (≤18.5)	251	9.7	184	13.2	67	5.6	
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-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

Characteristic	Total (n = 2600)		P*	Women (n = 1395)		P*	Men (n = 1205)		P*
	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

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

Characteristic	Total (n = 2600)		Women (n = 1395)		Men (n = 1205)	
	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

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

Characteristic	Total (n = 2422)			Women (n = 1271)			Men (n = 1151)		
	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

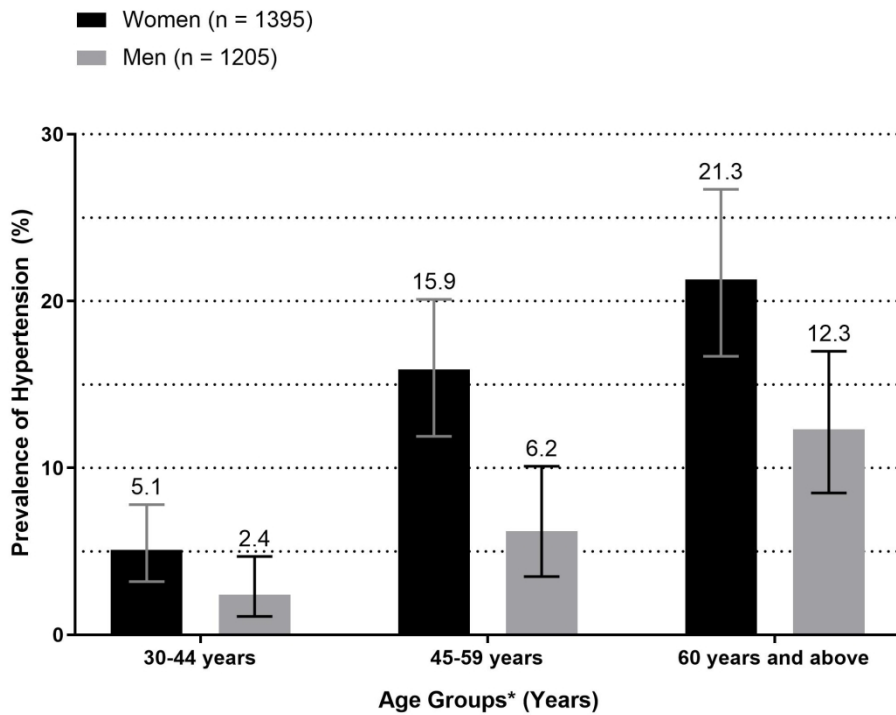
* Ever tobacco use includes ever smokeless or smoking tobacco use

‡ 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

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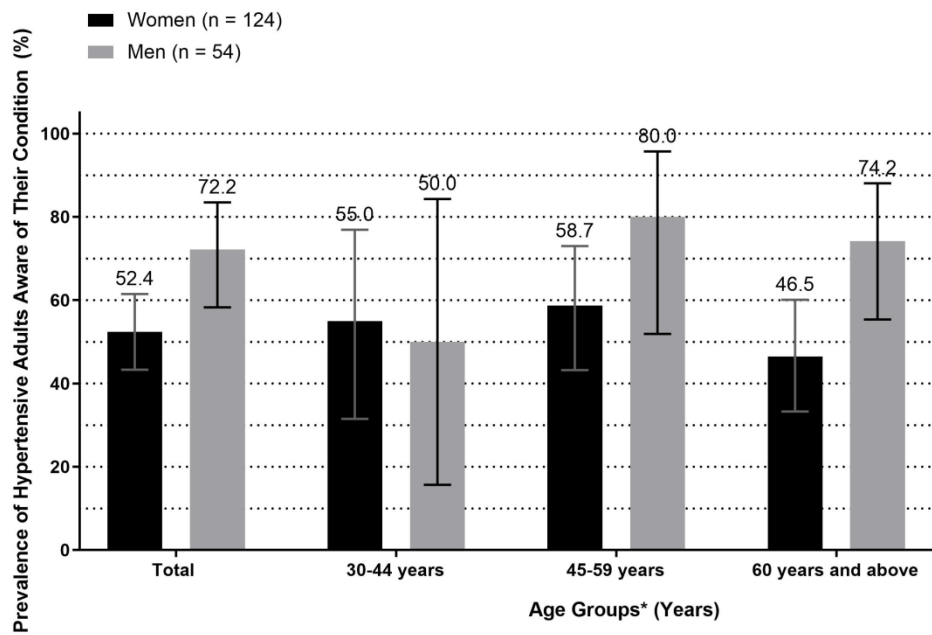


*Age group 18-29 years was not included as prevalence of hypertension was 0% for both men and women

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

185x149mm (300 x 300 DPI)

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*Age group 18-29 years was not included as prevalence of hypertension was 0% for both men and women

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

213x155mm (300 x 300 DPI)

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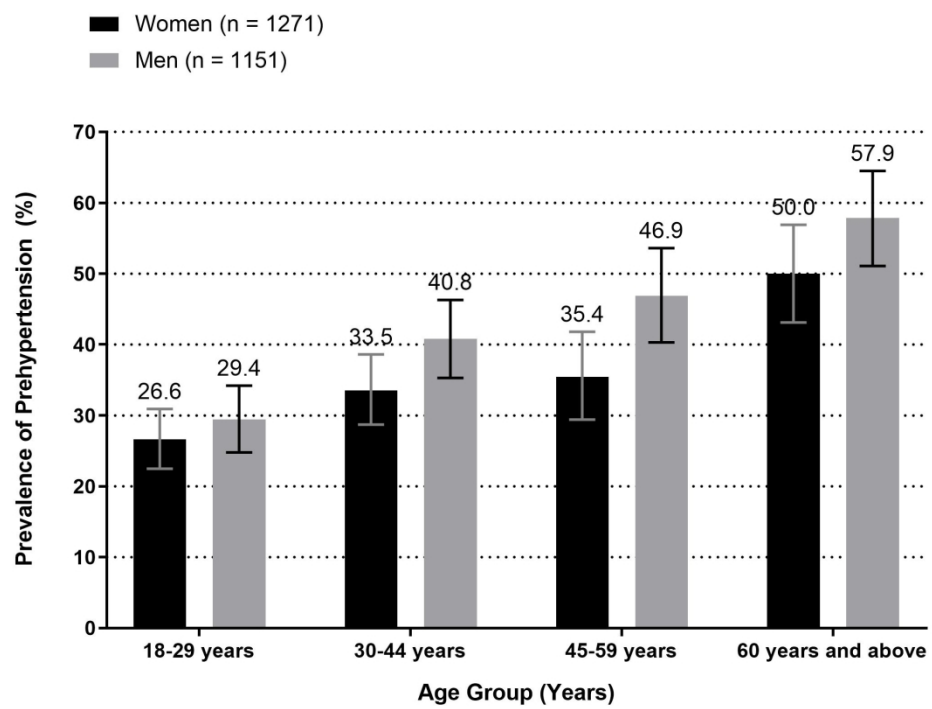


Figure 3: Prevalence of pre-hypertension stratified by age group and sex among rural adults in Bangladesh

187x137mm (300 x 300 DPI)

STROBE Statement

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

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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	
		(a) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5	
Participants	6	<i>Case-control study</i> —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		
		<i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants		
Variables	7	(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed	6,7	
		<i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case		
Data sources/measurement	8*	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6,7	
Bias	9	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	12	
Study size	10	Describe any efforts to address potential sources of bias	5	
Quantitative variables	11	Explain how the study size was arrived at	6,7	
		Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why		
		(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
Statistical methods	12	(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed	N/A	
		<i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed		
		<i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy		
		(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) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	9,10
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	
		<i>Cross-sectional study</i> —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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Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Cardiovascular medicine, Global health, Public health
Keywords:	Hypertension < CARDIOLOGY, EPIDEMIOLOGY, PUBLIC HEALTH

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3 **1 Sex differences in prevalence and determinants of hypertension among adults: a cross-sectional**
4 **2 survey of one rural village in Bangladesh**
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8 4 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

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5 69 **Article Summary**6 70 **Strengths and Limitations of the Study**

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9 71 • The population studied was enumerated by the Ekhlaspur Center of Health (ECOH) study staff,
10 72 which allowed us to provide accurate estimates of prevalence using a well-defined denominator
11 73 in a rural area of Bangladesh.
- 12 74 • We used WHO-recommended standardized methods to measure blood pressure to limit the
13 75 potential for measurement error.
- 14 76 • Generalizability of our results may be limited as community-level campaigns on non-
15 77 communicable disease prevention and lifestyle changes that may reduce their risk of developing
16 78 chronic diseases commonly took place in this village.
- 17 79 • Self-reported medication use may be subject to social desirability bias as participants are in
18 80 regular contact with ECOH staff members through community campaigns and prior surveillance
19 81 efforts.
- 20 82 • We were unable to measure important risk factors of hypertension such as diet, physical activity,
21 83 waist circumference, family history of cardiovascular disease, and blood lipid levels.

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102 Introduction

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

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

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132 Methods

133 Data for this analysis were collected from January 2014 to December 2015 among residents, aged
134 18 years or older, in a rural area of Bangladesh named, Ekhlaspur village of Matlab North Sub-district.

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3 135 Ekhlaspur is located about 60 kilometers south-east of Dhaka city, the capital of Bangladesh. Ekhlaspur
4 136 Centre of Health (ECOH), a local nongovernmental health promotion organization, conducts periodic
5 137 demographic surveys in the village¹⁴. ECOH was founded in 1999 (by MMZ) but it has been managed
6 138 and funded by the local community.

9 139 Data included in this analysis was obtained through ECOH's routine surveillance work and
10 140 biennial health checkup of all adult residents of the village. To inform the community about this survey,
11 141 ECOH management organized meetings and orientations with the community leaders, schools, and union
12 142 council members. This survey is part of the community's initiative to monitor their health status and to
13 143 detect any hypertension, diabetes and other risk factors. ECOH provides free medicines to those who have
14 144 prescriptions from doctors. Community-level campaigns have been organized to inform the people of the
15 145 village about NCDs and related risk factors. Health assistants of ECOH visited all households to select
16 146 eligible subjects but no more than three recall visits were done. Ethical guidelines as outlined and
17 147 approved by the Bangladesh Medical Research Council were followed throughout the study. Written
18 148 informed consent was obtained from the respondents in Bengali to participate in this survey.

19 149 ECOH conducted geographic surveillance to identify and compile a complete list of households
20 150 with demographic information of residents. As of 2015, the village had 1036 households. Residents aged
21 151 ≥ 18 years living in the village were the target population for this study. In total there were 4871 adults
22 152 aged ≥ 18 years (2520 men and 2351 women). However, 4414 residents (2202 men and 2212 women)
23 153 were living in the village permanently. The remaining 457 residents lived in either urban areas or outside
24 154 the country to earn their livelihoods and occasionally visited the village. Therefore, permanent residents
25 155 aged ≥ 18 years were considered eligible for the survey. Pregnant women were excluded.

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27 157 Patient and Public Involvement

28 158 These data were collected as part of routine surveillance conducted by ECOH, which is managed
29 159 and funded by the local community. Patients routinely attend health fairs and obtain free health care from
30 160 ECOH. There was no patient or public involvement in the interpretation of analytic results.

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32 162 Survey Instrument:

33 163 We administered a structured questionnaire to assess basic demographics and physical
34 164 measurements of each participant. The questionnaire was administered in Bengali. We obtained details on
35 165 household size and composition from the head of each household. Each participant provided information
36 166 on tobacco use, salt intake, health history including history of diabetes, hypertension, stroke, heart disease
37 167 and chronic respiratory illness, and physical measurements including blood pressure. History of
38 168 hypertension was assessed using the following questions: (1) Have you ever been diagnosed with

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3 169 hypertension by a health care provider?; (2) If yes, are you receiving treatment for the condition?; and (3)
4 170 If yes, where are you receiving your treatment? Treatment history of participants was confirmed by
5 171 ECOH field workers through prescription and medical charts. Blood pressure was measured by calibrated
6 172 aneroid sphygmomanometer by a trained field interviewer. Blood pressure measurements were
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8 173 consistently taken on the right arm at level of the heart and elbow-assisted while the participant was
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10 174 seated. After a test run, the first measurement was performed after five minutes of rest on the right arm.
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12 175 After three minutes, the second measurement was taken. The Korotkoff phase I (beginning of the sound)
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14 176 and the phase V of Korotkoff (disappearance of the sound) was recorded as systolic and diastolic blood
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16 177 respectively. The mean of these two blood pressure readings was utilized as the final blood pressure for
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18 178 each participant.
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20 180 Outcome Definition:

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22 181 Our primary outcomes of interest were prevalence of hypertension and of pre-hypertension. We
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24 182 utilized the World Health Organization guidelines diagnostic criteria to define hypertension. An
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26 183 individual was considered to have hypertension if systolic blood pressure (SBP) was ≥ 140 mmHg
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28 184 (millimeters of mercury) and/or, diastolic blood pressure (DBP) ≥ 90 mmHg and/or currently taking any-
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30 185 hypertensive medication based on self-report. Prehypertension was defined as SBP ≥ 120 mmHg but <
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32 186 140 mmHg and/or DBP ≥ 80 mmHg but <90 mmHg and not taking anti-hypertensive medication at the
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34 187 time of the survey.
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36 189 Covariates:

37 190 The following variables were used as risk factors: sex, age, education, occupation, body mass
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39 191 index (BMI), diabetes and tobacco use. Education was categorized into five groups: no education, less
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41 192 than primary (completed \leq grade 4), primary school (completed grade 5), secondary school (completed
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43 193 grade 10), and higher secondary and above (completed \geq grade 12). Occupation was categorized into five
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45 194 groups for analysis. These groups included: professional employment (government employee, non-
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47 195 government employee, business owner, farmer, agricultural worker, and other self-employed),
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49 196 unemployed or retired, industrial worker or day laborer, housemaker and other (beggar, rickshaw puller,
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51 197 cook, carpenter, tailor, security guard, migrant workers and fishermen). Utilizing height (centimeters) and
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53 198 weight (kilograms) measurements, we calculated BMI ($\text{height}/\text{weight}^2$) and categorized these
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55 199 measurements as follows: underweight (≤ 18.50), normal (18.6-25), overweight (25.1-30) and obese
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57 200 (>30). Participants were asked if they added any additional teaspoons of salt to their food during their
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59 201 meals. Added salt intake was categorized based on the number of tablespoons and the assumption that 1
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202 tablespoon was equivalent to 5 grams. Hyperglycemia was defined based on a random blood glucose

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3 203 measured of 11.1 or above and/or self-report of taking diabetes medication. We categorized participants
4 204 as tobacco users if they either smoked cigarettes, cigars or pipes, or if they used smokeless tobacco
5 205 products such as zarda, sadapata, gul and/or snuff. We defined past tobacco users as respondents who
6 206 were ever users of tobacco, however, currently do not use tobacco products.
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11 208 Data Analysis:

12 209 Sociodemographic variables were presented with median (interquartile range) for continuous
13 210 variables and with proportion for categorical variables. The overall, sex-specific, age-specific by sex, and
14 211 area-specific prevalence of hypertension were calculated. For bivariate analyses, study participants were
15 212 divided by sex and into five age groups (18-29, 30-44, 45-59, and 60+ years). A chi-square test was
16 213 performed to assess proportional differences in hypertension and treatment patterns across select
17 214 categorical variables.
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22 215 Adjusted and unadjusted Poisson regression using robust estimation of standard errors analyses
23 216 were performed to identify significant predictors, or risk factors, of pre-hypertension and hypertension¹⁵⁻
24 217¹⁷. Potential risk factors were assessed using bivariate Poisson regression analysis; an arbitrary p-value of
25 218 <0.10 was used as criteria to include the variable in the multivariable Poisson regression model to control
26 219 for confounding effects. For multivariable Poisson regression models, crude prevalence ratios (cPR),
27 220 adjusted prevalence ratios (aPR), and 95% confidence intervals (CI) for each independent variable were
28 221 calculated, $p < 0.05$ was used as the level of significance. Collinearity was assessed using the variance
29 222 inflation factor to ensure a strong linear relationship among independent variables included in the model
30 223 was not present. The outcome variable of the model to identify risk factors for hypertension was coded as
31 224 "1" if the participant was found to be hypertensive based on the definition described above and the rest
32 225 were coded as "0." To identify predictors of pre-hypertension, we excluded those with existing
33 226 hypertension at study measurement from the binary dependent variable of pre-hypertension. Accordingly,
34 227 the outcome variable was coded as "1" if the participant was found to be pre-hypertensive and the rest
35 228 were coded as "0." All statistical procedures were performed using Stata/SE 15.1 (StataCorp LP, Texas,
36 229 USA) software package.
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47 231 **Results**

48 232 Background Characteristics

49 233 Overall, out of 1036 households in the sampling frame, at least one participant from 866
50 234 households agreed to participate leading to an 83.6% response rate by household. On an individual level,
51 235 58.9% (2600/4414) of village residents participated in our survey. Per household, there were an average
52 236 3.0 participants (95% CI: 2.89-3.11). In our sample, there were 1205 (46.4%) men and 1395 (53.7%)
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3 237 female respondents (Table 1). The age of our participants ranged from 18 to 85 years. The mean age and
4 238 education level of participants were 41.6 (SD = 17.8) years and 4.9 (SD = 4.6) years, respectively. On
5 239 average, men were more educated than women, with 15.9% men pursuing above secondary education
6 240 compared to 6.3% women. About one-third of men were employed as either an industrial worker/day
7 241 laborer (38.3%) or professional employment (39.3%), and the majority of women were either a housewife
8 242 (87.2%) or unemployed (11.9%). Smoking habits varied by sex: 99% of women reported to have never
9 243 used smoking tobacco such as cigarettes, however, 51.3% of men either currently or previously used
10 244 smoking tobacco. More women reported to currently use smokeless tobacco compared to men (31.8% vs
11 245 21.4%). More women were overweight or obese than men (15.8% vs 7.6%). Additionally, more women
12 246 were categorized as hyperglycemic compared to men (3.2% vs 2.2%). Figure 1 provides a distribution of
13 247 systolic and diastolic blood pressure by age group and sex.
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22 249 Prevalence and Predictors of Hypertension

23
24 250 Overall, the prevalence of hypertension among our population of rural adults aged ≥ 18 years was
25 251 6.9% (95% CI: 5.9-7.9). The prevalence of hypertension was significantly higher among women (8.9%,
26 252 95% CI: 7.4-10.5) than men (4.5%, 95% CI: 3.4-5.8) (Chi-squared $P = <0.001$). Additionally, the
27 253 prevalence of hypertension increased with age among both men and women ($p <0.001$), with the highest
28 254 prevalence of hypertension among women aged 60 years and above (21.3%, 95% CI: 16.6-26.7) (Figure
29 255 2). For comparability to prior studies, we report the prevalence of hypertension if restricted to those aged
30 256 ≥ 25 years (8.5%) and ≥ 35 years (11.3%).
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35 257 Among women, the prevalence of hypertension decreased as education level increased (12.3%:
36 258 no education to 2.3% above secondary education), however, among men the prevalence of hypertension
37 259 increased as education level increased (3.6%: no education to 7.9%: above secondary education) (Table
38 260 2). Among overweight and obese participants, the prevalence of hypertension was significantly higher
39 261 than among those with normal BMI, particularly among men (60% of obese men had hypertension).
40 262 Additionally, the prevalence of hypertension was significantly higher among those with hyperglycemia or
41 263 blood glucose levels approaching the diabetic limit (> 11.1 mmol/L) (Table 2).
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46 264 Table 3 presents the results of multivariable Poisson regression with robust variance analyses to
47 265 identify predictors of hypertension. Significant predictors of hypertension differed among men and
48 266 women. Among women, those of older age, both underweight and overweight/obesity BMI, and with
49 267 hyperglycemia were more likely to have hypertension. When compared to women with normal BMI,
50 268 women categorized as underweight or a BMI of 18.5 and below had 1.6 times the prevalence of
51 269 hypertension (95% CI: 1.1 – 2.5). Additionally, women who were overweight (aPR: 2.3, 95% CI: 1.5-3.5)
52 270 and obese (aPR: 4.9, 95% CI: 2.4-10.0) had a significantly higher prevalence of hypertension when
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3 271 compared to women with normal BMI. After adjustment, educational status no longer appeared to have a
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5 272 significant relationship with hypertension prevalence although the crude analysis revealed a protective
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7 273 effect of higher education. Among men, those of older age, increasing educational level, being overweight
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9 274 and obese, and with hyperglycemia were more likely to have hypertension. Unlike in women, among men
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11 275 with an educational level above secondary education, the prevalence of hypertension was 3.8 times that of
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13 276 men with no formal education (aPR: 3.8, 95% CI: 1.8-8.2). Hyperglycemia was a significant determinant
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15 277 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).

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279 Awareness and Treatment of Hypertension

17 280 Overall, among those with hypertension, 58% were aware of their diagnosis (Figure 3). The
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19 281 proportion of those aware of their hypertension diagnosis was higher among men (72%) than women
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21 282 (52%). When assessed by age group, the proportion of women who were aware of their diagnosis
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23 283 decreased with increasing age, dropping from 55% among those aged 30-44 years to 46.5% among
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25 284 women aged 60 years and above. Among those who were aware of their hypertension diagnosis (n = 105),
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27 285 99.1% of participants (n = 104) self-reported to take antihypertensive medication. Among those who are
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29 286 taking medication to control their hypertension, 55.2% had normal blood pressure (SBP: <140 mmHg and
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31 287 DBP: <90 mmHg). The proportion of participants with controlled hypertension did not significantly differ
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33 288 by sex (men: 58.9%, women: 53.0%, chi squared p = 0.55).

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291 Prevalence and Predictors of Prehypertension

36 292 The prevalence of prehypertension among our population of rural adults was 37.7% (95% CI:
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38 293 35.7-39.6). Overall, the prevalence of prehypertension was higher among men (41.4%, 95% CI: 38.6-
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40 294 44.3) than women (34.2%, 95% CI: 31.6 – 36.9) (Table 4). This sex difference in prevalence of
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42 295 prehypertension was consistent across all age groups (Figure 4). The highest prevalence of
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44 296 prehypertension was observed among men and women aged 60 years and above (57.9%, 50%
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46 297 respectively) (Figure 4).

46 298 Table 4 presents the results of multivariable Poisson regression with robust variance analyses to
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48 299 identify predictors of prehypertension. Among both women, predictors of prehypertension included older
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50 300 age (≥ 45 years) and being overweight or obese. Among women who were aged 45-59 years the
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52 301 prevalence of hypertension was 1.4 times that of the prevalence among women aged 18-29 years.
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54 302 Additionally, the prevalence of women aged 60 years and above was 2.3 times that of women aged 18-29
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56 303 years. Women who were obese had 2 times the prevalence of hypertension compared to women with a
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58 304 normal body mass index. Similar predictors were identified among men: men who were obese had 1.9

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3 305 times the prevalence of men with a normal BMI. Increasing age among men also led to an increase in
4 306 hypertension prevalence. Hyperglycemia was not a significant determinant of prehypertension among
5 307 men or women (Table 4).
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9 309 **Discussion**

10 310 In this study of adults aged ≥ 18 years in one rural area of Bangladesh, the prevalence of
11 311 hypertension prevalence was significantly higher among women compared to men. The determinants of
12 312 hypertension were consistent across sex excluding educational level; as educational level increased, the
13 313 prevalence of hypertension increased among men whereas among women hypertension prevalence
14 314 decreased, indicating a potential protective effect. Women were less likely to be aware they had
15 315 hypertension compared to men, particularly older women aged ≥ 60 years. Among adults who were aware
16 316 of their condition, we did not find any sex differences in antihypertensive medication use as almost 100%
17 317 of adults who were previously diagnosed with hypertension self-reported to take antihypertensive
18 318 medication. Findings from this survey may highlight the need for sex-specific tailored interventions.
19 319 Additionally, results from this analysis may underscore the importance of identifying high-risk groups in
20 320 rural areas, particularly elderly women as their prevalence of hypertension rivals that of urban residents in
21 321 Bangladesh.
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30 322 In our study, the overall prevalence of hypertension was 6.9%, which is lower than prior studies
31 323 conducted in Bangladesh. Nationally representative data, including both urban and rural residents,
32 324 collected in 2010 among adults ≥ 25 years estimated the prevalence of hypertension and prehypertension
33 325 was 20% and 43%, respectively⁶. Similar to our study's findings, the prevalence of hypertension among
34 326 rural women (18.2%) was slightly higher than men (17.6%). Another nationally representative analysis
35 327 conducted in 2011 among adults ≥ 35 years found the age-standardized prevalence of hypertension and
36 328 prehypertension was 24.4% and 27.1%; the odds of having hypertension were higher among women
37 329 compared to men¹⁸ in both urban and rural regions¹⁹. In one study conducted in rural Bangladesh, the
38 330 prevalence of hypertension was 16% and factors such as increasing age and higher BMI was positively
39 331 associated with hypertension¹⁰. Although they found no difference in prevalence of hypertension by sex,
40 332 the prevalence of pre-hypertension was higher among men (33.6%) than women (30.6%), which is similar
41 333 to our findings. Another study conducted in a different rural area of Bangladesh identified a strikingly
42 334 high prevalence of hypertension among over 3000 adults aged ≥ 30 years across both sex groups of 40%
43 335 (95% CI: 38-42%)²⁰.
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52 336 Hypertension prevalence in our study may be lower than previously documented due to two
53 337 reasons. First, our cohort was younger and included adults aged ≥ 18 years. We found hypertension
54 338 prevalence among our younger participants (18-29 years) to be 0%, although the prevalence of
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3 339 prehypertension was almost 30% in both sexes. Second, the lower hypertension prevalence may be
4 340 attributable to various public health interventions promoted by ECOH over the past several decades to
5 341 lower and control blood pressure of Ekhlaspur residents. Through these public health interventions,
6 342 residents of Ekhlaspur have been advised to be more physically active, avoid tobacco and alcohol
7 343 products, and reduce dietary salt intake. ECOH has provided chronic disease preventive and treatment
8 344 services for several years at low or free cost. Additionally, the clinic provides patients with counselling on
9 345 lifestyle changes and provides antihypertensive medications free of charge. Free and low-cost preventive
10 346 services are not widespread in rural areas of Bangladesh. In 2014, it was estimated that only 16% of
11 347 health care facilities across the country (i.e. hospitals, community clinics) have the capacity to diagnose,
12 348 prescribe treatment for, and manage patients with hypertension²¹. In fact, only 10% of community clinics
13 349 and maternal and child welfare centers, and 17% of union level facilities, which are the most accessible
14 350 providers in rural areas, provided any cardiovascular services, and the services at these facilities are
15 351 limited to the measurement of blood pressure or referrals²¹. Additionally, among facilities with the
16 352 capacity to offer services for hypertension management, less than one-third had essential CVD medicines
17 353 readily available on-site for patients²¹. Prior studies have shown that barriers to seeking hypertension
18 354 treatment in Bangladesh include inadequate availability of services, poor quality of existing facilities,
19 355 shortage of medicine supplies, long distance to health care facilities, and cost of continued treatment once
20 356 diagnosed^{22,23}. ECOH has been able to address these barriers by providing consistent care to the residents
21 357 of Ekhlaspur and at free or low cost. As Bangladesh moves towards implementing universal health care
22 358²⁴, efforts should be focused on establishing clinics particularly in rural areas to make health care
23 359 accessible and to support the continuity of care.

24 360 Our study demonstrates important sex differences in both prevalence, determinants, and
25 361 awareness of hypertension in rural Bangladesh. Hypertension prevalence among women (8.9%) was
26 362 significantly higher than among men (4.5%, $p < 0.001$). Additionally, we found that as age increases, the
27 363 difference in prevalence by sex also increases drastically; among adults aged ≥ 60 years the difference in
28 364 prevalence of hypertension is almost double (21.3% among women vs 12.3%) among men. Moreover,
29 365 men were more likely to be aware of having hypertension than women, leaving almost half of women
30 366 with hypertension unaware and untreated for their condition. However, when adults were aware of their
31 367 condition there were no sex differences in hypertension treatment or medication use. Efforts to ensure
32 368 women have equal access to preventive care as men in rural areas of Bangladesh should be prioritized.

33 369 In our analysis, we found that female sex, older age, higher education, high BMI and blood
34 370 glucose levels approaching the diabetic range (≥ 11.1) were determinants of hypertension, which is similar
35 371 to prior nationally-representative studies conducted in Bangladesh^{13,25,26}. These determinants were
36 372 consistent across sex groups, excluding educational status. Among men, higher education led to an

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3 373 increase in hypertension prevalence when compared to no education. However, among women, higher
4 374 education appeared to have a protective effect when compared to no education although not statistically
5 375 significant after adjustment. Higher educational attainment among women may be lead to employment,
6 376 higher physical activity and active commuting, which have been shown to reduce sedentary behavior
7 377 among Bangladeshi women ²⁷.

11 378 This study has several strengths. First, we present novel prevalence data on hypertension and
12 379 prehypertension as we included adults aged 18 years and above, whereas prior studies have started their
13 380 cohorts at older ages. As such, these may be useful towards informing our progress towards NCD control
14 381 as defined by the indicators included in the WHO's Global Monitoring Framework²⁸. Additionally, we
15 382 used WHO-recommended standardized methods to measure BP among our study population to limit the
16 383 potential for measurement error. There are several limitations to be considered when interpreting our
17 384 results. Our study is limited to one rural area of Bangladesh and may not be reflective of other areas of the
18 385 country. Prior to this survey, community-level campaigns took place to educate the adults on NCD
19 386 prevention and lifestyle changes that may reduce their risk of developing chronic diseases. As such, they
20 387 were generally more educated about public health interventions, which may limit the generalizability of
21 388 our findings. Self-reported medication use may be subject to social desirability bias as participants are in
22 389 regular contact with ECOH staff members through community campaigns and prior surveillance efforts.
23 390 We were unable to measure important risk factors of hypertension such as diet, physical activity, waist
24 391 circumference, family history of cardiovascular disease, and blood lipid levels. Additionally, we did not
25 392 repeat blood pressure readings after 4 weeks to confirm a diagnosis of hypertension. Finally, due to the
26 393 cross-sectional nature of our study design, we were unable to assess temporality of our risk factors or
27 394 establish any causal relationship with our outcomes of interest.

38 395 Published in 2013, the Guidelines for Management of Hypertension in Bangladesh largely
39 396 recommend and focus on lifestyle measures to reduce the risk of hypertension in adults⁸. This is because
40 397 Bangladesh is a low resource setting with limited availability of trained health care providers and
41 398 treatment, particularly in rural areas. Affordability of treatment is an important factor all providers should
42 399 consider, since costs may impact adherence and continuity of care. In our setting, we observe a low
43 400 prevalence of hypertension, particularly among younger groups, and also hyperglycemia. We believe this
44 401 low prevalence is due to the availability and access to preventive health care, such as physical activity and
45 402 tobacco cessation campaigns. We recommend that other rural areas follow the national guidelines for
46 403 hypertension management, and promote similar lifestyle changes, to achieve similar burden reduction.
47 404 Interestingly, we observed that normotensives had higher added salt intake (90.6%) compared to
48 405 hypertensive adults (81.5%). This may be due to an ongoing dietary salt reduction campaign in Ekhlaspur
49 406 village focused on high-risk patients, including hypertensive adults. Clinic based data from ECOH have

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3 407 clearly demonstrated a sharp decline of added salt intake among those who have hypertension, dropping
4 408 from 73% at enrollment to 13% after about five months, based on self-report ²⁹ Similarly, we observed a
5 409 high proportion of hypertensive participants who previously used tobacco. Patients of ECOH with
6 410 hypertension have been counseled on the harms of tobacco use, both smokeless and smoking, and as such
7 411 the majority reported to use either tobacco form in the past.
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12 413 **Conclusion**

14 414 In conclusion, our sex-disaggregated analysis showed a higher burden of hypertension among
15 415 women compared to men in a rural area of Bangladesh. Furthermore, we found that women were less
16 416 likely to be have been previously diagnosed with hypertension compared to men and thus, more women
17 417 had uncontrolled hypertension. The prevalence of prehypertension was higher among men than women.
18 418 An alarmingly high proportion of those aged 18-29 years had prehypertension (27.9%). A preventive
19 419 community-based approach with sex-tailored educational efforts should be directed to those with
20 420 prehypertension, as they are at highest risk of developing hypertension. The primary health care system of
21 421 Bangladesh is limited, particularly in rural areas, due to a shortage of trained health care providers
22 422 including physicians and nurses. Efforts towards population-level prevention measures, specifically
23 423 lifestyle changes, should be promoted and directed towards risk groups identified through this analysis,
24 424 such as those who are overweight or obese.
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3 441 **Footnotes:**

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14 448 Author contributions: JYI conceptualized the manuscript, guided data analysis, interpreted critically,
15 449 wrote the manuscript; MMZ conceptualized the intervention, assisted with data analysis and manuscript
16 450 development; JA and SRC established methodologies, executed the campaign, supervised and monitored
17 451 data collection, trained the health workers; TZ conducted clinic-based counselling, trained counsellors on
18 452 counselling skills, reviewed literature and prepared citations; HK prepared questionnaires, maintained
19 453 records, worked as a data manager. All authors have read and approved the submission.
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25 455 Availability of data and materials: The de-identified participant data used and/or analyzed during the
26 456 current study are available from the corresponding author on reasonable request. Please contact M.
27 457 Mostafa Zaman at zamanm@who.int for further information and guidelines.
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31 459 Disclosure statement: The authors have no conflicts of interest to disclose.
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35 461 Ethics and consent: To inform the community about this survey, ECOH management organized meetings
36 462 and orientations with the community leaders, schools, and union council members. This survey is part of
37 463 the community's initiative to monitor their health status and to detect any hypertension, diabetes and other
38 464 risk factors. ECOH provides free medicines to those who have prescriptions from doctors. Community-
39 465 level campaigns have been organized to inform the people of the village about NCDs and related risk
40 466 factors. Health assistants of ECOH visited all households to select eligible subjects but no more than three
41 467 recall visits were done. Ethical guidelines as outlined and approved by the Bangladesh Medical Research
42 468 Council were followed throughout the study. Written informed consent was obtained from the
43 469 respondents in Bengali to participate in this survey.
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50 471 Funding: Data collection was conducted using ECOH's own funds generated by the local community as
51 472 regular surveillance. We did not receive any funding from external organizations to complete this work.
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475 **References**

- 476 1. WHO. A global brief on Hypertension: Silent Killer, global public health crisis. Geneva,
477 Switzerland: World Health Organization, 2013.
- 478 2. Lloyd-Sherlock P, Beard J, Minicuci N, et al. Hypertension among older adults in low- and
479 middle-income countries: prevalence, awareness and control. *International journal of*
480 *epidemiology* 2014;43(1):116-28. doi: 10.1093/ije/dyt215
- 481 3. Kearney PM, Whelton M, Reynolds K, et al. Global burden of hypertension: analysis of
482 worldwide data. *Lancet (London, England)* 2005;365(9455):217-23. doi: 10.1016/S0140-
483 6736(05)17741-1
- 484 4. Moniruzzaman TA, Rahman S Prevalence of hypertension among the Bangladeshi adult
485 population: a meta-analysis. *Reg Health Forum* 2013;17:15-19.
- 486 5. Zaman MM, Rouf MA. Prevalence of hypertension in a Bangladeshi adult population. *Journal*
487 *of human hypertension* 1999;13(8):547-9.
- 488 6. Rahman M, Zaman MM, Islam JY, et al. Prevalence, treatment patterns, and risk factors of
489 hypertension and pre-hypertension among Bangladeshi adults. *Journal of human*
490 *hypertension* 2018;32(5):334-48. doi: 10.1038/s41371-017-0018-x
- 491 7. Neupane D, McLachlan CS, Sharma R, et al. Prevalence of hypertension in member countries
492 of South Asian Association for Regional Cooperation (SAARC): systematic review and
493 meta-analysis. *Medicine* 2014;93(13):e74. doi: 10.1097/MD.0000000000000074
- 494 8. National Guidelines for Management of Hypertension in Bangladesh. Dhaka, Bangladesh:
495 WHO/SEARO/Country Office for Bangladesh and DGHS, Ministry of Health and
496 Family Welfare 2013.
- 497 9. Ahsan Karar Z, Alam N, Kim Streatfield P. Epidemiological transition in rural Bangladesh,
498 1986-2006. *Global health action* 2009;2 doi: 10.3402/gha.v2i0.1904
- 499 10. Khanam MA, Lindeboom W, Razzaque A, et al. Prevalence and determinants of pre-
500 hypertension and hypertension among the adults in rural Bangladesh: findings from a
501 community-based study. *BMC public health* 2015;15:203. doi: 10.1186/s12889-015-
502 1520-0

- 1
2
3 503 11. Fottrell E, Ahmed N, Shaha SK, et al. Distribution of diabetes, hypertension and non-
4 504 communicable disease risk factors among adults in rural Bangladesh: a cross-sectional
5 505 survey. *BMJ Glob Health* 2018;3(6):e000787. doi: 10.1136/bmjgh-2018-000787
6
7
8
9 506 12. Biswas T, Townsend N, Islam MS, et al. Association between socioeconomic status and
10 507 prevalence of non-communicable diseases risk factors and comorbidities in Bangladesh:
11 508 findings from a nationwide cross-sectional survey. *BMJ open* 2019;9(3):e025538. doi:
12 509 10.1136/bmjopen-2018-025538
13
14
15 510 13. Rahman M, Zaman MM, Islam JY, et al. Prevalence, treatment patterns, and risk factors of
16 511 hypertension and pre-hypertension among Bangladeshi adults. *Journal of human*
17 512 *hypertension* 2017 doi: 10.1038/s41371-017-0018-x
18
19
20
21 513 14. Ekhlaspur Center of Health 2018 [Available from: <http://ecohbd.org/index.php> accessed June
22 514 2018.
23
24
25 515 15. Coutinho LM, Scazufca M, Menezes PR. Methods for estimating prevalence ratios in cross-
26 516 sectional studies. *Revista de saude publica* 2008;42(6):992-8.
27
28
29 517 16. Behrens T, Taeger D, Wellmann J, et al. Different methods to calculate effect estimates in
30 518 cross-sectional studies. A comparison between prevalence odds ratio and prevalence
31 519 ratio. *Methods Inf Med* 2004;43(5):505-9.
32
33
34
35 520 17. Barros AJ, Hirakata VN. Alternatives for logistic regression in cross-sectional studies: an
36 521 empirical comparison of models that directly estimate the prevalence ratio. *BMC medical*
37 522 *research methodology* 2003;3:21. doi: 10.1186/1471-2288-3-21
38
39
40 523 18. Rahman MM, Gilmour S, Akter S, et al. Prevalence and control of hypertension in
41 524 Bangladesh: a multilevel analysis of a nationwide population-based survey. *Journal of*
42 525 *hypertension* 2015;33(3):465-72; discussion 72. doi: 10.1097/HJH.0000000000000421
43
44
45
46 526 19. Kibria GMA, Swasey K, Das Gupta R, et al. Differences in prevalence and determinants of
47 527 hypertension according to rural-urban place of residence among adults in Bangladesh.
48 528 *Journal of biosocial science* 2018:1-13. doi: 10.1017/S0021932018000366
49
50
51 529 20. Islam FM, Bhuiyan A, Chakrabarti R, et al. Undiagnosed hypertension in a rural district in
52 530 Bangladesh: The Bangladesh Population-based Diabetes and Eye Study (BPDES).
53 531 *Journal of human hypertension* 2016;30(4):252-9. doi: 10.1038/jhh.2015.65
54
55
56
57
58
59
60

- 1
2
3 532 21. NIPORT. Bangladesh Health Facility Survey 2014 Dhaka, Bangladesh: National Institute of
4 533 Population Research and Training (NIPORT), Associates for Community and Population
5 534 Research (ACPR), and ICF International. ; 2016 [Available from:
6 535 <https://dhsprogram.com/pubs/pdf/SPA23/SPA23.pdf> accessed 03/15 2019.
7
8
9
10 536 22. Legido-Quigley H, Naheed A, de Silva HA, et al. Patients' experiences on accessing health
11 537 care services for management of hypertension in rural Bangladesh, Pakistan and Sri
12 538 Lanka: A qualitative study. *PloS one* 2019;14(1):e0211100. doi:
13 539 10.1371/journal.pone.0211100
14
15
16 540 23. Khatib R, Schwalm JD, Yusuf S, et al. Patient and healthcare provider barriers to
17 541 hypertension awareness, treatment and follow up: a systematic review and meta-analysis
18 542 of qualitative and quantitative studies. *PloS one* 2014;9(1):e84238. doi:
19 543 10.1371/journal.pone.0084238
20
21
22
23 544 24. Rahman MS, Rahman MM, Gilmour S, et al. Trends in, and projections of, indicators of
24 545 universal health coverage in Bangladesh, 1995-2030: a Bayesian analysis of population-
25 546 based household data. *The Lancet Global health* 2018;6(1):e84-e94. doi: 10.1016/S2214-
26 547 109X(17)30413-8
27
28
29
30 548 25. Chowdhury MA, Uddin MJ, Haque MR, et al. Hypertension among adults in Bangladesh:
31 549 evidence from a national cross-sectional survey. *BMC cardiovascular disorders*
32 550 2016;16:22. doi: 10.1186/s12872-016-0197-3
33
34
35 551 26. Islam JY, Zaman MM, Haq SA, et al. Epidemiology of hypertension among Bangladeshi
36 552 adults using the 2017 ACC/AHA Hypertension Clinical Practice Guidelines and Joint
37 553 National Committee 7 Guidelines. *Journal of human hypertension* 2018;32(10):668-80.
38 554 doi: 10.1038/s41371-018-0087-5
39
40
41
42 555 27. Moniruzzaman M, Mostafa Zaman M, Islalm MS, et al. Physical activity levels in
43 556 Bangladeshi adults: results from STEPS survey 2010. *Public health* 2016;137:131-8. doi:
44 557 10.1016/j.puhe.2016.02.028
45
46
47 558 28. NCD Global Monitoring Framework: World Health Organization; 2017 [Available from:
48 559 http://www.who.int/nmh/global_monitoring_framework/en/ accessed 09/29 2017.
49
50
51 560 29. Zaman MM, Ahmed J, Choudhury SR, et al. Hypertension Clinic Service is a Good
52 561 Opportunity for Tobacco Cessation in Bangladeshi Villagers. *Cardiovascular Journal of*
53 562 *Bangladesh* 2016;9(1):19-22.
54
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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 Ekhaspur, Bangladesh (n = 2600)

Characteristic	Total (n = 2600)		Women (n = 1395)		Men (n = 1205)		P*
	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 [‡]							<0.001
Underweight (≤18.5)	251	9.7	184	13.2	67	5.6	
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

Characteristic	Total (n = 2600)		P*	Women (n = 1395)		P*	Men (n = 1205)		P*
	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	

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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

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

Characteristic	Total (n = 2600)		Women (n = 1395)		Men (n = 1205)	
	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

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

Characteristic	Total (n = 2422)			Women (n = 1271)			Men (n = 1151)		
	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

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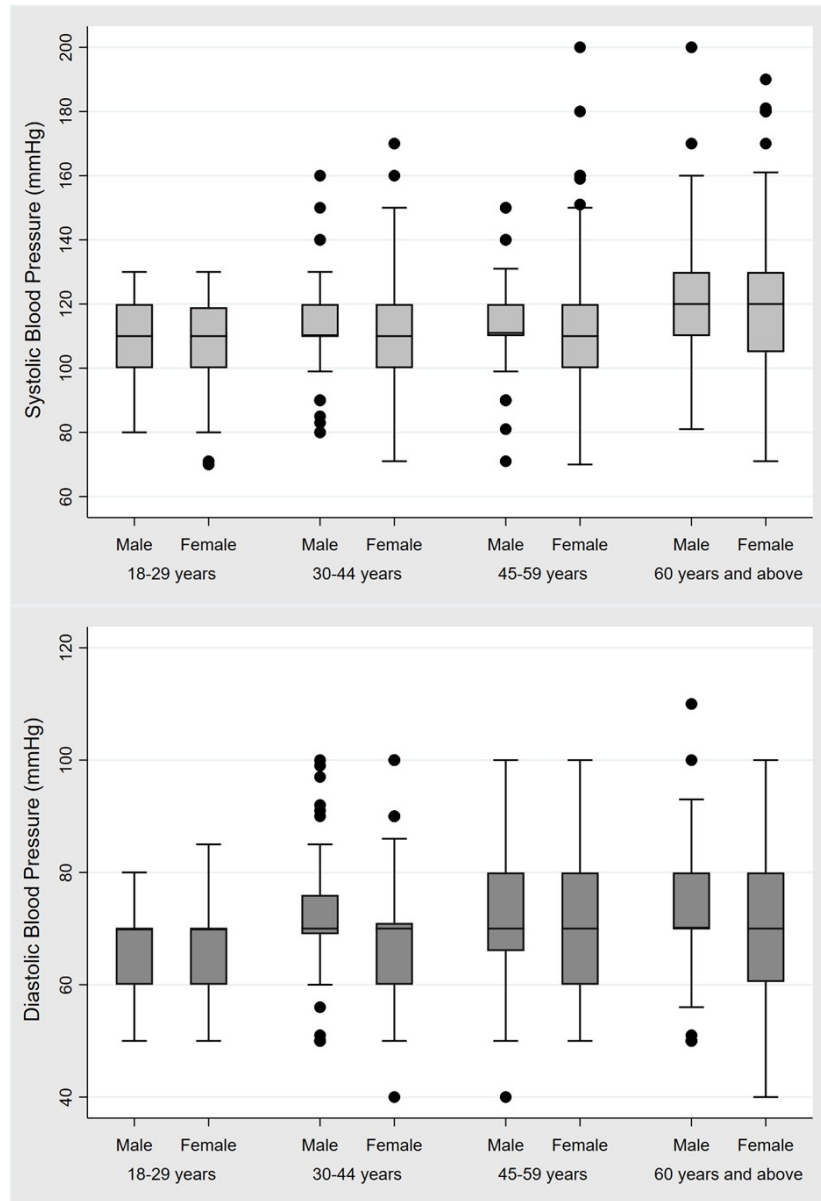
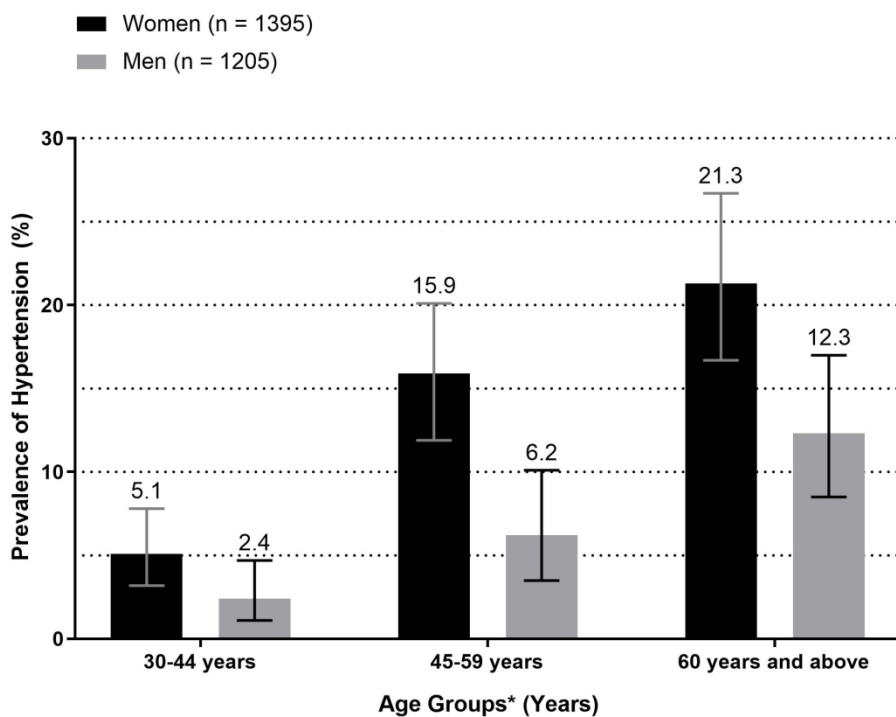


Figure 1: Distribution of systolic and diastolic blood pressure by age group and sex among rural adults in Bangladesh

159x231mm (150 x 150 DPI)

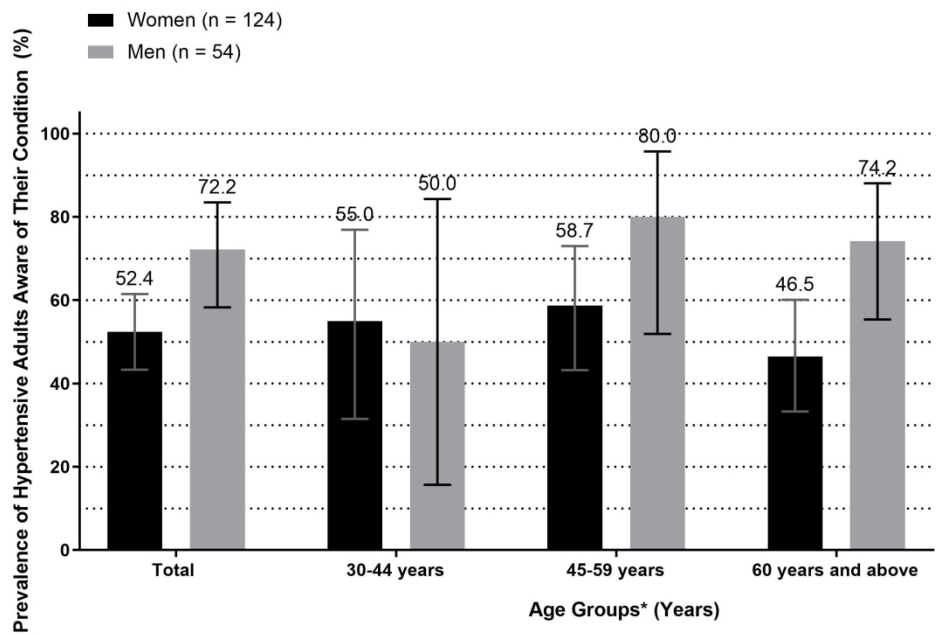


*Age group 18-29 years was not included as prevalence of hypertension was 0% for both men and women

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

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*Age group 18-29 years was not included as prevalence of hypertension was 0% for both men and women

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

213x155mm (300 x 300 DPI)

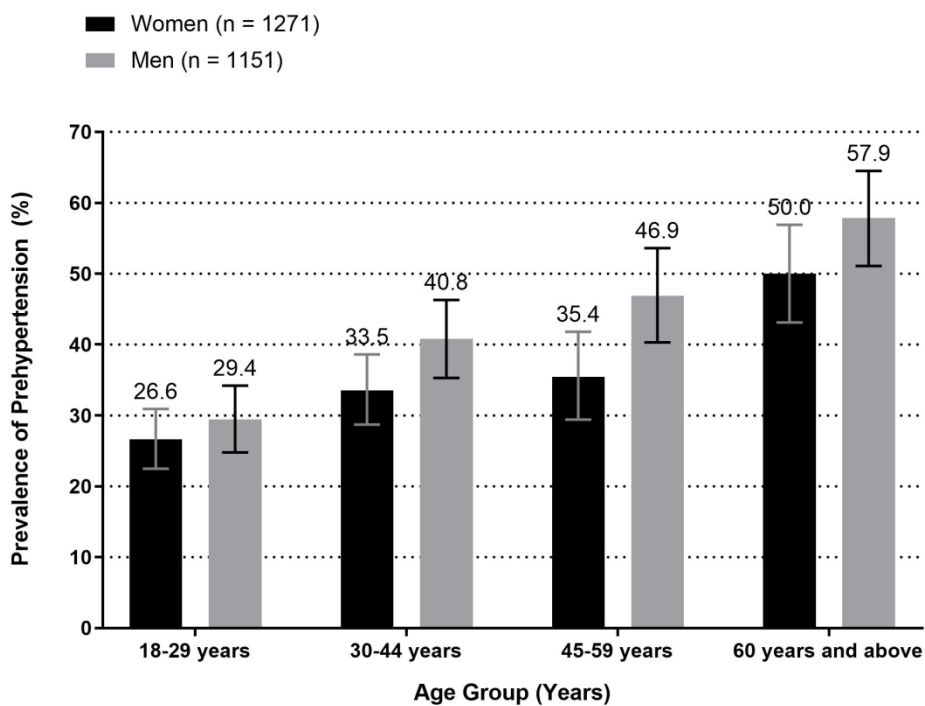


Figure 4: Prevalence of pre-hypertension stratified by age group and sex among rural adults in Bangladesh

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) <i>Cohort study</i> —Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	5
		<i>Case-control study</i> —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	
		<i>Cross-sectional study</i> —Give the eligibility criteria, and the sources and methods of selection of participants	
Variables	7	(b) <i>Cohort study</i> —For matched studies, give matching criteria and number of exposed and unexposed	6,7
		<i>Case-control study</i> —For matched studies, give matching criteria and the number of controls per case	
Data sources/measurement	8*	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6,7
Bias	9	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	12
Study size	10	Describe any efforts to address potential sources of bias	5
Quantitative variables	11	Explain how the study size was arrived at	5
		Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6,7
		(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
Statistical methods	12	(d) <i>Cohort study</i> —If applicable, explain how loss to follow-up was addressed	N/A
		<i>Case-control study</i> —If applicable, explain how matching of cases and controls was addressed	
		<i>Cross-sectional study</i> —If applicable, describe analytical methods taking account of sampling strategy	
		(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) <i>Cohort study</i> —Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	<i>Cohort study</i> —Report numbers of outcome events or summary measures over time	9,10
		<i>Case-control study</i> —Report numbers in each exposure category, or summary measures of exposure	
		<i>Cross-sectional study</i> —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.